

Functional Assessment Across Various Time Points Following Hip or Knee Arthroplasty: Exploring Patient-Centeredness of Outcome Measures

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Dedication

Peter Ustinov once said, “Parents are the bones on which children cut their teeth.” This truly resonates with my experience throughout this dissertation. It has been profoundly supported by the unwavering love, encouragement, and sacrifice of my parents. In gratitude, I dedicate this work to **my first and best friends, my parents.**

As Henry Adams once said, “A teacher affects eternity; he can never tell where his influence stops.” This is certainly true regarding the impact of **my esteemed professor, mentor, and guide, Dr. Stéphane Poitras.** His insight, wisdom, patience, and deep understanding are evident on every page of this dissertation and will continue to shape my future. In thanks, I dedicate this work to him.

As Elizabeth Kübler-Ross stated, “The most beautiful people we have known are those who have known defeat, known suffering, known struggle, known loss, and have found their way out of those depths.” This reflects the strength and resilience of **all patients** who have faced their health challenges with courage and perseverance. I dedicate this dissertation to them, whose remarkable journeys have deeply inspired my research.

Dissertation Abstract

Background: Although hip or knee arthroplasty is generally a successful intervention, it is documented that up to one-third of patients undergoing arthroplasty report suboptimal outcomes. The first step in accurately identifying patients experiencing or being at risk for poorer recovery and optimizing outcomes is selecting the appropriate outcome measures. An important factor in this selection process is the extent to which these measures reflect patients' perspectives. However, there is limited information on the degree to which existing outcome measures used to assess function after hip or knee arthroplasty align with patients' perspectives and needs.

Objectives: The overarching objective is to contribute to improving outcomes following hip or knee arthroplasty. Specifically, this dissertation research aims to evaluate the patient-centeredness of outcome measures used to assess function following hip or knee arthroplasty.

Methods: To meet this objective, I conducted seven research studies guided by the International Classification of Functioning, Disability, and Health (ICF) framework: (1) a narrative review of key findings related to managing poorer outcomes after hip or knee arthroplasty; (2) a cognitive interview with 18 patients who underwent hip or knee arthroplasty, evaluating a developed self-report questionnaire on functional priorities; (3) a systematic review and content analysis of 50 patient-reported outcome measures (PROMs) used to assess function after hip or knee arthroplasty; (4) a systematic review and content analysis of 28 performance-based tests (PBTs) used after hip or knee arthroplasty; (5) a survey of functional activities with patients who underwent hip or knee arthroplasty; (6) a patient-centered content validity analysis of 50 PROMs and 28 PBTs used after hip or knee arthroplasty; and (7) a scoping review of patient involvement in the development of 50 PROMs.

Results: The first study provided a foundation for guiding the subsequent studies in this dissertation and highlighted that the initial step in optimizing outcomes after hip or knee arthroplasty is selecting appropriate patient-centered functional outcome measures. To achieve this, a questionnaire was first developed based on the activity and participation components of the ICF core set for osteoarthritis (OA) and validated through cognitive interviews with patients, which provided a basis for the subsequent studies.

The third study provided a detailed content analysis of 50 PROMs by linking their items to the modified ICF OA core set. The findings revealed variability in the coverage of activity and participation categories across PROMs, with some categories being inadequately covered or infrequently addressed. Additionally, the results indicated that some PROM items addressed multiple concepts or used complex wording. In the fourth study, the ICF-based content analysis of 28 PBTs revealed that these tests covered 15 categories of the ICF OA core set but did not address 34 other categories.

To evaluate how well these PROMs and PBTs align with patients' perspectives, the fifth study surveyed 632 patients, identifying 26 key activities (i.e., activities that patients deemed important

and challenging) and 22 non-key activities (i.e., activities considered unimportant or not challenging). The findings showed that patients had different key activities at each time point, with a decline in the number of key activities over time. Mapping the results from studies 2 and 3 with study 5 revealed that none of the outcome measures fully captured the key activities at various stages of recovery. The results also showed that the coverage of key functional activities varied across outcome measures at different time points following hip or knee arthroplasty. In addition, PROMs had varying recall periods, with the previous week and four weeks being the most common

Finally, the last study revealed that approximately half of these PROMs did not involve patients in their development. This study demonstrated that various methods were employed to involve patients at different stages of the development process.

Conclusions: The overall findings from this dissertation highlighted that the 78 PROMs and PBTs used after hip or knee arthroplasty do not fully capture the key activities that are important to patients at various stages of recovery. The results emphasized the need to address these deficiencies to more accurately capture patient-relevant activities and needs. This can be achieved by increasing patient involvement in the development of these measures, using robust methods for item or activity development, enhancing comprehensibility, and optimizing response options and recall periods. Addressing these gaps may involve developing new outcome measures or modifying and combining existing ones. In addition, researchers should consider the evolving nature of key activities following arthroplasty to ensure that outcome measures remain relevant throughout the recovery process.

Résumé de Thèse

Contexte : Bien que l'arthroplastie de la hanche ou du genou soit généralement une intervention réussie, il est documenté qu'un tiers des patients ayant subi une arthroplastie rapportent des résultats sous-optimaux. La première étape pour identifier avec précision les patients connaissant ou à risque de connaître une récupération moins satisfaisante et pour optimiser les résultats consiste à sélectionner les mesures de résultat appropriées. Un facteur important dans ce processus de sélection est la mesure dans laquelle ces mesures reflètent les perspectives des patients. Cependant, il existe peu d'informations sur le degré auquel les mesures de résultat existantes utilisées pour évaluer la fonction après une arthroplastie de la hanche ou du genou sont en adéquation avec les perspectives et les besoins des patients.

Objectifs : L'objectif principal est de contribuer à l'amélioration des résultats après une arthroplastie de la hanche ou du genou. Plus précisément, cette recherche de thèse vise à évaluer l'orientation centrée sur le patient des mesures de résultat utilisées pour évaluer la fonction après une arthroplastie de la hanche ou du genou.

Méthodes : Pour atteindre cet objectif, j'ai mené sept études de recherche guidées par le cadre de la Classification Internationale du Fonctionnement, du Handicap et de la Santé (CIF) : (1) une revue narrative des principales conclusions concernant la gestion des résultats moins favorables après une arthroplastie de la hanche ou du genou ; (2) un entrevue cognitive avec 18 patients ayant subi une arthroplastie de la hanche ou du genou, évaluant un questionnaire d'auto-évaluation développé sur les priorités fonctionnelles ; (3) une revue systématique et une analyse de contenu de 50 mesures de résultat rapportées par les patients (MRRP) utilisées pour évaluer la fonction après une arthroplastie de la hanche ou du genou ; (4) une revue systématique et une analyse de contenu de 28 tests basés sur la performance (TBP) utilisés après une arthroplastie de la hanche ou du genou ; (5) une enquête sur les activités fonctionnelles auprès de patients ayant subi une arthroplastie de la hanche ou du genou ; (6) une analyse de validité de contenu centrée sur le patient de 50 MRRP et 28 TBP utilisés après une arthroplastie de la hanche ou du genou ; et (7) une revue exploratoire de l'implication des patients dans le développement de 50 MRRP.

Résultats : La première étude a posé les bases pour guider les études suivantes de cette thèse et a souligné que la première étape pour optimiser les résultats après une arthroplastie de la hanche ou du genou est de sélectionner des mesures de résultat fonctionnelles centrées sur le patient. Pour y parvenir, un questionnaire a d'abord été développé en se basant sur les composantes d'activité et de participation de la CIF pour l'ostéoarthrose (OA) et validé à travers des entrevues cognitives, ce qui a fourni une base pour les études ultérieures.

La troisième étude a fourni une analyse détaillée du contenu de 50 MRRP en reliant leurs éléments au à la CIF pour l'OA modifiée. Les résultats ont révélé une variabilité dans la couverture des catégories d'activité et de participation à travers les PROM, certaines catégories étant insuffisamment couvertes ou rarement abordées. De plus, les résultats ont indiqué que

certaines éléments des MRRP abordaient plusieurs concepts ou utilisaient un vocabulaire complexe. Dans la quatrième étude, l'analyse de contenu basée sur la CIF de 28 TBP a révélé que ces tests couvraient 15 catégories de la CIOF pour l'OA mais n'abordaient pas 34 autres catégories.

Pour évaluer dans quelle mesure ces MRRP et TBP correspondent aux perspectives des patients, la cinquième étude a sondé 632 patients, identifiant 26 activités clés (c'est-à-dire des activités jugées importantes et difficiles par les patients) et 22 activités non clés (c'est-à-dire des activités considérées comme peu importantes ou non difficiles). Les résultats ont montré que les patients avaient des activités clés différentes à chaque point temporel, avec une diminution du nombre d'activités clés au fil du temps. La cartographie des résultats des études 2 et 3 avec l'étude 5 a révélé qu'aucune des mesures de résultat ne capturait pleinement les activités clés à différents stades de la récupération. Les résultats ont également montré que la couverture des activités fonctionnelles clés variait entre les mesures de résultat à différents moments après l'arthroplastie de la hanche ou du genou. De plus, les MRRP avaient des périodes de rappel variées, la semaine précédente et quatre semaines étant les plus courantes.

Enfin, la dernière étude a révélé qu'environ la moitié de ces MRRP n'avaient pas impliqué les patients dans leur développement. Cette étude a démontré que diverses méthodes étaient utilisées pour impliquer les patients à différents stades de développement.

Conclusions : Les résultats globaux de cette thèse ont souligné que les 78 MRRP et TBP utilisés après une arthroplastie de la hanche ou du genou ne capturent pas pleinement les activités clés qui sont importantes pour les patients à différents stades de la récupération. Les résultats mettent en évidence la nécessité de remédier à ces lacunes pour capturer plus précisément les activités et les besoins pertinents pour les patients. Cela peut être accompli en augmentant la participation des patients dans le développement de ces mesures, en utilisant des méthodes robustes pour le développement des éléments ou des activités, en améliorant la compréhensibilité et en optimisant les options de réponse et les périodes de rappel. Remédier à ces lacunes pourrait impliquer le développement de nouvelles mesures de résultat ou la modification et la combinaison de celles existantes. De plus, les chercheurs devraient tenir compte de la nature évolutive des activités clés après l'arthroplastie pour s'assurer que les mesures de résultat restent pertinentes tout au long du processus de récupération.

Plain language summary

Background and objectives: Hip or knee replacement surgery is usually successful, but up to one-third of patients report less-than-ideal results. To help these patients recover better, it's important to choose the right ways to measure their progress. These measurements should reflect what activities matter to patients, but there's not much information on how well current measures do this. The main goal of this research is to improve results for patients who have had hip or knee replacement surgery. Specifically, it looks at how well current measures reflect what activities are important to patients.

Methods: I conducted seven studies. The first study reviewed existing research on managing less-than-ideal results after surgery. The second study involved interviewing 18 patients to develop a new questionnaire on what activities are important to them. The third study analyzed 50 questionnaires used by patients after surgery to assess results, and the fourth study analyzed 28 tests used by clinicians after surgery to assess results. The fifth study surveyed patients about the activities that are important and challenging after surgery. The sixth study evaluated how the 50 questionnaires and 28 tests assess these important activities. The seventh study reviewed patient involvement in the development of these 50 questionnaires.

Results: The first study laid the groundwork for the rest of the research by showing that the first step to improving results after hip or knee replacement is to choose measures that focus on what matters to patients. To do this, a questionnaire was created based on important activities for people with osteoarthritis. This questionnaire was tested with patients who underwent hip or knee replacement to make sure it was relevant, forming the basis for the following studies. The third study found that the 50 questionnaires failed to cover some relevant activities or used complicated language. The fourth study found that the 28 tests assessed some relevant activities but not all. To see how well these questionnaires and tests matched what patients care about, the fifth study surveyed 632 patients. It identified 26 important activities and 22 less important ones. The sixth study showed that no measure fully assessed all activities important to the patients. Finally, the last study showed that about half of the questionnaires did not involve patients in their development.

Conclusions: This research found that the current questionnaires and tests used after hip or knee replacement do not assess all the activities important to patients. To improve this, it is important to involve patients more when developing these measures and improve the clarity of questions. This may involve creating new measures or refining existing ones to better reflect patients' needs.

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List of Abbreviations

Abbreviation	Full Name
10MWT	10-meter Walk Test
20MWT	20-meter Walk Test
2MWT	2-minute Walk Test
30MWT	30-minute Walk Test
30-s CST	30-second Chair Stand Test
3MBWT	3-meter Backward Walk Test
40m FPWT	40-meter Fast-paced Walking Test
4MWT	4-meter Walk Test
4 SCT	Four-step Stair Climb Test
50FTW	50-Foot Timed Walk Test
5xSST	Five Times Sit-to-Stand Test
6MWT	6-minute Walk Test
8FTW	8-Foot Timed Walk Test
A-test	“A” like Activity or Assessment
AAOS	American Academy of Orthopaedic Surgeons
AKPS	Kujala Anterior Knee Pain Scale
AIMS	Arthritis Impact Measurement Scale
ASAP	Activity Scale for Arthroplasty Patients
BMI	Body Mass Index
CHAMPS	Community Healthy Activities Model Program for Seniors
COMI	Core Outcome Measures Index
COPM	Canadian Occupational Performance Measure
COSMIN	Consensus-based Standards for the Selection of Health Measurement Instruments
EPIC	Electronic Health Record
EQ-5D	EuroQol-5D
F8WT	Figure of 8 Walk Test
FAS	Functional Assessment System of Lower Extremity Dysfunction
FSST	Four Square Step Test
FSI	Functional Status Index
FIM	Functional Independence Measure
FJS	Forgotten Joint Scale
HAAS	High-Activity Arthroplasty Score
HAGOS	Hip and Groin Outcome Score
HHS	Harris Hip Score
HOOS	Hip Dysfunction and Osteoarthritis Outcome Score
HOOS-12	12-item Hip Dysfunction and Osteoarthritis Outcome Score
HOOS-JR	Hip Dysfunction and Osteoarthritis Outcome Score-Joint Replacement
HOOS-PS	Hip Dysfunction and Osteoarthritis Outcome Score - Physical Function Short Form
HOS	Hip Outcome Score
IRGL	Influence of Rheumatic Diseases on Health and Lifestyle
IKDC	International Knee Documentation Committee

JAS	Joint Awareness Score
JHEQ	Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire
JOA	Japanese Orthopaedic Association
KKS	Korean Knee Score
KOS-ADLS	Knee Outcome Survey Activities of Daily Living Scale
KPSI	Knee Patient-Specific Index
KSS	Knee Society Score
KSS-A	Adjusted 2011 Knee Society Score
KSS-S	Knee Society Score - Short-form
KOOS	Knee Injury and Osteoarthritis Outcome Score
KOOS-12	12-item Short Forms Knee Injury and Osteoarthritis Outcome Score
KOOS-JR	Knee Injury and Osteoarthritis Outcome Score Joint Replacement
KOOS-PS	Knee Injury and Osteoarthritis Outcome Score - Physical Function Short Form
LLFI	Lower Limb Functional Index
LLFI-10	Lower Limb Functional Index-10
LLTQ	Lower Limb Task Questionnaire
LEAS	Lower-Extremity Activity Scale
LEAP	Lower Extremity Activity Profile
M-FJS	Modified Forgotten Joint Score
MHAQ	Modified Health Assessment Questionnaire
MCID	Minimal Clinically Important Difference
MIC	Minimum Important Change
MDC	Minimum Detectable Change
MODEMS	Musculoskeletal Outcomes Data Evaluation and Management System
MSS	Modified Staffelein Score
MSK-HQ	Musculoskeletal Health Questionnaire
MROC	Multi-disciplinary Rehabilitation Outcome Checklist
No.	Number
OAKHQOL	Osteoarthritis Knee and Hip Quality of Life
OACS	Oxford Arthroplasty Early Change Score
OARS	Oxford Arthroplasty Early Recovery Score
OKS	Oxford Knee Score
OKS-APQ	Oxford Knee Score—Activity and Participation
OMERACT	Outcome Measures in Rheumatology
PAQ	Patient Administered Questionnaire
PASE	Physical Activity Scale for the Elderly
PASS	Patient Acceptable Symptom State
PKIP	Patient's Knee Implant Performance Questionnaire
PROM	Patient-Reported Outcome Measure
PROMIS R-Plus-OAK	Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee
PDQ	Pain Disability Questionnaire
PBT	Performance-Based Test
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses

REDCap	Research Electronic Data Capture
ROM	Range of Motion
sAIMS	Shortened version of the Arthritis Impact Measurement Scales
SANRA	Scale for the Assessment of Narrative Review Articles
SANE	Single Assessment Numeric Evaluation
SCT	Stair Climbing Test
SPPB	Short Physical Performance Battery
SF-12	12-item Short Form Health Survey
SF-36	36-item Short Form Health Survey
ST-score	Staffelstein Score
TUG	Timed Up and Go
TF	Treatment Failure Threshold
THAOQ	Total Hip Arthroplasty Outcome Questionnaire
UCLA	The University of California at Los Angeles
WHO	World Health Organization
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index
WORQ	Work, Osteoarthritis, or Joint-Replacement Questionnaire
yr	Year

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CHAPTER 1: Introduction

“It is much more important to know what sort of patient has a disease than what sort of disease a patient has.”

-William Osler

In this dissertation, my overarching objective is to contribute towards improving outcomes following hip or knee arthroplasty. Specifically, I aim to identify appropriate patient-centered outcome measures after these procedures. I seek to determine whether we are using the right tools during functional assessments after hip or knee arthroplasty. This chapter is structured into three parts. Firstly, I outline the organizational structure of my dissertation. Secondly, I provide a narrative review, which constitutes the first manuscript of my dissertation, explaining the rationale behind my research. Lastly, I discuss the definitions of relevant concepts for my dissertation, the theoretical frameworks guiding my research projects, the methodology employed in my dissertation studies, and ethical considerations.

PART 1: Organization of Dissertation

I structured my dissertation according to the University of Ottawa's doctoral thesis guidelines, adopting an article format. The first chapter includes an introduction, a thorough review of the literature that provides a rationale for this dissertation (manuscript 1), the definition of relevant concepts, and methodologies and ethical considerations. Chapters 2 through 7 are dedicated to describing six individual studies (manuscripts 2-7), focused on identifying the appropriate patient-centered outcome measures after hip or knee arthroplasty. Chapter 8 integrates the findings from these studies, providing a discussion of the research outcomes and their implications. Table 1.1 provides a brief overview of each chapter.

Table 1.1. Dissertation Organization

Chapter	Title	Aim	Method
1	Introduction (<i>Manuscript 1</i>)	<i>PART 1:</i> Explain the organization of dissertation, and study objectives. <i>PART 2:</i> To provide an overview of the key findings concerning the management of poorer outcomes after hip or knee arthroplasty that provides a rationale for this dissertation. <i>PART 3:</i> Describe relevant definitions Describe theoretical framework Describe the methodologies of six individual studies Explain the ethical considerations.	Narrative review
2	Cognitive think-aloud interview study (<i>Manuscript 2</i>)	To develop a self-report questionnaire evaluating functional priorities after hip or knee arthroplasty and evaluate patients' understanding of its items and conceptual relevance.	Qualitative think-aloud interview
3	Systematic review and content analysis of PROMs (<i>Manuscript 3</i>)	To identify the existing PROMs used in hip or knee arthroplasty for adults with osteoarthritis and assess their content validity using the modified ICF core set for OA	Systematic review and content analysis
4	Systematic review and content analysis of PBTs (<i>Manuscript 4</i>)	To identify the existing PBTs used in hip or knee arthroplasty and assess their content validity using the modified ICF core set for OA	Systematic review and content analysis
5	Survey of functional activities (<i>Manuscript 5</i>)	To determine key functional activities based on patients' perspective within 2 weeks, at 6, 12, and 26 weeks after hip or knee arthroplasty	Cross-sectional survey

6	Patient-centered content analysis <i>(Manuscript 6)</i>	To perform a patient-informed content analysis of current outcome measures used to evaluate function after hip or knee arthroplasty for OA, aiming to select an appropriate patient-centered outcome measure	Content validity analysis
7	Patient involvement scoping review <i>(Manuscript 7)</i>	To assess the extent of patient involvement in the development of PROMs used after hip or knee arthroplasty.	Scoping review
8	Integrated discussion	Provide an integrated discussion Describe findings implications Describe research limitations	Descriptive synthesis

ICF: International Classification of Functioning, Disability and Health; **OA:** Osteoarthritis; **PBT:** Performance-based tests; **PROMs:** patient-reported outcome measures

PART 2: Literature review (Manuscript 1)

Relationship of Manuscript 1 to the Dissertation

In this chapter, I present a manuscript that provides an overview of three main research areas: outcome assessment, factors predictive of or associated with poorer outcomes after arthroplasty, and management strategies for factors related to or predictive of poorer recovery. This narrative review supports my dissertation objective and highlights that the initial step in optimizing outcomes after hip or knee arthroplasty is identifying appropriate patient-centered functional outcome measures. These measures are essential for understanding, interpreting, and predicting the effects of disease and healthcare interventions. They also guide clinical decisions and highlight opportunities for improving care. Selecting outcome measures that align with patients' priorities is crucial, as poorly targeted measures can lead to irrelevant or misleading information, waste resources, and miss opportunities to identify potential benefits.

Selecting the appropriate outcome measures involves considering several key quality standards, including development processes, instrument design, psychometric properties, and cultural translation and adaptation processes. Among these, content validity holds the most clinical impact. It evaluates whether outcome measures accurately reflect the intended construct by assessing their relevance, comprehensiveness, and comprehensibility in relation to the construct, target population, and context of application. This narrative review highlighted uncertainty about how well current outcome measures for assessing function after hip or knee arthroplasty capture patients' perspectives. To truly respect and integrate patient priorities and perspectives, it is essential to evaluate outcome measures to ensure they accurately reflect the patient's experience. These findings from the narrative review were crucial in shaping the research questions for the subsequent six studies in my dissertation.

The manuscript resulting from this work has been published in *Musculoskeletal Care* under the CC BY-NC-ND license. Sections and references were formatted according to journal requirements, while the table numbering was adjusted to match this dissertation's formatting. The published article can be viewed at:

Karimijashni M, Ramsay T, Beaulé PE, Poitras S. Strategies to Manage Poorer Outcomes After Hip or Knee Arthroplasty: A Narrative Review of Current Understanding, Unanswered Questions, and Future Directions. *Musculoskeletal Care*. 2024;22(3):e1921.
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Manuscript 1: Strategies to manage poorer outcomes after hip or knee arthroplasty: A narrative review of current understanding, unanswered questions, and future directions

Abstract

Purpose: Although hip or knee arthroplasty is generally successful intervention, it is documented that 15% to 30% of patients undergoing arthroplasty report suboptimal outcomes. This narrative review aims to provide an overview of the key findings concerning the management of poorer outcomes after hip or knee arthroplasty.

Methods: A comprehensive search of articles was conducted up to November 2023 across three electronic databases. Only studies written in English were included, with no limitations applied regarding study design and time.

Results: Efficiently addressing poorer outcomes after arthroplasty necessitates a thorough exploration of appropriate methods for assessing recovery following hip or knee arthroplasty, ensuring accurate identification of patients at risk or experiencing poorer recovery. When selecting appropriate outcome measure tools, various factors should be taken into consideration, including understanding patients' priorities throughout the recovery process, assessing psychometric properties of outcome measure tools at different time points after arthroplasty, understanding how to combine/reconcile provider-assessed and patient-reported outcome measures, and determining the appropriate methods to interpret outcome measure scores. However, further research in these areas is warranted. In addition, the identification of key modifiable factors affecting outcomes and the development of interventions to manage these factors are needed.

Conclusion: There is growing attention paid to delivering interventions for patients at risk or not optimally recovering following hip or knee arthroplasty. To achieve this, it is essential to identify

the most appropriate outcomes measure tools, factors associated with poorer recovery and management of these factors.

Keywords: Hip or Knee Arthroplasty, Poor outcomes, Outcome measures

Background

knee and hip osteoarthritis (OA) is the most prevalent form of joint disease and is the leading cause of pain and disability (Domínguez-Navarro et al., 2018; Papalia et al., 2020). Once conservative treatments fail to manage the symptoms, joint arthroplasty is recommended intervention for advanced hip and knee OA as a clinically- and cost-effective treatment (Papalia et al., 2020; van Doormaal et al., 2020; Van Manen et al., 2012). The demand for hip or knee arthroplasty surgeries has increased in recent decades due to several factors, such as expanded surgical indications, increased life expectancy, rising prevalence of obesity, and an aging population (Crowninshield et al., 2006; S. Kim, 2008; Losina et al., 2012). A recent study has forecasted a further rise in hip or knee arthroplasty, projecting 791,760 total knee arthroplasties and 433,372 total hip arthroplasties annually in the United states by 2030, respectively (Shichman et al., 2023).

While hip or knee arthroplasty is a generally successful intervention in alleviating pain and improving functional status, research indicates that 15% to 30% of patients report suboptimal outcomes following arthroplasty (Ewen et al., 2012; L. Snell et al., 2018; Larsen et al., 2020). The underlying reasons for the poorer recovery after hip or knee arthroplasty are not well understood (Hamilton et al., 2020), but several factors have been identified to be associated with poorer outcomes. In addition, the lack of conclusive evidence has left clinicians with limited guidance in selecting the most effective postoperative interventions following hip or knee arthroplasty. Consequently, some patients may not receive the tailored postoperative interventions they require, leading to suboptimal outcomes and significant variations in clinical practice. This article aims to provide the key findings from a literature review of concepts concerning poorer outcomes after

hip or knee arthroplasty. It proposes current understandings and future directions where additional work is needed to address unanswered questions to ultimately improve outcomes after arthroplasty.

Methods

The reporting of this review followed the principles outlined in the Scale for the Assessment of Narrative Review Articles (SANRA) (Baethge et al., 2019). A comprehensive search for articles was conducted across three electronic databases (Medline, Embase, and CINAHL) up to November 2023, encompassing combinations of the following key terms: joint replacement, joint arthroplasty, poor outcomes, factors, predictive factors, prognostic factors, outcome measures, psychometrics properties, patients need, patient priority, functional priority. Inclusion was limited to total hip and knee arthroplasty due to osteoarthritis, and articles focusing on arthroplasty for other reasons were excluded. Only studies written in English were included. Various study designs, including clinical trials, prospective and retrospective studies, cross-sectional studies, commentaries, and systematic reviews, were included. Titles and abstracts of included studies followed by full texts of the studies were screened to select potentially relevant articles by the first author (MK). Google Scholar and articles found in the references of articles retrieved from the database searches were manually searched.

Results

The current state of research with unanswered questions

Several authors have proposed that pre and postoperative management should be targeting patients who are not recovering well and/or at risk of poor recovery instead of blanket provision for all (Hamilton et al., 2019; Riddle, 1998). Patients at risk or not optimally recovering after arthroplasty first need to be identified (Stynes et al., 2016). The following sections elaborate on the present understanding with future prospective of three sequential

interrelated concepts aimed at enhancing outcomes in patients at risk or experiencing poorer recovery, which includes: 1) the appropriate way to assess recovery after arthroplasty to identify patients with poorer outcomes, 2) pre-and post-operative predictive and/or associated factors of poorer recovery, and 3) management of these factors.

1. Outcome assessment after arthroplasty

Various concepts are used to assess recovery after arthroplasty including surgical adverse events, hospital length of stay, pain, impairments, function, quality of life, patient satisfaction, mental health, and global patient assessment (Riddle et al., 2021; Te Molder et al., 2020).

Extensive variation in types of outcome measures tools has been found across trials (Riddle et al., 2008), which in turn make comparisons across studies and synthesis of results difficult. The type of outcome measure tool selected will have an impact on detecting treatment effects (Barak & Duncan, 2006). Although multiple tools to measure outcomes of hip or knee arthroplasty exist, the instruments that are the most appropriate is unclear (Dowsey & Choong, 2013). Some of the outcomes are evaluated by healthcare providers (such as impairments or adverse events) while others are patient-reported. In general, weak correlations have been found between provider-assessed and patient-reported outcome measures (Bullens et al., 2001; Elibol et al., 2018; Kane et al., 2005; Prill et al., 2022). Although it is recommended that both provider-assessed and patient-reported outcomes should be captured to evaluate outcomes comprehensively after arthroplasty (Capin et al., 2022), it is not clear how they should be combined/reconciled if they provide different results.

Several factors should be considered when selecting an appropriate outcome measure for patients undergoing hip or knee arthroplasty, with patients' perspectives being the utmost factor to assess meaningful health improvement and provide patient-centered care (Abdellatif et al.,

2022). While some patient-reported outcome measures (PROMs) such as the Oxford and hip scores have been developed specifically for patients undergoing hip and knee arthroplasty such as Oxford knee and hip score, it is unclear to what extent they reflect patient perspectives after arthroplasty (Collins & Roos, 2012). It has been argued that PROMs lacking consideration of patient perspectives fail to adequately reflect their concerns and needs, thus compromising the patient-centered outcome assessment (Trujols et al., 2013). It is essential for patients to be actively involved in the development of PROMs to ensure that the operationalization of items reflects patient perspectives (Trujols et al., 2013; Wiering et al., 2017). However, previous reviews have indicated that patient involvement in the development process of the tools has been limited (Y. Wang et al., 2021; Wiering et al., 2017).

Patient priorities need to be considered because they may vary between patients. Previous research showed that abilities to do activities such as walking distance varied according to age and gender (Noble et al., 2005). Thus, the assessment of only basic function in younger and active patients who might have higher expectations of activities of daily living might be insufficient to capture the full extent of functional recovery following arthroplasty. On the other hand, assessment of basic functions could be appropriate for patients without any high demand activity expectations.

While patients' expectations and goals before surgery have been extensively investigated in the literature (Lange et al., 2017; Lützner et al., 2022; Mancuso et al., 1997; Noble et al., 2006; Zywił et al., 2013), there is still little understanding of which activities patients undergoing hip or knee arthroplasty prioritize at different time points after surgery. Preoperative patient expectations and goals can orient the surgical decision-making process (Lange et al., 2017; Lützner et al., 2022), but they are insufficient for postoperative decision-making.

Postoperative information is necessary for several reasons :1) response shift may occur after arthroplasty, which is a change in self-evaluation because of changes in internal standards, values, and the conceptualization of function after treatment (Schwartz & Sprangers, 2000). Previous studies have shown that patients might revise their functional priorities and expectations and redefine treatment success after hip or knee arthroplasty because their functional status and perception of functional health may have changed (T. K. Kim et al., 2010; Razmjou et al., 2006); 2) up to half of patients have overly optimistic attitudes on potential postoperative outcomes (Mannion et al., 2009; Noble et al., 2006); and 3) preoperative patient expectations tend to focus only on long-term goals (Lange et al., 2017; Lützner et al., 2022).

Variation of change and cut-off scores being used for each outcome measure can be used (Riddle & Dumenci, 2020; Te Molder et al., 2020; Terwee et al., 2010a). Different concepts have been used to interpret outcomes in patients undergoing arthroplasty, such as minimal clinically important difference (MCID) for improvement or worsening, minimum important change (MIC), minimum detectable change (MDC), patient acceptable symptom state (PASS), treatment failure (TF) threshold, scientifically sound statistical modeling method (i.e., discrete latent variable framework) , and examining recovery curves (Clement et al., 2021; L. K. Harris et al., 2023; Kennedy et al., 2011; Kvien et al., 2007; Riddle et al., 2022; Schmitt & Di Fabio, 2004). There are several challenges in deciding which concepts to use. First, it is not clear which concept is more relevant to identify patients at risk of poor outcomes. Some authors suggested feeling good (the concept of PASS) is a more relevant outcome for patients rather than feeling better (the concept of MCID for improvement) (Tubach et al., 2005, 2006). However, other researchers believe that the concept used depends on patient characteristics (Goh et al., 2022, 2023). Large variations in values in the same concepts vary across studies since they rely on different patient

demographics, disease severity and baseline function scores (Maredupaka et al., 2020; Rolfson et al., 2016; Terwee et al., 2010b; Wijeyesundera & Johnson, 2016). Patients with worse baseline function showed greater improvement, increasing the likelihood of achieving MCID but decreasing the likelihood of achieving PASS, while patients with better baseline function demonstrated the opposite (Maxwell et al., 2014). Previous research have also shown different thresholds for patients depending on age, gender and baseline function (Bahadır et al., 2021; Olsen et al., 2018; Y.-C. Wang et al., 2011). Second, several methodological approaches exist for calculating MCID, MIC, MDC, PASS and TF (Maredupaka et al., 2020; Wright et al., 2012). These approaches can generally be categorized into two groups: anchor-based and distribution-based methods (Karhade et al., 2021; Keurentjes et al., 2012; Terwee et al., 2010a) with lack of consensus about the best methodology to calculate these values. Third, there is currently no clear evidence if pre- or post-operative outcomes data should be used for baseline, and if poor response means subpar improvement (MCID for improvement) or worsening of outcomes (MCID for deterioration) (Humphrey et al., 2022; Kvien et al., 2007). Fourth, while a majority of studies have established the MCID, MIC, MDC and PASS values at six months and one year after arthroplasty, there is little information for these values in the first three months after surgery when most functional recovery typically occurs (Chan et al., 2020; Wiecezorek et al., 2020). Finally, instruments' psychometric properties and practicality is another aspect to consider when selecting appropriate outcome measure tools. Although, several studies have assessed the psychometric properties following arthroplasty, there is limited research on the first three months postoperative (Gagnier et al., 2017, 2018; K. Harris et al., 2016; Özden & Tümtürk, 2022; Ramkumar et al., 2015; Reynaud et al., 2020; Y. Wang et al., 2021).

2. Factors predictive or associated with poor outcomes after arthroplasty

Factors predictive of suboptimal recovery may allow to identify patients at risk of experiencing poorer recovery (Childs et al., 2004; Dumenci et al., 2019; van Doormaal et al., 2020). Table 1.2 illustrates the pre- and postoperative factors predictive of and associated with outcomes following knee and hip arthroplasty.

Table 1.2 Pre and postoperative factors predictive of and associated with postoperative outcomes.

	Preoperative factors	Postoperative factors
Impairment domains	• lower-extremity muscle strength (Devasenapathy et al., 2019a) • ROM (Batailler et al., 2021) • Pain (Lewis et al., 2015)	• lower extremity strength (Yoshida et al., 2008) • Pain (Zeni Jr & Snyder-Mackler, 2010)
Activity limitation domains	• Performance tests such as 6MWT, TUG, and SCT (Devasenapathy et al., 2019b) • PROMs such as WOMAC (Devasenapathy et al., 2019b; Harmelink et al., 2017)	• TUG performance (Bade et al., 2014; Poitras et al., 2015)
Participation restriction domains	• HRQoL such as EQ-5D, SF-36 (Devasenapathy et al., 2019b; Harmelink et al., 2017).	-
Personal domains	• Age (Hofstede et al., 2016) • Sex (Harmelink et al., 2017) • Race (Alvarez et al., 2022a) • Socioeconomic situation (Alvarez et al., 2022b) • Frailty (Schmucker et al., 2019) • Obesity (Agarwal et al., 2021) • Comorbidities (Podmore et al., 2018) • Vitamin D insufficiency (Emara et al., 2020) • Allergies (Buiris et al., 2016) • Tobacco use (Jette, Hunter, Burkett, Langham, Logerstedt, Piuze, Poirier, Radach, Ritter, Scalzitti, et al., 2020) • Joint complaint beyond the operated joint (Zhang et al., 2021) • Psychological factors such as anxiety, depression, kinesiophobia, central sensitization, pain catastrophizing, resilience, committed action (Vissers et al., 2012) • Patient's expectation (Boraiah et al., 2015; DeFroda et al., 2016)	• Self-efficacy (Orbell et al., 2001; van den Akker-Scheek et al., 2007)
Environmental domains	• Hospital and surgeon volume (Malik et al., 2018) • Surgery characteristics (Nadeem et al., 2021) • Reliable public transportation (Baker et al., 2012) • Home environment/living situation and caregiver support (Sergooris et al., 2023)	-

EQ-5D: EuroQol-5D; **HRQoL:** Health-related quality of life; **PROM:** Patient-reported outcome measure; **ROM:** Range of Motion; **SCT:** Stair Climbing Test; **6MWT:** Six Minute walk test; **SF-36:** 36-item Short Form Health Survey; **TUG:** Timed up and go; **WOMAC:** Western Ontario and McMaster Universities Arthritis Index

Predicting recovery after hip or knee arthroplasty is a complex construct and not determined by simple linear relationships (Barker et al., 2016). There remains uncertainty as to what factors best predict recovery, which could be explained by the variability between studies in patient demographic and clinical characteristics, outcomes used, methods used to interpret outcomes and timing of outcomes. In addition, it has been shown that preoperative models to identify patients at risk of poorer recovery have low predictive power (Wylde et al., 2017), which could be explained by the lower predictive ability of preoperative factors compared to postoperative factors (Hamilton et al., 2019; Dumenci et al., 2019; Harmelink et al., 2017). Most of the studies have investigated preoperative factors as predictors of postoperative outcome of hip or knee arthroplasty, with only a limited number of studies having focused on postoperative factors. Factors at the level of the individual have been the most studied and environmental factors less (Alviar et al., 2011). However, environmental factors such as family, friends and caregiver support, and hospital/surgeon procedure volume have been shown to be related to function after arthroplasty (Jette, Hunter, Burkett, Langham, Logerstedt, Piuze, Poirier, Radach, Ritter, & Scalzitti, 2020; Katz et al., 2007).

3. Management of factors associated with or predictive of poorer recovery

Most interventions have traditionally focused on patients undergoing arthroplasty in a general context rather than specifically addressing patients at risk of poorer outcomes (Kittelson et al., 2021). Some recent trials (Barker et al., 2020; Hamilton et al., 2020; Riddle et al., 2019) have focused on patients at risk of poorer outcomes after total knee arthroplasty, with no differences in outcomes found between treatment arms. These trials had some issues: 1) methods used to identify patients at risk of poorer recovery were not well justified, resulting in patients either being missed or falsely identified as being at risk (Riddle et al., 2021); 2) preoperative data

were used to identify patients at risk of poor outcomes in most trials, which appear less optimal for predicting poorer outcomes when compared to postoperative data; 3) trial interventions did not specifically address factors associated with poorer recovery.

Factors can be divided into modifiable and non-modifiable. Non-modifiable factors, such as sociodemographic factors, can help set realistic expectations with the patient (Bonasia et al., 2019), while modifiable factors, such as BMI and psychological factors, could be managed in clinical practice to optimize outcomes (Boraiah et al., 2015; DeFroda et al., 2016). Several studies for other musculoskeletal disorders have shown that treatment approaches matched to patient factors result in improved outcomes compared to nonmatched methods (Brennan et al., 2006; Childs et al., 2004; Fritz et al., 2003; Vibe Fersum et al., 2013). These findings show the necessity to design a system to identify patients at risk or experiencing poor recovery and manage factors associated with poorer recovery.

Future directions

This review has identified several unanswered questions to optimize poor outcomes after hip or knee arthroplasty. Future research could include the following:

- Determining how provider-assessed and patient-reported outcomes should be integrated or reconciled.
- Evaluating the patient-centeredness of outcome measures to assess recovery after hip or knee arthroplasty by identifying patient priorities after surgery.
- Assessing psychometric properties at various time points after arthroplasty (short, medium, and long term), as some properties such as clinical change or cut-off scores, responsiveness and floor/ceiling effect are time dependent.

- Determining MCID, MIC, MDC, and PASS values within the first three months post-surgery when significant functional recovery typically occurs.
- Ascertain which methods for interpreting outcomes are most pertinent for identifying patients with poor outcomes.
- Determining the MCID/MDC/MIC/PASS/TF values after arthroplasty for patients with different characteristics such as age and baseline function.
- Determining whether subpar improvement (MCID for improvement) or worsening of outcomes (MCID for deterioration) is more suitable for defining poor outcomes.
- Identify which factors, focusing on postoperative factors, are most strongly associated with or predictive of poorer recovery.
- Impact of environmental factors, such as wait time for surgery, access to rehabilitation, and health insurance coverage.
- Determining how and to what extent factors associated with poorer recovery can be modified, and the impact of these modifications on outcomes.

Conclusion

This narrative review has highlighted the diverse recovery of patients undergoing hip and knee arthroplasty influenced by various factors. While most patients may achieve full recovery through self-directed management, others at risk or experiencing poorer recovery may require a more intensive management approach, and interventions addressing factors associated with poorer recovery could optimize post-arthroplasty outcomes. However, further research on the following concepts is needed to effectively manage patients at risk or experiencing poorer recovery after arthroplasty: appropriate way to assess recovery after hip or knee arthroplasty; determining patients' priorities; understanding how to integrate provider-assessed and patient-reported

outcome measures; determining the psychometric properties of assessment tools and appropriate method to interpret the outcomes assessments; identification of key modifiable factors influencing outcomes and development and evaluation of interventions to manage these factors.

Conflict of interest

The authors do not report a potential conflict of interest.

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Reference

- Abdellatif, S., Hladkiewicz, E., Lalu, M. M., Boet, S., Gagne, S., & McIsaac, D. I. (2022). Patient prioritization of routine and patient-reported postoperative outcome measures: a prospective, nested cross-sectional study. Priorisation par les patients des mesures des issues postopératoires de routine et celles rapportées par les patients : une étude prospective transversale et imbriquée. *Canadian journal of anaesthesia = Journal canadien d'anesthésie*, 69(6), 693–703. <https://doi.org/10.1007/s12630-022-02191-7>
- Agarwal, N., To, K., Zhang, B., & Khan, W. (2021). Obesity does not adversely impact the outcome of unicompartmental knee arthroplasty for osteoarthritis: a meta-analysis of 80,798 subjects. *International journal of obesity (2005)*, 45(4), 715–724. <https://doi.org/10.1038/s41366-020-00718-w>
- Alvarez, P. M., McKeon, J. F., Spitzer, A. I., Krueger, C. A., Pigott, M., Li, M., & Vajapey, S. P. (2022). Race, Utilization, and Outcomes in Total Hip and Knee Arthroplasty: A Systematic Review on Health-Care Disparities. *JBJS reviews*, 10(3), e21.00161. <https://doi.org/10.2106/JBJS.RVW.21.00161>
- Alvarez, P. M., McKeon, J. F., Spitzer, A. I., Krueger, C. A., Pigott, M., Li, M., & Vajapey, S. P. (2022b). Socioeconomic factors affecting outcomes in total knee and hip arthroplasty: A systematic review on healthcare disparities. *Arthroplasty*, 4(1), 36. <https://doi.org/10.1186/s42836-022-00137-4>
- Alviar, M. J., Olver, J., Brand, C., Tropea, J., Hale, T., Pirpiris, M., & Khan, F. (2011). Do patient-reported outcome measures in hip and knee arthroplasty rehabilitation have robust measurement attributes? A systematic review. *Journal of rehabilitation medicine*, 43(7), 572–583. <https://doi.org/10.2340/16501977-0828>
- Bade, M. J., Kittelson, J. M., Kohrt, W. M., & Stevens-Lapsley, J. E. (2014). Predicting functional performance and range of motion outcomes after total knee arthroplasty. *American Journal of Physical Medicine & Rehabilitation/Association of Academic Physiatrists*, 93(7), 579.
- Baethge, C., Goldbeck-Wood, S., & Mertens, S. (2019). SANRA—a scale for the quality assessment of narrative review articles. *Research Integrity and Peer Review*, 4(1), 5. <https://doi.org/10.1186/s41073-019-0064-8>
- Bahadır, S., Yuksel, S., Ayhan, S., Nabi, V., Vila-Casademunt, A., Obeid, I., Sanchez Perez-Grueso, F. J., Acaroglu, E., & European Spine Study Group (2021). Variation of Minimum Clinically Important Difference by Age, Gender, Baseline Disability, and Change of Direction in Adult Spinal Deformity Population: Is It a Constant Value?. *World neurosurgery*, 146, e1171–e1176. <https://doi.org/10.1016/j.wneu.2020.11.124>
- Baker, P. N., Deehan, D. J., Lees, D., Jameson, S., Avery, P. J., Gregg, P. J., & Reed, M. R. (2012). The effect of surgical factors on early patient-reported outcome measures (PROMS) following total knee replacement. *The Journal of bone and joint surgery. British volume*, 94(8), 1058–1066. <https://doi.org/10.1302/0301-620X.94B8.28786>
- Barak, S., & Duncan, P. W. (2006). Issues in selecting outcome measures to assess functional recovery after stroke. *NeuroRx : the journal of the American Society for Experimental NeuroTherapeutics*, 3(4), 505–524. <https://doi.org/10.1016/j.nurx.2006.07.009>

- Barker, K. L., Beard, D., Price, A., Toye, F., Underwood, M., Drummond, A., Collins, G., Dutton, S., Campbell, H., Kenealy, N., Room, J., & Lamb, S. E. (2016). COMMunity-based Rehabilitation after Knee Arthroplasty (CORKA): study protocol for a randomised controlled trial. *Trials*, 17(1), 501. <https://doi.org/10.1186/s13063-016-1629-1>
- Barker, K. L., Room, J., Knight, R., Dutton, S. J., Toye, F., Leal, J., Kent, S., Kenealy, N., Schussel, M. M., & Collins, G. (2020). Outpatient physiotherapy versus home-based rehabilitation for patients at risk of poor outcomes after knee arthroplasty: CORKA RCT. *Health Technology Assessment (Winchester, England)*, 24(65), 1. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7750865/>
- Batailler, C., Lording, T., De Massari, D., Witvoet-Braam, S., Bini, S., & Lustig, S. (2021). Predictive Models for Clinical Outcomes in Total Knee Arthroplasty: A Systematic Analysis. *Arthroplasty today*, 9, 1–15. <https://doi.org/10.1016/j.artd.2021.03.013>
- Bonasia, D. E., Palazzolo, A., Cottino, U., Saccia, F., Mazzola, C., Rosso, F., & Rossi, R. (2019). Modifiable and Nonmodifiable Predictive Factors Associated with the Outcomes of Total Knee Arthroplasty. *Joints*, 7(1), 13–18. <https://doi.org/10.1055/s-0039-1678563>
- Boraiah, S., Joo, L., Inneh, I. A., Rathod, P., Meftah, M., Band, P., Bosco, J. A., & Iorio, R. (2015). Management of Modifiable Risk Factors Prior to Primary Hip and Knee Arthroplasty: A Readmission Risk Assessment Tool. *The Journal of bone and joint surgery. American volume*, 97(23), 1921–1928. <https://doi.org/10.2106/JBJS.N.01196>
- Brennan, G. P., Fritz, J. M., Hunter, S. J., Thackeray, A., Delitto, A., & Erhard, R. E. (2006). Identifying subgroups of patients with acute/subacute "nonspecific" low back pain: results of a randomized clinical trial. *Spine*, 31(6), 623–631. <https://doi.org/10.1097/01.brs.0000202807.72292.a8>
- Buirs, L. D., Van Beers, L. W., Scholtes, V. A., Pastoors, T., Sprague, S., & Poolman, R. W. (2016). Predictors of physical functioning after total hip arthroplasty: a systematic review. *BMJ open*, 6(9), e010725. <https://doi.org/10.1136/bmjopen-2015-010725>
- Bullens, P. H., van Loon, C. J., de Waal Malefijt, M. C., Laan, R. F., & Veth, R. P. (2001). Patient satisfaction after total knee arthroplasty: a comparison between subjective and objective outcome assessments. *The Journal of arthroplasty*, 16(6), 740–747. <https://doi.org/10.1054/arth.2001.23922>
- Capin, J. J., Bade, M. J., Jennings, J. M., Snyder-Mackler, L., & Stevens-Lapsley, J. E. (2022). Total Knee Arthroplasty Assessments Should Include Strength and Performance-Based Functional Tests to Complement Range-of-Motion and Patient-Reported Outcome Measures. *Physical therapy*, 102(6), pzac033. <https://doi.org/10.1093/ptj/pzac033>
- Chan, A. C. M., Pang, M. Y. C., Ouyang, H., & Jehu, D. A. M. (2020). Minimal Clinically Important Difference of Four Commonly Used Balance Assessment Tools in Individuals after Total Knee Arthroplasty: A Prospective Cohort Study. *PM & R : the journal of injury, function, and rehabilitation*, 12(3), 238–245. <https://doi.org/10.1002/pmrj.12226>
- Childs, J. D., Fritz, J. M., Flynn, T. W., Irrgang, J. J., Johnson, K. K., Majkowski, G. R., & Delitto, A. (2004). A clinical prediction rule to identify patients with low back pain most likely to benefit from spinal manipulation: a validation study. *Annals of internal medicine*, 141(12), 920–928. <https://doi.org/10.7326/0003-4819-141-12-200412210-00008>

- Clement, N. D., Scott, C. E. H., Hamilton, D. F., MacDonald, D., & Howie, C. R. (2021). Meaningful values in the Forgotten Joint Score after total knee arthroplasty. *The bone & joint journal*, 103-B(5), 846–854. <https://doi.org/10.1302/0301-620X.103B5.BJJ-2020-0396.R1>
- Collins, N. J., & Roos, E. M. (2012). Patient-reported outcomes for total hip and knee arthroplasty: commonly used instruments and attributes of a "good" measure. *Clinics in geriatric medicine*, 28(3), 367–394. <https://doi.org/10.1016/j.cger.2012.05.007>
- Crowninshield, R. D., Rosenberg, A. G., & Sporer, S. M. (2006). Changing demographics of patients with total joint replacement. *Clinical orthopaedics and related research*, 443, 266–272. <https://doi.org/10.1097/01.blo.0000188066.01833.4f>
- DeFroda, S. F., Rubin, L. E., & Jenkins, D. R. (2016). Modifiable Risk Factors in Total Joint Arthroplasty: A Pilot Study. *Rhode Island medical journal* (2013), 99(5), 28–31.
- Devasenapathy, N., Maddison, R., Malhotra, R., Zodepy, S., Sharma, S., & Belavy, D. L. (2019). Preoperative Quadriceps Muscle Strength and Functional Ability Predict Performance-Based Outcomes 6 Months After Total Knee Arthroplasty: A Systematic Review. *Physical therapy*, 99(1), 46–61. <https://doi.org/10.1093/ptj/pzy118>
- Devasenapathy, N., Maddison, R., Malhotra, R., Zodepy, S., Sharma, S., & Belavy, D. L. (2019). Preoperative Quadriceps Muscle Strength and Functional Ability Predict Performance-Based Outcomes 6 Months After Total Knee Arthroplasty: A Systematic Review. *Physical therapy*, 99(1), 46–61. <https://doi.org/10.1093/ptj/pzy118>
- Domínguez-Navarro, F., Igual-Camacho, C., Silvestre-Muñoz, A., Roig-Casasús, S., & Blasco, J. M. (2018). Effects of balance and proprioceptive training on total hip and knee replacement rehabilitation: A systematic review and meta-analysis. *Gait & posture*, 62, 68–74. <https://doi.org/10.1016/j.gaitpost.2018.03.003>
- Dowsey, M. M., & Choong, P. F. (2013). The utility of outcome measures in total knee replacement surgery. *International journal of rheumatology*, 2013, 506518. <https://doi.org/10.1155/2013/506518>
- Dumenci, L., Perera, R. A., Keefe, F. J., Ang, D. C., Slover, J., Jensen, M. P., & Riddle, D. L. (2019). Model-based pain and function outcome trajectory types for patients undergoing knee arthroplasty: a secondary analysis from a randomized clinical trial. *Osteoarthritis and cartilage*, 27(6), 878–884. <https://doi.org/10.1016/j.joca.2019.01.004>
- Elibol, N., Unver, B., Karatosun, V., & Gunal, I. (2018). Relationship between self-reported and performance-based tests in assessment of patients with total hip arthroplasty. *Hip international : the journal of clinical and experimental research on hip pathology and therapy*, 28(5), 566–570. <https://doi.org/10.1177/1120700017752557>
- Emara, A. K., Nageeb, E., George, J., Buttar, M. A., Higuera, C., & Piuze, N. S. (2020). Hypovitaminosis D in lower extremity Joint Arthroplasty: A systematic review and meta-analysis. *Journal of orthopaedics*, 21, 109–116. <https://doi.org/10.1016/j.jor.2020.03.010>
- Ewen, A. M., Stewart, S., St Clair Gibson, A., Kashyap, S. N., & Caplan, N. (2012). Post-operative gait analysis in total hip replacement patients-a review of current literature and meta-analysis. *Gait & posture*, 36(1), 1–6. <https://doi.org/10.1016/j.gaitpost.2011.12.024>

- Fritz, J. M., Delitto, A., & Erhard, R. E. (2003). Comparison of classification-based physical therapy with therapy based on clinical practice guidelines for patients with acute low back pain: a randomized clinical trial. *Spine*, 28(13), 1363–1372. <https://doi.org/10.1097/01.BRS.0000067115.61673.FF>
- Gagnier, J. J., Huang, H., Mullins, M., Marinac-Dabić, D., Ghambaryan, A., Eloff, B., Mirza, F., & Bayona, M. (2018). Measurement Properties of Patient-Reported Outcome Measures Used in Patients Undergoing Total Hip Arthroplasty: A Systematic Review. *JBJS reviews*, 6(1), e2. <https://doi.org/10.2106/JBJS.RVW.17.00038>
- Gagnier, J. J., Mullins, M., Huang, H., Marinac-Dabic, D., Ghambaryan, A., Eloff, B., Mirza, F., & Bayona, M. (2017). A Systematic Review of Measurement Properties of Patient-Reported Outcome Measures Used in Patients Undergoing Total Knee Arthroplasty. *The Journal of arthroplasty*, 32(5), 1688–1697.e7. <https://doi.org/10.1016/j.arth.2016.12.052>
- Goh, G. S., Baker, C. M., Tarabichi, S., Clark, S. C., Austin, M. S., & Lonner, J. H. (2022). The Paradox of Patient-Reported Outcome Measures: Should We Prioritize "Feeling Better" or "Feeling Good" After Total Knee Arthroplasty?. *The Journal of arthroplasty*, 37(9), 1751–1758. <https://doi.org/10.1016/j.arth.2022.04.017>
- Goh, G. S., Tarabichi, S., Baker, C. M., Qadiri, Q. S., & Austin, M. S. (2023). Should We Aim to Help Patients "Feel Better" or "Feel Good" After Total Hip Arthroplasty? Determining Factors Affecting the Achievement of the Minimal Clinically Important Difference and Patient Acceptable Symptom State. *The Journal of arthroplasty*, 38(2), 293–299. <https://doi.org/10.1016/j.arth.2022.08.014>
- Hamilton, D. F., Beard, D. J., Barker, K. L., Macfarlane, G. J., Tuck, C. E., Stoddart, A., Wilton, T., Hutchinson, J. D., Murray, G. D., Simpson, A. H. R. W., & TRIO investigators (2020). Targeting rehabilitation to improve outcomes after total knee arthroplasty in patients at risk of poor outcomes: randomised controlled trial. *BMJ (Clinical research ed.)*, 371, m3576. <https://doi.org/10.1136/bmj.m3576>
- Hamilton, D. F., Loth, F. C., MacDonald, D. J., MacFarlane, G. J., Beard, D. J., Simpson, A. H. R., Patton, J. T., & Howie, C. R. (2019). Exploring variation in patient access of post-discharge physiotherapy following total hip and knee arthroplasty under a choice based system in the UK: an observational cohort study. *BMJ open*, 9(2), e021614. <https://doi.org/10.1136/bmjopen-2018-021614>
- Harmelink, K. E. M., Zeegers, A. V. C. M., Hullegie, W., Hoogeboom, T. J., Nijhuis-van der Sanden, M. W. G., & Staal, J. B. (2017). Are There Prognostic Factors for One-Year Outcome After Total Knee Arthroplasty? A Systematic Review. *The Journal of arthroplasty*, 32(12), 3840–3853.e1. <https://doi.org/10.1016/j.arth.2017.07.011>
- Harris, K., Dawson, J., Gibbons, E., Lim, C. R., Beard, D. J., Fitzpatrick, R., & Price, A. J. (2016). Systematic review of measurement properties of patient-reported outcome measures used in patients undergoing hip and knee arthroplasty. *Patient related outcome measures*, 7, 101–108. <https://doi.org/10.2147/PROM.S97774>
- Harris, L. K., Troelsen, A., Terluin, B., Gromov, K., Overgaard, S., Price, A., & Ingelsrud, L. H. (2023). Interpretation Threshold Values for the Oxford Hip Score in Patients Undergoing Total Hip Arthroplasty: Advancing Their Clinical Use. *The Journal of bone and joint surgery. American volume*, 105(10), 797–804. <https://doi.org/10.2106/JBJS.22.01293>

- Hofstede, S. N., Gademan, M. G., Vliet Vlieland, T. P., Nelissen, R. G., & Marang-van de Mheen, P. J. (2016). Preoperative predictors for outcomes after total hip replacement in patients with osteoarthritis: a systematic review. *BMC musculoskeletal disorders*, 17, 212. <https://doi.org/10.1186/s12891-016-1070-3>
- Humphrey, T. J., Katakam, A., Melnic, C. M., & Bedair, H. S. (2022). Defining Failure in Primary Total Joint Arthroplasty: The Minimal Clinically Important Difference for Worsening Score. *The Journal of arthroplasty*, 37(4), 630–636.e1. <https://doi.org/10.1016/j.arth.2021.12.025>
- Jette, D. U., Hunter, S. J., Burkett, L., Langham, B., Logerstedt, D. S., Piuizzi, N. S., Poirier, N. M., Radach, L. J. L., Ritter, J. E., Scalzitti, D. A., Stevens-Lapsley, J. E., Tompkins, J., Zeni, J., Jr, & American Physical Therapy Association (2020). Physical Therapist Management of Total Knee Arthroplasty. *Physical therapy*, 100(9), 1603–1631. <https://doi.org/10.1093/ptj/pzaa099>
- Kane, R. L., Saleh, K. J., Wilt, T. J., & Bershadsky, B. (2005). The functional outcomes of total knee arthroplasty. *The Journal of bone and joint surgery. American volume*, 87(8), 1719–1724. <https://doi.org/10.2106/JBJS.D.02714>
- Karhade, A. V., Bono, C. M., Schwab, J. H., & Tobert, D. G. (2021). Minimum Clinically Important Difference: A Metric That Matters in the Age of Patient-Reported Outcomes. *The Journal of bone and joint surgery. American volume*, 103(24), 2331–2337. <https://doi.org/10.2106/JBJS.21.00773>
- Katz, J. N., Mahomed, N. N., Baron, J. A., Barrett, J. A., Fossel, A. H., Creel, A. H., Wright, J., Wright, E. A., & Losina, E. (2007). Association of hospital and surgeon procedure volume with patient-centered outcomes of total knee replacement in a population-based cohort of patients age 65 years and older. *Arthritis and rheumatism*, 56(2), 568–574. <https://doi.org/10.1002/art.22333>
- Kennedy, D. M., Stratford, P. W., Robarts, S., & Gollish, J. D. (2011). Using outcome measure results to facilitate clinical decisions the first year after total hip arthroplasty. *The Journal of orthopaedic and sports physical therapy*, 41(4), 232–239. <https://doi.org/10.2519/jospt.2011.3516>
- Keurentjes, J. C., Van Tol, F. R., Fiocco, M., Schoones, J. W., & Nelissen, R. G. (2012). Minimal clinically important differences in health-related quality of life after total hip or knee replacement: A systematic review. *Bone & joint research*, 1(5), 71–77. <https://doi.org/10.1302/2046-3758.15.2000065>
- Kim S. (2008). Changes in surgical loads and economic burden of hip and knee replacements in the US: 1997-2004. *Arthritis and rheumatism*, 59(4), 481–488. <https://doi.org/10.1002/art.23525>
- Kim, T. K., Kwon, S. K., Kang, Y. G., Chang, C. B., & Seong, S. C. (2010). Functional disabilities and satisfaction after total knee arthroplasty in female Asian patients. *The Journal of arthroplasty*, 25(3), 458–464.e4642. <https://doi.org/10.1016/j.arth.2009.01.018>
- Kittelson, A. J., Loyd, B. J., Graber, J., Himawan, M. A., Waugh, D., Davenport, J., Hoogeboom, T. J., & Stevens-Lapsley, J. (2021). Examination of exclusion criteria in total knee arthroplasty rehabilitation trials: influence on the application of evidence in day-to-day practice. *Journal of evaluation in clinical practice*, 27(6), 1335–1342. <https://doi.org/10.1111/jep.13564>
- Kvien, T. K., Heiberg, T., & Hagen, K. B. (2007). Minimal clinically important improvement/difference (MCII/MCID) and patient acceptable symptom state (PASS): what do these concepts mean?.

- Annals of the rheumatic diseases*, 66 Suppl 3(Suppl 3), iii40–iii41.
<https://doi.org/10.1136/ard.2007.079798>
- L Snell, D., Hipango, J., Sinnott, K. A., Dunn, J. A., Rothwell, A., Hsieh, C. J., DeJong, G., & Hooper, G. (2018). Rehabilitation after total joint replacement: a scoping study. *Disability and rehabilitation*, 40(14), 1718–1731. <https://doi.org/10.1080/09638288.2017.1300947>
- Lange, T., Schmitt, J., Kopkow, C., Rataj, E., Günther, K. P., & Lützner, J. (2017). What Do Patients Expect From Total Knee Arthroplasty? A Delphi Consensus Study on Patient Treatment Goals. *The Journal of arthroplasty*, 32(7), 2093–2099.e1. <https://doi.org/10.1016/j.arth.2017.01.053>
- Larsen, J. B., Mogensen, L., Arendt-Nielsen, L., & Madeleine, P. (2020). Intensive, personalized multimodal rehabilitation in patients with primary or revision total knee arthroplasty: a retrospective cohort study. *BMC sports science, medicine & rehabilitation*, 12, 5. <https://doi.org/10.1186/s13102-020-0157-1>
- Lewis, G. N., Rice, D. A., McNair, P. J., & Kluger, M. (2015). Predictors of persistent pain after total knee arthroplasty: a systematic review and meta-analysis. *British journal of anaesthesia*, 114(4), 551–561. <https://doi.org/10.1093/bja/aeu441>
- Losina, E., Thornhill, T. S., Rome, B. N., Wright, J., & Katz, J. N. (2012). The dramatic increase in total knee replacement utilization rates in the United States cannot be fully explained by growth in population size and the obesity epidemic. *The Journal of bone and joint surgery. American volume*, 94(3), 201–207. <https://doi.org/10.2106/JBJS.J.01958>
- Lützner, C., Postler, A. E., Druschke, D., Riedel, R., Günther, K. P., & Lange, T. (2022). Ask Patients What They Expect! A Survey Among Patients Awaiting Total Hip Arthroplasty in Germany. *The Journal of arthroplasty*, 37(8), 1594–1601.e4. <https://doi.org/10.1016/j.arth.2022.03.067>
- Malik, A. T., Jain, N., Scharschmidt, T. J., Li, M., Glassman, A. H., & Khan, S. N. (2018). Does Surgeon Volume Affect Outcomes Following Primary Total Hip Arthroplasty? A Systematic Review. *The Journal of arthroplasty*, 33(10), 3329–3342. <https://doi.org/10.1016/j.arth.2018.05.040>
- Mancuso, C. A., Salvati, E. A., Johanson, N. A., Peterson, M. G., & Charlson, M. E. (1997). Patients' expectations and satisfaction with total hip arthroplasty. *The Journal of arthroplasty*, 12(4), 387–396. [https://doi.org/10.1016/s0883-5403\(97\)90194-7](https://doi.org/10.1016/s0883-5403(97)90194-7)
- Mannion, A. F., Kämpfen, S., Munzinger, U., & Kramers-de Quervain, I. (2009). The role of patient expectations in predicting outcome after total knee arthroplasty. *Arthritis research & therapy*, 11(5), R139. <https://doi.org/10.1186/ar2811>
- Maredupaka, S., Meshram, P., Chatte, M., Kim, W. H., & Kim, T. K. (2020). Minimal clinically important difference of commonly used patient-reported outcome measures in total knee arthroplasty: review of terminologies, methods and proposed values. *Knee surgery & related research*, 32(1), 19. <https://doi.org/10.1186/s43019-020-00038-3>
- Maxwell, J. L., Felson, D. T., Niu, J., Wise, B., Nevitt, M. C., Singh, J. A., Frey-Law, L., & Neogi, T. (2014). Does clinically important change in function after knee replacement guarantee good absolute function? The multicenter osteoarthritis study. *The Journal of rheumatology*, 41(1), 60–64. <https://doi.org/10.3899/jrheum.130313>

- Nadeem, S., Mundi, R., & Chaudhry, H. (2021). Surgery-related predictors of kneeling ability following total knee arthroplasty: A systematic review and meta-analysis. *Knee Surgery & Related Research*, 33(1), 36. <https://doi.org/10.1186/s43019-021-00117-z>
- Noble, P. C., Conditt, M. A., Cook, K. F., & Mathis, K. B. (2006). The John Insall Award: Patient expectations affect satisfaction with total knee arthroplasty. *Clinical orthopaedics and related research*, 452, 35–43. <https://doi.org/10.1097/01.blo.0000238825.63648.1e>
- Noble, P. C., Gordon, M. J., Weiss, J. M., Reddix, R. N., Conditt, M. A., & Mathis, K. B. (2005). Does total knee replacement restore normal knee function?. *Clinical orthopaedics and related research*, (431), 157–165. <https://doi.org/10.1097/01.blo.0000150130.03519.fb>
- Olsen, M. F., Bjerre, E., Hansen, M. D., Tendal, B., Hilden, J., & Hróbjartsson, A. (2018). Minimum clinically important differences in chronic pain vary considerably by baseline pain and methodological factors: systematic review of empirical studies. *Journal of clinical epidemiology*, 101, 87–106.e2. <https://doi.org/10.1016/j.jclinepi.2018.05.007>
- Orbell, S., Johnston, M., Rowley, D., Davey, P., & Espley, A. (2001). Self-efficacy and goal importance in the prediction of physical disability in people following hospitalization: a prospective study. *British journal of health psychology*, 6(Pt 1), 25–40. <https://doi.org/10.1348/135910701169034>
- Özden, F., & Tümtürk, İ. (2022). Performance-based outcome measures in total knee arthroplasty: a systematic review. *Physical & Occupational Therapy In Geriatrics*, 40(3), 241-260.
- Papalia, R., Campi, S., Vorini, F., Zampogna, B., Vasta, S., Papalia, G., Fossati, C., Torre, G., & Denaro, V. (2020). The Role of Physical Activity and Rehabilitation Following Hip and Knee Arthroplasty in the Elderly. *Journal of clinical medicine*, 9(5), 1401. <https://doi.org/10.3390/jcm9051401>
- Podmore, B., Hutchings, A., van der Meulen, J., Aggarwal, A., & Konan, S. (2018). Impact of comorbid conditions on outcomes of hip and knee replacement surgery: a systematic review and meta-analysis. *BMJ open*, 8(7), e021784. <https://doi.org/10.1136/bmjopen-2018-021784>
- Poitras, S., Wood, K. S., Savard, J., Dervin, G. F., & Beaulé, P. E. (2015). Predicting early clinical function after hip or knee arthroplasty. *Bone & joint research*, 4(9), 145–151. <https://doi.org/10.1302/2046-3758.49.2000417>
- Prill, R., Becker, R., Schulz, R., Michel, S., & Hommel, H. (2022). No correlation between symmetry-based performance measures and patient-related outcome prior to and after total knee arthroplasty. *Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA*, 30(9), 3155–3161. <https://doi.org/10.1007/s00167-021-06570-3>
- Ramkumar, P. N., Harris, J. D., & Noble, P. C. (2015). Patient-reported outcome measures after total knee arthroplasty: a systematic review. *Bone & joint research*, 4(7), 120–127. <https://doi.org/10.1302/2046-3758.47.2000380>
- Razmjou, H., Yee, A., Ford, M., & Finkelstein, J. A. (2006). Response shift in outcome assessment in patients undergoing total knee arthroplasty. *The Journal of bone and joint surgery. American volume*, 88(12), 2590–2595. <https://doi.org/10.2106/JBJS.F.00283>

- Ramkumar, P. N., Harris, J. D., & Noble, P. C. (2015). Patient-reported outcome measures after total knee arthroplasty: a systematic review. *Bone & joint research*, 4(7), 120–127. <https://doi.org/10.1302/2046-3758.47.2000380>
- Riddle D. L. (1998). Classification and low back pain: a review of the literature and critical analysis of selected systems. *Physical therapy*, 78(7), 708–737. <https://doi.org/10.1093/ptj/78.7.708>
- Riddle, D. L., & Dumenci, L. (2020). Classifications of good versus poor outcome following knee arthroplasty should not be defined using arbitrary criteria. *BMC musculoskeletal disorders*, 21(1), 604. <https://doi.org/10.1186/s12891-020-03583-w>
- Riddle, D. L., Hamilton, D. F., Dumenci, L., & Beard, D. J. (2021). Phase 3 Trials of Enhanced Versus Usual Care Physical Therapy for Patients at Risk of Poor Outcome Following Knee Arthroplasty: A Perspective on Meaning and a Way Forward. *Physical therapy*, 101(11), pzab186. <https://doi.org/10.1093/ptj/pzab186>
- Riddle, D. L., Keefe, F. J., Ang, D. C., Slover, J., Jensen, M. P., Bair, M. J., Kroenke, K., Perera, R. A., Reed, S. D., McKee, D., & Dumenci, L. (2019). Pain Coping Skills Training for Patients Who Catastrophize About Pain Prior to Knee Arthroplasty: A Multisite Randomized Clinical Trial. *The Journal of bone and joint surgery. American volume*, 101(3), 218–227. <https://doi.org/10.2106/JBJS.18.00621>
- Riddle, D. L., Macfarlane, G. J., Hamilton, D. F., Beasley, M., & Dumenci, L. (2022). Cross-validation of good versus poor self-reported outcome trajectory types following knee arthroplasty. *Osteoarthritis and cartilage*, 30(1), 61–68. <https://doi.org/10.1016/j.joca.2021.09.004>
- Riddle, D. L., Stratford, P. W., & Bowman, D. H. (2008). Findings of extensive variation in the types of outcome measures used in hip and knee replacement clinical trials: a systematic review. *Arthritis and rheumatism*, 59(6), 876–883. <https://doi.org/10.1002/art.23706>
- Rolfson, O., Eresian Chenok, K., Bohm, E., Lübbecke, A., Denissen, G., Dunn, J., Lyman, S., Franklin, P., Dunbar, M., Overgaard, S., Garellick, G., Dawson, J., & Patient-Reported Outcome Measures Working Group of the International Society of Arthroplasty Registries (2016). Patient-reported outcome measures in arthroplasty registries. *Acta orthopaedica*, 87 Suppl 1(Suppl 1), 3–8. <https://doi.org/10.1080/17453674.2016.1181815>
- Schmitt, J. S., & Di Fabio, R. P. (2004). Reliable change and minimum important difference (MID) proportions facilitated group responsiveness comparisons using individual threshold criteria. *Journal of clinical epidemiology*, 57(10), 1008–1018. <https://doi.org/10.1016/j.jclinepi.2004.02.007>
- Schmucker, A. M., Hupert, N., & Mandl, L. A. (2019). The impact of frailty on short-term outcomes after elective hip and knee arthroplasty in older adults: A systematic review. *Geriatric Orthopaedic Surgery & Rehabilitation*, 10, 2151459319835109.
- Schwartz, C. E., Bode, R., Repucci, N., Becker, J., Sprangers, M. A., & Fayers, P. M. (2006). The clinical significance of adaptation to changing health: a meta-analysis of response shift. *Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation*, 15(9), 1533–1550. <https://doi.org/10.1007/s11136-006-0025-9>
- Sergooris, A., Verbrugghe, J., De Baets, L., Meeus, M., Roussel, N., Smeets, R. J. E. M., Bogaerts, K., & Timmermans, A. (2023). Are contextual factors associated with activities and participation after

- total hip arthroplasty? A systematic review. *Annals of physical and rehabilitation medicine*, 66(5), 101712. <https://doi.org/10.1016/j.rehab.2022.101712>
- Shichman, I., Roof, M., Askew, N., Nherera, L., Rozell, J. C., Seyler, T. M., & Schwarzkopf, R. (2023). Projections and Epidemiology of Primary Hip and Knee Arthroplasty in Medicare Patients to 2040-2060. *JB & JS open access*, 8(1), e22.00112. <https://doi.org/10.2106/JBJS.OA.22.00112>
- Stynes, S., Konstantinou, K., & Dunn, K. M. (2016). Classification of patients with low back-related leg pain: a systematic review. *BMC musculoskeletal disorders*, 17, 226. <https://doi.org/10.1186/s12891-016-1074-z>
- Te Molder, M. E. M., Smolders, J. M. H., Heesterbeek, P. J. C., & van den Ende, C. H. M. (2020). Definitions of poor outcome after total knee arthroplasty: an inventory review. *BMC musculoskeletal disorders*, 21(1), 378. <https://doi.org/10.1186/s12891-020-03406-y>
- Terwee, C. B., Roorda, L. D., Dekker, J., Bierma-Zeinstra, S. M., Peat, G., Jordan, K. P., Croft, P., & de Vet, H. C. (2010). Mind the MIC: large variation among populations and methods. *Journal of clinical epidemiology*, 63(5), 524–534. <https://doi.org/10.1016/j.jclinepi.2009.08.010>
- Terwee, C. B., Roorda, L. D., Dekker, J., Bierma-Zeinstra, S. M., Peat, G., Jordan, K. P., Croft, P., & de Vet, H. C. (2010). Mind the MIC: large variation among populations and methods. *Journal of clinical epidemiology*, 63(5), 524–534. <https://doi.org/10.1016/j.jclinepi.2009.08.010>
- Trujols, J., Portella, M. J., Iraurgi, I., Campins, M. J., Siñol, N., & de Los Cobos, J. P. (2013). Patient-reported outcome measures: are they patient-generated, patient-centred or patient-valued?. *Journal of mental health (Abingdon, England)*, 22(6), 555–562. <https://doi.org/10.3109/09638237.2012.734653>
- Tubach, F., Dougados, M., Falissard, B., Baron, G., Logeart, I., & Ravaud, P. (2006). Feeling good rather than feeling better matters more to patients. *Arthritis and rheumatism*, 55(4), 526–530. <https://doi.org/10.1002/art.22110>
- Tubach, F., Ravaud, P., Baron, G., Falissard, B., Logeart, I., Bellamy, N., Bombardier, C., Felson, D., Hochberg, M., van der Heijde, D., & Dougados, M. (2005). Evaluation of clinically relevant states in patient reported outcomes in knee and hip osteoarthritis: the patient acceptable symptom state. *Annals of the rheumatic diseases*, 64(1), 34–37. <https://doi.org/10.1136/ard.2004.023028>
- van den Akker-Scheek, I., Stevens, M., Groothoff, J. W., Bulstra, S. K., & Zijlstra, W. (2007). Preoperative or postoperative self-efficacy: which is a better predictor of outcome after total hip or knee arthroplasty?. *Patient education and counseling*, 66(1), 92–99. <https://doi.org/10.1016/j.pec.2006.10.012>
- van Doormaal, M. C. M., Meerhoff, G. A., Vliet Vlieland, T. P. M., & Peter, W. F. (2020). A clinical practice guideline for physical therapy in patients with hip or knee osteoarthritis. *Musculoskeletal care*, 18(4), 575–595. <https://doi.org/10.1002/msc.1492>
- Van Manen, M. D., Nace, J., & Mont, M. A. (2012). Management of primary knee osteoarthritis and indications for total knee arthroplasty for general practitioners. *The Journal of the American Osteopathic Association*, 112(11), 709–715.
- Vibe Fersum, K., O'Sullivan, P., Skouen, J. S., Smith, A., & Kvåle, A. (2013). Efficacy of classification-based cognitive functional therapy in patients with non-specific chronic low back pain: a

- randomized controlled trial. *European journal of pain (London, England)*, 17(6), 916–928. <https://doi.org/10.1002/j.1532-2149.2012.00252.x>
- Visser, M. M., Bussmann, J. B., Verhaar, J. A., Busschbach, J. J., Bierma-Zeinstra, S. M., & Reijnen, M. (2012). Psychological factors affecting the outcome of total hip and knee arthroplasty: A systematic review. *Seminars in Arthritis and Rheumatism*, 41(4), 576–588.
- Wang, Y., Yin, M., Zhu, S., Chen, X., Zhou, H., & Qian, W. (2021). Patient-reported outcome measures used in patients undergoing total knee arthroplasty. *Bone & joint research*, 10(3), 203–217. <https://doi.org/10.1302/2046-3758.103.BJR-2020-0268.R1>
- Wang, Y. C., Hart, D. L., Stratford, P. W., & Mioduski, J. E. (2011). Baseline dependency of minimal clinically important improvement. *Physical therapy*, 91(5), 675–688. <https://doi.org/10.2522/ptj.20100229>
- Wieczorek, M., Rotonda, C., Guillemin, F., & Rat, A. C. (2020). What Have We Learned About the Course of Clinical Outcomes After Total Knee or Hip Arthroplasty?. *Arthritis care & research*, 72(11), 1519–1529. <https://doi.org/10.1002/acr.24045>
- Wiering, B., de Boer, D., & Delnoij, D. (2017). Patient involvement in the development of patient-reported outcome measures: a scoping review. *Health expectations : an international journal of public participation in health care and health policy*, 20(1), 11–23. <https://doi.org/10.1111/hex.12442>
- Wijesundera, D. N., & Johnson, S. R. (2016). How Much Better Is Good Enough?: Patient-reported Outcomes, Minimal Clinically Important Differences, and Patient Acceptable Symptom States in Perioperative Research. *Anesthesiology*, 125(1), 7–10. <https://doi.org/10.1097/ALN.0000000000001159>
- Wright, A., Hannon, J., Hegedus, E. J., & Kavchak, A. E. (2012). Clinimetrics corner: a closer look at the minimal clinically important difference (MCID). *The Journal of manual & manipulative therapy*, 20(3), 160–166. <https://doi.org/10.1179/2042618612Y.0000000001>
- Wylde, V., Beswick, A. D., Dennis, J., & Gooberman-Hill, R. (2017). Post-operative patient-related risk factors for chronic pain after total knee replacement: a systematic review. *BMJ open*, 7(11), e018105. <https://doi.org/10.1136/bmjopen-2017-018105>
- Yoshida, Y., Mizner, R. L., Ramsey, D. K., & Snyder-Mackler, L. (2008). Examining outcomes from total knee arthroplasty and the relationship between quadriceps strength and knee function over time. *Clinical Biomechanics*, 23(3), 320–328. <https://www.sciencedirect.com/science/article/pii/S0268003307002446>
- Zeni, J. A., Jr, & Snyder-Mackler, L. (2010). Early postoperative measures predict 1- and 2-year outcomes after unilateral total knee arthroplasty: importance of contralateral limb strength. *Physical therapy*, 90(1), 43–54. <https://doi.org/10.2522/ptj.20090089>
- Zhang, M., Selzer, F., Losina, E., Collins, J. E., & Katz, J. N. (2021). Impact of Preoperative and Incident Musculoskeletal Problematic Areas on Postoperative Outcomes After Total Knee Replacement. *ACR Open Rheumatology*, 3(9), 583–592. <https://doi.org/10.1002/acr2.11241>

Zywiell, M. G., Mahomed, A., Gandhi, R., Perruccio, A. V., & Mahomed, N. N. (2013). Measuring expectations in orthopaedic surgery: a systematic review. *Clinical orthopaedics and related research*, 471(11), 3446–3456. <https://doi.org/10.1007/s11999-013-3013-8>

PART 3

In this section, I define relevant concepts pertinent to my dissertation projects, discuss the framework guiding my dissertation studies, outline the methodology employed in these studies, and address ethical considerations.

Relevant Definitions

In this section, I discuss the definitions of three concepts relevant to my dissertation projects: patient priorities, patient centered outcome measures, and functional recovery pattern following hip or knee arthroplasty.

Patient priorities

Clinical practice has historically been guided by clinicians' assumptions about what is important to patients. This poses a problem, as recent research indicates that clinicians' and researchers' beliefs may not align with patients' needs and priorities. On a practical level, intervention uptake and health outcomes may be compromised if patients' perspectives are not considered, resulting in suboptimal results (Edwards et al., 2019; Schattner et al., 2006). Health care has evolved significantly in recent years, largely due to the emergence of patient-centered care. This approach emphasizes respecting the autonomy and priorities of patients (Schattner et al., 2006), aiming to provide the best health care for each individual patient (Sacristan et al., 2016).

Patient priorities refer to specific and realistic health outcome goals that individuals aim to achieve based on what matters most to them (Naik & Catic, 2021). Priorities can be seen as "normative expectations," representing ideas about what should or ought to happen (Wensing et al., 1998). Conceptually, patient priorities align with values, preferences, and importance ratings, distinct from reported experiences and satisfaction with care delivery (Berta et al., 2008; Wensing et al., 1998). Reported experiences encompass perceptions of actual care events, while

satisfaction reflects an evaluation based on these experiences, using expectations or priorities as a reference point (Wensing et al., 1998).

Patients play a crucial role in improving healthcare by defining quality, evaluating delivery, and sharing their experiences. Their active participation in decisions, such as treatment choices, directly influences care quality. Understanding patients' priorities helps providers prioritize care elements, making healthcare more responsive to their needs. This approach results in more effective and appropriate resource allocation, increases patient and provider satisfaction, and enhances overall care quality and outcomes (Hickmann et al., 2022; Wensing et al., 1998).

Patient center care and Patient centered outcome measures

Historically, Donabedian pioneered a patient-centered approach to measuring quality of care, where the patient was seen as the ultimate judge of care excellence (Donabedian, 1966). There are multiple definitions of "centeredness," all emphasizing three key themes: 1) understanding the person and their experience of health conditions and disability holistically, which includes acknowledging psycho-social factors beyond physical functions and anatomical structures; 2) empowering patients in decision-making processes; and 3) fostering relationships in care and treatment that build trust through continuity and coordination (Algurén et al., 2020). The Institute of Medicine defines the patient-centered care as “care that is respectful of and responsive to the preferences, needs, and values of the individual and ensuring that the care recipient’s values guide all clinical decisions” (IOM Committee, 2001).

Patient-centered outcome measures directly quantify how disease and treatment affect health outcomes that are meaningful to patients. These measures are designed with patient input as essential, focusing on concepts such as well-being and functional ability. Patient-centered outcome measures encompass a variety of clinical assessment types, including patient-reported

outcomes, and performance outcomes. Patient-centered outcome measures must always be 'fit-for-purpose,' meaning they should measure outcomes that reflect patients' daily experiences with the disease, align with their preferences, expectations, and values, and apply across a spectrum of severity and manifestations (Morel & Cano, 2017).

Patient-centered outcome measures, if adequately developed, can directly address patients' primary concerns, providing a more meaningful and interpretable measure of patient benefit. This capability reduces uncertainty regarding treatment or care effectiveness and enhances our understanding of patient progression, guiding treatment decisions. Figure 1.1 illustrates a scenario where patient-centered outcome measures bring value across all healthcare stakeholders (Morel & Cano, 2017). In this dissertation, I focus on identifying fit-for-purpose patient-centered outcome measures used after hip or knee arthroplasty. Specifically, I examine patient-reported and performance outcomes to assess function following these procedures.

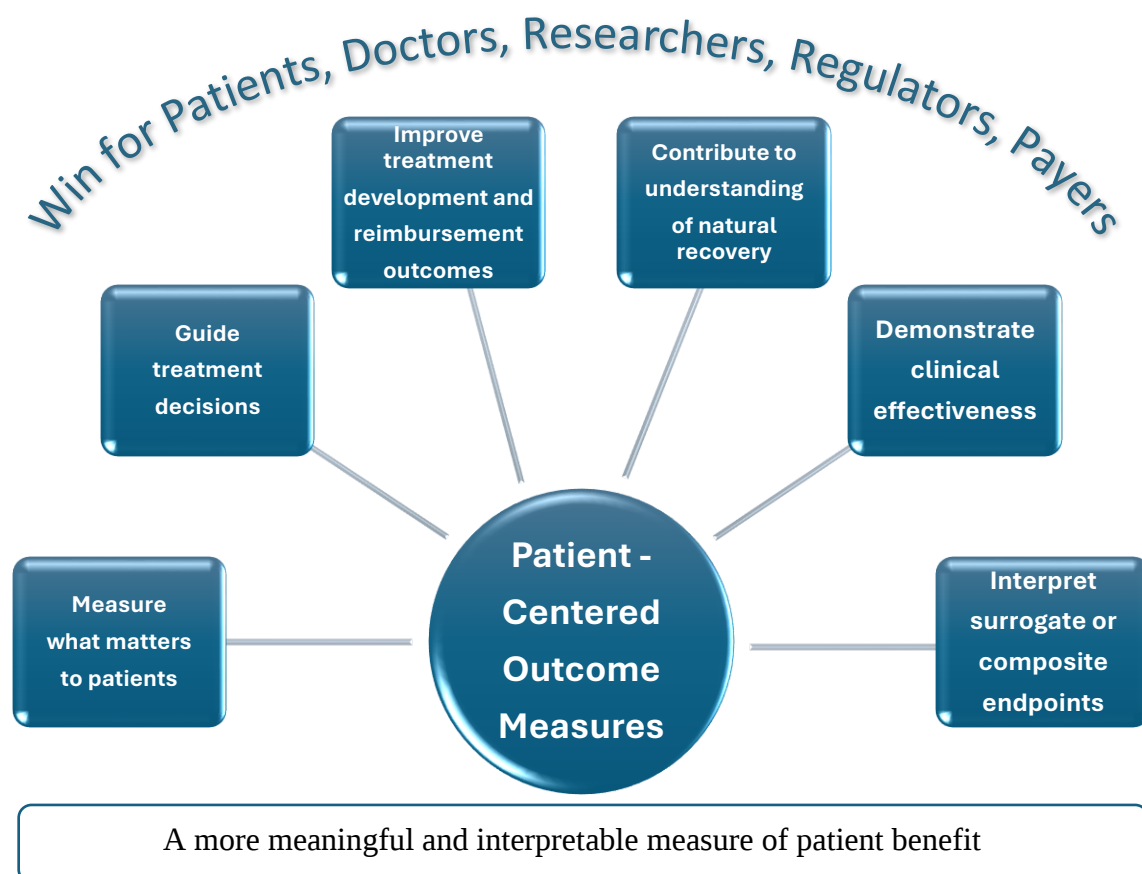


Figure 1.1. The role of patient-centered outcome measures in Enhancing healthcare.

Functional recovery pattern following hip or knee arthroplasty

Recovery pattern provide a meaningful reference for clinicians to benchmark the patients' progress, determine rehabilitation needs, and set realistic goals after hip or knee arthroplasty (Kennedy et al., 2008). It also gives patients the information to plan their return to normal activities. Clinicians can evaluate the patient's progress as being on target by examining the recovery curve. If a patient does not progress along average recovery patterns, the clinicians may need to reassess and capture more information to base further treatment (Kennedy et al., 2011). In addition, clinicians can use recovery curve data to schedule optimal follow-up appointments and measure their changes after hip or knee arthroplasty (Kennedy et al., 2008).

A patient's recovery of function after hip or knee arthroplasty has been measured in different follow-up periods and a variety of ways, including physical examination findings such as range of motion (Mizner et al., 2005; Pua et al., 2018), lower limb strength (Judd et al., 2014; Mizner et al., 2005; Pua et al., 2018), performance-based tests (PBTs) based on timed walking, stair climbing, and chair-rising (Judd et al., 2014; Kennedy, Hanna, et al., 2006; Kennedy, Stratford, et al., 2006; Mizner et al., 2005; Naylor et al., 2009), and patient-reported outcome measures (PROMs) such as Western Ontario and McMaster Universities Arthritis Index (WOMAC) (Dumenci et al., 2019; Hylkema et al., 2022; Kennedy, Stratford, et al., 2006; Lenguerrand et al., 2016; Naylor et al., 2009), Hip disability and Osteoarthritis Outcome Score (HOOS) (Judd et al., 2014), 36-item Short Form Health Survey (SF-36) (Judd et al., 2014; Mizner et al., 2005; Naylor et al., 2009). Overall, it has been suggested that patients should be evaluated more frequently in the first 13 weeks after hip or knee arthroplasty since the greatest magnitude of functional improvement occurs within the first 13 weeks following surgery. Improvement continues to occur from 13 to 26 weeks, but at a slower rate, and little

improvement occurs beyond 26 weeks after hip or knee arthroplasty (Wieczorek et al., 2020). Therefore, because most functional recovery occurs within 26 weeks and rehabilitation is most likely recommended in this timeframe, assessment of patients beyond 26 weeks after hip or knee arthroplasty has not been recommended in the context of rehabilitation (Kagan et al., 2018; Kennedy et al., 2008).

Theoretical Framework

In this section, I describe the framework that guides my dissertation studies and explain the rationale for selecting this framework.

The International Classification of Functioning, Disability, and Health (ICF) framework guides the development of the questionnaire, compares the content of existing outcome measures, and explores patients' key activities after hip or knee arthroplasty in Studies 2, 3, 4, and 5. The ICF is a comprehensive framework of health states developed and published by the World Health Organization (WHO) in 2001. It is based on an integrative model of functioning, disability, and health and provides a standardized language for describing an individual's health state (Organization, 2001; Rauch et al., 2008). The common language of the ICF can assist rehabilitation professionals not only in their daily work with patients but also when collaborating with other medical disciplines, hospitals, healthcare administrations, health authorities, and policymakers (Stucki et al., 2002). This framework contributes to broadening our understanding of the various ways in which chronic conditions can affect patients' functioning (Organization, 2001).

The ICF model has two parts: functioning/disability and contextual factors (Figure 1.2). The components of functioning/disability include:

1. Body structure is the anatomic parts of the body.

2. Body functions are physiological and psychological functions of the body.
3. Activities refer to an individual's ability to execute a task or an action in a standard environment.
4. Participation implies involvement in a real-life situation (Organization, 2001; Rauch et al., 2008).

The components of contextual factors include:

1. Environmental factors are the physical, social, and attitudinal situations in which people live,
2. Personal factors are the particular background of individuals' life and living situations and comprise features that are not part of a health condition (Organization, 2001; Rauch et al., 2008).

Within this model, disability is viewed as a universal human experience of functioning, not merely as the consequence of a disease but as the result of the complex interaction between a person's health condition and contextual factors, which include both personal attributes and environmental influences. The impact of these contextual factors is important because they can act as facilitators or barriers to functioning (Fayed et al., 2011; Organization, 2001; Rauch et al., 2008).

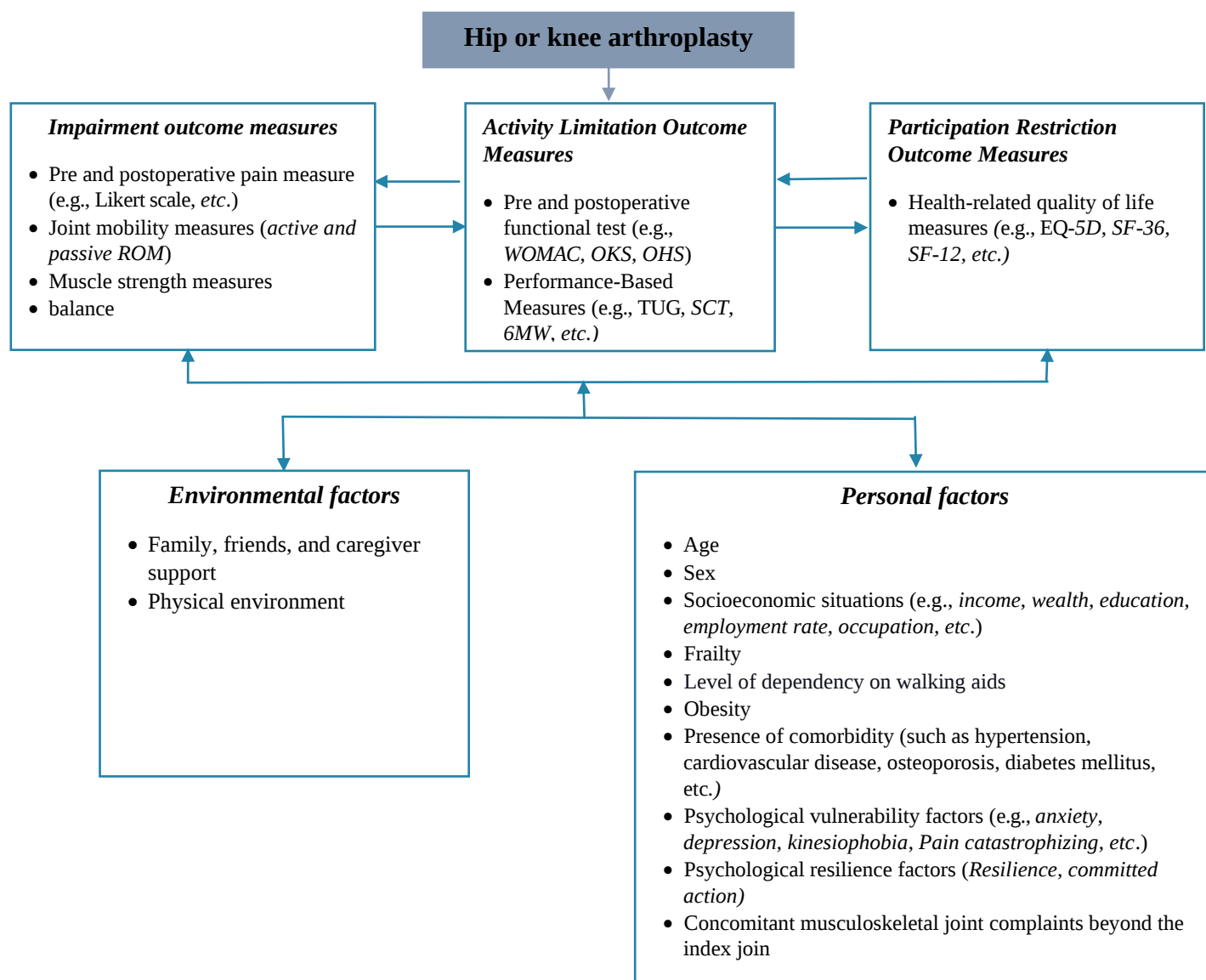


Figure 1.2. Components of ICF framework. **6MW** - 6-Minute Walk Test; **EQ-5D** - EuroQol 5-Dimension; **OKS** - Oxford Knee Score; **OHS** - Oxford Hip Score; **ROM** - Range of Motion; **SCT** - Stair Climb Test; **SF-12** - Short Form (12) Health Survey; **SF-36** - Short Form (36) Health Survey; **TUG** - Timed Up and Go; **WOMAC** - Western Ontario and McMaster Universities Osteoarthritis Index

The ICF is structured hierarchically: the first level is made up of chapters, and each chapter consists of second-level categories, followed by more detailed third-level and, for some cases, fourth-level categories. Figure 1.3 shows the details of structure and codes of the ICF.

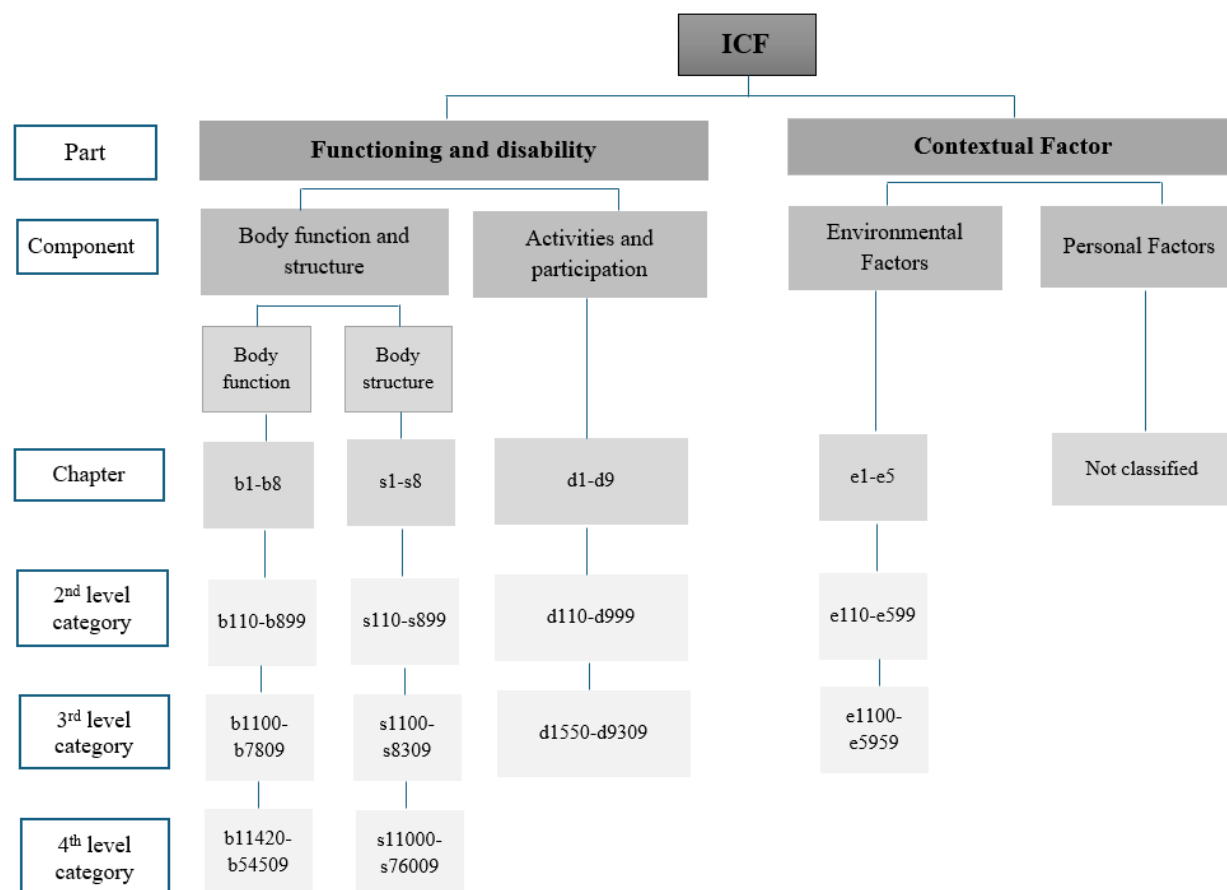


Figure 1.3. The structure and codes of the ICF

The ICF includes over 1450 categories, which limits its clinical application (Yen et al., 2014). To address this practical concern and enhance the applicability of the ICF in clinical practice and research, specific ICF categories describing the disability status of particular patient types are needed (Cieza et al., 2004), referred to as ICF core sets. The ICF core set for patients with OA was created to provide standards for multi-professional comprehensive patient assessment for this patient population (Dreinhofer et al., 2004). This core set contains 13 categories from the component body functions, 6 from the component body structures, 19 from the component activities and participation, and 17 from the component environmental factors (Dreinhofer et al., 2004). Table 1.3 shows the details of each category in ICF core set for OA.

Table 1.3 Categories of ICF core set for OA

Body functions and structure (ICF code category title)	Activity and Participation (ICF code category title)	Environmental factor (ICF code category title)
b130 Energy and drive functions	d410 Changing basic body position	e110 Products or substances for personal consumption
b134 Sleep functions	d415 Maintaining a body position	e115 Products and technology for personal use in daily living
b152 Emotional functions	d430 Lifting and carrying objects	e120 Products and technology for personal indoor and outdoor mobility and transportation
b280 Sensation of pain	d440 Fine hand use	e135 Products and technology for employment
b710 Mobility of joint functions	d445 Hand and arm use	e150 Design, construction and building products and technology of buildings for public use
b715 Stability of joint functions	d450 Walking	e155 Design, construction and building products and technology of buildings for private use
b720 Mobility of bone functions	d455 Moving around	e225 Climate
b730 Muscle power function	d470 Using transportation	e310 Immediate family
b735 Muscle tone functions	d475 Driving	e320 Friends
b740 Muscle endurance functions	d510 Washing oneself	e340 Personal care providers and personal assistants
b760 Control of voluntary movement functions	d530 Toileting	e355 Health professionals
b770 Gait pattern functions	d540 Dressing	e410 Individual attitudes of immediate family members
b780 Sensations related to muscles and movement functions	d620 Acquisition of goods and services	e450 Individual attitudes of health professionals
s720 Structure of shoulder region	d640 Doing housework	e460 Societal attitudes
s730 Structure of upper extremity	d660 Assisting others	e540 Transportation services, systems and policies
s740 Structure of pelvic region	d770 Intimate relationships	e575 General social support services, systems and policies
s750 Structure of lower extremity	d850 Remunerative employment	e580 Health services, systems and policies
s770 Additional musculoskeletal structures related to movement	d910 Community Life	
s799 Structures related to movement, unspecified	d920 Recreation and leisure	

I believe that the ICF provides an ideal framework for conceptualizing outcomes after hip or knee arthroplasty for several reasons. First, my dissertation focuses on primary elective hip or knee arthroplasty for end-stage OA, and the ICF OA core set encompasses a range of relevant domains for patients with advanced arthritis, as validated in previous studies. Secondly, the ICF core set for OA covers the typical range of functional challenges encountered during recovery after hip or knee surgery. Thirdly, the core set allows for tracking changes in patient functioning across different evaluation time points following hip or knee arthroplasty (Alviar et al., 2011).

ICF linking rules

The use of the ICF as a reference framework in outcome research requires a sound, standardized procedure that outcome measures to be linked to the ICF. Cieza et al. suggested rules for linking health-status measures to the ICF in 2002 (Cieza et al., 2002), updated them in 2005 to extend to other applications including specific clinical outcome measures (Stucki, 2005). Further refinements to these existing ICF linking rules were recently presented to enhance the clarity of the linking process (Cieza et al., 2019). In the latest version of ICF linking rules, Cieza et al. defined 10 linking rules to link health status measures to the ICF. Rules 1–3 involve becoming familiar with the ICF, identifying the main purpose of the instrument and relevant concepts to be linked to the ICF, while Rules 6–10 focus on linking concepts to the most appropriate ICF category or specifying their content if they cannot be linked to the ICF. I describe the details of these rules in chapter three.

In the last ten years, the ICF linking rules have been applied to a wide range of health status assessment questionnaires and numerous clinical assessments and interventions (Boldt et al., 2005; Brockow et al., 2004; Fayed et al., 2012; Geyh et al., 2004; Prodingen et al., 2008). They have also been used to link qualitative data collected from open-ended questions in focus groups and patient interviews (Coenen et al., 2006, 2012), analyze surveys involving health professionals and patients (Bauernfeind et al., 2009; Weigl et al., 2004), and for epidemiological studies (Cieza et al., 2011; Post et al., 2011).

Methodological Considerations

To achieve the goal of evaluating the patient-centeredness of outcome measures used following hip or knee arthroplasty, my research was structured into seven distinct studies. Study 1 is a narrative review focusing on three concepts related to managing suboptimal outcomes after hip or knee arthroplasty. Study 2 involved conducting qualitative cognitive think-loud interviews with patients who had undergone hip or knee arthroplasty. Studies 3 and 4 encompassed two systematic reviews and content analyses of PROMs and PBTs used following hip or knee arthroplasty. Study 5 included administering a cross-sectional survey to patients who had undergone these procedures. Study 6 involved synthesizing the results of studies three, four, and five to evaluate the patient-centeredness of functional outcome measures following hip or knee arthroplasty. Study 7 consisted of a scoping review focused on patient involvement in the development of PROMs identified in studies three. This section outlines the methodological approaches guiding each study within this research. Detailed descriptions of data sources, recruitment strategies, data collection, and analytic processes for Studies 2 to 7 are provided in Chapters 2 through 7 of this dissertation. Figure 1.4 summarizes the research methods employed in each individual study.

Overall purpose of dissertation:
To evaluate the patient-centeredness of outcome measures at different time points following hip or knee arthroplasty

	Objective	Methods	Inclusion criteria	Number of studies/participants	Outcomes
Study 1: Narrative review	To provide an overview of the key findings concerning the management of poorer outcomes after hip or knee arthroplasty.	Narrative review	English-language, peer-reviewed journal articles on poor outcomes after hip or knee arthroplasty	Not applicable	Determining a knowledge gap for the management of poorer outcomes after arthroplasty
Study 2: Cognitive think-aloud interview	To develop a self-report questionnaire evaluating functional priorities after hip or knee arthroplasty and evaluate patients' understanding of its items and conceptual relevance	Qualitative cognitive think-aloud interview	Adults (18 years or older) who underwent primary elective hip or knee arthroplasty due to OA, had surgery 1, 6, 13, or 26 weeks prior, and who spoke English.	N=18 patients	Developing a questionnaire and evaluating its face and content validity
Study 3: Systematic review and content analysis of PROMs	To identify the existing PROMs used in hip or knee arthroplasty and assess their content validity using the modified ICF core set for OA	Systematic review and content analysis	Disease (OA) or joint-specific (hip, knee, or lower limb) PROMs developed in English or undergone translation and validation in English	N=50 PROMs	Proving a list of existing PROMs and ICF-based coding lists of their contents
Study 4: Systematic review and content analysis of PBTs	To identify the existing PBTs used in hip or knee arthroplasty and assess their content validity using the modified ICF core set for OA	Systematic review and content analysis	PBTs used after hip or knee arthroplasty involve individuals performing one or more functional activities, which are evaluated by an assessor	N=28 PBTs	Proving a list of existing PBTs and ICF-based coding lists of their contents
Study 5: Functional activities survey	To explore key functional activities from patients' perspective at different timepoint during the first six months after hip or knee arthroplasty	Cross-sectional survey	Adults (18 years or older) who underwent primary elective hip or knee arthroplasty due to OA, had surgery 1, 6, 13, or 26 weeks prior, and who spoke English.	N=632 patients	Determining key and non-key functional activities based on patients' perspective
Study 6: Patient-centered content analysis	To identify how well the functional outcome measures for hip or knee arthroplasty cover the activities important to patients	Patient-centered content-validity analysis	Raw mapping code lists of outcome measures to patients' key activities after hip or knee arthroplasty	N=78 functional outcome measures	Determining the coverage of key activities by outcome measures used after hip or knee arthroplasty
Study 7: Patient involvement scoping review	To evaluate the content of these outcome measures to identify the extent they are patient-centered	Scoping review	Study with focus on developing PROMs for assessing functional outcomes after hip or knee arthroplasty	N=50 studies	Providing information about the level of patient involvement in developing PROM

Figure 1.4. Overview of Research Methods. **ICF:** International Classification of Functioning, Disability and Health; **OA:** Osteoarthritis; **PBT:** Performance-based tests **PROM:** Patient-reported outcome measures

Methodologies

In this section, I outline the methodologies guiding each research study and provide justification for their selection. This helps emphasize the methodological consistency across the seven individual studies.

Narrative review (Study 1)

Study 1 aimed to elucidate strategies for managing suboptimal outcomes following hip or knee arthroplasty. To achieve this, I conducted a narrative review guided by the principles outlined in the Scale for the Assessment of Narrative Review Articles (SANRA) (Baethge et al., 2019). Narrative reviews aim to offer a comprehensive understanding of a topic by theoretically and contextually analyzing existing literature (Kowalczyk & Truluck, 2013). I chose this approach over a systematic review because my objective was not to address a specific question but rather to explore the topic broadly. Narrative reviews are well-suited for providing a holistic perspective on a topic or theme. Therefore, this methodology was appropriate for providing an overview of strategies for optimizing outcomes after hip or knee arthroplasty, aiming to present current insights and suggest future directions. This study was pivotal in shaping the research questions for subsequent studies in my dissertation.

Cognitive think-aloud interview Methodology (Study 2)

Study 2 aims to develop a self-report questionnaire that assesses key functional activities following hip or knee arthroplasty and evaluates patients' understanding of its items and conceptual relevance. I developed a questionnaire based on the ICF OA core set, which prompted respondents to provide answers regarding their functional activities after surgery. While the questionnaire was refined in collaboration with three physiotherapists, potential patient challenges, such as misinterpretation, execution difficulties, or issues with response options,

could arise. Solutions include clarifying wording, simplifying tasks, and ensuring that response options align with respondents' perspectives (Conrad et al., 1999). To address these potential challenges and refine the questionnaire from the patients' perspective, I conducted a qualitative study involving cognitive interviews. Cognitive interviewing is a psychologically oriented method for investigating respondents' mental processes. It involves administering preliminary questionnaires to a subset of respondents from the target populations before final versions are distributed to the entire sample and collecting verbal feedback on their responses. Its purpose is to understand how individuals interpret and respond to survey instructions, items, and response options, ensuring that the questions accurately capture the intended information (Zumbo & Hubley, 2017). Therefore, cognitive interviews provide evidence for the confirmation, revision, deletion, or replacement of items. The major techniques for cognitive interviews include concurrent probing (questions asked during each item response), retrospective probing (questions asked after all item responses), and concurrent verbalization ('think aloud' during each item response) (Willis, 2004). For this study, I selected concurrent verbalization. I also conducted retrospective probes immediately after the think-aloud interview to clarify concurrent verbalizations. Follow-up probes included questions such as "*It seemed like you paused for a while on this question; can you recall what you were thinking at that moment?*" or "*Can you explain how you arrived at that response?*" I did not select concurrent probing, as it is more disruptive to task performance and may unduly influence cognitive processing (Simon & Ericsson, 1984).

Therefore, the cognitive interview methodology served as a valuable approach for assessing the content validity of the questionnaire designed to evaluate patients' key activities after hip or knee arthroplasty in Study 5. In addition, it validated the ICF core set for OA among

patients undergoing hip or knee arthroplasty. The objective was to determine the appropriateness and applicability of all functional activities in the ICF core set for OA after hip or knee arthroplasty to inform content analysis in studies 3 and 4.

Systematic review and content analysis Methodology (Study 3, 4)

The objectives of studies three or four are to identify the existing outcome measures, including PROMs and PBTs used after hip or knee arthroplasty and to assess their content using the modified ICF core set for OA validated in Study 2. To achieve this, I first conducted two systematic literature reviews to compile a list of the existing outcome measures. The systematic reviews followed Cochrane reviews methodology (Chandler et al., 2019) and Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines (Liberati, 2009). To identify the outcome measures, I reviewed studies that either developed new outcome measures or evaluated their psychometric properties. This approach followed recommendations from the Consensus-based Standards for the Selection of Health Measurement Instruments (COSMIN) (Prinsen et al., 2018). I selected systematic review methodology because it is an appropriate approach to compile international evidence addressing specific questions which employs explicit, systematic methods to minimize bias, thereby yielding more reliable findings for drawing conclusions and making decisions (Munn et al., 2018). Then, I evaluated the content of the included outcome measures by linking their items to the modified ICF OA core set using established ICF linking rules (Cieza et al., 2019). The objective of this linking process was to generate raw mapping code lists and categorize them for the components of each outcome measure. These coding lists facilitated comparison between different outcome measures. This linking process serves to establish the relationship of the outcome measures to the domains and categories of ICF. It provides a standardized method to break down complex items covering

multiple domains into their respective constructs. Therefore, using ICF linking rules was appropriate for achieving the objectives of Studies Three and Four, ensuring that our analysis was comprehensive, consistent, and aligned with internationally recognized standards, thereby enhancing the validity and reliability of our findings.

Cross-sectional survey methodology (Study 5)

The objective of Study 5 was to explore key functional activities from patients' perspectives within 2 weeks and at 6, 13, and 26 weeks after hip or knee arthroplasty. To achieve this objective, I selected a cross-sectional survey with patients undergoing hip or knee arthroplasty. The survey design is defined as “a set of research procedures in which investigators administer a survey to a sample or to the entire population of people to describe the attitudes, opinions, behaviors, or characteristics of the population” (Creswell & Guetterman, 2019). More specifically, in a cross-sectional survey design, the data are collected at one point in time and do not follow participants over a period, unlike longitudinal studies (Goldberg et al., 2013). The rationale for choosing this research design is to efficiently reach a large sample within a specific period of time (Setia, 2016; Thompson & Panacek, 2007). This approach provides convenience in several ways, such as: a) respondents can answer at a convenient time; b) respondents can take as much time as needed to respond to questions and complete them in multiple sessions; and c) it reduces the threat of socially desirable responses, leading to more honest disclosure compared to other methodologies such as interviews or focus groups (Paulhus, 2017).

Patient-centered content validity analysis methodology (Study 6)

Study 6 aimed to analyze the patient-centeredness of outcome measures used after hip or knee arthroplasty. To achieve this, I integrated the findings from studies three, four and five to interpret the raw linking codes based on patients' perspectives. I followed COSMIN terminology

(Terwee et al., 2018). COSMIN is an initiative led by an international, multidisciplinary team that seeks to enhance the selection of outcome measurement instruments in both research and clinical settings. In this study, I evaluated two aspects of content validity, including relevance and comprehensiveness of outcome measures. Relevance implies that all items of outcome measures should pertain to key functional activities after hip and knee arthroplasty, while comprehensiveness ensures that no key activities are missing (Terwee et al., 2018).

Outcome measures often measure complex and intangible concepts, which complicates evaluating the clarity of the construct, the relevance of each item, and the comprehensiveness of the measures. One method to address this is to ask patients about their perceptions of relevance and comprehensiveness. Therefore, our approach of incorporating the list of codes related to aspects of outcome measures with the activities that matter to patients was an effective way to evaluate whether the PROM sufficiently addresses patients' key activities and to identify any key activities that may be overlooked.

Scoping review methodology (Study 7)

The objective of Study 7 was to assess the extent of patient involvement in the development of PROMs used after hip or knee arthroplasty. For this aim, I conducted a scoping review of the literature on this topic, following Arksey and O'Malley's methodological framework (Arksey & O'Malley, 2005). The aim of scoping reviews is to map the literature on a specific topic, identify research gaps, and explore various types and sources of evidence, especially when the topic is in its early stages or too diverse for a systematic review (Daudt et al., 2013). By adopting a scoping methodology, this review offered an extensive understanding of patient involvement in the development of outcome measures and enhanced our knowledge of their patient-centeredness. In addition, this approach could highlight the gaps in patient

involvement in the development of outcome measures used after hip or knee arthroplasty, guiding future research on developing new measures or modifying existing ones. Therefore, this methodology was deemed the most suitable for identifying, extracting, and summarizing literature on patient involvement in the development of outcome measures.

Ethical Considerations

In the concluding part of this introduction chapter, I address the ethical considerations pertinent to my dissertation research, concerning two participant-involved studies (Studies 2 and 5). I outline the ethical research protocols and discuss privacy safeguards implemented during interviews (Study 2) and the survey process (Study 5).

Studies two and five were initiated after receiving approval from the Research Ethics Board of The Ottawa Hospital and the University of Ottawa Research Ethics Board. The certificates of ethics approval are provided in Appendix A. I followed TCPS 2 (Tri-Council Policy Statement 2) guidelines, ensuring respect for human dignity by considering three core principles: Respect for Persons, Concern for Welfare, and Justice (Government of Canada, 2023). For both studies, I identified eligible participants through screening of arthroplasty clinics at The Ottawa Hospital. Patients with consent to contact on their chart in the EPIC electronic health record system were called to verbally discuss participation in the think-aloud interview or survey. If consent was given to be approached, all study procedures, including the study's purpose, procedures, potential risks, possible benefits, and their rights as research participants, were explained in a manner appropriate for their understanding. The participants were given ample time to have their questions addressed prior to consenting. For Study 2, consent was obtained either verbally (using a verbal consent form) or in written format (using an informed consent form). Copies of the consent forms for Study 2 are provided in Appendix B. If written

consent was obtained, a copy of the signed consent form was given to the participant. For verbal consent, the process was thoroughly documented in the participant's research record, and the information sheet was sent to participants. For Study 5, an implied consent form was used, where completing the survey implied consent. This approach was clearly communicated to all participants involved. The consent form for Study 5 is also provided in Appendix B. For both studies, consent to email was obtained to send the information sheet to consenting participants for Study 2, and the online questionnaire and implied consent form for Study 5. In addition, for Study 5, I mailed or physically gave the paper-based questionnaire and implied consent form during in-clinic visits with orthopedic surgeons to some participants. For Study 2, a Microsoft Teams link for the interview was also sent through email. I used an interview guide to ask participants to say out loud whatever comes to their mind while answering the survey questions. The interview guide is provided in Appendix C. All think-aloud interviews were audio recorded using an encrypted digital audio recorder. The recordings were kept until they were transcribed and then securely destroyed. Surveys were completed through The Ottawa Hospital Research Electronic Data Capture (REDCap) link. Data was directly input by the participants into The Ottawa Hospital REDCap for the survey study. The Ottawa Hospital REDCap data was exported after recruiting every 50 participants. All data (master log, exported REDCap survey data, think-aloud interview audio-video recordings, transcribed recordings, consent forms) were stored in a password-protected electronic database, accessible to the research team. Data security was also ensured with physical safeguards by storing the hard copies of transcribed interviews and data analysis in a locked cabinet at The Ottawa Hospital in the locked research office of the orthopedic division. For both studies, study records will be retained for ten years after the completion of the studies.

Summary of Introduction Chapter

The purpose of my dissertation is to evaluate the patient-centeredness of outcome measures used after hip or knee arthroplasty to optimize outcomes (see Figure 1.5). This chapter provided an overview of key definitions, a literature review, and theoretical considerations that inform the research design and methodological approach of my dissertation. I detailed the methodological approaches employed in my research studies, including narrative review, cognitive interviews, systematic reviews, cross-sectional study, patient-centered content analysis and scoping review. Finally, ethical considerations within my dissertation work were also outlined. In the following six chapters, I present studies two to seven and discuss their respective findings.

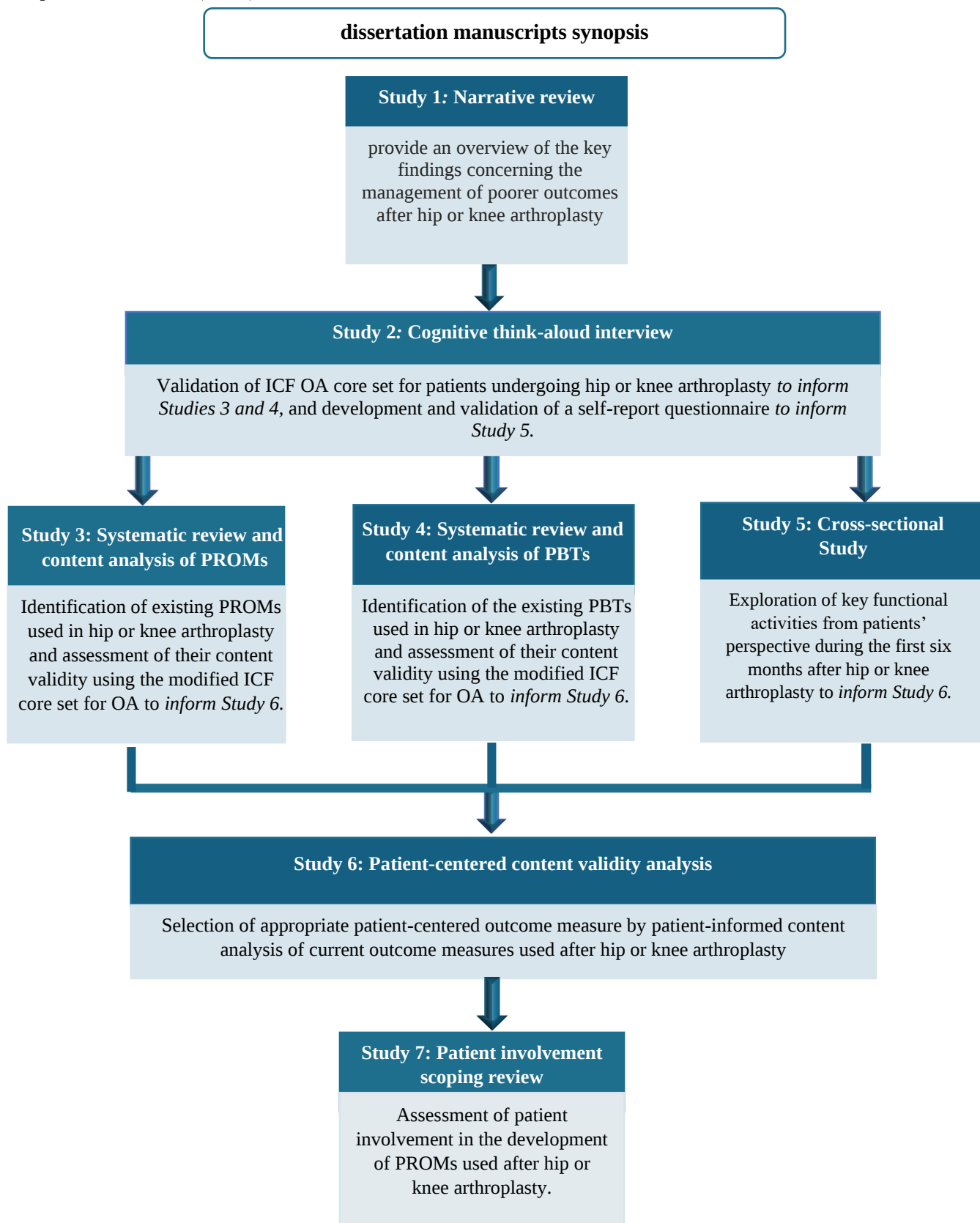


Figure 1.5 Outline of studies included in this dissertation. **ICF**: International Classification of Functioning, Disability and Health; **OA**: Osteoarthritis; **PBT**: Performance-based tests **PROM**: Patient-reported outcome measures.

CHAPTER 2: Cognitive Think-Aloud Interview (Manuscript 2)

Relationship of Manuscript 2 to the Dissertation

In this chapter, I present the manuscript detailing a qualitative think-aloud cognitive interview conducted with patients who underwent hip or knee arthroplasty (Study 2). This study serves as the basis for studies 3, 4, and 5 in my dissertation. As described in Chapter 1, I chose the ICF core set for OA as the framework for guiding my dissertation studies. However, the ICF OA core set has not yet been validated for patients undergoing hip or knee arthroplasty. The aim of this study was twofold: first, to develop a questionnaire for assessing functional priorities and abilities after hip and knee arthroplasty and to evaluate its face and content validity; second, to tailor an ICF OA core set for patients undergoing these procedures. The study involved think-aloud cognitive interviews with 18 participants. During these interviews, patients identified ambiguities in wording, which we subsequently simplified. Ten activities from the OA core set were excluded due to lack of face validity, two activities were added, and four activities were modified. Ultimately, this resulted in a modified version of the ICF OA core set comprising 49 third- and second-level categories, which was used for two systematic reviews aimed at analyzing the content of existing outcome measures used after hip or knee arthroplasty (Studies 3 and 4). Furthermore, this study developed and validated a questionnaire for a survey aimed at identifying key functional activities after hip and knee arthroplasty (Study 5).

The manuscript resulting from this work was published in *Disability and Rehabilitation*.

Permissions from journal to use published manuscript in PhD thesis is provided in appendix D. It adheres to the journal's formatting requirements. However, the figures and tables numbering were renumbered to match this dissertation's formatting. The published article can be viewed at:

Karimijashni M, Westby M, Ramsay T, Beaulé PE, Poitras S. Development and content validation of a questionnaire identifying patients' functional priorities and abilities after hip or knee arthroplasty. *Disability and Rehabilitation*. 2024 Aug 16:1-5.

Manuscript 2: Development and content validation of a questionnaire identifying patients' functional priorities and abilities after hip or knee arthroplasty

Abstract

Background: To develop a self-report questionnaire evaluating functional priorities after hip or knee arthroplasty and evaluate patients' understanding of its items and conceptual relevance.

Methods: A self-report questionnaire was first developed based on the International Classification of Functioning, Disability, and Health (ICF) core set for osteoarthritis (OA). In the second stage, two research physiotherapists thoroughly reviewed and refined the questionnaire, and another physiotherapist conducted cognitive think-aloud interviews with 18 patients to assess the face and content validity of the questionnaire.

Results: All categories and corresponding activities of ICF core set for OA were used to develop the questionnaire. Several questionnaire issues were identified and addressed. Most challenges were related to comprehension, followed by item ordering and visual elements. Patients identified ambiguous wording which we subsequently simplified. Ten activities of the core set were excluded due to lack of face validity, two activities were added, and four activities were modified.

Conclusion and implication: The findings suggest that the ICF core set for OA needs to be adjusted for patients undergoing hip or knee arthroplasty and highlight the feasibility of applying a modified core set to assess functional priorities after hip or knee arthroplasty.

Keywords: knee and hip arthroplasty, functional priorities, content validity, questionnaire development

Implications for Rehabilitation

- The questionnaire developed in this study can be used to assess patients' functional priorities after hip or knee arthroplasty for osteoarthritis.
- Several activities that comprise the International Classification of Functioning, Disability, and Health (ICF) core set for osteoarthritis could be used to assess functional priorities after hip or knee arthroplasty.
- Some categories need to be removed or modified within this core set based on feedback from patients during the think-aloud sessions in our study.
- Using our questionnaire to determine postoperative patient priorities can help identify appropriate patient-centered outcome measures to use after hip or knee arthroplasty.

Introduction

Healthcare systems are moving toward patient-centered services by focusing on patient priorities, which are health outcome goals based on what matters most to patients [1-3]. Patients can contribute to better healthcare quality by sharing their goals and experiences with healthcare providers [4]. To establish patient-centered management priorities, healthcare providers must understand patient needs and expectations [5]. Healthcare services tailored to meet patient goals have been demonstrated to enhance outcomes and patient satisfaction while reducing healthcare costs [6,7].

Hip or knee arthroplasty is an effective procedure for advanced osteoarthritis (OA), with a majority of patients experiencing improved pain, function and health-related quality of life outcomes [8]. However, there is evidence that 10 to 30% of patients report suboptimal outcomes after hip or knee arthroplasty [9,10]. Reasons for these poorer outcomes after hip or knee arthroplasty remain unclear [11]. To define poor outcomes, it is important to understand which aspects of outcomes are important to patients. This knowledge will assist clinicians in identifying patients with suboptimal outcomes, leading to tailored rehabilitation intervention which in turn, contribute to the optimization of results after arthroplasty. Existing outcome measures can be assessed against postoperative patient priorities to determine if they are patient-centered, guiding clinicians to select appropriate measures and assess postoperative outcomes that are important for patients.

Despite the thorough exploration of patients' expectations and goals before arthroplasty [12-15]. and their role in the surgical decision-making process [12,13], this preoperative data is insufficient for postoperative decision-making. Postoperative information is essential as patients may reassess their goals and expectations after arthroplasty due to the changes in their functional status and perception of health [16,17]. Many patients have very optimistic preoperative

expectations regarding surgery results, potentially leading to unmet expectations and subsequent dissatisfaction [15,18]. Additionally, only considering preoperative patient expectations makes it challenging to define goals at different time points during the postoperative period [12,13].

Thus, there is a need to explore postoperative patient priorities after hip or knee arthroplasty, yet limited information exists on this subject. Although few studies [19,20] have identified some aspects of functional priorities at specific postoperative time points, a comprehensive evaluation of patients' priorities throughout the entire postoperative recovery period is lacking. To address this gap, an instrument is first needed to provide a more detailed insight into patients' perspectives after surgery. The current study aimed to develop a patient questionnaire to assess functional priorities after hip and knee arthroplasty and evaluate its face and content validity.

Methods

This research was designed following the steps proposed by Burns et al. [21] and Passmore et al. [22] and consists of three phases: 1) developing the questionnaire, 2) assessing the face and content validity of the questionnaire through expert input and think-aloud interviews with patients who underwent hip or knee arthroplasty, [23] and 3) pilot testing the draft questionnaire. Figure 2.1 shows a flow diagram of the methodology for this study. This study was approved by Ottawa Health Sciences Network Research Ethics Board (20230252-01H), and the University of Ottawa Board of Ethics (H-06-23-9425).

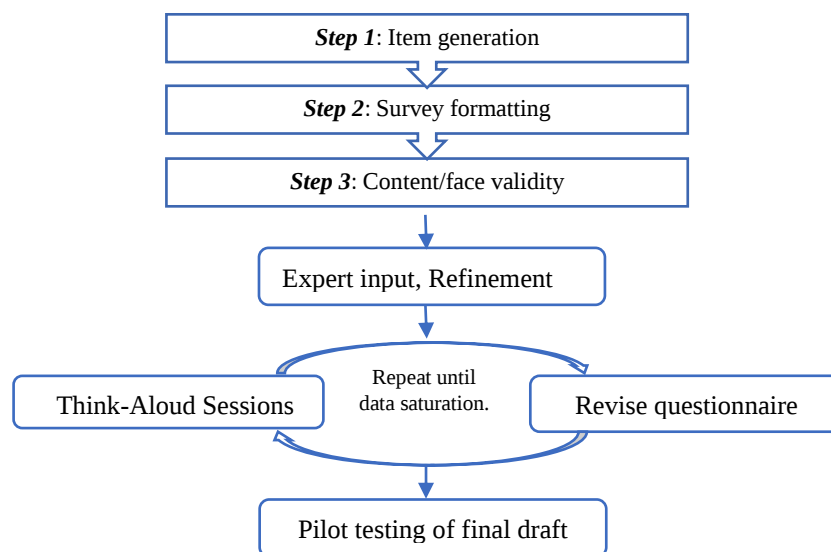


Figure 2.1 Questionnaire development and cognitive validation.

The development of the questionnaire consisted of three steps:

Step one: Item generation

The aim of this step is to thoroughly explore potential domains for incorporation into the questionnaire. We selected the International Classification of Functioning, Disability, and Health (ICF) to generate the items in this questionnaire. The ICF is a comprehensive and integrated framework designed to assess the health and health-related states of diverse populations [24]. Previous research has highlighted the usefulness of ICF as a framework and classification system in the development of more effective questionnaires [25]. The ICF is organized into two distinct parts: (a) functioning and disability, and (b) contextual factors [24] (Figure 2.2). The expansive nature of the ICF poses a challenge to its practical application. To address this, lists of relevant categories tailored to certain conditions have been structured into core sets. The ICF core set for patients with OA was developed in 2004 and systematically identifies and categorizes key aspects of functioning and disability related to OA [26]. It includes 13 chapters for body function (most of which related to the neuromusculoskeletal and movement related functions), 6

chapters for body structure (all of them from the structures related to movement), 19 chapters for activities and participation (mobility, self-care, domestic life, etc.), and 17 for environmental factors (products and technology, support and relationship, etc.). Within these chapters are second-level categories such as changing and maintaining a body position, lifting and carrying objects, walking, going up and down stairs, and moving around. Within each second-level category are third-level activities including lying down, squatting, kneeling, sitting, standing, etc. Figure 2.3 shows an example of the ICF hierarchically from the activity and participation component. This multifaceted approach provides in-depth insights into the diverse dimensions of daily activities. Only the activity and participation component of the ICF was selected for this questionnaire because individuals undergoing arthroplasty due to OA identified functional outcomes improvement, including engaging in daily activities at the individual and societal levels as the main aim of arthroplasty [16, 17, 26, 27].

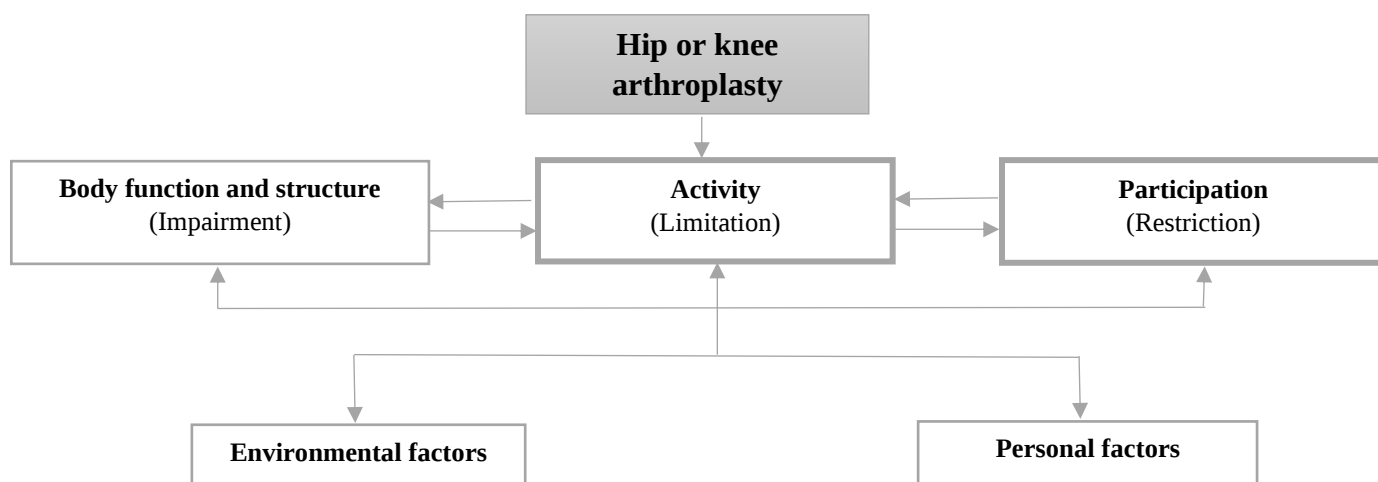


Figure 2.2 Components of ICF framework.

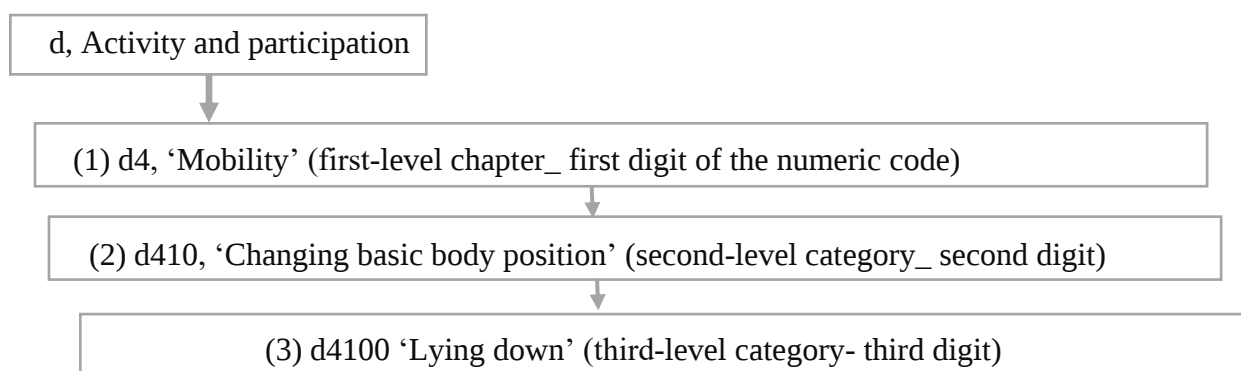


Figure 2.3 An example of the ICF hierarchically from the activity and participation component.

The OA core set was used to generate items for the questionnaire since previous research has shown the potential clinical utility of this core set in the assessment of arthroplasty outcomes [28]. It encompasses the common range of functional issues faced during the recovery period following hip or knee arthroplasty enhancing the content validity of our questionnaire [27,28]. Also, it has been validated from both physiotherapists and patient perspectives [29-32]. The OA core set addresses second-level categories, but the survey included third-level activities to ensure a thorough exploration of the individual's participation in diverse life activities using original ICF wording. It is worth noting that an ICF core set for total knee arthroplasty was recently developed [33]. However, patients were not involved in the development process.

Step two: Initial questionnaire development

In this step, the questions and response options were formulated by the first author (MK) with the goal of ensuring conciseness, clarity and interpretability. Each activity is evaluated based on current importance and ability. The importance of functional activities is rated on a 4-point scale from "not important" to "very important," and the ability to perform activities is rated from "unable to do" to "no difficulty". A 4-point scale (very important, important, slightly important, and not important) [34]. was used to limit neutrality and force respondents to make a

clear directional choice and provide concrete opinions. This scale is also easier to understand, requires less effort to answer [35]. and maximizes response rates [36]. We included an image from the ICF illustration library for each activity to enhance comprehension by providing more precise information and facilitating ease in answering [37].

Step three: Questionnaire tool validation

Validating procedure

The questionnaire went through two stages to assess its face/content validity. First, three physiotherapist research team members (SP, MW, MK) reviewed the questionnaire items and commented on the wording of the questions and determined whether the questions captured the objectives pursued [38]. Second, a think-aloud process was applied with the intended users of the questionnaire, e.g. patients who had undergone hip or knee arthroplasty. This cognitive interview method assesses validity by investigating response processes [39]. Patients are prompted to vocalize their thoughts by thinking aloud while answering questionnaire items, allowing them to verbalize thoughts that would typically remain silent during the process [40]. The think-aloud method allows for investigating the challenges patients may encounter when completing the questionnaire, including issues with comprehension, retrieval, judgment, and responding. This approach aims to ensure the functionality, clarity and user-friendliness of the questionnaire and is thought to give a more realistic picture of the problems compared to more direct interview methods that may interrupt task completion [41]. The interviewer remains silent so long as individuals continue to think aloud. Participants are consistently encouraged to keep thinking aloud if they stop verbalizing thoughts for more than ten seconds. They are not asked to explain or justify what they are doing nor to report their strategies.

Setting and participants

This study was conducted within the orthopedic department at The Ottawa Hospital in Ottawa, Canada, a large academic-affiliated institution situated in an urban setting with a high volume of arthroplasties. The inclusion criteria were adults (18 years or older) who underwent primary elective hip or knee arthroplasty due to OA, had surgery 1, 6, 13, or 26 weeks prior, and who spoke English. Recruitment timing was based on the typical post-arthroplasty recovery pattern [42,43]. One week post-surgery captured acute recovery. Approximately six weeks post-surgery was selected for the first post-acute measurement as most adverse events usually occur within 30 days of surgery [44,45] and most patients can be considered stable six weeks after surgery. The assessments at 13 and 26 weeks were selected to capture the majority of overall functional recovery and reflect the typical timeframe of rehabilitation [46,47]. Patients with a severe mental impairment, with hearing or speech impairment, and those unable to read were excluded.

Sampling and recruitment

We used a phone-based remote recruitment strategy to recruit the patients and purposive sampling. This sampling method allows the recruitment of participants across various criteria, including age, gender, surgery type, post-surgery timepoint. This approach leads to a more representative sample of the whole population and enhances comprehensiveness of the study [48,49]. For this purpose, screening for potential patients was first performed via Electronic Health Record (EPIC) at the Ottawa Hospital which contains comprehensive information regarding patient's medical history. After identifying eligible participants, we then manually reviewed charts for study confirmation. One researcher (MK) then phoned individuals with

documented consent for research in their EPIC chart. Consent for this study was obtained verbally over the phone or in written format.

Data collection

Consenting participants attended a single, cognitive interview session. Think-aloud interviews were held in person or virtually using Microsoft Teams. All interviews were carried out by one interviewer (MK) who is an experienced physiotherapist and a PhD candidate in rehabilitation sciences. After explaining the think-aloud process, participants were asked whether they found the concepts and items of the questionnaire to be relevant, appropriate, and comprehensible in accordance with the questionnaire objectives. After each interview, participants were encouraged to share their general comments on the questionnaire. All sessions were audio-recorded using an encrypted digital audio recorder and subsequently transcribed for analysis. The interviewer collected the demographic data, including age, sex, gender, body mass index, surgery date, and time since surgery during the interview sessions. Protection of privacy and confidentiality of participants was ensured by de-identifying data using their unique study IDs. All data, including master log, audio recordings, transcribed recordings, and consent forms were stored in a password-protected shared folder which could only be accessed by the research team. Data security was also ensured with physical safeguards by storing the hard copy of transcribed interviews and data analysis in a locked cabinet and research office in the orthopedic division at The Ottawa Hospital.

Sample Size

We aimed to recruit at least ten participants and planned to continue recruiting further participants, if necessary, until data saturation was reached, when no new problems arose for two consecutive participants. Recruitment of participants was continued until data saturation [50], when

no new problems arose for two consecutive participants. For this purpose, the analysis of each transcript was carried out iteratively after its corresponding interview to monitor for data saturation.

Data analysis

Data was entered into IBM SPSS (version 29) to produce descriptive statistics of participant demographics. One researcher (MK) analyzed interview transcripts using the inductive content analysis approach [51, 52] and regularly debriefed with other team researchers (SP, MW) to discuss problems raised and modify questionnaire items [53].

Results

We developed our questionnaire based on the ICF core set for OA, and validated it through two stages, including expert refinement, and cognitive think-aloud interview. See Appendix A for the final version of the questionnaire.

Initial questionnaire validation by the research team

All third-level activities of the OA core set were critically evaluated by research team members, including three experienced physiotherapists (SP, MW, MK), with some items being removed or revised when reaching a consensus (Table 2.2).

Removed items

Nine activities were removed: menstrual care (d5302) was excluded to ensure the questionnaire's applicability to all genders; choosing appropriate clothing (d5404), maintaining head position (d4155), fine hand use (d440), hand and arm use (d445) since they do not involve lower extremities; carrying on the head (d4304), human-powered vehicles (d4700), using humans for transportation (d4703), driving animal-powered vehicles (d4752) since they are less applicable in Canada (Table 2.2).

Revised items

Only the second-level categories of "toileting" (d530), "acquisition of goods and services" (d620), "doing housework" (d640), "assisting others" (d660), "intimate relationship" (d770), and "community life" (d970) were used as the details provided by the third level activities are less relevant for functional assessment after knee or hip arthroplasty [35]. Since the abilities related to hobbies, play, crafts, arts and culture were similar, they were merged into the category "Hobbies/ play /Crafts/ Arts and culture"

"Lying down" (d4100) was split into lying down and getting up. "Center of gravity" was removed from "shifting the body's center of gravity" (d4106) to simplify the term. To highlight the movement of the activity, "squatting" (d4101), "kneeling" (d4102), "sitting" (d4103) and "standing" (d4104) were modified to "squatting down", "kneeling down", "sitting on a chair" and "rising from a chair", respectively. To improve clarity, "using private motorized transportation" (d4701), "using public motorized transportation"(d4702), "driving human-powered transportation" (d4750), and "driving motorized vehicles" (d4751) were changed to "getting in and out of a car", "using public transportation", "biking", and "driving" respectively. Examples of "slope, uneven, or moving surfaces, such as grass, gravel and snow" and "such as walking around a marketplace or shop, around or through crowded areas" were added to "walking on different surfaces" (d4501), and "walking around obstacles" (d4503) from the ICF description. "Climbing" (4551) was divided into climbing, and going up and down stairs based on the updated 2018 version of the ICF [54]. "Drying oneself" (d5102) was changed to drying your body and the explanation of "drying some part or parts of your body or the whole body, such as after washing" was added based on the ICF description. "Acquisition of goods and services" (620) was changed to shopping. The explanation of "cleaning the house, washing clothes, using

household appliances, storing food and disposing of garbage" and "assisting others with their learning, communicating, self-care, and movement, within the house or outside" were added to "doing housework" (d640) and "assisting others" (d660) respectively from the ICF description (Table 2.2).

We modified several activity illustrations to make them more relevant to developed countries or the lower limb: maintaining a lying position was changed from prone to supine; sitting was changed from the floor to a chair; lifting was changed from an object on a table to the floor; carrying in the hand was changed from a glass to a suitcase; carrying on shoulders, and back was changed from a child to a backpack; putting on clothes was change from upper extremity to lower extremity (Table 2.2).

Questionnaire validation with think-aloud interviews

Eighteen participants were recruited in the study. Detailed participant demographic information is presented in Table 2.1. Three in-person and 15 virtual interviews were conducted between July and September 2023. Each interview lasted between 30 minutes and one hour.

Table 2.1 Think-aloud interview demographic characteristics.

Age, yrs.		63 (51-76)
Median (range)		
Sex, No.	Female	10
	Male	8
Gender, No.	Woman	10
	Man	8
BMI, kg/m²		31 (19.18-52.34)
Median (range)		
Surgery Type, No.	Total knee arthroplasty	10
	Total hip arthroplasty	7
	Hip resurfacing	1
Time after Surgery, No.	2 weeks postop	6
	6 weeks postop	3
	13 weeks postop	5
	26 weeks postop	4

BMI: Body mass index; **No.:** Number; **yr:** year

Issues identified and corresponding modifications

The issues faced by participants were classified into three themes: clarity/comprehension, item order, and visual elements. All participants conveyed that they did not find the number of questions burdensome or overwhelming. Table 2.2 shows participant quotes from the think-aloud interviews. In the following section, corresponding quotes are referenced as "*Quote X*".

Theme 1: Clarity and comprehension

General concepts

All ICF activity descriptions were removed, except those that required further clarification. This approach streamlined the questionnaire by eliminating unnecessary elements to enhance its simplicity and user-friendliness, which can increase the response rate.

The ability to perform activities with or without the use of aids was unclear to some participants. The following clarification was added to the instructions: "Consider your current ability with or without an aid (such as cane, crutches, knee braces, etc.)".

Changing and maintaining body position

The term "maintaining" was replaced with "holding" in all relevant questions, as the former was not clear during the think-aloud interview (*Quote 11*). Since some participants encountered issues related to holding, "how difficult is it to hold..." was changed to "for how long can you hold...". "Lying down and getting up" and "kneeling down" were unclear for some patients, as the ability could depend on the height of the surface (*Quotes 1,3*). "In the bed" was added for "lying down and getting up," and "on the ground" for "kneeling down". Similarly, the term "partial or full squat" was added to squatting and holding a squatting position (*Quotes 2, 14*). Some participants found the question about sitting and standing unclear (*Quotes 4-7*). The terms "average chair" and "with or without arms" were added for further clarity. "Such as

standing at the sink or in a line" was added to holding a standing position to provide clarification.

"Over or to the side (such as reaching down for an object)" was added to bending (*Quote 8*).

"From side to side" was added to shifting the body with the explanation "for example, moving from one foot to another while standing or shifting your weight while sitting" (*Quote 9*). "Such as back to side" was added to rolling over (*Quote 10*). "During the day" was added to holding a lying position for further clarification (*Quotes 12,13*).

Lifting and carrying objects

There were issues about the location and weight of the object during lifting and putting down activities (*Quotes 15, 16, 20*). "From the floor" was added to lifting and putting down and divided into light and heavy objects. Also, "less than 1 pound" was used for light and "more than 10 pounds" for heavy [55,56]. A similar issue was raised for carrying in the hand (*Quote 17*), so "such as a suitcase or grocery bag" was added. The term "hip" in carrying on the shoulder, hip and back was omitted (*Quote 18*), with "such as a backpack" added for clarification (*Quote 19*).

Walking

Some participants mentioned that walking short and long distances were unclear (*Quotes 21, 22*), so "less than 1 km" for short distances and "more than 1 km" for long distances were added based on the ICF descriptions. "On flat surfaces" was also added (*Quote 23*). Additionally, the questions were restructured from "how difficult is it to walk short and long distances" to "How far can you walk short and long distances?". We excluded the term "ice" as an example in the question concerning walking on different surfaces since participants mentioned it was much more challenging (*Quote 24*).

Moving around

The question regarding crawling was removed due to its lack of face validity for patients after arthroplasty (*Quote 25*). Similarly, the terms "ladder" and "rocks" were excluded from the

question related to climbing and retained "a curb or step" (*Quote 26*). Going up and down stairs was divided into two separate questions, since patients noted that the ability to ascend stairs differs from the ability to descend (*Quote 27*) and "10 to 12 stairs" was added for more clarification (*Quote 28*). Moreover, the term "jogging" was incorporated within the running activity (*Quote 29*). Similarly, "swimming" was moved from "moving around" section to become a sports example (*Quote 30*)

Moving around using transportation

Due to ambiguity related to "getting in and out of a car", "using public transportation", and "biking" (*Quotes 31-34*), "own car or a taxi", "a bus or train", and "to go to a place or for recreation" were added to these activities respectively.

Washing oneself

Washing body parts was reworded to "washing lower body parts" to make it more relevant to patients after hip or knee arthroplasty (*Quote 35*).

Toileting

Due to ambiguity in the question about going to the toilet (*Quote 36*), we included the description "such as getting to the washroom, getting into and out of position, manipulating clothing, and cleaning oneself" based on the wording from the ICF description.

Dressing

The description of putting on and taking off footwear was enriched by incorporating the example of "shoes and/or socks" (*Quote 37*).

Domestic life and intimate relationships

A participant pointed out that shopping could encompass online shopping, which was not aligned with the intended focus (*Quote 38*) and was therefore modified to "going shopping". The term "intimate" was changed to "sexual" for more clarification (*Quote 40*).

Assisting others

The explanation "with their learning, communicating" was excluded (*Quote 39*) to focus on the physical aspect of assisting others.

Employment

Participants noted that the abilities to do the activities for self-employment, part-time and full-time employment were similar (*Quote 43*). Consequently, they were unified under the term "work" (*Quote 41*). In consideration of ambiguity related to "work" (*Quote 42*), it was split into two questions: paid job and unpaid work. Furthermore, recognizing that a significant number of patients undergoing hip or knee arthroplasty are retired, we included the response option "I am retired" in the question related to employment.

Community, social and civic life

Community life was merged with socializing due to their overlapping concepts (*Quote 44*). Participants stated that the term "sport" was somewhat ambiguous (*Quote 45*). To address this, we provided examples of sports common among people undergoing hip or knee arthroplasty [57, 58]. Moreover, based on existing literature highlighting the impact of dancing on physical health [59, 60], dancing was reclassified from an art and culture activity to a sport activity.

Theme 2: Items ordering

Some participants noted challenges in differentiating between changing and maintaining body position. To address this, changing and maintaining body position questions were put one after the other for each activity. There were comments on the order of ability and importance, and importance was put before ability.

We also moved similar activities together, "rolling over" was placed after "lying in bed and getting up", "putting down objects" was placed after "lifting objects", "running/jogging" was

moved from the "moving around" section to "community, social, and civic life" section after sports.

Theme 3: Visual elements

Several comments were received regarding the images during the cognitive interviewing process. For example, the picture for walking long distances on flat surfaces seemed like walking on hills. The image depicting walking long distances on flat surfaces was adjusted to more accurately match the question. A research team member (MK) made the following image modifications: "holding the squatting position" from full to partial squat; "walking for long distances" from hills to flat surfaces; "washing the whole body" from sitting to standing; "washing body part" from hands to feet; "standing" from standing from the floor to standing from a chair"; "kneeling" from sitting to kneel to standing to kneel; "lying down" from the floor to bed; "maintaining a sitting position" from a table to a chair. Images for descending stairs, ascending a curb or step, washing lower body parts and rolling over were created by modifying existing ICF illustrations.

Table 2.2 OA ICF core set categories revision with verbatim quotations from participants during the think aloud interview.

ICF level	Original activity and participation of ICF core set for OA	Decision	Reason for removal or revision	Modified version
1st	d4 Mobility			
2nd	d410 Changing basic body position	Remove	Using third level.	NA
3rd	d4100 Lying down	Revise	<u>Research group consensus:</u> "getting up" was added to match the ICF description. <u>Think-aloud:</u> "In bed" was added. Quote 1: "That question is not clear like if it just asked me lying down in bed, I would say no difficulty. It's not really. I never had difficulty with, but on the floor getting down and getting up off the floor is umm the challenge and that's an important thing for me. But the question doesn't talk about those. all depends on the height of the of the horizontal service surface that you want there. "	Lying down in bed and getting up
	d4101 Squatting	Revise	<u>Research group consensus:</u> "down" was added to highlight the movement of the activity. <u>Think-aloud:</u> "partial or full squat" was added. Quote 2: "It depends on how deep the squat goes, like I can't do a full squat, but I can definitely sit in a chair and get up and do that. So that question's kind of a little ambiguous."	Squatting down (partial or full squat)
	d4102 Kneeling	Revise	<u>Research group consensus:</u> "down" was added to highlight the movement of the activity. <u>Think-aloud:</u> "on the ground" was added. Quote 3: "again it depends on the level, right? If I'm going to kneel down to the floor, that's one thing. If I'm going on to a Uh, bench or something? That's a different thing. UM. I'm assuming you're kneeling on the floor."	Kneeling down on the ground
	d4103 Sitting	Revise	<u>Research group consensus:</u> "on a chair" was added to highlight the movement of the activity. <u>Think-aloud:</u> "average height" was added. Quote 4: "It kind of depends on the chair: I avoid squishy ones because they're hard to get out of it, but I would say no difficulty. It's average chair" <u>Think-aloud:</u> " with or without arms" was added. Quote 5: "this is difficult because some chairs have arms. Some chairs don't, so a chair without arms is a lot harder to get out of than a chair with arms, right? Because I can use the arms to get out of the chair. So that's again confusing. Again, you should be telling you asking what kind of chair with arms. Chair without arms because the dining room chair has no arm"	Sitting on a chair (average height with or without arms)
	d4104 Standing	Revise	<u>Research group consensus:</u> Modified to "rising from a chair" to highlight the movement of the activity. <u>Think-aloud:</u> "average height" was added. Quote 6: "A chair can be many things and very different in different situations, so I don't know"	Rising from a chair (average height with or without arms)

			<u>Think-aloud</u>: "with or without arms" was added. Quote7: "It all depends on what some people are used or like. So it'd be nicer to have some kind of clarification there, like a hard chair or a or a dining room chair or something like that, or change it all"	
	d4105 Bending	Revise	<u>Think-aloud</u>: "over or to the side (such as reaching down for an object)" was added. Quote 8: "What kind of bend are you asking for? Are you talking like a bend from the back or a bend from the knees?"	Bending over or to the side (such as reaching down for an object)
	d4106 Shifting the body's centre of gravity	Revise	<u>Research group consensus</u>: "Center of gravity" was removed to simplify. <u>Think-aloud</u>: "From side to side" was added with the explanation "such as, moving from one foot to another while standing or shifting your weight while sitting" Quote 9: "It would be better if you were clear on the question, like if it meant shifting your body weight to one leg like you're the knee that you have replaced, that would be a better question, or if you could word it around that"	Shifting the body from side to side (such as moving from one foot to another while standing or shifting your weight while sitting)
	d4107 Rolling over	Revise	<u>Think-aloud</u>: "Such as back to side" was added. Quote 10: "You wanna roll over something to think about? Is this just this is when you're sleeping because the picture shows the person on the bed, right? So yeah, maybe you could say for side sleepers or how however you want to do it. I mean umm, because I know with me when I'm sleeping at night, it's a little more difficult because I still have a pillow. I'm a side sleeper. I still have a pillow between my legs."	Rolling over (such as back to side)
2nd	d415 Maintaining a body position (Second-level category)	Remove	Using third level.	NA
3rd	d4150 Maintaining a lying position	Revise	<u>Think-aloud</u>: "maintaining" was replaced with "holding" to highlight the static posture of the activity Quote 11: "I think that this is somewhat at the very least somewhat repetition in my mind that so unless you want to be more clear if presenting the question, uh, to to make it a little more evident or obvious to people such as myself trying to respond what you mean by as what would distinguish between the two? " <u>Think-aloud</u>: "during the day" was added. Quote 12: "I don't lie down during the day unless I'm napping which I am not doing a lot." Quote 13: "So how do you want me to answer that? That's so that's the way I sleep. I guess more than one hour."	Hold a lying position during the day
	d4151 Maintaining a squatting position	Revise	<u>Think-aloud</u>: "maintaining" was replaced with "holding" to highlight the static posture of the activity. See quote 11. <u>Think-aloud</u>: The term "partial or full squat" was added. Quote 14: "I can squat, but I cannot do a deep squat where my quadriceps are parallel to the ground like I can only squat like I can squat this much. So how many degrees is that? I don't know what is that you tell"	Hold a squatting position (partial or full squat)
	d4152 Maintaining a kneeling position	Revise	<u>Think-aloud</u>: The "maintaining" was replaced with "holding" to highlight the static posture of the activity. See quote11.	Hold a kneeling position

	d4153 Maintaining a sitting position	Revise	<u>Think-aloud</u> : The "maintaining" was replaced with "holding" to highlight the static posture of the activity. See quote 11 .	Hold a sitting position
	d4154 Maintaining a standing position	Revise	<u>Think-aloud</u> : The term "maintaining" was replaced with "holding" to highlight the static posture of the activity. See quote 11 . <u>Think-aloud</u> : "such as standing at the sink or in a line" was added to highlight the static movement of the activity Quote 14 : <i>I'm thinking of if I go out with friend and we're going someplace, you know, we can easily walk around for more than an hour. So is that correct? OK, so if I'm standing, say at the sink, Something like that.</i>	Hold a standing position (such as standing at the sink or in a line)
	d4155 Maintaining head position	Remove	<u>Research group consensus</u> : Does not involve lower extremity activities	NA
2nd	d430 Lifting and carrying objects	Remove	Using third level.	NA
3rd	d4300 Lifting	Revise/ add	<u>Think-aloud</u> : "From the floor" was added and divided into light and heavy objects. Quote 15 : <i>"I think for me it looks a little bit heavy and it's on the floor which is very different from lifting a grocery bag off the table".</i> <u>Think-aloud</u> : "Less than 1 pound" was used for light and "more than 10 pounds" for heavy. Quote 16 : <i>"I lift an object. No difficulty. Lift a heavy object. I couldn't. I wouldn't even try, so the objects I would try to lift an average weight I don't have any clue what an average weight is. I have no idea. Are you talking about a 10-pound bag of potatoes and trying to lift a 10-pound bag of potatoes, or are you talking about my pillow that fell off the bed and I'm trying to lift it and put it back on? Umm, I don't know."</i>	Lifting a light object from the floor (less than 1 pound) Lifting a heavy object from the floor (more than 10 pounds)
	d4301 Carrying in the hands	Revise	<u>Think-aloud</u> : "such as a suitcase or grocery bag" was added. Quote 17 : <i>"Are we talking about, like the suitcase? Are we talking about carrying like this? You're carrying like this like grocery bags. Umm, are different than like carrying laundry baskets then I don't know, but how specifically would be?"</i>	Carrying in the hands (such as a grocery bag or suitcase)
	d4302 Carrying in the arms	Retain	NA	Carrying in the arms
	d4303 Carrying on shoulders, hip and back	Revise	<u>Think-aloud</u> : "hip" was omitted. Quote 18 : <i>"For the hip, I would, but don't know, never do this, but I just don't carry it like that. Umm for the other two I have no difficulty for this shoulder and back"</i> <u>Think-aloud</u> : "such as a backpack" added. Quote 19 : <i>"you might want to give an example for that. Such as like you looks like a picture of a backpack or what would you carry on your shoulder was like the young child."</i>	Carrying on shoulders or back (such as a backpack)
	d4304 Carrying on the head	Remove	<u>Research group consensus</u> : Less applicable in developed countries	NA
	d4305 Putting down objects	Revise	<u>Think-aloud</u> : "On the floor" was added. Quote 20 : <i>"Would this be like somebody handed you something and then you have to put it down or like putting it down on a table as opposed to putting it down on the floor. So you don't wanna clarify how you're putting it down because it's for me, there's a difference between just bending over, putting it down, and then kneeling, putting it down"</i>	Putting down objects on the floor

2nd	d440 Fine hand use	Remove	<u>Research group consensus</u> : Does not involve lower extremity activities	NA
2nd	d445 Hand and arm use		<u>Research group consensus</u> : Does not involve lower extremity activities	NA
2nd	d450 Walking	Remove	Using third level.	NA
3rd	d4500 Walking short distances	Revise	<u>Think-aloud</u>: "less than 1 km" was added. Quote 21: "how far can you walk? Can you walk 100 meters? Can you walk 200 meters? And you walk 2 kilometers. Can you walk 10 kilometers?" Quote 22: "Don't think I can do a kilometer yet. I don't think I can do that yet. I don't know how many steps are in a km. I do everything by steps right? It was 850 steps that I could do in December was 450. I know I'm up. I'm almost at my 800 again, but I don't think that's a kilometer." <u>Think-aloud</u>: "On flat surfaces" was added. Quote 23: "Flat surface or hills doesn't matter to you. Then you should say that, you don't say that. So it like, so you don't care about steps or stairs or anything like that in this one, right. You want to be flat surfaces, so no stairs, no hills. You should be saying that."	Walking short distances (less than 1km) on flat surfaces
	d4501 Walking long distances	Revise	<u>Think-aloud</u> : "more than 1 km" and "On flat surfaces" were added. See quotes 21-23	Walking long distances (more than 1km) on flat surfaces
	d4502 Walking on different surfaces	Revise	<u>Research group consensus</u>: Examples of "slope, uneven, or moving surfaces, such as grass, gravel and snow" were added from the ICF description. <u>Think-aloud</u>: "ice" as an example was removed. Quote 24: "walking on ice even if I didn't have a hip problem, I hate it. So, I would say with a lot of difficulty. So, I'd say it depends on which of these you know, because that's quite a range of surfaces. So, walking on grass sloping all that no problem ice there would be difficulty."	Walking on different surfaces (slope, uneven, or moving surfaces, such as grass, gravel and snow)
	d4503 Walking around obstacles	Revise	<u>Research group consensus</u> : "such as walking around a marketplace or shop, around or through crowded areas" was added.	Walking around obstacles (such as walking around a marketplace or shop, around or through crowded areas)
2nd	d455 Moving around	Remove	Using third level.	
3rd	d4550 Crawling	Remove	<u>Think-aloud</u>: lack of face validity for patients after arthroplasty Quote 25: "How is important to be able to crawl right? Is this really necessary? Like I don't know how many people crawl unless we're in the military or drunk. Did you need that though? Really to know if a person can crawl."	NA
	d4551 Climbing	Revise/add	<u>Research group consensus</u>: "going up and down stairs" category (d451 going up and down stairs) was added. <u>Think-aloud</u>: "ladder" and "rocks" were removed. Quote 26: "I'm not sure I would have that in the same question. Maybe I would have that as two questions. Well, how different would be to climb on rocks? How difficult it would be to climb a ladder or climb stairs or climb curves? Climb the ladder is different than climbing rocks because rocks are uneven."	Going up stairs (10 to 12 stairs) Going down stairs (10 to 12 stairs)

			<u>Think-aloud:</u> going up and down stairs was divided into two separate questions, since patients noted that the ability to ascend stairs differs from the ability to descend. Quote 27: "Did you want to break that down? Because I know with knee surgery and knees there's a big difference between people who can go upstairs good because downstairs is with pain. So wouldn't you ought to be more specific so that you have you can figure out where they're pains being generated from either going up or down the stair." <u>Think-aloud:</u> "10 to 12 stairs" were added. Quote 28: "it's not important at this point, or I'll say slightly if you I do have two little steps at the front of the house, so I can do it, but so I'm going to say slightly important because I don't go, I'm going to start going out more, but these are two little steps and I can do it with a little difficulty."	Going up a curb or step
	d4552 Running	Revise	<u>Think-aloud:</u> "jogging" was incorporated within the running activity Quote 29: "what do you mean by running? Is jogging running? Joggers aren't runners. You could probably just put both jogger slash running and just cover both bases because all you're interested is the movement cause somebody who jogs can jog faster than some people can run, but there is a difference, right? So I'd include both."	Running/jogging
	d4553 Jumping	Retain	NA	Jumping
	d4554 Swimming	Remove	<u>Think-aloud:</u> "swimming" was moved from the "moving around" section to a sports example. Quote 30: "the only thing that I engage in sports would be swimming. And that's not really a group or anything activity really. Do you consider swimming as a sport?"	NA
2nd	d470 Using transportation	Remove	Using third level.	
3rd	d4700 Using human-powered vehicles	Remove	<u>Research group consensus:</u> Less applicable in developed countries	NA
	d4701 Using private motorized transportation	Revise	<u>Research group consensus:</u> Changed to "getting in and out of a car" <u>Think-aloud:</u> "such as own car or taxi" was added. Quote 31: "Maybe you put in brackets (taxi, friend's car), underneath the main question, you specify the parameters." Quote 32: "Umm no private. Ohh no look. OK, this is a taxi. So they're calling that private. OK. So, whether so public? Yeah, it's a separate question. Getting on a bus or a train, getting in a taxi."	Getting in and out of a car (such as own car or taxi)
	d4702 Using public motorized transportation	Revise	<u>Research group consensus:</u> Changed to "using public transportation" <u>Think-aloud:</u> "such as a bus or train" was added. See quotes 31 and 32.	using public transportation (such as a bus or train)
	d4703 Using humans for transportation	Remove	<u>Research group consensus:</u> Less applicable in developed countries	NA
2nd	d475 Driving	Remove	Using third level.	
3rd	d4750 Driving human-powered transportation	Revise	<u>Think-aloud:</u> Changed to "biking" Quote 33: "Umm, without the picture here. What? What are you talking about?"	Biking (to go to a place or recreational)

			<u>Think-aloud</u> : "to go to a place or recreational" was added Quote 34 : "what happens if I just want to do recreational biking? So wouldn't that be redundant? Again, you're worried about transportation."	
	d4751 Driving motorized vehicles	Revise	<u>Research group consensus</u> : Changed to "driving vehicles"	Driving vehicles
	d4752 Driving animal-powered vehicles	Remove	<u>Research group consensus</u> : Less applicable in developed countries	NA
1st	d5 Self-care			
2nd	d510 Washing oneself	Remove	Using third level.	NA
3rd	d5100 Washing body parts	Revise	<u>Think-aloud</u> : "lower" and "such as legs and feet" added. Quote 35 : "Are these questions only for a hip and knee replacement, or what is it for? OK, so I can't imagine anyone having problems washing their hands, face or hair or nails because of this."	Washing lower body parts (such as legs and feet)
	d5101 Washing whole body	Retain	NA	Washing whole body
	d5102 Drying oneself	Revise	<u>Research group consensus</u> : Changed to "drying your body" and added "drying some part or parts of your body or the whole body, such as after washing" based on the ICF description.	Drying your body (drying some part or parts of your body or the whole body, such as after washing)
2nd	d530 Toileting (Second-level category)	Retain	<u>Think-aloud</u> : Changed to "going to the toilet" and added "such as getting to the washroom, getting into and out of position, manipulating clothing, and cleaning oneself" based on the ICF description. Quote 36 : "Do they mean doing the discharge or do they mean just getting to the toilet? I guess it would be getting to the bathroom would be. Is that what they're meaning?"	Going to the toilet (such as getting to the washroom, getting into and out of position, manipulating clothing, and cleaning oneself)
3rd	d5300 Regulating urination	Remove	<u>Research group consensus</u> : Using second level.	NA
	d5301 Regulating defecation	Remove	<u>Research group consensus</u> : Using second level.	NA
	d5302 Menstrual care	Remove	<u>Research group consensus</u> : Using second level.	NA
2nd	d540 Dressing	Remove	Using third level.	NA
3rd	d5400 Putting on clothes	Retain	NA	Putting on clothes
	d5401 Taking off clothes	Retain	NA	Taking off clothes
	d5402 Putting on footwear	Revise	<u>Think-aloud</u> : Added the example of "shoes or socks" Quote 37 : "Maybe you could put shoes and socks in brackets for question three and four."	Putting on footwear (shoes or socks)
	d5403 Taking off footwear	Revise	<u>Think-aloud</u> : Added the example of "shoes or socks" See quote 37 .	Taking off footwear (shoes or socks)
	d5404 Choosing appropriate clothing	Remove	<u>Research group consensus</u> : Does not involve lower extremity activities	NA
1st	d6 Domestic life			
2nd	d620 Acquisition of goods and services	Revise	<u>Research group consensus</u> : Changed to "shopping"	Going shopping

			Think-aloud: Changed to "going shopping" Quote 38: "it's just any kind of shopping, right? Doesn't matter if it's clothes or whatever, it's just shopping. Really shopping so? Do you care? Do you wanna elaborate on that? Because I can do online shopping. Do you care? Because it's online shopping or I'm shopping at, getting out and shopping. I know, but that's your, you said shopping."	
3rd	d6200 Shopping	Remove	<u>Research group consensus:</u> Using second level.	NA
	d6201 Gathering daily necessities	Remove	<u>Research group consensus:</u> Using second level.	NA
2nd	d640 Doing housework	Revise	<u>Research group consensus:</u> Added the explanation of "cleaning the house, washing clothes, using household appliances, storing food and disposing of garbage" from the ICF description.	Doing housework (cleaning the house, washing clothes, using household appliances, storing food and disposing of garbage)
3rd	d6400 Washing and drying clothes and garments	Remove	<u>Research group consensus:</u> Using second level	NA
	d6401 Cleaning cooking area and utensils	Remove	<u>Research group consensus:</u> Using second level.	NA
	d6402 Cleaning living area	Remove	<u>Research group consensus:</u> Using second level.	NA
	d6403 Using household appliances	Remove	<u>Research group consensus:</u> Using second level.	NA
	d6404 Storing daily necessities	Remove	<u>Research group consensus:</u> Using second level.	NA
	d6405 Disposing of garbage	Remove	<u>Research group consensus:</u> Using second level.	NA
2nd	d660 Assisting others	Retain	<u>Research group consensus:</u> the explanation of "assisting others with their learning, communicating, self-care, and movement, within the house or outside" from the ICF description. <u>Think-aloud:</u> "with their learning, communicating" in the example was excluded. Quote 39: "It's assisting others, with their learning, communicating self-care and movement is kind of a little different than assisting people in general"	Assisting others (assisting others with their self-care, movement, within the house or outside)
3rd	d6600 Assisting others with self-care	Remove	<u>Research group consensus:</u> Using second level.	NA
	d6601 Assisting others in movement	Remove	<u>Research group consensus:</u> Using second level.	NA
	d6602 Assisting others in communication	Remove	<u>Research group consensus:</u> Using second level.	NA
	d6603 Assisting others in interpersonal relations	Remove	<u>Research group consensus:</u> Using second level.	NA

	d6605 Assisting others in health maintenance	Remove	<u>Research group consensus</u> : Using second level.	NA
2nd	d770 Intimate relationships	Revise	<u>Think-aloud</u> : Changed to "Sexual relationships" Quote 40 : "it depends on what you mean by intimate. Now when you say intimate, are you just talking sex intercourse?"	Sexual relationships
3rd	d7700 Romantic relationships	Remove	<u>Research group consensus</u> : Using second level	NA
	d7701 Spousal relationships	Remove	<u>Research group consensus</u> : Using second level	NA
	d7702 Sexual relationships	Remove	<u>Research group consensus</u> : Using second level	NA
1st	d8 Major life areas			
2nd	d850 Remunerative employment	Revise/ add	<u>Think-aloud</u> : Changed to "work". Quote 41 : "Ohh what is remunerative. What does that mean? " <u>Think-aloud</u> : Split into two questions: paid job and unpaid work (adding d855 Non-remunerative employment). Quote 42 : "depends on what kind of work you're wanting me to do. If you were wanting me to bake and I have to stand in the kitchen to make Christmas dinner, yeah, that's a lot of difficulty. but it depends on what your work is, right? We've got people that have had hip surgery and they worked in construction. So for them, their work construction, that would be horrible for me. I do mine on my computer and I'm sitting. That's not so hard. Paid work is what it should say."	Paid job (part-time or full-time) Unpaid work (such as volunteer work)
3rd	d8500 Self employment	Remove	<u>Think-aloud</u> : Using second level Quote 43 : "whether it's part-time independent or full time, it's all work, right? It's the same thing. I'm not sure what you're going to get from these questions like it depends on what your job is, what's the purpose of these questions?"	NA
	d8501 Part-time employment	Remove	<u>Think-aloud</u> : Using second level. See quote 43 .	NA
	d8502 Full-time employment	Remove	<u>Think-aloud</u> : Using second level. See quote 43 .	NA
1st	d9 Community, social and civic life			
2nd	d910 Community Life	revise	<u>Think-aloud</u> : Merged with "d9205 Socializing" and examples were added from the ICF description. Quote 44 : "engaging in community such as social. What's important? I come from a big family. We have a lot of relatives and visitors. They come visit me right now. I haven't been going out. "	Socializing /Participate in community life Such as: visiting friends or relatives, meeting in public places, local groups, social organizations, ceremonies (e.g marriages, etc.)
3rd	d9100 Informal associations	Remove	<u>Research group consensus</u> : Using second level	NA
	d9101 Formal associations	Remove	<u>Research group consensus</u> : Using second level	NA
	d9102 Ceremonies	Remove	<u>Research group consensus</u> : Using second level	NA
2nd	d920 Recreation and leisure	Remove	Using third level.	NA

3rd	d9200 Play	Revise	<u>Research group consensus</u> : Merged with "d9202 Arts and culture", "d9203 Crafts", and "d9204 Hobbies". Examples were added from the ICF description.	Hobbies/ Play /Crafts/ Arts and culture Such as: gardening, going to the theatre, cinema, museum, reading, singing, playing an instrument, pottery or knitting, playing chess or cards, etc.
	d9201 Sports	Revise	<u>Think-aloud</u> : Added examples of sports common among people undergoing hip or knee arthroplasty. Quote 34 : "This would be a bit of a challenge. It would to me it is important to engage in some kind of a sports, especially weight training, would you consider that to be a sport, weight training?"	Sports such as: Swimming, Golf, Dancing, Workout/gym, Hiking, Skating, Skiing, Bowling, Etc.
	d9202 Arts and culture	Revise	<u>Research group consensus</u> : Merged with " d9200 Play", "d9203 Crafts", and "d9204 Hobbies". Examples were added from the ICF description.	Hobbies/ Play /Crafts/ Arts and culture Such as: gardening, going to the theatre, cinema, museum, reading, singing, playing an instrument, pottery or knitting, playing chess or cards, etc.
	d9203 Crafts	Revise	<u>Research group consensus</u> : Merged with "d9202 Arts and culture", "d9200 Play", and "d9204 Hobbies". Examples were added from the ICF description.	Hobbies/ Play /Crafts/ Arts and culture Such as: gardening, going to the theatre, cinema, museum, reading, singing, playing an instrument, pottery or knitting, playing chess or cards, etc.
	d9204 Hobbies	Revise	<u>Research group consensus</u> : Merged with "d9202 Arts and culture", "d9203 Crafts", and "d9200 Play". Examples were added from the ICF description.	Hobbies/ Play /Crafts/ Arts and culture Such as: gardening, going to the theatre, cinema, museum, reading, singing, playing an instrument, pottery or knitting, playing chess or cards, etc.
	d9205 Socializing	Revise	<u>Research group consensus</u> : Merged with "d910 Community Life". Examples were added from the ICF description.	Socializing /Participate in community life Such as: gardening, going to the theatre, cinema, museum, reading, singing, playing an instrument, pottery or knitting, playing chess or cards, etc.

Pilot testing

Following the think-aloud session, we conducted a pilot test of the online questionnaire. This test involved 10 participants, including 5 who underwent hip arthroplasty and 5 who underwent knee arthroplasty within 1, 6, 13, and 26 weeks prior to the study. The primary objective of this initial testing was to assess whether participants encountered any challenges while completing the questionnaire. Participants were free to complete the questionnaire using a computer, tablet or phone.

We administered the questionnaire through Research Electronic Data Capture (REDCap), a secure web application designed for building and managing online surveys and databases for research studies. One of our research team members (MK) converted the questionnaire to the REDCap platform. One researcher (MK) contacted eligible individuals via phone to invite them to participate. We applied an implied consent format placed at the beginning of the questionnaire. During the pilot testing phase, the participants did not face any specific issues or barriers. Minor adjustments were made to the questionnaire design to enhance readability, primarily focused on modifying font styles and sizes to ensure optimal clarity and accessibility for participants.

Discussion

We developed a questionnaire to determine the activities deemed important by patients with OA undergoing hip or knee arthroplasty based on the activity and participation components of ICF core set for OA. Additionally, we evaluated the face and content validity of the questionnaire through the research team's refinement and patient's think-aloud interviews. Content validity is fundamental requirement in questionnaire development which has evolved from initially relying on clinician expertise to adopting a more inclusive approach involving patient engagement [61]. The think-aloud interviews with patients underwent hip or knee

arthroplasty and iteratively refining the items based on input from patients ensured that our questionnaire captures the complexities of functioning from perspectives and lived experiences of patients after hip or knee arthroplasty.

A major finding of our study was the lack of comprehensibility of ICF terminology, as some items were difficult for patients to understand [62]. One of the frequent issues patients encountered was difficulty in distinguishing between maintaining and changing body positions, which we addressed by rewording and reordering the questions. Both maintaining and changing body positions are fundamental activities of daily living, each requiring different muscle strength and stability [63]. This ambiguity can result in misinterpretations by patients, leading to inaccuracies in data collection and potential response bias [64]. Although ICF framework was originally designed to provide a unified and standardized language for describing health and health-related states across different populations, patients in our study encountered issues with the complex wording of the ICF during the think-aloud interviews. It has been argued that measurement instruments should typically be created for a reading level equivalent to age 12 [65]. Hence, we simplified the wording of the ICF framework to make the information accessible to individuals from diverse backgrounds and varying reading levels. Therefore, although ICF was intended for clinical use, it requires adaptation to effectively address patient purposes [66].

Another finding of this study pertained to the relevance of ICF activity items to assess the function of patients undergoing hip or knee arthroplasty [62]. Our study indicated that most third-level categories of the OA ICF core set can be used to measure functioning at various time points during the first six months following hip or knee arthroplasty. However, several activities lacked face validity for multiple reasons, including not being relevant to lower extremities, almost never performed, not encompassing all genders, or not being applicable to developed

countries, which suggests the need for reconsideration regarding their inclusion for hip or knee arthroplasty. These results align with previous studies suggesting the removal of fine hand use (d440) and hand and arm use (d445) for patients undergoing hip or knee arthroplasty [28]. It is noteworthy that all previous assessments of the ICF core set for OA [31-34], were conducted using the second level categories/items which is quite broad, thus potentially overlooking detailed assessments of activities. Our study was the first to use the third level of the OA core set which captures a more comprehensive understanding of patients' functioning in various aspects of daily life. However, some third level activities within six categories may not be necessary since they require similar abilities justifying the use of second-level categories. Including all activities adds unnecessary complexity and burden to the evaluation process. Thus, it is crucial to consider respondent burden to maximize response rate and minimize missing data.

As for the comprehensiveness aspect of content validity, i.e. ensuring that no key aspects of the construct were overlooked [62]. The results of this study suggest that the OA and total knee arthroplasty ICF core sets would benefit from review and modifications to capture the functioning of patients post hip or knee arthroplasty. Previous research has also suggested that the OA core set was missing other relevant categories for patients after arthroplasty [30]. We recommend adding unpaid work and going up and down stairs to the OA core set, and also adding changing and maintaining body position, driving, shopping, doing housework, assisting others, intimate relationship and community life to the total knee arthroplasty core set. We also recommend adding weight parameters to lifting, adding flat surfaces to walking short and long distances, narrowing the focus of washing to lower body parts, and separating the activities lying down and getting up.

Our study was aimed at identifying an ICF core set for patients undergoing hip or knee arthroplasty. Comparing our results with the recently developed ICF core set for total knee arthroplasty [33]. We found that the latter overlooked some dimensions that have been shown as important aspects from the patient perspective, such as "acquisition of goods and services" (d620), "doing housework" (d640), and "driving" (d475) [20]. One possible reason for this oversight could be insufficient patient involvement in the development process of the ICF core set for total knee arthroplasty. As healthcare increasingly adopts a person-centered approach, it becomes crucial to actively involve patients in their assessments. Patients often bring unique perspectives on how health domains should be prioritized and measured, ensuring that questionnaires reflect issues that are pertinent to them. However, previous research indicates that patients have not always been adequately engaged in questionnaire development [67].

Limitations

The study participants are residents of one Canadian province, and the findings may not be directly applicable to other populations. Our results could be replicated in other countries with potentially different activity goals and environmental contexts, including resources. In addition, our recruitment was limited to English-speaking patients who underwent primary elective knee and hip arthroplasty for OA, which may impact the generalizability of our findings. Another limitation was that content analysis of transcripts was performed by one researcher, albeit with peer checking conducted by other research team members. Our recruitment focused on patients at 2, 6, 13, and 26 weeks after hip or knee arthroplasty, limiting the applicability of the questionnaire to other timeframes. However, since functional recovery mainly takes place during the first 6 months after arthroplasty [46,47], it is less likely that the findings would significantly change beyond this timeframe. In addition, since we did not record participants'

health literacy or education levels, it is not clear to what extent results apply to patients with lower literacy. However, the sampling used where we invited patients instead of them reaching out to us, the high acceptance rate and the attainment of data saturation increases our confidence that we surveyed patients with varying levels of literacy.

Conclusion

The developed questionnaire based on the ICF core set for OA can be used to assess which activities are important for patients with OA undergoing arthroplasty, contributing to a better understanding of desired outcomes and patient expectations at different time points during post-operative recovery. The questionnaire validation process through the think-aloud interviews identified and addressed issues concerning comprehension, item order, and visual elements. Furthermore, the pilot study highlighted the feasibility of the online questionnaire and using third-level activities of the ICF core set for OA to assess activity importance for patients after hip or knee arthroplasty.

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Conflict of interest

The authors do not report a potential conflict of interest

References

1. Naik AD, Catic A. Achieving patient priorities: an alternative to patient-reported outcome measures (PROMs) for promoting patient-centred care. *BMJ Qual Saf.* 2021;30(2):92-95. doi:10.1136/bmjqs-2020-012244.
2. Cheraghi-Sohi S, Hole AR, Mead N, et al. What patients want from primary care consultations: a discrete choice experiment to identify patients' priorities. *Ann Fam Med.* 2008;6(2):107-115. doi:10.1370/afm.816
3. Epstein RM, Street RL Jr. The values and value of patient-centered care. *Ann Fam Med.* 2011;9(2):100-103. doi:10.1370/afm.1239
4. Wensing M, Jung HP, Mainz J, Olesen F, Grol R. A systematic review of the literature on patient priorities for general practice care. Part 1: Description of the research domain. *Soc Sci Med.* 1998;47(10):1573-1588. doi:10.1016/s0277-9536(98)00222-6
5. Britto MT, DeVellis RF, Hornung RW, DeFries GH, Atherton HD, Slap GB. Health care preferences and priorities of adolescents with chronic illnesses. *Pediatrics.* 2004;114(5):1272-1280. doi:10.1542/peds.2003-1134-L
6. Little P, Everitt H, Williamson I, et al. Observational study of effect of patient centredness and positive approach on outcomes of general practice consultations. *BMJ.* 2001;323(7318):908-911. doi:10.1136/bmj.323.7318.908
7. Stewart M, Brown JB, Donner A, et al. The impact of patient-centered care on outcomes. *J Fam Pract.* 2000;49(9):796-804.
8. Neuprez A, Neuprez AH, Kaux JF, et al. Total joint replacement improves pain, functional quality of life, and health utilities in patients with late-stage knee and hip osteoarthritis for up to 5 years. *Clin Rheumatol.* 2020;39(3):861-871. doi:10.1007/s10067-019-04811-y
9. Singh JA, O'Byrne M, Harmsen S, Lewallen D. Predictors of moderate-severe functional limitation after primary Total Knee Arthroplasty (TKA): 4701 TKAs at 2-years and 2935 TKAs at 5-years. *Osteoarthritis Cartilage.* 2010;18(4):515-521. doi:10.1016/j.joca.2009.12.001
10. Wylde V, Hewlett S, Learmonth ID, Dieppe P. Persistent pain after joint replacement: prevalence, sensory qualities, and postoperative determinants. *Pain.* 2011;152(3):566-572. doi:10.1016/j.pain.2010.11.023
11. Te Molder MEM, Smolders JMH, Heesterbeek PJC, van den Ende CHM. Definitions of poor outcome after total knee arthroplasty: an inventory review. *BMC Musculoskelet Disord.* 2020;21(1):378. Published 2020 Jun 13. doi:10.1186/s12891-020-03406-y
12. Lützner C, Postler AE, Druschke D, Riedel R, Günther KP, Lange T. Ask Patients What They Expect! A Survey Among Patients Awaiting Total Hip Arthroplasty in Germany. *J Arthroplasty.* 2022;37(8):1594-1601.e4. doi:10.1016/j.arth.2022.03.067

13. Lange T, Schmitt J, Kopkow C, Rataj E, Günther KP, Lützner J. What Do Patients Expect From Total Knee Arthroplasty? A Delphi Consensus Study on Patient Treatment Goals. *J Arthroplasty*. 2017;32(7):2093-2099.e1. doi:10.1016/j.arth.2017.01.053
14. Mancuso CA, Salvati EA, Johanson NA, Peterson MG, Charlson ME. Patients' expectations and satisfaction with total hip arthroplasty. *J Arthroplasty*. 1997;12(4):387-396. doi:10.1016/s0883-5403(97)90194-7
15. Noble PC, Conditt MA, Cook KF, Mathis KB. The John Insall Award: Patient expectations affect satisfaction with total knee arthroplasty. *Clin Orthop Relat Res*. 2006;452:35-43. doi:10.1097/01.blo.0000238825.63648.1e
16. Kim TK, Kwon SK, Kang YG, Chang CB, Seong SC. Functional disabilities and satisfaction after total knee arthroplasty in female Asian patients. *J Arthroplasty*. 2010;25(3):458-464.e4642. doi:10.1016/j.arth.2009.01.018
17. Razmjou H, Yee A, Ford M, Finkelstein JA. Response shift in outcome assessment in patients undergoing total knee arthroplasty. *J Bone Joint Surg Am*. 2006;88(12):2590-2595. doi:10.2106/JBJS.F.00283
18. Mannion AF, Kämpfen S, Munzinger U, Kramers-de Quervain I. The role of patient expectations in predicting outcome after total knee arthroplasty. *Arthritis Res Ther*. 2009;11(5):R139. doi:10.1186/ar2811
19. Weiss JM, Noble PC, Conditt MA, et al. What functional activities are important to patients with knee replacements?. *Clin Orthop Relat Res*. 2002;(404):172-188. doi:10.1097/00003086-200211000-00030
20. Rastogi R, Davis AM, Chesworth BM. A cross-sectional look at patient concerns in the first six weeks following primary total knee arthroplasty. *Health Qual Life Outcomes*. 2007;5:48. Published 2007 Aug 1. doi:10.1186/1477-7525-5-48
21. Burns KE, Duffett M, Kho ME, et al. A guide for the design and conduct of self-administered surveys of clinicians. *CMAJ*. 2008;179(3):245-252. doi:10.1503/cmaj.080372
22. Passmore C, Dobbie AE, Parchman M, Tysinger J. Guidelines for constructing a survey. *Fam Med*. 2002;34(4):281-286.
23. Connell J, Carlton J, Grundy A, et al. The importance of content and face validity in instrument development: lessons learnt from service users when developing the Recovering Quality of Life measure (ReQoL). *Qual Life Res*. 2018;27(7):1893-1902. doi:10.1007/s11136-018-1847-y
24. DIN, P. C. B. (2001). International classification of functioning, disability and health.
25. Threats TT. Use of the ICF for guiding patient-reported outcome measures. *Perspectives on Neurophysiology and Neurogenic Speech and Language Disorders*. 2012;22(4):128-35.8
26. Dreinhöfer K, Stucki G, Ewert T, et al. ICF Core Sets for osteoarthritis. *J Rehabil Med*. 2004;(44 Suppl):75-80. doi:10.1080/16501960410015498

27. Pisoni C, Giardini A, Majani G, Maini M. International Classification of Functioning, Disability and Health (ICF) core sets for osteoarthritis. A useful tool in the follow-up of patients after joint arthroplasty. *Eur J Phys Rehabil Med*. 2008;44(4):377-385.
28. Alviar MJ, Olver J, Pallant JF, et al. Can the ICF osteoarthritis core set represent a future clinical tool in measuring functioning in persons with osteoarthritis undergoing hip and knee joint replacement?. *J Rehabil Med*. 2012;44(11):955-961. doi:10.2340/16501977-1041
29. Bossmann T, Kirchberger I, Glaessel A, Stucki G, Cieza A. Validation of the comprehensive ICF core set for osteoarthritis: the perspective of physical therapists. *Physiotherapy*. 2011;97(1):3-16. doi:10.1016/j.physio.2009.11.011
30. Xie F, Lo NN, Lee HP, Cieza A, Li SC. Validation of the Comprehensive ICF Core Set for Osteoarthritis (OA) in patients with knee OA: a Singaporean perspective. *J Rheumatol*. 2007;34(11):2301-2307.
31. Kurtaiş Y, Oztuna D, Küçükdeveci AA, Kutlay S, Hafiz M, Tennant A. Reliability, construct validity and measurement potential of the ICF comprehensive core set for osteoarthritis. *BMC Musculoskelet Disord*. 2011;12:255. doi:10.1186/1471-2474-12-255
32. Weigl M, Wild H. European validation of The Comprehensive International Classification of Functioning, Disability and Health Core Set for Osteoarthritis from the perspective of patients with osteoarthritis of the knee or hip. *Disabil Rehabil*. 2018;40(26):3104-3112. doi:10.1080/09638288.2017.1377295
33. Huang SW, Chen YW, Escorpizo R, Liao CD, Liou TH. Development International Classification of Functioning, Disability and Health Core Set for Post Total Knee Replacement Rehabilitation Program: Delphi-Based Consensus Study in Taiwan. *Int J Environ Res Public Health*. 2021;18(4):1630. doi:10.3390/ijerph18041630
34. Mendonca D, Warren NA. Perceived and unmet needs of critical care family members. *Crit Care Nurs Q*. 1998;21(1):58-67. doi:10.1097/00002727-199805000-00009
35. Nemoto T, Beglar D. Likert-scale questionnaires. In JALT 2013 conference proceedings 2014 (pp. 1-8).
36. Chang L. A psychometric evaluation of 4-point and 6-point Likert-type scales in relation to reliability and validity. *Applied psychological measurement*. 1994;18(3):205-15.
37. Reynolds L, Johnson R. Is a picture is worth a thousand words? Creating effective questionnaires with pictures. *Practical Assessment, Research, and Evaluation*. 2019;16(1):8.
38. Taherdoost H. Validity and reliability of the research instrument; how to test the validation of a questionnaire/survey in a research. How to test the validation of a questionnaire/survey in a research. 2016 Aug 10.
39. Zumbo BD, Hubley AM. Understanding and Investigating Response Processes in Validation Research. Vol 26. Springer; 2017.

40. Willis GB. Cognitive interviewing: A tool for improving questionnaire design. sage publications; 2004.
41. Kuusela H, Paul P. A comparison of concurrent and retrospective verbal protocol analysis. *Am J Psychol.* 2000;113(3):387-404.
42. Dumenci L, Perera RA, Keefe FJ, et al. Model-based pain and function outcome trajectory types for patients undergoing knee arthroplasty: a secondary analysis from a randomized clinical trial. *Osteoarthritis Cartilage.* 2019;27(6):878-884. doi:10.1016/j.joca.2019.01.004
43. Kennedy DM, Stratford PW, Hanna SE, Wessel J, Gollish JD. Modeling early recovery of physical function following hip and knee arthroplasty. *BMC Musculoskelet Disord.* 2006;7:100. Published 2006 Dec 11. doi:10.1186/1471-2474-7-100
44. Maloy GC, Kammien AJ, Rubin LE, Grauer JN. Adverse Events After Total Hip Arthroplasty are not Sufficiently Characterized by 30-Day Follow-Up: A Database Study. *J Arthroplasty.* 2023;38(3):525-529. doi:10.1016/j.arth.2022.10.020
45. Bohl DD, Ondeck NT, Basques BA, Levine BR, Grauer JN. What Is the Timing of General Health Adverse Events That Occur After Total Joint Arthroplasty?. *Clin Orthop Relat Res.* 2017;475(12):2952-2959. doi:10.1007/s11999-016-5224-2
46. Oatis CA, Li W, DiRusso JM, et al. Variations in Delivery and Exercise Content of Physical Therapy Rehabilitation Following Total Knee Replacement Surgery: A Cross-Sectional Observation Study. *Int J Phys Med Rehabil.* 2014;Suppl 5:002. doi:10.4172/2329-9096.S5-002
47. Kittelson AJ, Elings J, Colborn K, et al. Reference chart for knee flexion following total knee arthroplasty: a novel tool for monitoring postoperative recovery. *BMC Musculoskelet Disord.* 2020;21(1):482. doi:10.1186/s12891-020-03493-x
48. Palinkas LA, Horwitz SM, Green CA, Wisdom JP, Duan N, Hoagwood K. Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Adm Policy Ment Health.* 2015;42(5):533-544. doi:10.1007/s10488-013-0528-y
49. Coyne IT. Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries?. *J Adv Nurs.* 1997;26(3):623-630. doi:10.1046/j.1365-2648.1997.t01-25-00999.x
50. Leese J, Li LC, Nimmon L, Townsend AF, Backman CL. Moving Beyond “Until Saturation Was Reached”: Critically Examining How Saturation Is Used and Reported in Qualitative Research. *Arthritis Care Res (Hoboken).* 2021;73(9):1225-1227. doi:10.1002/acr.24600
51. Stemler S. An overview of content analysis. Practical assessment, research, and evaluation. 2000;7(1):17.
52. Miles MB, Huberman AM. Qualitative data analysis: An expanded sourcebook. sage; 1994.
53. Spall S. Peer debriefing in qualitative research: Emerging operational models. *Qualitative inquiry.* 1998;4(2):280-92.

54. Implemented ICF Update Proposals 2018. Accessed December 30, 2023.
<https://www.who.int/publications/m/item/implemented-icf-update-proposals-2018>
55. Tyser AR, Beckmann J, Franklin JD, et al. Evaluation of the PROMIS physical function computer adaptive test in the upper extremity. *J Hand Surg Am*. 2014;39(10):2047-2051.e4.
doi:10.1016/j.jhsa.2014.06.130
56. Roddey TS, Olson SL, Cook KF, Gartsman GM, Hanten W. Comparison of the University of California-Los Angeles Shoulder Scale and the Simple Shoulder Test with the shoulder pain and disability index: single-administration reliability and validity. *Phys Ther*. 2000;80(8):759-768.
57. Swanson EA, Schmalzried TP, Dorey FJ. Activity recommendations after total hip and knee arthroplasty: a survey of the American Association for Hip and Knee Surgeons. *J Arthroplasty*. 2009;24(6 Suppl):120-126. doi:10.1016/j.arth.2009.05.014
58. Sowers CB, Carrero AC, Cyrus JW, Ross JA, Golladay GJ, Patel NK. Return to Sports After Total Hip Arthroplasty: An Umbrella Review for Consensus Guidelines. *Am J Sports Med*. 2023;51(1):271-278.
doi:10.1177/03635465211045698
59. Hui E, Chui BT, Woo J. Effects of dance on physical and psychological well-being in older persons. *Arch Gerontol Geriatr*. 2009;49(1):e45-e50. doi:10.1016/j.archger.2008.08.006
60. Keogh JW, Kilding A, Pidgeon P, Ashley L, Gillis D. Physical benefits of dancing for healthy older adults: a review. *J Aging Phys Act*. 2009;17(4):479-500. doi:10.1123/japa.17.4.479
61. MacDermid JC. ICF Linking and cognitive interviewing are complementary methods for optimizing content validity of outcome measures: an integrated methods review. *Front Rehabil Sci*. 2021;2:702596.
62. Terwee CB, Prinsen CAC, Chiarotto A, et al. COSMIN methodology for evaluating the content validity of patient-reported outcome measures: a Delphi study. *Qual Life Res*. 2018;27(5):1159-1170.
doi:10.1007/s11136-018-1829-0
63. Schenkman M, Berger RA, Riley PO, Mann RW, Hodge WA. Whole-body movements during rising to standing from sitting. *Phys Ther*. 1990;70(10):638-651. doi:10.1093/ptj/70.10.638
64. Groves RM, Fowler Jr FJ, Couper MP, Lepkowski JM, Singer E, Tourangeau R. *Survey Methodology*. John Wiley & Sons; 2011.
65. Streiner DL, Norman GR, Cairney J. Health measurement scales: a practical guide to their development and use. Oxford University Press, USA; 2015.
66. Stucki G, Cieza A, Ewert T, Kostanjsek N, Chatterji S, Üstün TB. Application of the International Classification of Functioning, Disability and Health (ICF) in clinical practice. *Disabil Rehabil*. 2002;24(5):281-282. doi:10.1080/09638280110105222
67. Wiering B, De Boer D, Delnoij D. Asking what matters: The relevance and use of patient-reported outcome measures that were developed without patient involvement. *Health Expect*. 2017;20(6):1330-1341.
doi:10.1111/hex.12573

Appendix A. Final version of the questionnaire

Please read these important instructions:

Please rate each activity on two aspects:

1. How **important** the activity is to you **today**. When rating importance, please do not think about your ability to do it. Only consider how important it is for you **today**, not what you think will be important in the future.
2. Your **ability** to do the activity **today**. If you are using an aid (such as a cane, crutches, walker, etc.), assess your ability with the aid you use.

Thank you for participating in our study!

Changing and holding a body position

Lying down in bed and getting up



Today, being able to lie down in bed and get up is ...

- ☐ Not important
- ☐ Slightly Important
- ☐ Important
- ☐ Very important

Today, how difficult is it to lie down in bed and get up?

- ☐ Unable to do
- ☐ A lot of difficulty
- ☐ A little difficulty
- ☐ No difficulty
- ☐ I don't know
- ☐ I never do this

Rolling over (such as back to side)



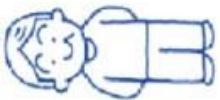
Today, being able to roll over is ...

- ☐ Not important
- ☐ Slightly Important
- ☐ Important
- ☐ Very important

Today, how difficult is it to roll over?

- ☐ Unable to do
- ☐ A lot of difficulty
- ☐ A little difficulty
- ☐ No difficulty
- ☐ I don't know
- ☐ I never do this

Hold a lying position during the day



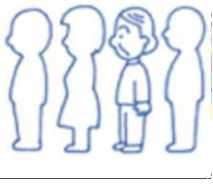
Today, being able to hold a lying position during the day is ...

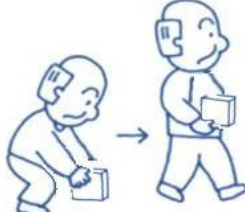
- ☐ Not important
- ☐ Slightly Important
- ☐ Important
- ☐ Very important

Today, how long can you hold a lying position during the day?

- ☐ Unable to do
- ☐ Less than 10 minutes
- ☐ 11-30 minutes
- ☐ 31-60 minutes
- ☐ More than 1 hour
- ☐ I don't know
- ☐ I never do this

Squatting down (partial or full squat) 	<u>Today</u>, being able to squat down is ... <u>Today</u>, how difficult is it to squat down?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Hold a squatting position (partial or full squat) 	<u>Today</u>, being able to hold a squatting position is ... <u>Today</u>, how long can you hold a squatting position?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ Less than 1 minute ☐ 1-5 minutes ☐ More than 5 minutes ☐ I don't know ☐ I never do this
Kneeling down on the ground 	<u>Today</u>, being able to kneel down is ... <u>Today</u>, how difficult is it to kneel down?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Hold a kneeling position 	<u>Today</u>, being able to hold a kneeling position is ... <u>Today</u>, how long can you hold a kneeling position?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ Less than 1 minute ☐ 1-5 minutes ☐ More than 5 minutes ☐ I don't know ☐ I never do this

Sitting on a chair (average height with or without arms) 	<u>Today</u>, being able to sit on a chair is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important <u>Today</u>, how difficult is it to sit on a chair? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Hold a sitting position 	<u>Today</u>, being able to hold a sitting position is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important <u>Today</u>, how long can you hold a sitting position? ☐ Unable to do ☐ Less than 10 minutes ☐ 11-30 minutes ☐ 31-60 minutes ☐ More than 1 hour ☐ I don't know ☐ I never do this
Rising from a chair (average height with or without arms) 	<u>Today</u>, being able to rise from a chair is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important <u>Today</u>, how difficult is it to rise from a chair? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Hold a standing position (such as standing at the sink or in a line) 	<u>Today</u>, being able to hold a standing position is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important <u>Today</u>, how long can you hold a standing position? ☐ Unable to do ☐ Less than 10 minutes ☐ 11-30 minutes ☐ More than 30 minutes ☐ I don't know ☐ I never do this

Bending over or to the side (such as reaching down for an object) 	Today, being able to bend over or to the side is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important Today, how difficult is it to bend over or to the side? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Shifting the body from side to side (such as moving from one foot to another while standing or shifting your weight while sitting) 	Today, being able to shift your body is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important Today, how difficult is it to shift your body? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Lifting and carrying objects	
Lifting a light object from the floor (less than 1 pound) 	Today, being able to lift a light object from the floor is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important Today, how difficult is it to lift a light object from the floor? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Lifting a heavy object from the floor (more than 10 pounds) 	Today, being able to lift a heavy object from the floor is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important Today, how difficult is it to lift a heavy object from the floor? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

Putting down objects on the floor 	Today, being able to put down objects on the floor is ... Today, how difficult is it to put down objects on the floor?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Carrying in the hands (such as a grocery bag or suitcase) 	Today, being able to carry an object in your hands is ... Today, how difficult is it to carry an object in your hands?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Carrying in the arms 	Today, being able to carry an object in your arms is ... Today, how difficult is it to carry an object in your arms?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Carrying on shoulders or back (such as a backpack) 	Today, being able to carry an object on your shoulders or back is ... Today, how difficult is it to carry an object on your shoulders or back?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

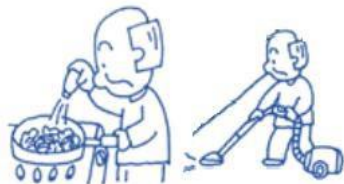
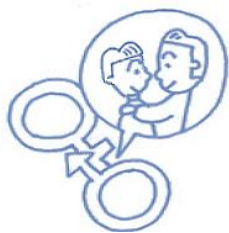
Walking		
Walking short distances (less than 1km) on flat surfaces 	Today, being able to walk short distances is ... Today, how far can you walk short distances (less than 1km)?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ Less than 70 steps (50m) ☐ 71 - 300 steps (51-200m) ☐ 301 - 500 steps (201-500m) ☐ 501 - 1500 steps (501m-1km) ☐ I don't know ☐ I never do this
Walking long distances (more than 1km) on flat surfaces 	Today, being able to walk long distances is ... Today, how far can you walk long distances (more than 1km)?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ 1500 - 5000 steps (1km - 4km) ☐ 5001 - 10 000 steps (4 -7km) ☐ More than 10 000 steps (more than 7km) ☐ I don't know ☐ I never do this
Walking on different surfaces (slope, uneven, or moving surfaces, such as grass, gravel and snow) 	Today, being able to walk on different surfaces is ... Today, how difficult is it to walk on different surfaces?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Walking around obstacles (such as walking around a marketplace or shop, around or through crowded areas) 	Today, being able to walk around obstacles is ... Today, how difficult is it to walk around obstacles?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

Moving around		
Going up stairs (10 to 12 stairs) 	Today, being able to go up stairs is ... Today, how difficult is it to go up stairs?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Going down stairs (10 to 12 stairs) 	Today, being able to go down stairs is ... Today, how difficult is it to go down stairs?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Going up a curb or step 	Today, being able to go up a curb or step is ... Today, how difficult is it to go up a curb or step?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Jumping 	Today, being able to jump is ... Today, how difficult is it to jump?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

Moving around using transportation		
Getting in and out of a car (such as own car or taxi) 	Today, being able to get in and out of a car is ... Today, how difficult is it to get in and out of a car?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Using public transportation (such as a bus or train) 	Today, being able to use public transportation is ... Today, how difficult is it to use public transportation?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Biking (to go to a place or recreational) 	Today, being able to bike is ... Today, how difficult is it to bike?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Driving vehicle 	Today, being able to drive vehicle is ... Today, how difficult is it to drive vehicle?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

Self-care		
Washing lower body parts (such as legs and feet) 	Today, being able to wash your lower body parts is ... Today, how difficult is it to wash your lower body parts?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Washing whole body 	Today, being able to wash your whole body is ... Today, how difficult is it to wash your whole body?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Drying your body (drying some part or parts of your body or the whole body, such as after washing) 	Today, being able to dry your body is ... Today, how difficult is it to dry your body?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Going to the toilet (getting to washroom, getting into and out of position, removing and putting back on clothing, and cleaning oneself.) 	Today, being able to go to the toilet is ... Today, how difficult is it to go to the toilet?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

Putting on clothes 	<u>Today</u>, being able to put on clothes is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important <u>Today</u>, how difficult is it to put on clothes? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Taking off clothes 	<u>Today</u>, being able to take off clothes is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important <u>Today</u>, how difficult is it to take off clothes? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Putting on footwear (shoes or socks) 	<u>Today</u>, being able to put on footwear is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important <u>Today</u>, how difficult is it to put on footwear? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Taking off footwear (shoes or socks) 	<u>Today</u>, being able to take off footwear is ... ☐ Not important ☐ Slightly Important ☐ Important ☐ Very important <u>Today</u>, how difficult is it to take off footwear? ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

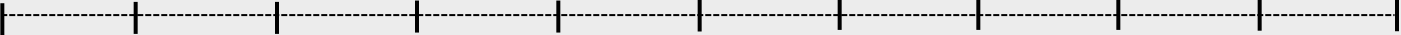
Domestic life and Intimate relationships		
Going shopping 	Today, being able to go shopping is ... Today, how difficult is it to go shopping?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Doing housework (cleaning the house, washing clothes, using household appliances, storing food and disposing of garbage) 	Today, being able to do housework is ... Today, how difficult is it to do housework?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Assisting others (assisting others with their self-care, movement, within the house or outside) 	Today, being able to assist others is ... Today, how difficult is it to assist others?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Sexual relationships 	Today, being able to have sexual relationships is ... Today, how difficult is it to have sexual relationships?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

Employment		
Paid job (part-time, or full-time)  	Today, being able to do a paid job is ... Today, how difficult is it to do a paid job?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I am retired/ I never do this
Unpaid work (such as volunteer work) 	Today, being able to do unpaid work is ... Today, how difficult is it to do unpaid work?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
Community, social and civic life		
Socializing /Participate in community life such as: • Visiting friends or relatives • Meeting in public places, local groups, social organizations, ceremonies (e.g marriages, etc.) 	Today, being able to socialize and participate in community life is ... Today, how difficult is it to socialize and participate in community life?	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

Sports such as: • Swimming • Golf • Dancing • Workout/gym • Hiking • Skating • Skiing • Bowling • Etc. 	Today, being able to do sports is ...	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important
Running/jogging 	Today, being able to run or jog is ...	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important
Hobbies/ play /Crafts/ Arts and culture Such as: • Gardening • Going to the theatre, cinema, museum • Reading • Singing • Playing an instrument • Pottery or knitting • Playing chess or cards • Etc. 	Today, being able to participate in hobbies, play, crafts, arts and culture is ...	☐ Not important ☐ Slightly Important ☐ Important ☐ Very important
	Today, how difficult is it to participate in hobbies, play, crafts, arts and culture?	☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

If **other activities** important to you **today** were not included in this questionnaire, please tell us about them. Rate each activity for your ability to do it and its importance **today**.

1.....	☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
2.....	☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
3.....	☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this
4.....	☐ Slightly Important ☐ Important ☐ Very important ☐ Unable to do ☐ A lot of difficulty ☐ A little difficulty ☐ No difficulty ☐ I don't know ☐ I never do this

Please answer the following questions.					
Which surgery did you undergo? Hip replacement ☐ Knee replacement ☐					
Are you currently avoiding certain movements or positions based on your doctor or physiotherapist recommendations? Yes ☐ No ☐					
On average, how much pain have you had in your operated hip or knee in the past 24 hours, 0 being no Worse pain and 100 the worst pain imaginable?					
No pain Moderate pain Worse pain imaginable  (Place a mark on the scale above)					
Do you have any problems or pain in other joints beyond the operated joint? Yes ☐ No ☐					
If yes, the problems or pain is in which joint (s)? Please check all that apply. Right hip ☐ Right knee ☐ Right foot ☐ Left hip ☐ Left knee ☐ Left foot ☐ Low back ☐ neck ☐ Shoulder ☐					
Do you presently use any walking aids? Please check all that apply.					
Wheelchair ☐ Walker ☐ Cane ☐ Crutches ☐ Scooter ☐ Other walking aids ☐ Not using any aid ☐					
With whom do you live? alone ☐ with family ☐					
Do you have family/relatives that live nearby? Yes ☐ No ☐					
Do you have someone who is dependent on you for their care? Yes ☐ No ☐					
What is your place of residence? House ☐ Apartment ☐ Retirement Home ☐ Long Term Care Facility ☐ Other ☐					
What is the level of activity of your job?					
Sedentary ☐ Light physical ☐ Heavy physical ☐ Retired ☐					

	What is your age?
	What was your sex at birth? Male ☐ Female ☐ What is your gender? Man ☐ Woman ☐ or: please specify ☐
	In order to calculate your body mass index, please provide your height and weight. Height feet/inches Weight lbs
	You may belong to one or more racial or cultural groups on the following list. Select all that apply. White ☐ First Nation, Métis, Inuk (Inuit) ☐ South Asian (e.g., East Indian, Pakistan, Sri Lankan) ☐ Chinese ☐ Black ☐ Filipino ☐ Latin American ☐ Arab ☐ Southeast Asian (e.g., Vietnamese, Cambodian, Malaysian, Laotian) ☐ West Asian (e.g., Iranian, Afghan) ☐ Korean ☐ Japanese ☐ Prefer not to say ☐ Do not know ☐ Other-Specify:

Thank you for taking the time to complete this questionnaire!

CHAPTER 3: Systematic Review and Content Analysis of PROMs (Manuscript 3)

Relationship of Manuscript 3 to the Dissertation

The manuscript presented in this chapter describes a systematic review and content analysis of patient-reported outcome measures (PROMs) used to assess function after hip or knee arthroplasty (Study 3). The relevance of outcome measure contents to the targeted construct is a critical factor in the selection and application of outcome measures. However, there is limited understanding of the content covered by PROMs used after hip or knee arthroplasty. Thus, the objective of the systematic review was to identify the existing PROMs used in hip or knee arthroplasty and assess their content validity using the modified International Classification of Functioning, Disability and Health (ICF) core set for osteoarthritis (OA) validated in Study 2. In this review, I focused only on disease (OA) or joint-specific (hip, knee, or lower limb) PROMs, and excluded generic PROMs (e.g., Short Form-12). The review identified 50 PROMs used after hip or knee arthroplasty. Content analysis revealed that the mobility chapter of activities and participation was the most frequent component, followed by sensory function and the pain chapter of body function and structure. Additionally, the analysis showed that included activity and participation categories vary widely between PROMs. This content analysis helps to better understand what each PROM is measuring and provides the foundation for Study 6 of this dissertation to map the results of this study to the key functional activities identified in Study 5, facilitating the selection of patient-centered outcome measures.

This manuscript was published in *Arthritis Care & Research* under the CC BY-NC license. It is formatted as per the journal requirements. However, the numbering of the tables and figures have been modified according to the formatting of this dissertation. Also, the acronym "PBT" for "performance-based test" has been used to align with this dissertation. The published article can be viewed at:

Karimijashni M, Abtahi F, Abbasalipour S, et al. Functional patient-reported outcome measures after hip or knee arthroplasty: A systematic review and content analysis using the International Classification of Functioning, Disability and Health (ICF). *Arthritis Care Res.* n/a(n/a). doi:10.1002/acr.25413

Manuscript 3: Functional patient-reported outcome measures after hip or knee arthroplasty: A systematic review and content analysis using the International Classification of Functioning, Disability and Health (ICF)

Abstract

Objective: This systematic review aimed to identify the existing patient-reported outcome measures (PROMs) used in hip or knee arthroplasty for adults with osteoarthritis and assess their content validity using the modified International Classification of Functioning, Disability and Health (ICF) core set for osteoarthritis (OA).

Methods: Four databases were systematically searched to identify disease or joint-specific PROMs evaluating function after hip or knee arthroplasty. Two reviewers independently evaluated the content of PROMs based on established ICF linking rules.

Results: From 449 studies included in this review, 50 PROMs were identified. The mobility chapter of activities and participation was the most common component, followed by sensory function and pain chapter of body function and structure. The most frequent ICF activity and participation categories were d451:going up and down stairs, d4701:using private motorized transportation, d4104:standing, and d4154:maintaining a standing position. However, 11 ICF categories of the modified OA coreset were not captured in any PROMs. This ICF-based content analysis of PROMs revealed that included activity and participation categories vary widely, with little overlap between PROMs. The Knee injury and Osteoarthritis Outcome Score and Hip disability and Osteoarthritis Outcome Score had the most coverage for activity and participation (36.7%).

Conclusion: Even though our search identified 50 specific PROMs, there remain gaps in content related to activity and participation coverage. By providing a content analysis of the PROMs

used after hip or knee arthroplasty, this study may help clinicians select PROMs based on covered categories and relevant clinical objectives.

Keywords: Hip or knee arthroplasty; Outcome measures; ICF framework

Significance and Innovations

- Of 50 PROMs used to assess functional outcomes after hip or knee arthroplasty, 28 PROMs were specifically developed for these surgical procedures, and the remaining were designed for other lower extremity conditions.
- The ICF-based content analysis of PROMs used after hip or knee arthroplasty revealed that the mobility chapter of activity and participation is the most prominently represented chapter. However, certain ICF categories within these chapters were either inadequately or rarely addressed across the PROMs.
- By highlighting the extent to which PROMs cover the activity and participation categories of the modified ICF OA coreset, this content analysis offers valuable insights for clinicians and researchers in selecting the most suitable PROM for diverse clinical and research needs. Furthermore, it provides a foundation for modifying existing PROMs or developing new ones when current instruments fail to encompass the desired category of interest.

Introduction

Hip or knee arthroplasty are used widely for treating patients with end-stage osteoarthritis (OA)^{1,2} to reduce pain, restore function, and improve quality of life.^{3,4} Outcome measures provide a common language among providers to assess and report patient status and surgery results.⁵ Outcome after hip or knee arthroplasty can be defined in different ways, such as mortality, morbidity, clinical and radiological findings, adverse events, revision rates, pain, length of hospital stay, and physical function.^{6,7} Physical function can be measured by performance-based tests (PBTs) and patient-reported outcome measures (PROMs).^{5,8} In recent years, there has been a growing focus on evaluating outcomes from the patient's perspective,⁹ and an effective way to capture this is through PROMs.¹⁰⁻¹² PROMs can be used to capture some of the core outcome domains for arthroplasty.¹³

Several factors should be considered when selecting an appropriate PROM for patients undergoing hip or knee arthroplasty. The most critical factor is the content validity of outcome measures, which is an often neglected area.¹⁴ Content validity considers whether the PROM captures items that are relevant to the target population and intervention of interest.¹⁵ Previous research showed that PROMs used in hip or knee arthroplasty often do not adequately measure relevant areas of activity and participation of patients.^{10,15,16} Thus, determining the extent to which PROMs do reflect patients' priorities and perspectives has been identified as a research priority.¹¹

The International Classification of Functioning, Disability and Health (ICF), a comprehensive framework of health states developed and published by the World Health Organization (WHO), is based on the integrative model of functioning, disability, and health and provides a standard language for describing an individual's health state.^{18,19} This framework

helps us broaden our understanding of how chronic conditions can affect patients' functioning and provides a universal understanding of function, activity and participation.¹⁹ The ICF has been applied as an independent and external framework to explore the contents of instruments to give insight into selecting the most appropriate outcome measures.¹⁹

ICF core sets were developed to make the ICF more applicable in clinical practice and research since the ICF includes over 1450 categories.^{20,21} The ICF core set for patients with OA, developed in 2004,²² addresses relevant elements to patients with advanced OA²³ and typical problems in physical functioning during recovery after hip or knee arthroplasty.²⁴ The ICF is structured hierarchically: the first level consists of chapters, and each chapter includes second- and third-level categories. For instance, the third-level ICF category d4104:standing is part of the second-level category d410:changing basic body position, which in turn belongs to the chapter d4:mobility.²⁵

Attempts have been made to link a limited number of PROMs used for hip or knee arthroplasty to the first and second levels of the ICF.^{15,16} The first and second levels broadly categorize function, such as changing and maintaining body positions. The third-level categories of the ICF further specify these categories, such as sitting or maintaining a sitting position, allowing for detailed assessment of concepts aligned with PROM items, thereby ensuring accurate evaluation of different aspects of functioning. However, to our knowledge, this has yet to be carried out. Therefore, the objective of this systematic review was to assess the content of existing PROMs used in hip or knee arthroplasty for adults with hip or knee OA using the modified ICF OA core set.

Methods

This systematic review followed the Cochrane reviews methodology²⁶ and was reported based on the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) checklist guidelines.²⁷ The protocol was prospectively registered on PROSPERO (CRD42023395420).

Eligibility criteria

The SPIDER framework²⁸ was used to outline inclusion/exclusion criteria.

Sample

Eligible studies involved adults (18 years and older) who underwent primary elective hip or knee arthroplasty, including total joint arthroplasty, uni-compartmental knee arthroplasty, and hip resurfacing or hemi-arthroplasty due to OA. Studies were eligible if at least 85% of patients underwent hip or knee arthroplasty due to OA. Studies with patients who underwent hip or knee arthroplasty for other conditions (e.g., rheumatoid arthritis, dysplasia, trauma, fracture), had revision or bilateral procedures were excluded.

Phenomenon of interest

Inclusion criteria: The phenomenon of interest is a PROM evaluating functional outcomes after primary elective hip or knee arthroplasty for adults with OA. Since the ultimate goal of hip or knee arthroplasty and rehabilitation after arthroplasty is the comprehensive improvement in patients' activities and participation,^{29–32} PROMs were included if they contained at least two concepts in either the activity or the participation components of the ICF. A PROM was included if it resulted in a numerical value on either a continuous or ordinal scale. PROMs containing both clinician-assessed and patient-reported items were included if at least half of the items were patient-reported. Only disease (OA) or joint-specific (hip, knee, or lower

limb) PROMs developed in English or undergone translation and validation in English were eligible.

Exclusion criteria: Generic PROMs (e.g., Short Form-12) were excluded because it has been shown that they are better suited to compare populations across conditions, assess mental and emotional health aspects, and investigate the cost-utility of interventions.³³ PROMs specifically developed to inform preoperative decision-making by predicting postoperative functional outcomes before surgery were excluded. Also, single item PROMs were excluded. Moreover, PROMs were excluded if their psychometric properties were only assessed and reported prior to 2008, since Outcome Measures in Rheumatology (OMERACT) standards were introduced in 2008.³⁴ There was otherwise no restriction on the publication period during the screening.

Design

All data-driven study designs were eligible. This included studies aiming at developing PROM(s) to evaluate outcomes following hip or knee arthroplasty or testing psychometric properties, such as reliability (internal consistency, reliability, and measurement error/agreement), validity (content, construct, and criterion validity), and responsiveness. Additionally, studies were eligible if they examined and compared different PROMs.

Evaluation

We evaluated the content of eligible PROMs by linking the items to the modified ICF OA core set, including 49 second and third level categories. The linkage process followed established ICF linking rules.^{35,36} The ICF OA core set has been extensively validated in previous research for patients with OA.^{37–39} To evaluate its face and content validity specifically for patients undergoing hip or knee arthroplasty, we conducted cognitive think-aloud interviews

with patients who underwent these procedures in our previous study.⁴⁰ The findings from these cognitive interviews resulted in the exclusion of ten categories, the addition of two categories, and the modification of four categories to better align with patients undergoing hip or knee arthroplasty. For example, upper extremity activities were excluded since not related to lower extremity OA. The details of these adjustments were described in our previous research.⁴⁰ Appendix A provides detailed categories of the modified ICF OA core set.

Research type and other

This systematic review included any research design (qualitative and quantitative) of all languages that could be translated by our research team (French, Persian). Studies published in peer-reviewed journals, unpublished, grey literature (e.g., governmental reports and clinical practice guidelines) and theses were included to ensure all PROMs evaluate outcomes after hip or knee arthroplasty were identified. Only full text articles were included. All types of reviews, editorials, and commentaries were excluded. We also excluded studies that only used PROM as the instrument for outcome measurement. For instance, studies such as in randomized controlled trials where the PROM is exclusively used to assess the outcome. Our decision followed the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) recommendation for systematic review of outcome measures, ensuring the appropriateness of the study selection process.⁴¹

Data sources and search strategy

The published studies were identified by searching four electronic databases: CINAHL, MEDLINE, Embase, and Cochrane CENTRAL from inception until April 2024. The search strategy was developed with the assistance of an experienced medical librarian using eligibility criteria to target instruments following hip or knee arthroplasty and was tailored to each

database. Key search terms and synonyms were searched using four main concepts, including target population, measurement instrument, construct, and measurement properties based on the recommendation by COSMIN.⁴¹

A precise search filter for publications related to measurement properties described by Terwee et al. was adopted.⁴² The full search strategies for all databases are detailed in Appendix B. The first author (MK) also manually screened the reference lists of included articles and grey literature to identify other potentially eligible studies.

Data management and selection process

All search results were imported into Zotero reference management software⁴³ and the Covidence web-based platform for systematic reviews,⁴⁴ and duplicate studies were removed. Two pairs of independent reviewers (MK, FA, SA, PR, AD) initially screened titles and abstracts for potentially eligible studies. Studies meeting the inclusion criteria or being uncertain then underwent full-text screening. The same independent reviewers screened the full text to confirm eligibility. The study selection process and reasons for exclusion were recorded in Covidence.⁴⁴ Any discrepancy between reviewers was discussed until consensus was reached or judged by a senior researcher (SP) if necessary.

Data collection and items

Data was extracted by one reviewer using a predetermined, standardized data extraction form verified for accuracy by a second independent reviewer. Two reviewers first piloted two studies to establish consistency and accuracy of extraction and made necessary revisions. The following information was extracted: 1) title, authors list, journal, country of study, and year of publication; 2) study aim, design, and sample size; 3) study population including demographic characteristics (e.g., age, sex, type of surgery, duration after surgery, etc.); 4) details on PROMs

such as name, year the PROM was developed, construct(s), classification of outcome measures including multiple-item or single-item measure, development target population, PROMs' items, response options (measurement level/scale – continuous, Likert, categorical), scoring, range of scores, and interpretation of the score. Inconsistencies in data extraction were discussed until a consensus was reached. If the reported data were insufficient, we contacted corresponding authors at least at two times two weeks apart before considering the data as missing for the review.

Content analysis of PROMs and ICF linking procedure

We evaluated the content of PROMs by linking each PROM item to the modified ICF OA core set. Established rules to link health-status measures to the ICF were used (Appendix C).^{35,36,45} Each PROM was evaluated by two independent coders knowledgeable with the ICF OA core set and the ICF linking educational tool.⁴⁶ The coders first identified concepts contained in each item of included PROMs and then linked them to the most precise ICF category following the linking decision tree (Appendix D). Inconsistencies were addressed through discussion with a third reviewer. For each item, the coder assigned second and third level ICF code for the components of activity and participation. Since the aim of hip or knee arthroplasty is to enhance patients' activity and participation, body function/structure and environmental factors were only coded to the first level.

PROM concepts that could not be linked to one of the categories of the OA core set were coded as either "concepts not covered by core set" or "concepts not addressed adequately". "Concepts not covered by core set" contained sufficient information but were not aligned with a category of the OA core set and consisted of two subcategories: 1) "other specified, or 2)" covered beyond OA core set". "Concepts not addressed adequately" did not provide sufficient

information and consisted of three subcategories: 1) "unspecified", 2) "not definable" or 3) "question mark". Appendix E outlines the details of these categories.

Coverage of activity and participation for each PROM was determined by calculating its ratio of activity and participation categories covered at the second/third level to the total number of activity and participation categories in the modified ICF OA core set.⁴⁷

$$\text{Coverage} = \frac{\text{PROM's number of activity and participation categories covered at the second/third level}}{\text{Total number of activity and participation categories in the modified ICF OA core set (n=49)}} \times 100$$

For each PROM item, the response perspective and response options were recorded. The perspective refers to whether the item assesses a person's satisfaction with performance (appraisal), their actual performance or capacity (descriptive), or the need for assistance or devices in task completion (need/dependency). Since an item may assess both performance and capacity depending on the patient's interpretation, the descriptive perspective was not further subdivided into capacity and performance.³⁶ Response options encompass intensity, frequency, duration, confirmation or agreement, and qualitative attributes.

Results

Study selection

The electronic literature searches yielded 22842 hits. After screening 13,895 titles and abstracts and 575 full texts, 432 articles were included. We identified 17 additional articles from reference lists of included articles or citation tracking. The PRISMA diagram illustrates the study selection process (Appendix F). The data underlying the results of this study is available upon request.

PROMs characteristics

After extracting the included studies, 32 PROMs plus 18 modified versions of PROMs met the inclusion criteria for content comparison and 67 PROMs were excluded. Appendix G shows the excluded tools with the reasons for exclusion. Of 50 PROMs, 19 addressed knee arthroplasty, 13 were for hip arthroplasty and 18 addressed both procedures. Appendix H shows the full names and acronyms and major characteristics of all identified PROMs. The measures were developed between 1982 and 2023. The target population was individuals with lower extremity problems, with 28 PROMs specifically designed for patients undergoing hip or knee arthroplasty.

PROMs used after knee arthroplasty

The linking results of the concepts across 19 PROMs used after knee arthroplasty are presented in Tables 3.1, 3.2 and Appendix I. No category of the modified ICF OA core set was present in all PROMs. Within the activity and participation component, 37 categories were found. The categories of d451:going up and down stairs, and d4104:standing were the most frequently used, employed in 16, and 12 PROMs respectively. However, 12 categories were not found in any PROM. These categories include:shifting the body's centre of gravity; carrying in the hands; carrying in the arms; carrying on shoulders, and back; putting down objects; walking around obstacles; driving motorized vehicles; washing body parts; putting on clothes; taking off clothes; assisting others; intimate relationships. Within the body function and structure component, the b2:sensory functions and pain category, was the most frequently used and found in 15 PROMs. Two environmental factors (e1:products and technology, e3:support and relationships) were included in five PROMs.

Regarding the coverage for activity and participation, the Knee injury and Osteoarthritis Outcome Score (KOOS) had the widest coverage (36.7%), addressing 18 out of 49 modified ICF OA core set categories. It was followed by 2011 Knee Society Score (2011 KSS), Adjusted 2011 KSS (2011 KSS-A) and Patient Administered Questionnaire (PAQ)-knee, all covering 14 categories (28.6%). Three PROMs (Oxford Knee Score—activity and participation (OKS-APQ), KOOS- Physical Function Short Form (KOOS-PS), and Western Ontario and McMaster Universities Osteoarthritis Index total knee arthroplasty function short form (WOMAC-TKA short form) covered only activities and participation, while other PROMs had at least one concept linked to body function and structure or environmental factors (Table 3.2).

Some categories were covered multiple times within the same PROM. For instance, d9201:sports was covered 14 times in the 2011KSS. In addition, numerous PROM items incorporated concepts linked to multiple activity and participation categories. The Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee (PROMIS-OAK) and KOOS had the highest number of items with seven linked to more than one category, followed by 2011 KSS-A with six. For instance, the KOOS question regarding "lying in bed (turning over, maintaining knee position)" covered the categories of d4150:maintaining a lying position and d4107:rolling over. In contrast, each item of five PROMs (Hospital for Special Surgery Patellar score (HSSP), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADLS), KOOS-PS, Kujala Anterior Knee Pain Scale (AKPS), WOMAC-TKA short form) covered one category only.

Fifty-nine concepts in 15 PROMs were not covered by activity and participation categories of the modified OA core set, with the PROMIS-OAK, Patient's Knee Implant Performance Questionnaire (PKIP) having the highest number of categories. Table 2 shows the

details of activity and participation categories not covered by the core set. 81 concepts across 17 PROMs were inadequately addressed due to insufficient information. The International Knee Documentation Committee (IKDC) and 2011 KSS had the highest number of concepts inadequately addressed with 11 concepts each. HSSP and WOMAC-TKA short form exclusively had items with sufficient information.

Table 3.1. Number of categories of modified ICF OA core set represented in specific PROMs used to assess outcomes after knee arthroplasty.

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Body functions and structure																			
b1 Mental functions	1				1		1	1	1							1	9	29	
b2 Sensory functions and pain	1	1	3	1	5	8	2	8	4		4	1	2	4		2		16	
b7 Neuromusculoskeletal and movement-related functions / s7 Structures related to movement			6	7				9			2	6	3	2		1	7	6	
Not covered by ICF coresets for OA								1	1						1		1	2	
Activity and Participation																			
d4 Mobility																			
d410 Changing basic body position																			
d4100 Lying down and getting up					1+1 ²	1+1 ²		1+1 ²	1 ²	1									
d4101 Squatting			1 ²	1 ²	1 ²	1 ²		1 ²	1 ²			1 ²	1 ²			1 ²			
d4102 Kneeling			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²	1		1 ²	1 ²		
d4103 Sitting			1 ²		1 ²	1 ²		2 ²	1 ²							1 ²			
d4104 Standing		1	1	1	1	1	1	1+1 ²	1	1	1+1 ²			1					1
d4105 Bending						1		1		1	1						1		1
d4106 Shifting the body's centre of gravity																			
d4107 Rolling over								1											
d415 Maintaining a body position																			
d4150 Maintaining a lying position					1 ²	1 ²		2+1 ²	1 ²										
d4151 Maintaining a squatting position			1 ²	1 ²	1 ²			1 ²		1 ²		1 ²	1 ²			1 ²			
d4152 Maintaining a kneeling position			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²			1 ²	1 ²		
d4153 Maintaining a sitting position		1	1 ²	1	1 ²	1 ²		1+2 ²	1 ²			1				1 ²			
d4154 Maintaining a standing position				1	1	1		1+1 ²	1		1 ²							1	1
d430 Lifting and carrying objects																			
d4300 Lifting a light object/d4300 Lifting a heavy object						2 ²		2 ²			2 ²								
d4301 Carrying in the hands																			
d4302 Carrying in the arms																			
d4303 Carrying on shoulders, and back																			
d4305 Putting down objects																			
d4308 Lifting and carrying, other specified					1			1							1				
d450 Walking																			
d4500 Walking short distances																1		1	
d4501 Walking long distances					1	1	1									2		3	
d4502 Walking on different surfaces					1	1	1										2	1	
d4503 Walking around obstacles																			
d4508 Other specified walking				1	2		1	2	1					1	1			1	1
d4509 Walking, unspecified			4 ²	2 ²	1 ²	2 ²	1 ²					1 ²	1 ²	1 ²	1 ²			1 ²	
d451 Going up stairs/ d451 Going down stairs		2	2	2	2+2 ²	2+2 ²	2+2 ²	4	2		2	2 ²	2	1		2	6	2+2 ²	2
d455 Moving around																			
d4551 Climbing					2		1										2		
d4553 Jumping			5					1				1							
d4558 Other specified moving around			4		2			2	1	1	1				1				
d470 Using transportation																			
d4701 Using private motorized transportation					1			1	1					1		1	3		1
d4702 Using public motorized transportation														1					
d475 Driving																			
d4750 Driving human-powered transportation					1	2	1									1			
d4751 Driving motorized vehicles																			
d5 Self-care																			
d510 Washing oneself																			
d5100 Washing body parts																			
d5101 Washing whole body								1						1		1			
d5102 Drying oneself														1					
d530 Toileting								1								1	2	1	
d540 Dressing																			

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OXS	OXS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
d5400 Putting on clothes																			
d5401 Taking off clothes																			
d5402 Putting on footwear						1		1		1						1	1		
d5403 Taking off footwear						1		1											
d6 Domestic life																			
d620 Acquisition of goods and services								1						1					
d640 Doing housework	3		4		1	2	1	2						1		1		8	
d660 Assisting others																			
d7 Interpersonal interactions and relationships																			
d770 Intimate relationships																			
d8 Major life areas																			
d850 Remunerative employment	3 [?]												1		1 [?]			2 [?]	
d855 non-remunerative employment	3 [?]														1 [?]			2 [?]	
d9 Community, social and civic life																			
d910 Community Life/ d9205 Socializing															1	1		9	
d920 Recreation and leisure																			
d9200 Play / d9202 Arts and culture/ d9203 Crafts/ d9204 Hobbies					1	1	1									1			
d9201 Sports/ d4554 Swimming			5		14	3	13						1		1	6			
d4552 Running			5		2		2	1				1	1			1		1	
d9208 Other specified recreation and leisure																		1	
d9209 Recreation and leisure, unspecified	1 [?]				2 [?]	1 [?]										2 [?]		2 [?]	
Not covered by modified ICF coresets for OA	2		1	7	1	1		2	1				1	1	2	1	9	11	
d2202 Undertaking multiple tasks independently																			
d230 Carrying out daily routine																			
d298 other specified general tasks and demands																			
d570 Looking after one's health																			
d598 Other specified self-care																			
d630 Preparing meals																			
d820 School education																			
Environmental factor																			
e1 Products and technology					3	1							1			1			
e3 Support and relationships																		1	

? = concepts not addressed adequately.

COMI: Core Outcome Measures Index; **HSSP:** Hospital for Special Surgery Patellar score; **IKDC:** International Knee Documentation Committee; **KOS-ADLS:** Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS:** 2011 Knee Society Score; **2011 KSS-A:** Adjusted 2011 Knee Society Score; **KSS-S:** Knee Society Score- Short-form; **KOOS:** Knee Injury and Osteoarthritis Outcome Score; **KOOS-12:** 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS:** Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR:** Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS:** Kujala Anterior Knee Pain Scale; **OXS:** Oxford knee score; **OXS-APQ:** Oxford knee score—activity and participation; **PAQ :** Patient Administered Questionnaire; **PKIP:** Patient's Knee Implant Performance Questionnaire ;**PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

Table 3.2. Frequencies of items, ICF categories, and coverage of ICF linkage of specific PROMs used after knee arthroplasty.

	COMI-knee	HSSP	IKDC	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Number of items	6	4	18	17	31	20	10	42	12	7	7	13	12	12	8	29	24	76	7
Number of Second/third level of activity and participation categories covered	1	4	7	5	14	14	11	18	5	4	4	3	5	9	2	14	7	10	6
Coverage of Second/third level of activity and participation %	2 %	8.2%	14.3%	10.2%	28.6%	28.6%	22.4%	36.7%	10.2%	8.2%	8.2%	6.1%	10.2%	18.4%	4.1 %	28.6%	14.3%	20.4%	12.2%
Activity and participation concepts not covered by the modified ICF OA core set	2	0	5	8	6	1	1	7	3	1	1	0	1	2	5	0	9	13	1
Concepts not addressed adequately	6	0	11	4	11	8	3	8	3	2	2	3	3	1	3	5	2	7	0
Number of items with more than one concept of activity and participation	3	0	5	0	2	6	2	7	2	0	2	0	2	3	2	3	5	7	0

COMI: Core Outcome Measures Index; **HSSP:** Hospital for Special Surgery Patellar score; **IKDC:** International Knee Documentation Committee; **KOS-ADLS:** Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS:** 2011 Knee Society Score; **2011 KSS-A:** Adjusted 2011 Knee Society Score; **KSS-S:** Knee Society Score- Short-form; **KOOS:** Knee Injury and Osteoarthritis Outcome Score; **KOOS-12:** 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS:** Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR:** Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS:** Kujala Anterior Knee Pain Scale; **OKS:** Oxford knee score; **OKS-APQ:** Oxford knee score—activity and participation; **PAQ :** Patient Administered Questionnaire; **PKIP:** Patient’s Knee Implant Performance Questionnaire; **PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

PROMs used after hip arthroplasty

The linking results of the concepts across 13 PROMs used after hip arthroplasty are presented in Tables 3.3, 3.4 and Appendix I. 36 activity and participation categories were covered in the 13 PROMs, with d451:going up and down stairs, and d4701:using private motorized transportation being the most commonly used in 12 and nine PROMs respectively. However, 13 categories were not found in any PROM, matching those not covered by PROMs for knee arthroplasty, with the addition of maintaining a kneeling position. For body function and structure, the category of b2:sensory functions and pain, was the most used, found in ten PROMs. One environmental factor (e1:products and technology) was included in four PROMs.

Regarding the coverage for activity and participation, the Hip disability and Osteoarthritis Outcome Score (HOOS) had the widest coverage (36.7%), covering 18 out of 49 categories. It was followed by PAQ-hip (26.5%) and Hip Outcome Score (HOS) (24.5%), covering 13 and 12 categories. All concepts of the HOOS short form (HOOS-PS) and WOMAC-THA short form were linked to activities and participation, while other PROMs included at least one concept linked to body function and structure or environmental factors.

Some categories were covered several times within the same PROM. For instance, d9201:sports was covered six times in the PAQ-hip. Also, several PROM items contained concepts linked to multiple activity and participation categories. HOOS and Hip and Groin Outcome Score (HAGOS) had the highest number of items, with seven linked to more than one category. For instance, the HAGOS question regarding "pain during sitting or lying" covered four categories including d4103:sitting, d4153:maintaining a sitting position, d4100:lying down and getting up and d4150:maintaining a lying position. Conversely, each item of HOOS-PS and Mayo Hip score covered one category only.

Twenty-eight concepts in nine PROMs were not covered by activity and participation categories of the core set, with the HOOS, HOS and HAGOS having the highest number of unlinked items. Table 3.4 shows the details of activity and participation categories not covered by the core set. 39 concepts across 12 PROMs were inadequately addressed due to insufficient information. HOOS had the highest number of concepts inadequately addressed with eight concepts, followed by HOS and HAGOS with seven concepts. All items of the WOMAC-THA short form contained sufficient information.

Table 3.3 Number of categories of modified ICF OA core set represented in specific PROMs used to assess outcomes after hip arthroplasty.

ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Body functions and structure													
b1 Mental functions	2			1	1				3			1	
b2 Sensory functions and pain	2	1	1	5	4		2		6	1	5	2	
b7 Neuromusculoskeletal and movement-related functions / s7 Structures related to movement		1	1	7				1	8	1	2	1	
Not covered by ICF coresets for OA b110 Consciousness functions				1	1				1				
Activity and Participation													
d4 Mobility													
d410 Changing basic body position													
d4100 Lying down and getting up				1+1 ²	1 ²				1 ²				
d4101 Squatting				1 ²				1 ²	1 ²				
d4102 Kneeling						1 ²							
d4103 Sitting				2 ²	1 ²		1 ²		1 ²				
d4104 Standing				1+1 ²	1		1	1 ²	1 ²		1		1
d4105 Bending				1			1		1				1
d4106 Shifting the body's centre of gravity													
d4107 Rolling over				1			1	1	1				
d415 Maintaining a body position													
d4150 Maintaining a lying position				2+1 ²	1 ²		1		2+1 ²				
d4151 Maintaining a squatting position				1 ²				1 ²	1 ²				
d4152 Maintaining a kneeling position													
d4153 Maintaining a sitting position		1	1	1+2 ²	1 ²	1 ²	1 ²		1+1 ²				
d4154 Maintaining a standing position				1+1 ²	1			1+1 ²	1 ²				1
d430 Lifting and carrying objects													
d4300 Lifting a light object/d4300 Lifting a heavy object				2 ²			2 ²		2 ²				
d4301 Carrying in the hands													
d4302 Carrying in the arms													
d4303 Carrying on shoulders, and back													
d4305 Putting down objects													
d4308 Lifting and carrying, other specified				1					1				1
d4309 Lifting and carrying, unspecified								1 ²					
d450 Walking													
d4500 Walking short distances		1	1					1				1	
d4501 Walking long distances		1	1					1		1		2	
d4502 Walking on different surfaces				3	1		1		3				
d4503 Walking around obstacles													
d4508 Other specified walking				2	1			2			1		1
d4509 Walking, unspecified				1 ²				1 ²	1 ²		1 ²		
d451 Going up stairs/ d451 Going down stairs		2 ²	2 ²	4	2	1	2	2	3	2 ²	2 ²	2	1
d455 Moving around													
d4551 Climbing								4					
d4553 Jumping						1		2					
d4558 Other specified moving around				1		1		2	2				
d470 Using transportation													
d4701 Using private motorized transportation				1	1	1		1	1	1	1	1	1
d4702 Using public motorized transportation			1								1		
d475 Driving													
d4750 Driving human-powered transportation												1	
d4751 Driving motorized vehicles													
d5 Self-care													

ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
d510 Washing oneself													
d5100 Washing body parts													
d5101 Washing whole body				1				1			1	1	
d5102 Drying oneself											1		
d530 Toileting				1								1	
d540 Dressing													
d5400 Putting on clothes													
d5401 Taking off clothes													
d5402 Putting on footwear		1	1	1							1	1	1
d5403 Taking off footwear				1									
d6 Domestic life													
d620 Acquisition of goods and services				1							1		
d640 Doing housework	2			2					1		1	1	1
d660 Assisting others													
d7 Interpersonal interactions and relationships													
d770 Intimate relationships													
d8 Major life areas													
d850 Remunerative employment	1 [?]												
d855 non-remunerative employment	1 [?]												
d9 Community, social and civic life													
d910 Community Life/ d9205 Socializing	1											1	
d920 Recreation and leisure													
d9200 Play / d9202 Arts and culture/ d9203 Crafts/ d9204 Hobbies												1	
d9201 Sports/ d4554 Swimming								4	1			6	
d4552 Running				1		1		1	2			1	
d9209 Recreation and leisure, unspecified								1 [?]				1 [?]	
Not covered by modified ICF coresets for OA	1			2	1			1	4	1	1	1	1
d230 Carrying out daily routine													
d298 Other specified general tasks and demands													
d4351 Kicking													
d4450 Pulling, d4451 Pushing													
d520 Caring for body parts													
d570 Looking after one's health													
d630 Preparing meals													
Environmental factor													
e1 Products and technology		1	1							1		1	

? = concepts not addressed adequately.

COMI: Core Outcome Measures Index; **HHS:** Harris Hip Score; **HOOS:** Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-12:** 12-item Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-JR:** Hip dysfunction and Osteoarthritis Outcome Score-Joint Replacement; **HOOS-PS:** Hip dysfunction and Osteoarthritis Outcome Score -Physical function short form; **HOS:** Hip Outcome Score; **HAGOS:** Hip and Groin Outcome Score; **OHS:** Oxford Hip score; **PAQ:** Patient Administered Questionnaire; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

Table 3.4. Frequencies of items, ICF categories, and coverage of ICF linkage of specific PROMs used after hip arthroplasty.

	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Number of items	6	7	8	40	12	6	6	37	37	7	12	26	8
Number of Second/third level of activity and participation categories covered	2	4	5	18	6	4	7	12	11	2	8	13	7
Coverage of Second/third level of activity and participation %	4.1 %	8.16 %	10.2 %	36.7 %	12.2 %	8.16 %	14.3 %	24.5 %	22.4 %	4.1 %	16.3 %	26.5 %	14.3 %
Concepts not covered by activity and participation of modified ICF OA core set	1	0	0	6	2	1	0	5	7	1	2	0	3
Concepts not addressed adequately	4	1	1	8	3	1	2	7	7	1	2	2	0
Number of items with more than one concept of activity and participation	2	1	1	7	2	0	3	3	7	0	3	3	1

COMI: Core Outcome Measures Index; **HHS:** Harris Hip Score; **HOOS:** Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-12:** 12-item Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-JR:** Hip dysfunction and Osteoarthritis Outcome Score-Joint Replacement; **HOOS-PS:** Hip dysfunction and Osteoarthritis Outcome Score -Physical function short form; **HOS:** Hip Outcome Score; **HAGOS:** Hip and Groin Outcome Score; **OHS:** Oxford Hip score; **PAQ:** Patient Administered Questionnaire; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

PROMs used after hip or knee arthroplasty

The linking results of the concepts across 18 PROMs used after knee or hip arthroplasty are presented in Table 3.5, 3.6 and appendix I. Thirty-six activity and participation categories were found in the 18 PROMs, with d451:going up and down stairs, d4154:maintaining a standing position, and d4701:using private motorized transportation the most frequently used in 14, 11 and 11 PROMs respectively. However, 13 categories were not found in any PROM. These categories include: kneeling; shifting the body's centre of gravity; carrying in the hands; carrying in the arms; carrying on shoulders, and back; putting down objects; walking around obstacles; driving human-powered transportation; washing body parts; drying oneself; putting on clothes; taking off clothes; and d660:assisting others. For body function and structure, the categories of b2:sensory functions and pain, b1:mental functions and b7/s7:neuromusculoskeletal and movement-related functions/structures related to movement were used in ten, ten and nine PROMs respectively. Two environmental factors categories (e1:products and technology, e3:support and relationships) were covered in five PROMs.

Regarding the activity and participation coverage, Lower Extremity Functional Scale (LEFS) had the widest coverage (28.6%), covering 14 out of 49 categories. It was followed by Lower Limb Functional Index (LLFI) with 26.5%, covering 13 categories, and WOMAC, Lower Limb Task Questionnaire (LLTQ) and OAKHQOL (Osteoarthritis Knee and Hip Quality of Life), each having 24.5% coverage with 12 categories. The LEFS and Tubach-WOMAC covered only activities and participation, while other PROMs included at least one concept linked to body function and structure or environmental factors.

Some categories were repeatedly covered within the same PROM. For instance, d640:doing housework was covered three times in LEFS. Also, several PROM items contained

concepts linked to multiple activity and participation categories. The LLFI had the highest number of items, with seven linked to more than one category. For instance, the question in the LLFI regarding "my walking or normal recreation or sporting activity is affected" covered d4509:walking, unspecified, d9209:recreation and leisure, unspecified, d9201:sports. Conversely, all items of the Lysholm score, Marx scale, Oxford Arthroplasty Early Change Score (OACS), Oxford Arthroplasty Early Recovery Score (OARS), Whitehouse-WOMAC, Tubach-WOMAC and WOMAC-Short form covered one category only.

Thirty-seven concepts in 12 PROMs were not covered by activity and participation categories of the modified ICF OA core set, with the LLFI and OAKHQOL having the highest number of categories. Table 3.6 shows the details of activity and participation categories not covered by the OA core set. Forty concepts across 14 PROMs were inadequately addressed due to insufficient information. LLFI and OAKHQOL had the highest number of concepts inadequately addressed with six concepts, followed by WOMAC with five concepts. All items of the American Academy of Orthopedic Surgeons (AAOS) scale, Marx scale, Tubach-WOMAC contained sufficient information.

Table 3.5. Number of categories of modified ICF OA core set represented in specific PROMs used to assess outcomes after hip or knee arthroplasty.

ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Body functions and structure																		
b1 Mental functions		12	10	6		4	1				14	7	5	1		1		
b2 Sensory functions and pain						1	1		1		5	3	3	5	3	5		3
b7 Neuromusculoskeletal and movement-related functions / s7 Structures related to movement	2					1	1	1	4	1		1	1	2				
Not covered by ICF coresets for OA b1642 Time management											1							
Activity and Participation																		
d4 Mobility																		
d410 Changing basic body position																		
d4100 Lying down and getting up								1					1	1+1 ²	1+1 ²	1		
d4101 Squatting			1 ²		1 ²	1 ²	1 ²	1	1 ²									
d4102 Kneeling																		
d4103 Sitting												1 ²		1 ²		1 ²		
d4104 Standing		1	1	1				1				1 ²	1 ²	1+1 ²		1+1 ²	1	1
d4105 Bending						1	1				1			1				
d4106 Shifting the body's centre of gravity																		
d4107 Rolling over					1													
d4109 Changing basic body position, unspecified						1 ²												
d415 Maintaining a body position																		
d4150 Maintaining a lying position	1													1 ²	1 ²			
d4151 Maintaining a squatting position			1 ²		1 ²	1 ²	1 ²		1 ²									
d4152 Maintaining a kneeling position								1										
d4153 Maintaining a sitting position		1	1		1	1					2	1 ²		1 ²		1 ²		
d4154 Maintaining a standing position		1	1		1	1	1	2			2	1 ²	1 ²	1+1 ²		1 ²		
d4159 Maintaining a body position, unspecified											2 ²							
d430 Lifting and carrying objects																		
d4300 Lifting a light object/d4300 Lifting a heavy object					2 ²	1	1											
d4301 Carrying in the hands																		
d4302 Carrying in the arms																		
d4303 Carrying on shoulders, and back																		
d4305 Putting down objects																		
d4308 Lifting and carrying, other specified						1	1				1			1				
d450 Walking																		
d4500 Walking short distances					2			1										
d4501 Walking long distances		1	1	1	1	1												
d4502 Walking on different surfaces		1	1	1				1										
d4503 Walking around obstacles																		
d4508 Other specified walking	1													1		1	1	1
d4509 Walking, unspecified		1 ²				1 ²		1 ²			1 ²	2 ²	1 ²	1 ²	1 ²	1 ²		1 ²
d451 Going up stairs/ d451 Going down stairs	2	2 ²	2 ²		2	2 ²		2	2 ²		1+2 ²	2		2+2 ²	1+2 ²	1+2 ²	2	2+2 ²
d455 Moving around																		
d4551 Climbing						1												
d4553 Jumping					1			2										
d4558 Other specified moving around					1	1		2		1								
d470 Using transportation																		
d4701 Using private motorized transportation		1	1	1	1			1			1			1	1	1	1	1
d4702 Using public motorized transportation						1		1			1							
d475 Driving																		
d4750 Driving human-powered transportation																		
d4751 Driving motorized vehicles						1												
d5 Self-care																		

Chapter 3: Systematic Review and Content Analysis of PROMs

ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
d510 Washing oneself																		
d5100 Washing body parts																		
d5101 Washing whole body		1	1	1	1						1			1				
d5102 Washing oneself																		
d5109 Washing oneself, unspecified						1 [?]	1 [?]											
d530 Toileting														1			1	1
d540 Dressing						1					1							
d5400 Putting on clothes																		
d5401 Taking off clothes																		
d5402 Putting on footwear	1				1									1		1	1	1
d5403 Taking off footwear	1													1				
d6 Domestic life																		
d620 Acquisition of goods and services											1			1			1	1
d640 Doing housework		1	1	1	3	2	2				1			2	1			
d660 Assisting others																		
d7 Interpersonal interactions and relationships																		
d770 Intimate relationships											2							
d8 Major life areas																		
d850 Remunerative employment					1 [?]	1 [?]	1 [?]				1							
d855 non-remunerative employment					1 [?]	1 [?]	1 [?]											
d9 Community, social and civic life																		
d910 Community Life/ d9205 Socializing						1	1											
d920 Recreation and leisure																		
d9200 Play /d9202 Arts and culture/		1	1	1	1	1	1											
d9203 Crafts/ d9204 Hobbies																		
d9201 Sports/ d4554 Swimming		2		1	1	1				1								
d4552 Running					2			3		1								
d9209 Recreation and leisure, unspecified					1 [?]	1 [?]					1 [?]							
Not covered by modified ICF coreset for OA					1	6	4	2		1	6			2	1			
d230 Carrying out daily routine																		
d298 Other specified general tasks and demands																		
d350 Conversation																		
d4351 Kicking																		
d4450 Pulling, d4451 Pushing																		
d498 other specified mobility																		
d5204 Caring for toenails																		
d598 Other specified self-care																		
d630 Preparing meals																		
d760 Family relationships																		
d820 School education																		
Environmental factor																		
e1 Products and technology	1								1		1							
e3 Support and relationships						2	1				5							

? = concepts not addressed adequately.

AAOS: American Academy of Orthopaedic Surgeons; **FJS:** Forgotten joint scale; **MFJS:** Modified Forgotten Joint Score; **JAS:** Joint Awareness Score; **LEFS:** Lower extremity functional scale; **LLFI:** Lower Limb Functional Index; **LLFI-10:** Lower Limb Functional Index-10; **LLTQ:** Lower Limb Task Questionnaire; **OAKHQOL:** Osteoarthritis Knee and Hip Quality of Life; **OARS:** Oxford Arthroplasty Early Recovery Score; **OACS:** Oxford Arthroplasty Early Change Score; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index.

Table 3.6. Frequencies of items, ICF categories, and coverage of ICF linkage of specific PROMs used after hip or knee arthroplasty.

	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OARS	OACS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Number of items	7	12	10	6	20	25	10	20	8	4	43	14	14	24	8	12	8	11
Number of Second/third level of activity and participation categories covered	5	10	9	8	14	13	6	12	0	2	12	2	1	12	4	5	7	7
Coverage of Second/third level of activity and participation %	10.2%	20.4%	18.4%	16.3%	28.6%	26.5%	12.2%	24.5%	0%	2%	24.5%	4.1%	2%	24.5%	8.16%	10.2%	14.3%	14.3%
Concepts not covered by activity and participation of modified ICF OA core set	1	0	0	0	2	8	5	4	0	2	7	0	0	4	1	1	1	1
Concepts not addressed adequately	0	2	2	0	4	7	3	1	2	0	6	4	5	5	3	4	0	2
Number of items with more than one concept of activity and participation	2	2	1	2	3	7	4	3	0	1	3	0	0	2	1	0	0	0

AAOS: American Academy of Orthopaedic Surgeons; **FJS:** Forgotten joint scale; **MFJS:** Modified Forgotten Joint Score; **JAS:** Joint Awareness Score; **LEFS:** Lower extremity functional scale; **LLFI:** Lower Limb Functional Index; **LLFI-10:** Lower Limb Functional Index-10; **LLTQ:** Lower Limb Task Questionnaire; **OAKHQOL:** Osteoarthritis Knee and Hip Quality of Life; **OARS:** Oxford Arthroplasty Early Recovery Score; **OACS:** Oxford Arthroplasty Early Change Score; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index.

Perspective adopted and response option category

The descriptive perspective was most commonly used across PROM items, followed by the appraisal and need/dependency perspectives which were applied in 9 and 8 items respectively. Regarding the response option, intensity rating was most common and duration least common. The perspectives adopted and categorization of responses by each PROM are presented in Appendix I.

Discussion

A comprehensive review of existing PROMs used after hip or knee arthroplasty identified 50 PROMs. Our study provides detailed information regarding the content of these 50 PROMs by linking meaningful concepts to the modified ICF OA core set. These findings from content analysis offer useful guidance in selecting the appropriate PROM for different clinical and research purposes. By knowing the aspects covered by a PROM, clinicians and researchers can ensure the relevance of the PROM to their objectives. Also, this content analysis has the potential to guide the development of further instruments or modification of existing PROMs by identifying ICF categories deemed important by patients, but not adequately addressed by existing PROMs.

One key finding of this content analysis is the prominent representation of activity and participation, particularly the mobility chapter in all PROMs. This aligns with the perspective of patients, who consistently rank activity and participation as their primary concern following hip or knee arthroplasty.¹⁷ However, the covered activity and participation categories vary widely. This could explain the heterogeneity of study results using different PROMs to assess outcomes after hip or knee arthroplasty. However, there are many similarities between PROMs. For example, categories d451:going up and down stairs, d4701:using private motorized

transportation, d4104:standing, and d4154:maintaining a standing position were commonly used. Conversely, some relevant activity and participation categories were either not captured or infrequently captured across PROMs. For example, putting on clothes was not covered in any PROMs, and intimate relationships and driving were addressed in only one PROM despite their importance to patients.^{17,48} KOOS and HOOS for example did not capture aspects that have been shown as important issues for patients after hip or knee arthroplasty such as driving, interpersonal interactions and relationships, major life areas, community, and social and civic life.^{17,48}

Given that some tools (e.g. HOOS and KOOS) were not originally developed for hip or knee arthroplasty patients, modification of these PROMs based on aspects that are deemed important by patients after arthroplasty could be beneficial. On the other hand, some of the included PROMs which were specifically developed for hip or knee arthroplasty (e.g. OKS and HOOS-12) did also not address some core aspects of activity and participation.¹⁷ Therefore, clinicians and researchers aiming to fully assess these categories should prioritize PROMs that cover them. Alternatively, researchers with expertise in instrument development may choose to modify existing PROMs or develop new ones if no instruments currently address categories of interest. In addition, some PROMs with limited activity and participation coverage, such as Marx scale and OARS, focus only on specific domains. In contrast, those with broader coverage such as KOOS, 2011 KSS-A, HOOS contain items across more activity and participation components. The extent of activity and participation coverage does not indicate superiority or inferiority of PROMs. Different PROMs, whether focusing on specific or broader aspects of activity and participation, may be suitable depending on their alignments with the intended purpose.

Some PROM items cover more than one concept of activity and participation, increasing the complexity of the item which could potentially impact its interpretation from the patient's perspective.⁴⁰ For example, one item of the 2011 KSS-A, "How much does your knee bother you during hobbies (e.g. distance walking, gardening, cycling, swimming etc.)?", encompasses four distinct concepts. This complexity may pose challenges for patients in understanding and selecting an appropriate response, particularly if they experience difficulty in some activities while having no trouble with others. In addition, some wording could lead to challenges in interpreting the item, particularly the concepts that fail to distinguish between changing and maintaining body position. For example, an item in 2011 KSS concerning squatting could be interpreted as either "squatting" or "maintaining a squatting position". Another instance involves an item from PAQ-knee, "Please rate your degree of satisfaction with your ability to use your knee?", which lacks adequate information because of the term "ability to use". Therefore, PROMs containing a high number of items with multiple concepts or concepts not addressed adequately may not yield accurate results.

In terms of representation of modified ICF OA core set categories beyond activity and participation, 44 PROMs encompass concepts related to four body function and structure categories, 14 PROMs include concepts related to two environmental factors. It has been shown that these additional factors, such as pain and social support can affect activity and participation outcomes after arthroplasty.⁴⁹⁻⁵¹ However, it warrants consideration as to whether they should be incorporated in PROMs assessing activity and participation, as these components typically address distinct aspects.

As functional recovery varies across different time periods,⁵¹ the aspects considered important by patients may also shift following arthroplasty.¹⁷ An understanding of the content

covered by different PROMs enables clinicians and researchers to choose the most appropriate measure that captures relevant aspects during various stages of recovery. For example, 21 PROMs captured concepts related to higher intensity activity such as running and doing sports which may not be appropriate to use in the acute phase of recovery. On the other hand, capturing simple tasks such as changing basic body position (e.g. sitting or lying down and getting up) found in 40 PROMs, may not be appropriate at later stages of the recovery.

Although the first step in selecting an appropriate PROM is the content assessment, additional criteria such as psychometric properties and practical considerations (e.g., ease of use, accessibility) should also be considered. Therefore, PROMs that cover a broad range of relevant functional concepts while minimizing irrelevant ones, such as concepts beyond the ICF OA core set or related to impairments, increase comprehensiveness while reducing the total number of items. This approach may make them simpler to use and pose less burden on the patient. For example, while KOOS and HOOS have the highest modified ICF OA core set coverage (36.7%), they consist of 42 and 40 items, respectively. Conversely, 2011 KSS-A, LEFS, and PAQ-hip also offer high coverage (28.6%, 28.6%, and 26.5 %, respectively) with fewer items (20, 20, and 26, respectively). The PROMIS set of tools, such as PROMIS-OAK included in this review, offer item banks of generic measures applicable across different populations, and have gained popularity in recent years. One advantage of these is the implementation of computer adaptive testing algorithms based on item response theory. These algorithms utilized subjects' previous experience to strategically select the most relevant questions from an item bank, which improves the patient's experience by reducing completion time while increasing precision. As a result, they minimize response items, reduce respondent burden, and enhance content validity.⁵²

Limitation

One potential study limitation could be the possibility of not identifying all relevant PROMs. Despite conducting a comprehensive search in consultation with a health science librarian and taking additional steps to find all PROMs, we limited our search to English, French, and Persian language articles. It is possible that we have missed some PROMs published in other languages. To address this limitation, we included versions that were cross-culturally translated into English to encompass the maximum number of eligible PROMs available. However, we do not believe that this limitation significantly impacted our study results. Another limitation is that while we used the well-established ICF linking rules described by Cieza,³⁶ this method lacks standardization and has limitations, especially in describing "not definable" and "not covered" items. Thus, we did not use the subgroups of "not definable" and "not covered" (e.g. not definable general health, not covered health condition) for linking.

Conclusion

ICF-based content analysis of 50 PROMs used to evaluate outcomes after hip or knee arthroplasty revealed variability and gaps in activity and participation coverage, with few similarities observed across PROMs. Additionally, some PROM items addressed multiple concepts and used complex wording. This content analysis will help clinicians and researchers choose the most suitable PROM according to their specific objectives. It also serves as a basis for modifying or developing PROMs for use after hip or knee arthroplasty.

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Conflict of interest

The authors do not report a potential conflict of interest

References

1. Ravi B, Croxford R, Reichmann WM, et al. The changing demographics of total joint arthroplasty recipients in the United States and Ontario from 2001 to 2007. *Best Pract Res Clin Rheumatol*. 2012;26(5):637-647.
2. Jüni P, Reichenbach S, Dieppe P. Osteoarthritis: rational approach to treating the individual. *Best Pract Res Clin Rheumatol*. 2006;20(4):721-740.
3. Ethgen O, Bruyère O, Richy F, et al. Health-related quality of life in total hip and total knee arthroplasty: a qualitative and systematic review of the literature. *JBJS*. 2004;86(5):963-974.
4. Hannon CP, Goodman SM, Austin MS, et al. 2023 American College of Rheumatology and American Association of Hip and Knee Surgeons Clinical Practice Guideline for the Optimal Timing of Elective Hip or Knee Arthroplasty for Patients With Symptomatic Moderate-to-Severe Osteoarthritis or Advanced Symptomatic Osteonecrosis With Secondary Arthritis for Whom Nonoperative Therapy Is Ineffective. *Arthritis Care Res (Hoboken)*. 2023;75(11):2227-2238.
5. Halawi MJ. Outcome measures in total joint arthroplasty: current status, challenges, and future directions. *Orthopedics*. 2015;38(8):e685-e689.
6. Ashby E, Grocott MPW, Haddad FS. Outcome measures for orthopaedic interventions on the hip. *J. bone jt. surg..* 2008;90(5):545-549.
7. Wylde V, Blom AW. Assessment of outcomes after hip arthroplasty. *HIP INT*. 2009;19(1):1-7.
8. Bolink SA, Grimm B, Heyligers IC. Patient-reported outcome measures versus inertial performance-based outcome measures: a prospective study in patients undergoing primary total knee arthroplasty. *The Knee*. 2015;22(6):618-23.
9. Deshpande PR, Rajan S, Sudeepthi BL, et al. Patient-reported outcomes: a new era in clinical research. *Perspect Clin Res..* 2011;2(4):137.
10. Bellamy N, Kirwan J, Boers M, et al. Recommendations for a core set of outcome measures for future phase III clinical trials in knee, hip, and hand osteoarthritis. Consensus development at OMERACT III. *J Rheumatol*. 1997;24(4):799–802.
11. Trujols J, Portella MJ, Iraurgi I, et al. Patient-reported outcome measures: Are they patient-generated, patient-centred or patient-valued? *J Ment Health*. 2013;22(6):555-562.
12. for Drug HSFC, for Biologics HSFC, for Devices HSFC, Health R. Guidance for industry: patient-reported outcome measures: use in medical product development to support labeling claims: draft guidance. *Health Quali. Life Outcomes*. 2006;4:79.
13. Singh JA, Dowsey MM, Dohm M, et al. Achieving consensus on total joint replacement trial outcome reporting using the OMERACT filter: endorsement of the final core domain set for total

- hip and total knee replacement trials for endstage arthritis. *Journal Rheumatol.* 2017;44(11):1723-1726.
14. MacDermid JC. ICF Linking and cognitive interviewing are complementary methods for optimizing content validity of outcome measures: an integrated methods review. *Front. Rehabil. Sci.* 2021;2:702596.
 15. Terwee CB, Bot SD, de Boer MR, et al. Quality criteria were proposed for measurement properties of health status questionnaires. *J Clin. Epidemiol.* 2007;60(1):34-42.
 16. Alviar MJ, Olver JH, Brand C, et al. Do patient-reported outcome measures used in assessing outcomes in rehabilitation after hip and knee arthroplasty capture issues relevant to patients? Results of a systematic review and ICF linking process. *J. Rehab Med.* 2011;43(5):374-381.
 17. Rastogi R, Davis AM, Chesworth BM. A cross-sectional look at patient concerns in the first six weeks following primary total knee arthroplasty. *Health Qual Life Outcomes.* 2007;5(1):48.
 18. Rauch A, Cieza A, Stucki G. How to apply the International Classification of Functioning, Disability and Health (ICF) for rehabilitation management in clinical practice. *Eur J Phys Rehabil Med* 2008;44(3):329-342.
 19. Organization WH. World Health Organization international classification of functioning, disability and health. *Geneva: World Health Organization.* Published online 2001.
 20. Yen TH, Liou TH, Chang KH, et al. Systematic review of ICF core set from 2001 to 2012. *Disabil. Rehabil.* 2014;36(3):177-184.
 21. Cieza A, Ewert T, Ustun TB, et al. Development of ICF Core Sets for patients with chronic conditions. *J Rehabil Med.* 2004;44:9-11.
 22. Dreinhofer K, Stucki G, Ewert T, et al. ICF Core Sets for osteoarthritis. *J Rehabil Med.* 2004;(44):75-80.
 23. Alviar MJ, Olver JH, Brand C, et al. Do patient-reported outcome measures used in assessing outcomes in rehabilitation after hip and knee arthroplasty capture issues relevant to patients? Results of a systematic review and ICF linking process. *J Rehabil Med.* 2011;43(5):374-381.
 24. Pisoni C, Giardini A, Majani G, et al. International Classification of Functioning, Disability and Health (ICF) core sets for osteoarthritis. A useful tool in the follow-up of patients after joint arthroplasty. *Eur J Phys Rehabil Med.* 2008;44(4):377-385.
 25. Benner JL, Noten S, Limsakul C, et al. Outcomes in adults with cerebral palsy: systematic review using the International Classification of Functioning, Disability and Health. *Dev Med Child Neurol.* 2019;61(10):1153-1161.

26. Higgins JP, Thomas J, Chandler J, et al. Cochrane handbook for systematic reviews of interventions. John Wiley & Sons; 2019.
27. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *J Clin Epidemiol*. 2009;62(10):e1-e34.
28. Cooke A, Smith D, Booth A. Beyond PICO: the SPIDER tool for qualitative evidence synthesis. *Qual Health Res*. 2012;22(10):1435-1443.
29. Lützner C, Postler AE, Druschke D, et al. Ask Patients What They Expect! A Survey Among Patients Awaiting Total Hip Arthroplasty in Germany. *J Arthroplasty*. 2022;37(8):1594-1601.e4.
30. Lange T, Schmitt J, Kopkow C, et al. What do patients expect from total knee arthroplasty? A Delphi consensus study on patient treatment goals. *J. Arthroplasty*. 2017;32(7):2093-2099.
31. Lange T, Schmitt J, Kopkow C, et al. What do patients expect from total knee arthroplasty? A Delphi consensus study on patient treatment goals. *J. Arthroplasty*. 2017;32(7):2093-2099.
32. Beaulé PE, Dorey FJ, Hoke R, et al. The value of patient activity level in the outcome of total hip arthroplasty. *J. Arthroplasty*. 2006;21(4):547-552.
33. Collins NJ, Roos EM. Patient-reported outcomes for total hip and knee arthroplasty: commonly used instruments and attributes of a “good” measure. *Clin. Geriatr. Med.*. 2012;28(3):367-394.
34. Riddle DL, Stratford PW, Singh JA, et al. Variation in outcome measures in hip and knee arthroplasty clinical trials: a proposed approach to achieving consensus. *J. Rheumatol*. 2009;36(9):2050-2056.
35. Stucki G. ICF linking rules: an update based on lessons learned. *J rehabil med*. 2005;37(4):212-218.
36. Cieza A, Fayed N, Bickenbach J, et al. Refinements of the ICF Linking Rules to strengthen their potential for establishing comparability of health information. *Disabil. Rehabil*. 2019;41(5):574-583.
37. Bossmann T, Kirchberger I, Glaessel A, et al. Validation of the comprehensive ICF core set for osteoarthritis: the perspective of physical therapists. *Physiotherapy*. 2011;97(1):3-16.
38. Xie F, Lo N, Lee H, et al. Validation of the International Classification of Functioning, Disability, and Health (ICF) Brief Core Set for osteoarthritis. *Scand. J. Rheumatol.*. 2008;37(6):450-461.
39. Kurtaiş Y, Öztuna D, Küçükdeveci AA, et al. Reliability, construct validity and measurement potential of the ICF comprehensive core set for osteoarthritis. *BMC Musculoskelet Disord*. 2011;12(1):255.

40. Karimijashni M, Westby M, Ramsay T, Beaulé PE, Poitras S. Development and content validation of a questionnaire identifying patients' functional priorities and abilities after hip or knee arthroplasty. *Disabil Rehabil*. 2024 Aug 16:1-5.
41. Prinsen CA, Mokkink LB, Bouter LM, et al. COSMIN guideline for systematic reviews of patient-reported outcome measures. *Qual Life Res*. 2018;27(5):1147-1157.
42. Terwee CB, Jansma EP, Riphagen II, et al. Development of a methodological PubMed search filter for finding studies on measurement properties of measurement instruments. *Qual Life Res*. 2009;18(8):1115-1123.
43. Zotero | Your personal research assistant. Accessed October 15, 2022. <https://www.zotero.org/>
44. Covidence - Better systematic review management. Covidence. Accessed October 15, 2022. <https://www.covidence.org/>
45. Cieza A, Brockow T, Ewert T, et al. Linking health-status measurements to the international classification of functioning, disability and health. *J Rehabil Med*. 2002;34(5):205-210.
46. ICF e-learning. Accessed February 5, 2024. <https://www.icf-elearning.com/>
47. Geyh S, Cieza A, Kollerits B, et al. Content comparison of health-related quality of life measures used in stroke based on the international classification of functioning, disability and health (ICF): a systematic review. *Qual Life Res*. 2007;16:833-851.
48. Weiss JM, Noble PC, Conditt MA, et al. What functional activities are important to patients with knee replacements? *Clin. Orthop. Relat. Res. (1976-2007)*. 2002;404:172-188.
49. Jette DU, Hunter SJ, Burkett L, et al. Physical therapist management of total knee arthroplasty. *Phys. ther.* 2020;100(9):1603-1631.
50. Harmelink KE, Zeegers AV, Hullegie W, et al. Are there prognostic factors for one-year outcome after total knee arthroplasty? A systematic review. *J. Arthroplasty*. 2017;32(12):3840-3853.
51. Wieczorek M, Rotonda C, Guillemin F, et al. What have we learned about the course of clinical outcomes after total knee or hip arthroplasty?. *Arthritis Care Res*. 2020 Nov;72(11):1519-29.
52. Khalil LS, Darrith B, Franovic S, et al. Patient-reported outcomes measurement information system (PROMIS) global health short forms demonstrate responsiveness in patients undergoing knee arthroplasty. *J. arthroplasty*. 2020;35(6):1540-4.

Appendices

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Appendix G. Excluded tools with reasons

Appendix H. Characteristics of the included Specific PROM

Appendix I. Tool assessment based on ICF linking rules.

Outcome measures used after knee arthroplasty Characteristics of the included Specific PROMs

1. Core Outcome Measures Index (COMI)-Knee
2. Hospital for Special Surgery Patellar score (HSSP)
3. International Knee Documentation Committee (IKDC)
4. Knee Outcome Survey Activities of Daily Living Scale (KOS-ADLS)
5. 2011 Knee Society Score (2011 KSS)
 - 5.1 Adjusted 2011 KSS (2011 KSS-A)
 - 5.2 Knee Society Score- Short-form (KSS-S)
6. Knee Injury and Osteoarthritis Outcome Score (KOOS)
 - 6.1 12-item short forms Knee Injury and Osteoarthritis Outcome Score (KOOS-12)
 - 6.2 Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form (KOOS-PS)
 - 6.3 Knee Injury and Osteoarthritis Outcome Score Joint Replacement (KOOS-JR)
7. Kujala Anterior Knee Pain Scale (AKPS)
8. Lille Score
9. Oxford knee score (OKS)
10. Oxford knee score—activity and participation (OKS-APQ)
11. Patient Administered Questionnaire (PAQ)- Knee
12. Patient's Knee Implant Performance Questionnaire (PKIP)
13. Patient-Reported Outcomes Measurement Information System (PROMIS) R-Plus-Osteoarthritis of the Knee (OAK)
14. WOMAC-Total knee arthroplasty function short forms

Outcome measures used after hip arthroplasty

1. Core Outcome Measures Index (COMI)-hip
2. Self-reported Harris hip score
 - 2.1 Modified Harris hip score

3. Hip dysfunction and Osteoarthritis Outcome Score (HOOS)
 - 3.1 HOOS-12
 - 3.2 HOOS-PS
 - 3.3 HOOS-JR
4. Hip Outcome Score (HOS)
5. Hip and Groin Outcome Score (HAGOS)
6. Mayo Hip Score
7. Oxford Hip score (OHS)
8. Patient Administered Questionnaire (PAQ)-Hip
9. WOMAC-Total hip arthroplasty function short forms

Outcome measures used after hip or knee arthroplasty

1. American Academy of Orthopaedic Surgeons (AAOS) Hip and Knee Core Scale (Hip and Knee Outcomes Questionnaire or MODEMS (Musculoskeletal Outcomes Data Evaluation and Management System) Hip/Knee Core scale)
2. Forgotten Joint Score (FJS)
 - 2.1 Modified Forgotten Joint Score (MFJS)
 - 2.2 Joint Awareness Score (JAS)
3. Lower extremity functional scale (LEFS)
4. Lower Limb Functional Index (LLFI)
 - 4.1 Lower Limb Functional Index-10 (LLFI-10)
5. Lower Limb Task Questionnaire (LLTQ)
6. Lysholm score
7. Marx Activity Rating Scale
8. Osteoarthritis Knee and Hip Quality of Life (OAKHQOL)
9. Oxford Arthroplasty Early Recovery Score (OARS)
10. Oxford Arthroplasty Early Change Score (OACS)
11. Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)
 - 11.1 Hirsch-WOMAC
 - 11.2 Whitehouse-WOMAC
 - 11.3 Tubach-WOMAC
 - 11.6 WOMAC short form

Appendix A. Modified ICF core set for OA for patients undergoing hip or knee arthroplasty

Activity and Participation component (ICF code/category title) - 39 third level categories +7 second level categories - 49 third and second level categories	Body functions and structure component (ICF code/category title) - 4 first level categories	Environmental factor component (ICF code/category title) - 5 first level categories
d4 Mobility (First level chapter)	b1 Mental functions (First level chapter)	e1 Products and technology (First level chapter)
d410 Changing basic body position (Second-level category) (Third-level category) d4100 Lying down and getting up d4101 Squatting d4102 Kneeling d4103 Sitting d4104 Standing d4105 Bending d4106 Shifting the body's centre of gravity d4107 Rolling over (8 third level) <i>d4108 Other specified changing basic body position</i> <i>d4109 Changing basic body position, unspecified</i>	b2 Sensory functions and pain	e2 Natural environment and human-made changes to environment
	b7 Neuromusculoskeletal and movement-related functions	e3 Support and relationships
	s7 Structures related to movement	e4 Attitudes
d415 Maintaining a body position (Second-level category) (Third-level category) d4150 Maintaining a lying position d4151 Maintaining a squatting position d4152 Maintaining a kneeling position d4153 Maintaining a sitting position d4154 Maintaining a standing position (5 third level) <i>d4158 Maintaining a body position, other specified</i> <i>d4159 Maintaining a body position, unspecified</i>		e5 Services, systems and policies

d430 Lifting and carrying objects (<u>Second-level category</u>) (Third-level category) d4300 Lifting a light object d4300 Lifting a heavy object d4301 Carrying in the hands d4302 Carrying in the arms d4303 Carrying on shoulders and back d4305 Putting down objects (6 third level) <i>d4308 Lifting and carrying, other specified</i> <i>d4309 Lifting and carrying, unspecified</i> d450 Walking (<u>Second-level category</u>) (Third-level category) d4500 Walking short distances d4501 Walking long distances d4502 Walking on different surfaces d4503 Walking around obstacles (4 third level) <i>d4508 Other specified walking</i> <i>d4509 Walking, unspecified</i> d451 Going up stairs d451 Going down stairs (2 second level) d455 Moving around (<u>Second-level category</u>) (Third-level category) d4551 Climbing d4553 Jumping (2 third level) <i>d4558 Other specified moving around</i> <i>d4559 Moving around, unspecified</i>		
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d470 Using transportation (Second-level category) (Third-level category) d4701 Using private motorized transportation d4702 Using public motorized transportation <i>(2 third level)</i> <i>d4708 Other specified using transportation</i> <i>d4709 Using transportation, unspecified</i> d475 Driving (Second-level category) (Third-level category) d4750 Driving human-powered transportation d4751 Driving motorized vehicles <i>(2 third level)</i> <i>d4758 Other specified driving</i> <i>d4759 Driving, unspecified</i> d5 Self-care (First level chapter) d510 Washing oneself (Second-level category) (Third-level category) d5100 Washing body parts d5101 Washing whole body d5102 Drying oneself <i>(3 third level)</i> <i>d5108 Other specified washing oneself</i> <i>d5109 Washing oneself, unspecified</i> d530 Toileting (Second-level category) <i>(1 second level)</i> d540 Dressing (Second-level category) (Third-level category) d5400 Putting on clothes d5401 Taking off clothes		
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d5402 Putting on footwear d5403 Taking off footwear <i>(4 third level)</i> <i>d5408 Other specified dressing</i> <i>d5409 Dressing, unspecified</i>		
d6 Domestic life		
d620 Acquisition of goods and services (<u>Second-level category</u>) <i>(1 second level)</i> d640 Doing housework (<u>Second-level category</u>) <i>(1 second level)</i> d660 Assisting others (<u>Second-level category</u>) <i>(1 second level)</i>		
d7 Interpersonal interactions and relationships		
d770 Intimate relationships (<u>Second-level category</u>) <i>(1 second level)</i>		
d8 Major life areas		
d850 Remunerative employment (<u>Second-level category</u>) <i>(1 second level)</i> d855 Non-remunerative employment (<u>Second-level category</u>) <i>(1 second level)</i>		
d9 Community, social and civic life		
d910 Community Life(<u>Second-level category</u>) / d9205 Socializing (<u>Third-level category</u>) <i>(1 third/second level)</i> d920 Recreation and leisure (<u>Second-level category</u>)		

(Third-level category) d9200 Play d9204 Hobbies /d9203 Crafts / d9202 Arts and culture d9201 Sports/ d4554 Swimming d4552 Running (3 third level) <i>d9208 Other specified recreation and leisure</i> <i>d9209 Recreation and leisure, unspecified</i>		
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Appendix B. Search Strategies

Ovid Medline

- 1 arthroplasty, replacement, hip/ or arthroplasty, replacement, knee/
- 2 hip prosthesis/ or knee prosthesis/
- 3 (knee* adj3 (replace* or implant* or arthroplast* or prosth*)) .ti,ab,kf.
- 4 (hip* adj3 (replace* or implant* or arthroplast* or prosth* or resurfac*)) .ti,ab,kf.
- 5 or/1-4
- 6 physical performance measure* .ti,ab,kf.
- 7 (objective adj3 (test* or instrument* or measure* or method* or evaluation* or disability or function or assessment*)) .ti,ab,kf.
- 8 Gait Analysis/
- 9 (gait adj3 (analys* or evaluation)) .ti,ab,kf.
- 10 ((performance or performance-based or performance based or observational or observational-based) adj3 (test* or measure* or instrument* or method* or index or indices or assessment* or evaluation* or analys*)) .ti,ab,kf.
- 11 (Observed adj3 (disability or function)) .ti,ab,kf.
- 12 Walk Test/
- 13 (walk* adj3 test*) .ti,ab,kf.
- 14 "Task Performance and Analysis"/
- 15 or/6-14
- 16 (physical function* or physical activity or physical activities or physical performance* or functional activity or functional activities or functional performance* or performance* or function* or activity limitation* or functional limitation* or disability or disabilities) .ti,ab,kf.
- 17 exp physical functional performance/
- 18 "Activities of Daily Living"/
- 19 Motor Activity/
- 20 or/16-19
- 21 15 and 20
- 22 Patient Reported Outcome Measures/
- 23 Patient Outcome Assessment/
- 24 patient outcome assessment* .ti,ab,kf.
- 25 (patient centred outcome* or patient centered outcome*) .ti,ab,kf.

- 26 patient reported outcome*.ti,ab,kf.
- 27 (Health and (index* or indices or profile* or status)).ti,ab,kf.
- 28 ((patient or self or carer or proxy) and (report or reported or reporting or rated or rating or ratings or based or assessed or assessment or assessments)).ti,ab,kf.
- 29 (PROMS or PROM).ti,ab,kf.
- 30 (((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) and (outcome or outcomes or instrument or instruments or measure or measures or questionnaire or questionnaires or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab,kf.
- 31 or/22-30
- 32 21 or 31
- 33 instrumentation.fs.
- 34 Validation Study.pt.
- 35 exp reproducibility of results/
- 36 reproducib*.ti,ab.
- 37 exp psychometrics/
- 38 (psychometr* or clinimetr* or clinometr*).ti,ab.
- 39 exp observer variation/
- 40 observer variation.ti,ab.
- 41 exp discriminant analysis/
- 42 (reliab* or valid* or coefficient or internal consistency).ti,ab.
- 43 (cronbach* and (alpha or alphas)).ti,ab.
- 44 (item correlation? or item selection? or item reduction?).ti,ab.
- 45 (agreement or precision or imprecision or precise values).ti,ab,kf.
- 46 test-retest.ti,ab.
- 47 (test and retest).ti,ab.
- 48 (reliab* and (test or retest)).ti,ab.
- 49 (stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intra-observer or intertechnician or intertechnician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or inter-assay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa* or coefficient of variation).ti,ab.

- 50 repeatab*.ti,ab,kf.
- 51 ((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab,kf.
- 52 (generaliza* or generalisa* or concordance).ti,ab.
- 53 (intraclass and correlation*).ti,ab.
- 54 (discriminative or known group or factor analysis or factor analyses or factor structure* or dimensionality or subscale* or multitrait scaling analys* or item discriminant or interscale correlation or interscale correlations).ti,ab.
- 55 ((error or errors) and (measure* or correlat* or evaluat* or accuracy or accurate or precision or mean)).ti,ab.
- 56 (individual variability or interval variability or rate variability or variability analysis).ti,ab.
- 57 (uncertainty and (measurement or measuring)).ti,ab.
- 58 (standard error of measurement or sensitiv* or responsive*).ti,ab.
- 59 (limit and detection).ti,ab.
- 60 (minimal detectable concentration or interpretab*).ti,ab.
- 61 (small* and (real or detectable) and (change or difference)).ti,ab.
- 62 (meaningful change or minimal important change or minimal important difference or minimally important change or minimally important difference or minimal detectable change or minimal detectable difference or minimally detectable change or minimally detectable difference or minimal real difference or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.
- 63 or/33-62
- 64 5 and 32 and 63
- 65 (address or biography or comment or directory or editorial or festschrift or lecture or legal case or legislation or letter or news or congress or consensus development conference or consensus development conference, nih or review or systematic review or scientific integrity review).pt.
- 66 64 not 65
- 67 exp animals/ not exp humans/
- 68 66 not 67
- 69 65 or 67
- 70 64 not 69

Embase

- 1 hip replacement/ or hip arthroplasty/ or total hip replacement/
- 2 knee replacement/ or knee arthroplasty/ or total knee arthroplasty/
- 3 hip prosthesis/ or knee prosthesis/
- 4 (knee* adj3 (replace* or implant* or arthroplast* or prosth*)).ti,ab,kw.
- 5 (hip* adj3 (replace* or implant* or arthroplast* or prosth* or resurfac*)).ti,ab,kw.
- 6 or/1-5
- 7 physical performance measure*.ti,ab,kw.
- 8 (objective adj3 (test*or instrument* or measure* or method* or evaluation* or disability or function or assessment*)).ti,ab,kw.
- 9 Gait Analysis/
- 10 (gait adj3 (analys* or evaluation)).ti,ab,kw.
- 11 ((performance or performance-based or performance based or observational or observational-based) adj3 (test* or measure* or instrument* or method* or index or indices or assessment* or evaluation* or analys*)).ti,ab,kw.
- 12 (Observed adj3 (disability or function)).ti,ab,kw.
- 13 exp walk test/
- 14 (walk* adj3 test*).ti,ab,kw.
- 15 "Task Performance and Analysis"/
- 16 or/7-15
- 17 (physical function* or physical activity or physical activities or physical performance* or functional activity or functional activities or functional performance* or performance* or function* or activity limitation* or functional limitation* or disability or disabilities).ti,ab,kw.
- 18 exp physical performance/
- 19 daily life activity/
- 20 motor activity/
- 21 or/17-20
- 22 16 and 21
- 23 exp patient-reported outcome/
- 24 patient outcome assessment/
- 25 patient outcome assessment*.ti,ab,kw.
- 26 (patient centred outcome* or patient centered outcome*).ti,ab,kw.

- 27 patient reported outcome*.ti,ab,kw.
- 28 (Health and (index* or indices or profile* or status)).ti,ab,kw.
- 29 ((patient or self or carer or proxy) and (report or reported or reporting or rated or rating or ratings or based or assessed or assessment or assessments)).ti,ab,kw.
- 30 (PROMS or PROM).ti,ab,kw.
- 31 (((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) and (outcome or outcomes or instrument or instruments or measure or measures or questionnaire or questionnaires or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab,kw.
- 32 or/23-31
- 33 22 or 32
- 34 exp validation study/
- 35 exp reproducibility/
- 36 reproducib*.ti,ab.
- 37 exp psychometry/
- 38 (psychometr or clinimetr* or clinometr*).ti,ab.
- 39 exp observer variation/
- 40 observer variation.ti,ab.
- 41 exp discriminant analysis/
- 42 (reliab* or valid* or coefficient or internal consistency).ti,ab.
- 43 (cronbach* and (alpha or alphas)).ti,ab.
- 44 (item correlation or item correlations or item selection or item selections or item reduction or item reductions).ti,ab.
- 45 (agreement or precision or imprecision or precise values).ti,ab,kw.
- 46 test-retest.ti,ab.
- 47 (test and retest).ti,ab.
- 48 (reliab* and (test or retest)).ti,ab.
- 49 (stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intra-observer or intertechnician or intertechnician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or inter-assay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa* or coefficient of variation).ti,ab.

- 50 repeatab*.ti,ab,kw.
- 51 ((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab,kw.
- 52 (generaliza* or generalisa* or concordance).ti,ab.
- 53 (intraclass and correlation*).ti,ab.
- 54 (discriminative or known group or factor analysis or factor analyses or factor structure* or dimensionality or subscale* or multitrait scaling analys* or item discriminant or interscale correlation or interscale correlations).ti,ab.
- 55 ((error or errors) and (measure* or correlat* or evaluat* or accuracy or accurate or precision or mean)).ti,ab.
- 56 (individual variability or interval variability or rate variability or variability analysis).ti,ab.
48935
- 57 (uncertainty and (measurement or measuring)).ti,ab.
- 58 (standard error of measurement or sensitiv* or responsive*).ti,ab.
- 59 (limit and detection).ti,ab.
- 60 (minimal detectable concentration or interpretab*).ti,ab.
- 61 (small* and (real or detectable) and (change or difference)).ti,ab.
- 62 (meaningful change or minimal important change or minimal important difference or minimally important change or minimally important difference or minimal detectable change or minimal detectable difference or minimally detectable change or minimally detectable difference or minimal real difference or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.
- 63 or/34-62
- 64 6 and 33 and 63
- 65 (Conference Abstract or Conference Review or Editorial or Erratum or Letter or Note or review).pt.
- 66 64 not 65
- 67 exp animal/ not exp human/
- 68 66 not 67

Cochrane Central Register of Controlled Trials

- 1 arthroplasty, replacement, hip/ or arthroplasty, replacement, knee/
- 2 hip prosthesis/ or knee prosthesis/
- 3 (knee* adj3 (replace* or implant* or arthroplast* or prosth*)).ti,ab.

- 4 (hip* adj3 (replace* or implant* or arthroplast* or prosth* or resurfac*)).ti,ab.
- 5 or/1-4
- 6 physical performance measure*.ti,ab.
- 7 (objective adj3 (test*or instrument* or measure* or method* or evaluation* or disability or function or assessment*)).ti,ab.
- 8 (Observed adj3 (disability or function)).ti,ab.
- 9 gait analysis/
- 10 (gait adj3 (analys* or evaluation)).ti,ab.
- 11 ((performance or performance-based or performance based or observational or observational-based) adj3 (test* or measure* or instrument* or method* or index or indices or assessment* or evaluation* or analys*)).ti,ab.
- 12 Walk Test/
- 13 (walk* adj3 test*).ti,ab.
- 14 "Task Performance and Analysis"/
- 15 or/6-14
- 16 (physical function* or physical activity or physical activities or physical performance* or functional activity or functional activities or functional performance* or performance* or function* or activity limitation* or functional limitation* or disability or disabilities).ti,ab.
- 17 exp physical functional performance/
- 18 "Activities of Daily Living"/
- 19 motor activity/
- 20 or/16-19
- 21 15 and 20
- 22 patient reported outcome measures/
- 23 Patient Outcome Assessment/
- 24 patient outcome assessment*.ti,ab.
- 25 (patient centred outcome* or patient centered outcome*).ti,ab.
- 26 patient reported outcome*.ti,ab.
- 27 (Health and (index* or indices or profile* or status)).ti,ab.
- 28 ((patient or self or carer or proxy) adj3 (report* or apprais* or rate* or rating* or based or assessed or assessment* or evaluate or response*)).ti,ab.
- 29 (PROMS or PROM).ti,ab.

- 30 ((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) and (outcome or outcomes or instrument or instruments or measure or measures or questionnaire or questionnaires or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab.
- 31 or/22-30
- 32 21 or 31
- 33 instrumentation.fs.
- 34 validation studies as topic/
- 35 exp "reproducibility of results"/
- 36 reproducib*.ti,ab.
- 37 psychometrics/
- 38 (psychometr or clinimetr* or clinometr*).ti,ab.
- 39 observer variation/
- 40 observer variation.ti,ab.
- 41 Discriminant Analysis/
- 42 (reliab* or valid* or coefficient or internal consistency).ti,ab.
- 43 (cronbach* and (alpha or alphas)).ti,ab.
- 44 (item correlation? or item selection? or item reduction?).ti,ab.
- 45 (agreement or precision or imprecision or precise values).ti,ab.
- 46 test-retest.ti,ab.
- 47 (test and retest).ti,ab.
- 48 (reliab* and (test or retest)).ti,ab.
- 49 (stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intra-observer or intertechnician or intertechnician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or inter-assay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa* or coefficient of variation).ti,ab.
- 50 repeatab*.ti,ab.
- 51 ((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab.
- 52 (generaliza* or generalisa* or concordance).ti,ab.
- 53 (intraclass and correlation*).ti,ab.

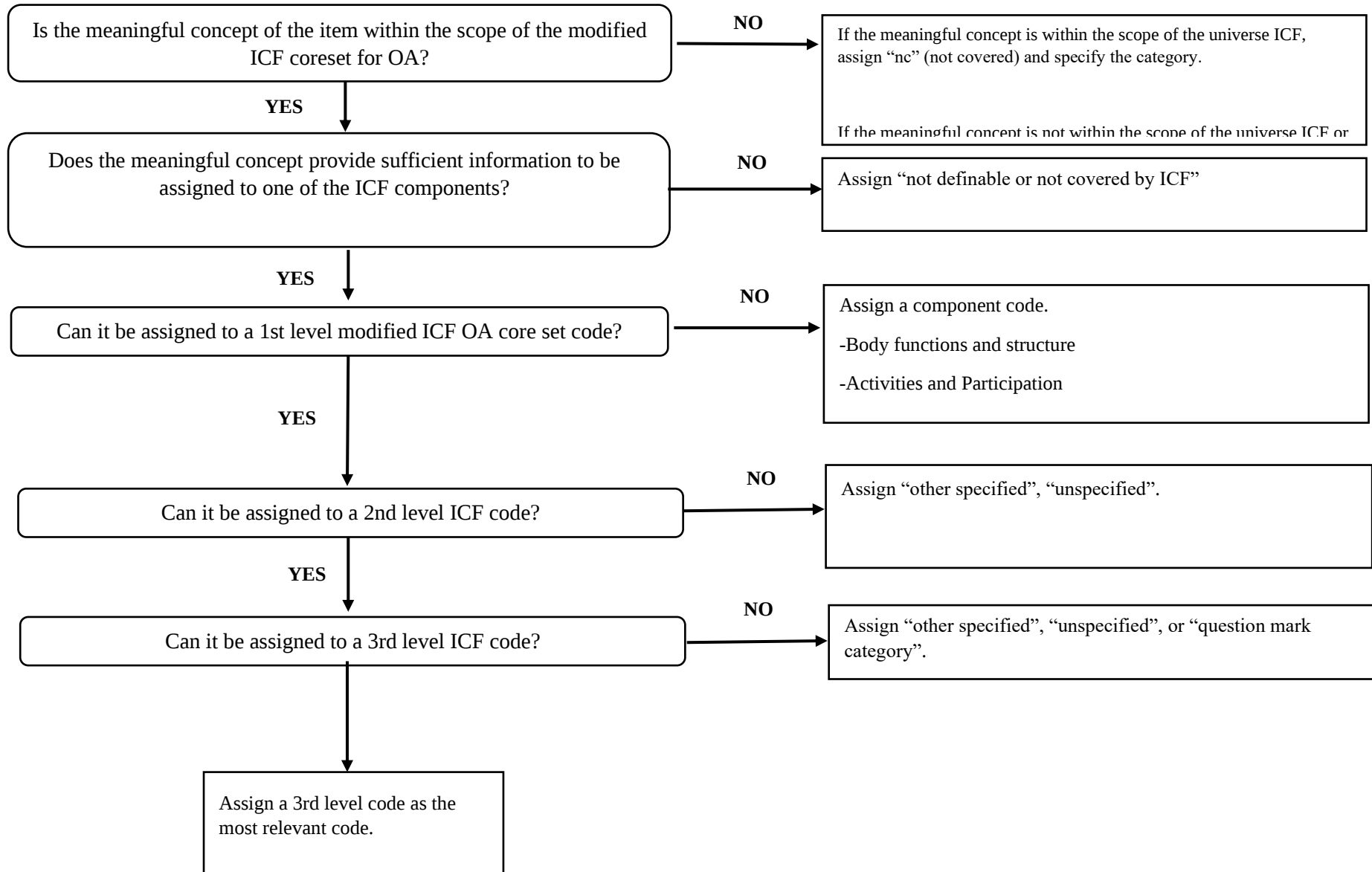
- 54 (discriminative or known group or factor analysis or factor analyses or factor structure* or dimensionality or subscale* or multitrait scaling analys* or item discriminant or interscale correlation or interscale correlations).ti,ab.
- 55 ((error or errors) and (measure* or correlat* or evaluat* or accuracy or accurate or precision or mean)).ti,ab.
- 56 (individual variability or interval variability or rate variability or variability analysis).ti,ab.
- 57 (uncertainty and (measurement or measuring)).ti,ab.
- 58 (standard error of measurement or sensitiv* or responsive*).ti,ab.
- 59 (limit and detection).ti,ab.
- 60 (minimal detectable concentration or interpretab*).ti,ab.
- 61 (small* and (real or detectable) and (change or difference)).ti,ab.
- 62 (meaningful change or minimal important change or minimal important difference or minimally important change or minimally important difference or minimal detectable change or minimal detectable difference or minimally detectable change or minimally detectable difference or minimal real difference or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.
- 63 or/33-62
- 64 5 and 32 and 63
- 65 (address or biography or comment or directory or editorial or festschrift or lecture or legal case or legislation or letter or news or congress or consensus development conference or consensus development conference, nih or review or systematic review or scientific integrity review).pt.
- 66 64 not 65
- 67 exp animals/ not exp humans/
- 68 66 not 67

Appendix C. Refined ICF Linking Rules with examples.

Rule	Example
1 Before undertaking the task of linking meaningful concepts with ICF categories, ensure a solid understanding of the conceptual and taxonomical fundamentals of the ICF. Familiarize yourself with the chapters, domains, and categories within the detailed classification, including their definitions.	
2 Determine the intended purpose of the information by asking questions such as "What is the focus of this piece of information?" or "What does this item entail?". These answers will guide in identifying the primary concept(s) most pertinent to be linked to the ICF.	
3 Identify any supplementary concepts present in the information alongside the main concept(s) already recognized in the previous step. If a measure item encompasses multiple concepts, each concept must be linked individually.	For example, in item 8 of the SF-36 'During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)', the concept 'pain', 'work outside the home' and 'housework' are linked to b280 sensation of pain, d859 work and employment, other specified and unspecified and d640 doing housework respectively.
4 Determine the perspective taken on within a certain piece of information when linking it to the ICF.	
5 Identify and document the categorization of response options if they pertain to concepts other than those contained in the corresponding item.	For example, in the item 'self-care' of the EQ-5D, which contains the response categories 'I have no problems with self-care', 'I have some problems washing or dressing myself' and 'I am unable to wash or dress myself', not only 'self-care' but also the concepts 'washing myself' and 'dressing myself' are linked.
6 Link all meaningful concepts, the most relevant and additional ones, to the most precise ICF category.	"Play cards and other games." (West Haven-Yale Multidimensional Pain Inventory, Item C4) -Main concept: Play cards and other games -Most precise ICF category: d9200 Play
7 Use "other specified" or "unspecified" ICF categories as deemed appropriate.	For example, in the item 'usual activities (e.g., work, study, housework family or leisure activities)' of the EQ-5D, the concepts 'work', 'study', 'housework' 'family' or 'leisure activities' are linked to the corresponding 'unspecified' -ICF categories in addition to the linkage of the concept 'usual activities'. E.g., work is linked to the ICF category d8509 remunerative employment, unspecified.
"other specified" is to be used when the concept does not align with any of the other specific categories within the corresponding level of a chapter. . "unspecified" is used when the concept to be linked fits within a given chapter, but there is inadequate information to assign it to a specific ICF category	

- | | | |
|------------------|--|--|
| <p>8</p> | <p>If the information provided by the meaningful concept is insufficient to determine the most precise ICF category, assign the concept to "nd" (not definable).</p> <ul style="list-style-type: none"> - Concepts referring to health in general, physical health or mental (emotional) health in general, are assigned <i>nd-gh</i> (not definable-general health), <i>nd-ph</i> (not definable-physical health) or <i>nd-mh</i> (not definable-mental health) respectively, as well as to disability in general (<i>nd-dis</i>), functioning (<i>nd-func</i>), or a child's development (<i>nd-dev</i>). | <p>Unspecified concepts, such as "functional status," "health," "disability," or "symptoms" were considered indefinable for linking.</p> |
| <p>9</p> | <p>If the meaningful concept is not included in the ICF but clearly represents a personal factor, such as sex, gender, or education as defined in the ICF, assign the concept to "pf" (personal factors).</p> | |
| <p>10</p> | <p>If the meaningful concept is not contained in the ICF, assign this concept to nc (not covered)</p> <ul style="list-style-type: none"> - Meaningful concepts referring to a diagnosis or health condition are assigned to nc-hc (not covered-health condition). - Meaningful concepts referring to the quality of life or life, in general, are assigned nc-qol (not covered-quality of life) | |

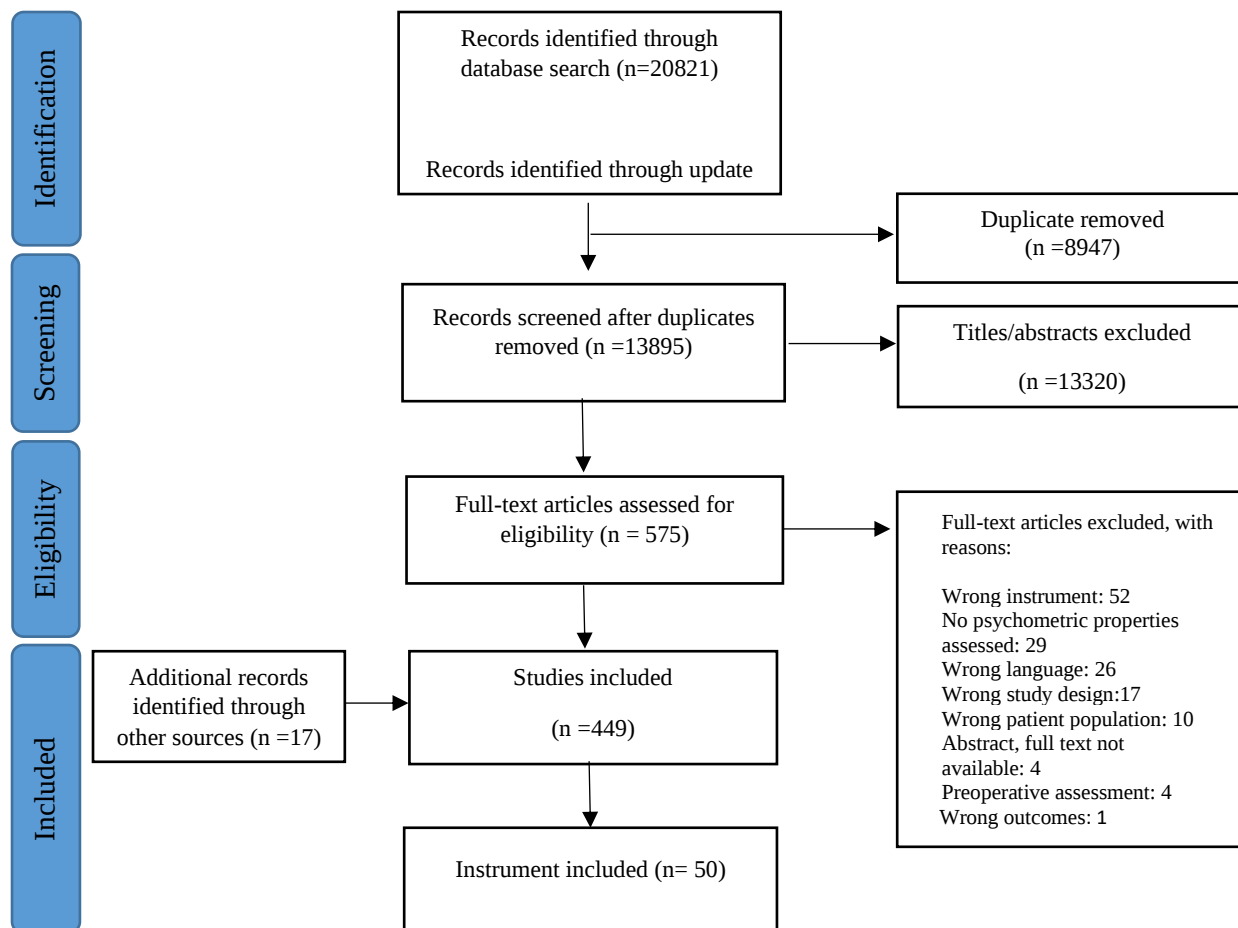
Appendix D. ICF Linking decision tree



Appendix E. Definition of concepts that could not be linked to categories of modified OA ICF core set.

Category		Description	Example
Concepts not covered by OA core set	<i>Other specified</i>	Concepts linked to the first level category of the core set but not represented by a third level category	"Walking on flat surfaces" is an example of "other specified" concept that could not be linked to the third-level category.
	<i>Covered beyond OA core set</i>	concepts linked to a category beyond the core set	"Cooking" is an example of the not covered concept that can be linked to d630 (Preparing meals) that is beyond the coreset (d630 Preparing meals).
Concepts not addressed adequately	<i>Unspecified</i>	Concepts linked to the first level category but lacking sufficient information to link them to a third level category	Recreational activities" is an example of the unspecified category due to insufficient information
	<i>Not definable or covered by ICF</i>	Concepts that were too vague or not covered by the ICF	"Quality of life" is an example of not definable concept
	<i>Question mark</i>	Concepts linked to several categories of the core set	"Standing" is an example of question mark concept as it can include both changing and maintaining a standing position

Appendix F. PRISMA Flowchart of study screening and selection



Appendix G. Excluded tools with reasons.

	Excluded tool	Reason
1	Knee Surgery Perception Questionnaire (KSPQ)	It was developed to assess the discrepancy between patient-desired outcomes and achievable functional outcomes- its aim is not the scope of this review
2	Hungerford score	It is clinician-assessed
3	Bristol score	It is clinician-assessed
4	Japanese Orthopaedic Association (JOA)	It is clinician-assessed
5	Harris hip score (HHS)	It is clinician-assessed
6	Feller scores	It is clinician-assessed
7	New Multi-disciplinary Rehabilitation Outcome Checklist” (MROC) Scale	It is not a patient-reported outcome measure
8	1989 Knee Society Score (KSS) Or American Knee Society score (AKSS)	The majority of the items are objective assessed.
9	Tegner activity scale	Single item questionnaire
10	Global Rating Score of Knee Function	Single item questionnaire
11	MSK functional limitations index	Single item questionnaire
12	Patient Joint Perception (PJP)	Single item questionnaire
13	Single Assessment Numeric Evaluation (SANE)	Single item questionnaire
14	Modified single assessment numerical evaluation (M-SANE)	Single item questionnaire
15	The University of California at Los Angeles (UCLA) activity scale	Single item questionnaire
16	Lower-Extremity Activity Scale (LEAS)	Single item questionnaire
17	Subjective hip value	Single item questionnaire
18	Work, Osteoarthritis or joint-Replacement Questionnaire (WORQ)	It focuses on subgroups of patients (patients who had knee-related issues after surgery and worked (or wanted to)) and is not applicable to whole population.
19	high-flexion knee score (HFKS)	It focuses on subgroups of patients (patients with expectations of high function and high flexion) and is not applicable to whole population.
20	Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire (JHEQ)	It focuses on subgroups of patients (includes questions related to common Asian-lifestyle movements, such as using a squatting pan toilet or getting up from the floor) and is not applicable to whole population.
21	Functional hip score	It focuses on subgroups of patients (younger, high-demand adult patient) and is not applicable to whole population.
22	High-Activity Arthroplasty Score (HAAS)	It focuses on subgroups of patients (patients with high physical demands) and is not applicable to whole population.
23	Activity Scale for Arthroplasty Patients (ASAP)	It focuses on subgroups of patients (high-activity patients) and is not applicable to whole population.
24	Korean Knee score (KKS)	It focuses on subgroups of patients (patients demanding high knee flexion) and is not applicable to whole population.
25	Work, Osteoarthritis or joint-Replacement Questionnaire (WORQ)	It is a work activity-related questionnaire and is not applicable to whole population.
26	Knee Patient-Specific Index (KPSI)	The questionnaire is not available
27	Staffelstein Score (ST-score)	The English version of the questionnaire is not available
28	Modified Staffelstein-Score (MSS)	The English version of the questionnaire is not validated.
29	Daily Activity Questionnaire	Its score is not elaborated with details.
30	Kingsbury questionnaire	It does not resulted in a numerical value, either continuous, categorical/ordinal or dichotomous.

31	THAOQ (Total Hip Arthroplasty Outcome Questionnaire)	In articles before 2007
32	McKnee	In articles before 2007
33	British Orthopedic association score	In articles before 2007
34	Patient-Specific Index (PASI)	In articles before 2007
35	Pain and function of the hip (PFH)	In articles before 2007
36	Hip-rating questionnaire	In articles before 2007
37	functional milestone scale	In articles before 2007
38	short musculoskeletal function assessment	In articles before 2007
39	Lequesne scores	In articles before 2007
40	The McMaster-Toronto Arthritis Patient Preference Disability Questionnaire (MACTAR)	In articles before 2007
41	Lower Exiremity Activity Profile (LEAP)	In articles before 2007
42	The Arthritis Impact Measurement Scale (AIMS)	In articles before 2007
43	Shortened version of the Arthritis Impact Measurement Scales (sAIMS)	In articles before 2007
44	Influence of Rheumatic Diseases on Health and Lifestyle (IRGL) questionnaire- a Dutch version of the AIMS	In articles before 2007
45	Charnley hip score	In articles before 2007-clinicians assessed.
46	Judet and Judet score	In articles before 2007
47	MODEMS (Musculoskeletal Outcomes Data Evaluation and Management System) Hip/Knee Core scale	In articles before 2007
48	Functional Status Index (FSI)	In articles before 2007
49	FAS (Functional Assessment System of lower extremity dysfunction)	In articles before 2007
50	Waugh index	In articles before 2007
51	Merle d'Aubigné and Postel score	In articles with wrong population.
52	Pain Disability Questionnaire (PDQ)	Generic- It was not developed specifically for patients with lower extremity problems
53	The Index of Well-Being	Generic- It was not developed specifically for patients with lower extremity problems
54	The Health Assessment Questionnaire	Generic- It was not developed specifically for patients with lower extremity problems
55	Sickness Impact Profile	Generic- It was not developed specifically for patients with lower extremity problems
56	the Functional Status Questionnaire (FSQ)	Generic- It was not developed specifically for patients with lower extremity problems
57	The Modified Health Assessment Questionnaire (MHAQ)	Generic- It was not developed specifically for patients with lower extremity problems
58	London Handicap Scale	Generic- It was not developed specifically for patients with lower extremity problems
59	Canadian Occupational Performance Measure (COPM)	Generic- It was not developed specifically for patients with lower extremity problems
60	Musculoskeletal Health Questionnaire (MSK-HQ)	Generic- It was not developed specifically for patients with lower extremity problems
61	Community Healthy Activities Model Program for Seniors (CHAMPS)	Generic- It was not developed specifically for patients with lower extremity problems
62	The Short Questionnaire to Assess Health-enhancing physical activity (SQUASH)	Generic- It was not developed specifically for patients with lower extremity problems
63	Patient-Specific Functional Scale	Generic- It was not developed specifically for patients with lower extremity problems

64	Disability Rating Index	Generic- It was not developed specifically for patients with lower extremity problems
65	International Physical Activity Questionnaire	Generic- It was not developed specifically for patients with lower extremity problems
66	Functional Independence Measure (FIM)	Generic- It was not developed specifically for patients with lower extremity problems
67	Physical Activity Scale for the Elderly (PASE) questionnaire	Generic- It was not developed specifically for patients with lower extremity problems

Appendix I. Characteristics of the included Specific PROMs

Instrument / Abbreviation/ Development year	Items/ Dimensions	Score Interpretation (Number of items and response options)	Development target population
Outcome measure tools used after knee arthroplasty			
Core Outcome Measures Index-Knee/ COMI-Knee/2016	6 items/5 domains Pain, function, symptom-specific wellbeing, quality of life, and disability	Total score ranges between 0-10. Higher score indicates worse knee status.	Patients underwent TKA
Hospital for Special Surgery Patellar score/ HSSP/2006	<i>Objective</i> 3 items/3 domains Tenderness (1 item), Crepitus (1 items), Quadriceps strength (1 items) <i>Subjective</i> 7 items/5 domains Pain (1 items), Function (3 items),	Total score ranges between 0-100. Lower score indicates worse knee status.	Patients underwent TKA
International Knee Documentation Committee/ IKDC/2001	19 items/ 3 domains Symptoms (7 items), Function (2 items), Sports activities (2 items, one item has nine subscales)	Total score ranges between 0-100. Lower score indicates worse functioning or highest level of symptoms.	Patients with a variety of knee conditions, including ligament and meniscal injuries, articular cartilage lesions, and patellofemoral pain
Knee Outcome Survey Activities of Daily Living Scale/ KOS- ADLS/1998	14 items/ 2 domains Symptoms (6 items), Functional limitation (8 items)	Maximum score is 70 points, which can be converted to a 0–100% scale. Lower score indicates worse functioning or higher level of symptoms.	Patients with various pathological disorders of the knee, including ligamentous and meniscal injuries, patellofemoral pain, and osteoarthritis
2011 Knee Society Score/ 2011 KSS/ 2011	<i>Objective component:</i> Seven items <i>Subjective component:</i> 34 items, 4 domains Symptom (three items) Patient-satisfaction (five items) Patient expectations (three items) Functional activities (19 items): <i>Subscales:</i> 1) walking & Standing (5 item) 2) standard activities (6 items) 3)advanced activities (5 items) 4) discretionary activities (3 items)	<i>Objective component:</i> 100 points <i>Subjective component:</i> Symptom score (0-25 points) Satisfaction score (0-40 points) Expectation score (0-15 points) Functional activity score (0-100 points). 1) walking & Standing (30 points) 2) standard activities (30 points) 3)advanced activities (25 points) 4) discretionary activities (15 points) <i>Symptom score:</i> Higher score indicates worse status.	Patients underwent TKA

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		<i>Other scores:</i> Lower score indicates worse knee status.	
Adjusted 2011 KSS/ 2011 KSS-A/2016	<i>Objective component:</i> Seven items <i>Subjective component:</i> 20 items/ 3 domains Symptom (3 items) Patient-satisfaction (4 items) Patient expectations (2 items) Functional activities (11 items): <i>Subscales:</i> 1) walking & Standing (3 items) 2) standard activities (4 items) 3)advanced activities (4 items)	<i>Subjective component:</i> Symptom Score (0-25 points) Satisfaction score (0-32 points) Expectation score (0-10 points) Functional activity score (0-70 points). 1) walking & Standing (30 points) 2) standard activities (20 points) 3)advanced activities (20 points) <i>Symptom score:</i> Higher score indicates worse status. <i>Other scores:</i> Lower score indicates worse knee status.	Patients underwent TKA
Short-form Knee Society Score/ Short-form KSS/2016	<i>Subjective component:</i> 10 items/ 3 domains Symptom (3 items) Patient-satisfaction (1 items) Functional activities (8 items): <i>Subscales:</i> 1) walking & Standing (1 item) 2) standard/advanced activities (4 items) 4) discretionary activities (1 items)	<i>Subjective component:</i> Symptom Score (0-25 points) Satisfaction score (0-8 points) Functional activity score (0-100 points). 1) walking & Standing (20 points) 2) standard/advanced activities (65 points) 4) discretionary activities (15 points) <i>Symptom score:</i> Higher score indicates worse status. <i>Other scores:</i> Lower score indicates worse knee status.	Patients scheduled to undergo TKA or underwent TKA
Knee Injury and Osteoarthritis Outcome Score/ KOOS/1998	42 items/ 5 domains Pain (9 items), symptoms (4 items), activities of ADL (17 items), sport/rec (5 items), Knee-related QoL items (4 items)	Score of each item ranges from 0 (severe problems) to 4 (no problems). Each subscale is converted to 0 to 100 points. Each subscale is converted to 0 to 100 points, with 0 indicating extreme knee problems, and 100 indicating no knee problems.	Anterior cruciate ligament injury, meniscus injury, or post- traumatic osteoarthritis.
12-item short forms Knee Injury and Osteoarthritis Outcome Score/ KOOS-12/2019	12 items/ 3 domains Pain (4 items), activities of ADL (4 items), Knee-related QoL items (4 items)	Score of each item ranges from 0 (severe problems) to 4 (no problems). Each subscale is converted to 0 to 100 points, with 0 indicating extreme knee	Patients underwent THA or TKA

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		problems, and 100 indicating no knee problems.	
Knee Injury and Osteoarthritis Outcome Score Physical function Short form / KOOS-PS /2008	7 items/ 1 domains activities of ADL (7 items)	Score of each item ranges from 0 (severe problems) to 4 (no problems). Each subscale is converted to 0 to 100 points, with 0 indicating extreme knee problems, and 100 indicating no knee problems.	Patients with varying degrees of OA, from community samples to TKA candidates
Knee Injury and Osteoarthritis Outcome Score Joint Replacement / KOOS-JR /2016	7 items/ 3 domains Pain (4 items), symptoms (1 items), activities of ADL (2 items)	Score of each item ranges between 0 (severe problems)- 4 (no problems). Each subscale is scored from 0 to 100 points. Lower score indicates extreme knee problems.	Patient underwent TKA
Kujala Anterior Knee Pain Scale/ AKPS /1993	13 items/ 2 domains Symptoms Functional limitations	Total score ranges between 0-100. Lower score indicates worse knee status.	Individuals with anterior knee pain, patellar subluxation, and patellar dislocation
Lille Score/1999	12 items/ 3 domains Symptoms Function Quality of life	The score ranges between 0-100. Lower score indicates worse knee status.	Individuals with patello-femoral instability
Oxford knee score/ OXS /1998	12 items/ 2 domains Pain Function	Each item is scored from 0 to 4. Total score ranges between 0-48. Lower score indicates worse knee status.	Patients underwent TKA
Oxford knee score—activity and participation/ OXS-APQ /2014 (Complement OXS, it was not intended as a stand-alone instrument)	8 items/ 1 domain Activity and participation	Each item is scored from 0 to 4. Total score ranges between 0-32. Lower score indicates a decreased level of activity and participation.	Patients scheduled to undergo TKA or UKA or underwent TKA or UKA
Patient Administered Questionnaire-Knee/ PAQ- Knee /2012	29 items/ 4 domain Pain, function, psychological wellbeing, and satisfaction	Total score ranges between 0-100. (Sum up 18 out of the 29 questions) Lower score indicates worse knee status.	Patients with osteoarthritis or underwent TKA
Patient's Knee Implant Performance Questionnaire/ PKIP /2014 (Could be a complementary tool)	24 items/ 4 domains Stability, confidence, activity modification, satisfaction.	5-, 6-, or 11-point ordinal response scales. Total score ranges between 0-100. Lower score indicates worse outcomes or patient-perceived functioning.	Patients underwent TKA

Patient-Reported Outcomes Measurement Information System (PROMIS) R-Plus-Osteoarthritis of the Knee/ OAK /2018	76 Items/ 14 domains Anger, Anxiety, Depression, Life satisfaction, Fatigue, Pain intensity, Pain interference, Physical function, Sleep disturbance, Symptoms, Ability to participate in social roles and activities, Independence, Satisfaction with social roles and activities, Social isolation	4- or 5-point ordinal response scales. Lower score indicates worse patient status.	Patient with knee osteoarthritis or underwent TKA
WOMAC-Total knee arthroplasty function short forms/2013	8 items/ 1 domain Function	Each item is scored from 0 to 4. Total score ranges between 0- 100. Higher score indicates worse physical function	Patients underwent TKA
Outcome measure tools used after hip arthroplasty			
Core Outcome Measures Index-Knee/ COMI-Hip /2013	6 items/ 5 domains Pain, function, symptom-specific wellbeing, quality of life, and disability	Total score ranges between 0-10. Higher score indicates worse hip status.	Patients underwent THA
Self-reported Harris Hip score/Self-reported HHS /2001	7 items/ 4 domains Pain, Symptom, use of walking support, function	Total score ranges between 0-100. Lower score indicates worse hip status.	Patients underwent THA
Modified Harris score/ HHS /2005	8 items/3 domains Pain, Function-Gait, Functional Activities	Total score ranges between 0-100. Lower score indicates high pain and worse function.	Patients underwent hip arthroscopy
Hip dysfunction and Osteoarthritis Outcome Score/ HOOS /2003	40 items/ 5 domains Pain (10 items), symptoms (5 items), activities of ADL (17 items), sport/rec (4 items), Knee-related QoL items (4 items)	Score of each item ranges between 0 (severe problems) - 4 (no problems). Each subscale is converted to 0 to 100 points, with 0 indicating extreme hip problems, and 100 indicating no hip problems.	Patients with hip disability with or without hip OA.
12-item Hip dysfunction and Osteoarthritis Outcome Score/ HOOS-12 /2019	12 items/ 3 domains Pain (4 items), activities of ADL (4 items), Knee-related QoL items (4 items)	The score of each item ranges between 0 (severe problems) - 4 (no problems). Each subscale is converted to 0 to 100 points, with 0 indicating extreme hip problems, and 100 indicating no hip problems.	Patients underwent THA or TKA
Hip dysfunction and Osteoarthritis Outcome Score Physical function short form/ HOOS-PS /2008	6 items/ 1 domains ADL (1 item)	The score of each item ranges between 0 (severe problems) - 4 (no problems). Each subscale is converted to 0 to 100 points, with 0 indicating extreme hip	Patients with varying degrees of OA from community to THA candidates.

		problems, and 100 indicating no hip problems.	
Hip dysfunction and Osteoarthritis Outcome Score Joint Replacement/ HOOS-JR /2016	6 items/ 2 domains Pain (2 items), activities of ADL (4 items)	The score of each item ranges between 0 (severe problems) - 4 (no problems). Each subscale is converted to 0 to 100 points, with 0 indicating extreme hip problems, and 100 indicating no hip problems.	Patients underwent THA
Hip Outcome Score/ HOS /2006	26 items/ 2 domains ADL (17 items), Sport (9 items)	Each subscale ranges between 0 –100 Lower score indicates worse function.	Individuals with acetabular tears
Hip and Groin Outcome Score/ HAGOS /2011	37 items/ 6 domains Symptoms (7 items), Pain (10 items), ADL (5 items), Sport and recreation (8 items), Participation in physical activities (2 items), QoL (5 items).	The score of each item ranges from 0 (severe problems) to 4 (no problems). Total score ranges from 0 –100 Lower score indicates worse hip problem.	Patients with hip and/or groin disability
Mayo Hip Score/1985	7 items/ 3 domains Pain, Function, Hip mobility	Total score ranges from 0 –80 Lower score indicates worse hip problem.	Patients underwent revision of THA
Oxford Hip score/ OHS /1996	12 items/ 2 domains Pain Function	Each item is scored from 0 to 4. Total score ranges from 0 to 48. Lower score indicates worse hip status	Patients underwent THA
Patient Administered Questionnaire-Hip/ PAQ-Hip /2012	26 items/ 4 domain Pain, function, psychological wellbeing, and satisfaction	Total score ranges from 0 to 100. (Sum up 17 out of the 29 questions) Lower score indicates worse hip status.	Patient with osteoarthritis or underwent THA
WOMAC-Total hip arthroplasty function short forms/2013	8 items/ 1 domain Function	Each item is scored from 0 to 4. Total score ranges from 0 to 100 points. Higher score indicates worse physical function	Patients underwent THA
Outcome measure tools used after hip or knee arthroplasty			
American Academy of Orthopaedic Surgeons (AAOS) Hip and Knee Core Scale/ Hip and Knee Outcomes Questionnaire/2004	7 items/ 3 domain Pain (7 items), function (2 items), symptoms (2 items)	Total score ranges between 0 to 100. Lower score indicates poor outcome/worse health	Patient with hip or knee disorder
Forgotten Joint Score/ FJS /2012	12 items/1 domain Patients' ability to forget replaced joint during the activities of daily living	Each item is scored from 0 to 5. Total score ranges between 0-100. Lower score indicate worse condition.	Patient underwent THA and TKA

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Modified Forgotten Joint Score/ MFJS /2018	10 items/ 1 domain Patients' ability to forget replaced joint during the activities of daily living	Each item is scored from 0 to 5. Total score ranges between 0-100. Lower score indicate worse condition.	Patient underwent THA and TKA
Joint Awareness Score/ JAS /2023	10 items/ 1 domain Patients' ability to forget replaced joint during the activities of daily living	Each item is scored from 0 to 5. Total score ranges between 0-100. Lower score indicate worse condition.	Patient underwent TKA
Lower extremity functional scale/ LEFS /1999	20 items/ 1 domain Function	Each item is scored from 0 to 4. Total score ranges between 0-80. Lower score indicate worse physical function.	Patient with any lower-extremity musculoskeletal condition
Lower Limb Functional Index/ LLFI /2012	25 items/ 1 domain Various aspect of ADL	Total score ranges between 0-100. Lower score indicates worse lower limb function.	Patients with lower-limb conditions
Lower Limb Functional Index-10/ LLFI-10 /2016	10 items/one domain Various aspect of ADL	Total score ranges between 0-100. Lower score indicates worse lower limb function.	Patients with lower-limb conditions
Lower Limb Task Questionnaire/ LLTQ /2007	20 items/ 2 domains ADL, Sport/rec	Each item is scored from 0 to 05. Total score for each domain (ADL, and Sport/rec) ranges from 0 to 40. Lower score indicates more difficulty performing the given task (e.g., walking for 10min, getting in and out of a car)	Patients with experience of a lower-limb injury
Lysholm score/ 1982	8 items/ 8 domains limp, locking, pain, stair-climbing, support, instability, swelling, and squatting	Total score ranges between 0-100. Lower score indicates lower limb function.	Patients with knee ligament injury
Marx Activity Rating Scale/2001	4 items/ one domain Four activities: running, cutting, deceleration, and pivoting	Total score ranges between 0-16, which report the frequency of the activities performed in the healthiest state.	Patients with knee disorder
Osteoarthritis Knee and Hip Quality of Life/ OAKHQOL /2005	43 items/ 5 domains Physical activity, mental health, pain, social support, and social functioning.	Each item is scored from 0 to 10. Total score ranges between 0-100. Lower score indicates worse quality of life.	Patients with hip or knee OA
Oxford Arthroplasty Early Recovery Score/ OARS /2020	14 items/ 4 domains Pain. Nausea and feeling unwell, Fatigue and sleep, function and mobility	Total score ranges between 0-100. Lower score indicates worse patient status.	Patients underwent THA and TKA

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Oxford Arthroplasty Early Change Score/ OACS /2020	14 items/ 4 domains Pain, effects of healthcare on outcomes, fatigue and sleep, function and mobility	Total score ranges between -50 to 50 (0 indicates preoperative status). Lower score indicates worse patient status.	Patients underwent THA and TKA
Western Ontario and McMaster Universities Osteoarthritis Index/ WOMAC /1988	24 items/ 3 domain pain (five items), stiffness (two items), and physical function (17 items)	Each item is scored from 0 to 4. The score can be reported as a subscale score (which is preferred method) as follows: function: 0 to 68; pain: 0-20; stiffness: 0-8. The score can also be reported as a total score ranges between 0-100. Higher score indicates worse pain, stiffness, and physical function	Patients with osteoarthritis of the hip or knee.
Hirsch-Western Ontario and McMaster Universities Osteoarthritis Index/ Hirsch-WOMAC /2000	8 items/ 2 domain Pain (3 items), Physical function (5 items)	Each item is scored from 0 to 4. Total score ranges between 0-32. Higher score indicates worse pain, and physical function	Patients underwent THA and TKA
Whitehouse- Western Ontario and McMaster Universities Osteoarthritis Index/ Whitehouse-WOMAC /2003	12 items/ 2 domain Pain (5 items), Physical function (7 items)	Each item is scored from 0 to 4. Total score ranges between 0-48. Higher score indicates worse pain, and physical function	Patients underwent THA and TKA
Tubach-Western Ontario and McMaster Universities Osteoarthritis Index/ Tubach -WOMAC /2005	8 items/ 1 domain Physical function (8 items)	Each item is scored from 0 to 4. Total score ranges between 0-32. Higher score indicates worse physical function	Patients with osteoarthritis of the hip or knee.
WOMAC short form/2011	11 items / 2 domains Pain (3 items), function (8 items).	Each item is scored from 0 to 4. Total score ranges between 0-100. Higher score indicates worse pain, stiffness, and physical function	Patients underwent THA

ADL: Activities of Daily Living; **OA:** Osteoarthritis; **QoL:** Quality of Life; **THA:** Total Hip Arthroplasty; **TKA:** Total Knee Arthroplasty; **UKA:** Unicompartmental Knee Arthroplasty

Appendix I. Tool assessment based on ICF linking rules.**Outcome measure tools used after TKA****1. Core Outcome Measures Index-Knee (COMI-Knee)**

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
1	How severe was your knee pain in the last week?	NA	b2 Sensory functions and pain	Numeric scale from 0 (no pain) to 10 (worst pain that I can imagine)	Intensity
2	During the past week, how much did your knee problem interfere with your normal work (including both work outside the home and housework)?	Descriptive	<i>nc or nd</i> [?] <i>d850 Remunerative employment OR</i> <i>d855 Non-remunerative employment</i> [?] <i>d640 Doing housework</i>	Not at all, A little bit, Moderately Quite a bit, Extremely	Intensity
3	If you had to spend the rest of your life with the symptoms you have right now, how would you feel about it?	NA	b1 Mental functions	Very satisfied, Somewhat satisfied Neither satisfied nor dissatisfied Somewhat dissatisfied, Very dissatisfied	Intensity
4	Please reflect on the last week. How would you rate your quality of life?	NA	<i>nc or nd</i> [?]	Very good, Good, Moderate, Bad Very bad	Intensity
5	During the last 4 weeks, how many days did you cut down on the things you usually do (work, housework, school, recreational activities) because of your knee problem?	Descriptive	<i>d850 Remunerative employment OR</i> <i>d855 Non-remunerative employment</i> [?] <i>d640 Doing housework</i> <i>nc (d820 School education)</i> <i>d9209 Recreation and leisure,</i> <i>unspecified</i> [?]	None, Between 1 and 7 days Between 8 and 14 days, Between 15 and 21 days, More than 21 days	Frequency
6	During the last 4 weeks, how many days did your knee problem keep you from going to work (job, school, housework)?	Descriptive	<i>d850 Remunerative employment OR</i> <i>d855 Non-remunerative employment</i> [?] <i>nc (d820 School education)</i> <i>d640 Doing housework</i>	None, Between 1 and 7 days, Between 8 and 14 days, Between 15 and 21 days, More than 21 days	Frequency

nc: not covered; **nd:** not definable; **?:** concepts not addressed adequately.

2. *Hospital for Special Surgery Patellar (HSSP) score*

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
SUBJECTIVE					
Anterior knee pain					
	How do you rate the pain on the front of your knee while rising from this low chair?	NA	b2 Sensory functions and pain d4104 Standing	VAS score 0–10	Intensity
Functional limitations					
Do you feel that the anterior part of your knee is limiting you while:					
	Climbing stairs	Descriptive	d451 Going up stairs	No functional limitations Limitation in one function Limitation in two functions Limitation in all functions	Intensity
	Descending stairs	Descriptive	d451 Going down stairs	No functional limitations Limitation in one function Limitation in two functions Limitation in all functions	Intensity
	Sitting for prolonged time (30 minutes at 90°)	Descriptive	d4153 Maintaining a sitting position	No functional limitations Limitation in one function Limitation in two functions Limitation in all functions	Intensity
OBJECTIVE					
	Tenderness (Palpation of medial and/or lateral patellar retinaculum-facet)			Absent Present	
	Creptus (during active ROM)			None Mild (for a limited ROM) Moderate (throughout entire ROM) Severe (catching/clunk)	
	Quadriceps strength			Normal Reduced Deficient	

3. International Knee Documentation Committee (IKDC)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
	Symptoms				
	Grade symptoms at the highest activity level at which you think you could function without significant symptoms, even if you are not actually performing activities at this level.				
1	What is the highest level of activity that you can perform without significant knee pain?	Descriptive	b2 Sensory functions and pain d4553 Jumping d4558 Other specified moving around <i>nc or nd</i> ? d9201 Sports d4552 Running <i>d4509 Walking, unspecified</i> ? d640 Doing housework	4- Very strenuous activities like jumping or pivoting as in basketball or soccer 3- Strenuous activities like heavy physical work, skiing or tennis 2- Moderate activities like moderate physical work, running or jogging 1- Light activities like walking, housework or yard work 0- Unable to perform any of the above activities due to knee pain	Intensity
2	During the past 4 weeks, or since your injury, how often have you had pain?	NA	b2 Sensory functions and pain	a number between “0, Constant “and “10, never”	Frequency
3	If you have pain, how severe is it?	NA	b2 Sensory functions and pain	a number between “0, Not at all “and “10, Extremely”	Intensity
4	During the past 4 weeks, or since your injury, how stiff or swollen was your knee?	NA	b7 Neuromusculoskeletal and movement-related functions s7 Structures related to movement	Not at all- Mildly- Moderately- Very- Extremely	Intensity
5	What is the highest level of activity you can perform without significant swelling in your knee?	Descriptive	s7 Structures related to movement d4553 Jumping d4558 Other specified moving around <i>nc or nd</i> ? d9201 Sports d4552 Running <i>d4509 Walking, unspecified</i> ? d640 Doing housework	4- Very strenuous activities like jumping or pivoting as in basketball or soccer 3- Strenuous activities like heavy physical work, skiing or tennis 2- Moderate activities like moderate physical work, running or jogging 1- Light activities like walking, housework, or yard work 0- Unable to perform any of the above activities due to knee swelling	Intensity
6	During the past 4 weeks, or since your injury, did your knee lock or catch?	NA	b7 Neuromusculoskeletal and movement-related functions	Yes No	Confirmation or agreement

7	What is the highest level of activity you can perform without significant giving way in your knee?	Descriptive	b7 Neuromusculoskeletal and movement-related functions d4553 Jumping d4558 Other specified moving around <i>nc or nd</i> ? d9201 Sports d4552 Running <i>d4509 Walking, unspecified</i> ? d640 Doing housework	4- Very strenuous activities like jumping or pivoting as in basketball or soccer 3-Strenuous activities like heavy physical work, skiing or tennis 2-Moderate activities like moderate physical work, running or jogging 1-Light activities like walking, housework or yard work 0-Unable to perform any of the above activities due to giving way of the knee	Intensity
Sport activities					
8	What is the highest level of activity you can participate in on a regular basis?	Descriptive	d4553 Jumping d4558 Other specified moving around <i>nc or nd</i> ? d9201 Sports d4552 Running <i>d4509 Walking, unspecified</i> ? d640 Doing housework	4-Very strenuous activities like jumping or pivoting as in basketball or soccer 3-Strenuous activities like heavy physical work, skiing or tennis 2-Moderate activities like moderate physical work, running or jogging 1-Light activities like walking, housework or yard work 0- Unable to perform any of the above activities	Intensity
9	How does your knee affect your ability to:				
a	Go up stairs	Descriptive	d451 Going up stairs	Not difficult at all, Minimally difficult, Moderately Difficult, Extremely difficult, Unable to do	Intensity
b	Go down stairs	Descriptive	d451 Going down stairs	Not difficult at all, Minimally difficult, Moderately Difficult, Extremely difficult, Unable to do	Intensity
c	Kneel on the front of your knee	Descriptive	<i>d4102 Kneeling OR d4152 Maintaining a kneeling position?</i>	Not difficult at all, Minimally difficult, Moderately Difficult, Extremely difficult, Unable to do	Intensity
d	Squat	Descriptive	<i>d4101 Squatting OR d4151 Maintaining a squatting position?</i>	Not difficult at all, Minimally difficult, Moderately Difficult, Extremely difficult, Unable to do	Intensity
e	Sit with your knee bent	Descriptive	<i>d4103 Sitting OR d4153 Maintaining a sitting position?</i>	Not difficult at all, Minimally difficult, Moderately Difficult, Extremely difficult, Unable to do	Intensity
f	Rise from a chair	Descriptive	d4104 Standing	Not difficult at all, Minimally difficult, Moderately Difficult, Extremely difficult, Unable to do	Intensity

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g	Run straight ahead	Descriptive	d4552 Running	Not difficult at all, Minimally difficult, Moderately Difficult, Extremely difficult, Unable to do	Intensity
h	Jump and land on your involved leg	Descriptive	d4553 Jumping	Not difficult at all, Minimally difficult, Moderately Difficult, Extremely difficult, Unable to do	Intensity
i	Stop and start quickly	NA	b7 Neuromusculoskeletal and movement-related functions	Not difficult at all, Minimally difficult, Moderately Difficult, Extremely difficult, Unable to do	Intensity
Function					
10	How would you rate the function of your knee on a scale of 0 to 10 with 10 being normal, excellent function and 0 being the inability to perform any of your usual daily activities which may include sports? Function prior to your knee injury Current function of your knee	Appraisal	nc (d230 Carrying out daily routine) d9201 Sports	a number between “0, Couldn’t perform daily activities “ and “10, No limitation in daily activities”	Intensity

nc: not covered; **nd:** not definable; **?:** concepts not addressed adequately.

4. Knee Outcome Survey Activities of Daily Living Scale (KOS-ADLS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Symptoms					
1	To what degree does pain in your knee affect your daily activity level?	Descriptive	b2 Sensory functions and pain nc (d230 Carrying out daily routine)	5. I never have pain in my knee. 4. I have pain in my knee, but it does not affect my daily activity. 3. Pain affects my activity slightly. 2. Pain affects my activity moderately. 1. Pain affects my activity severely. 0. Pain in my knee prevents me from performing all daily activities.	Intensity
2	To what degree does grinding or grating of your knee affect your daily activity level?	Descriptive	b7 Neuromusculoskeletal and movement-related functions nc (d230 Carrying out daily routine)	5. I never have grinding or grating in my knee. 4. I have grinding or grating in my knee, but it does not affect my daily activity. 3. Grinding or grating affects my activity slightly. 2. Grinding or grating affects my activity moderately. 1. Grinding or grating affects my activity severely. 0. Grinding or grating in my knee prevents me from performing all daily activities.	Intensity
3	To what degree does stiffness in your knee affect your daily activity level?	Descriptive	b7 Neuromusculoskeletal and movement-related functions nc (d230 Carrying out daily routine)	5. I never have stiffness in my knee. 4. I have stiffness in my knee, but it does not affect my daily activity. 3. Stiffness affects my activity slightly. 2. Stiffness affects my activity moderately. 1. Stiffness affects my activity severely. 0. Stiffness in my knee prevents me from performing all daily activities.	Intensity
4	To what degree does swelling in your knee affect your daily activity level?	Descriptive	s7 Structures related to movement nc (d230 Carrying out daily routine)	5. I never have swelling in my knee. 4. I have swelling in my knee, but it does not affect my daily activity. 3. Swelling affects my activity slightly. 2. Swelling affects my activity moderately. 1. Swelling affects my activity severely. 0. Swelling in my knee prevents me from performing all daily activities.	Intensity
5	To what degree does slipping of your knee affect your daily activity level?	Descriptive	b7 Neuromusculoskeletal and movement-related functions nc (d230 Carrying out daily routine)	5. I never have slipping of my knee. 4. I have slipping of my knee, but it does not affect my daily activity. 3. Slipping affects my activity slightly. 2. Slipping affects my activity moderately. 1. Slipping affects my activity severely. 0. Slipping of my knee prevents me from performing all daily activities.	Intensity
6	To what degree does buckling of your knee affect your daily activity level?	Descriptive	b7 Neuromusculoskeletal and movement-related functions	5. I never have buckling of my knee. 4. I have buckling of my knee, but it does not affect my daily activity level.	Intensity

			nc (d230 Carrying out daily routine)	3. Buckling affects my activity slightly. 2. Buckling affects my activity moderately. 1. Buckling affects my activity severely. 0. Buckling of my knee prevents me from performing all daily activities.	
7	o what degree does weakness or lack of strength of your leg affect your daily activity level?	Descriptive	b7 Neuromusculoskeletal and movement-related functions nc (d230 Carrying out daily routine)	5. My leg never feels weak. 4. My leg feels weak, but it does not affect my daily activity. 3. Weakness affects my activity slightly. 2. Weakness affects my activity moderately. 1. Weakness affects my activity severely. 0. Weakness of my leg prevents me from performing all daily activities	Intensity
Functional Limitations With Activities of Daily Living					
8	How does your knee affect your ability to walk?	Descriptive	d4509 Walking, unspecified ?	5. My knee does not affect my ability to walk. 4. I have pain in my knee when walking, but it does not affect my ability to walk. 3. My knee prevents me from walking more than 1 mile. 2. My knee prevents me from walking more than 1/2 mile. 1. My knee prevents me from walking more than 1 block. 0. My knee prevents me from walking.	Intensity
9	Because of your knee, do you walk with crutches or a cane?	Descriptive	d4508 Other specified walking	3. I can walk without crutches or a cane. 2. My knee causes me to walk with 1 crutch or a cane. 1. My knee causes me to walk with 2 crutches. 0. Because of my knee, I cannot walk even with crutches.	Intensity
10	Does your knee cause you to limp when you walk?	Descriptive	b7 Neuromusculoskeletal and movement-related functions d4509 Walking, unspecified ?	2. I can walk without a limp. 1. Sometimes my knee causes me to walk with a limp. 0. Because of my knee, I cannot walk without a limp.	Intensity
11	How does your knee affect your ability to go up stairs?	Descriptive	d451 Going up stairs	5. My knee does not affect my ability to go up stairs. 4. I have pain in my knee when going up stairs, but it does not limit my ability to go up stairs. 3. I am able to go up stairs normally, but I need to rely on use of a railing. 2. I am able to go up stairs one step at a time with use of a railing. 1. I have to use crutches or a cane to go up stairs. 0. I cannot go up stairs.	Intensity
12	How does your knee affect your ability to go down stairs?	Descriptive	d451 Going down stairs	5. My knee does not affect my ability to go down stairs. 4. I have pain in my knee when going down stairs, but it does not limit my ability to go down stairs.	Intensity

				3. I am able to go down stairs normally, but I need to rely on use of a railing. 2. I am able to go down stairs one step at time with use of a railing. 1. I have to use crutches or a cane to go down stairs. 0. I cannot go down stairs.	
13	How does your knee affect your ability to stand?	Descriptive	Maintaining a standing position	5. My knee does not affect my ability to stand. I can stand for unlimited amounts of time. 4. I have pain in my knee when standing, but it does not limit my ability to stand. 3. Because of my knee I cannot stand for more than 1 hour. 2. Because of my knee I cannot stand for more than 1/2 hour. 1. Because of my knee I cannot stand for more than 10 minutes. 0. I cannot stand because of my knee.	Intensity
14	How does your knee affect your ability to kneel on the front of your knee?	Descriptive	d4102 Kneeling OR d4152 Maintaining a kneeling position?	5. My knee does not affect my ability to kneel on the front of my knee. I can kneel for unlimited amounts of time. 4. I have pain when kneeling on the front of my knee, but it does not limit my ability to kneel. 3. I cannot kneel on the front of my knee for more than 1 hour. 2. I cannot kneel on the front of my knee for more than 1/2 hour. 1. I cannot kneel on the front of my knee for more than 10 minutes. 0. I cannot kneel on the front of my knee.	Intensity
15	How does your knee affect your ability to squat?	Descriptive	d4101 Squatting OR d4151 Maintaining a squatting position?	5. My knee does not affect my ability to squat. I can squat all the way down. 4. I have pain when squatting, but I can still squat all the way down. 3. I cannot squat more than 3/4 of the way down. 2. I cannot squat more than 1/2 of the way down. 1. I cannot squat more than 1/4 of the way down. 0. I cannot squat at all.	Intensity
16	How does your knee affect your ability to sit with your knee bent?	Descriptive	d4153 Maintaining a sitting position	5. My knee does not affect my ability to sit with my knee bent. I can sit for unlimited amounts of time. 4. I have pain when sitting with my knee bent, but it does not limit my ability to sit. 3. I cannot sit with my knee bent for more than 1 hour. 2. I cannot sit with my knee bent for more than 1/2 hour. 1. I cannot sit with my knee bent for more than 10 minutes. 0. I cannot sit with my knee bent	Intensity

17	How does your knee affect your ability to rise from a chair?	Descriptive	d4104 Standing	5. My knee does not affect my ability to rise from a chair. 4. I have pain when rising from the seated position, but it does not affect my ability to rise from the seated position. 2. Because of my knee I can only rise from a chair if I use my hands and arms to assist. 0. Because of my knee I cannot rise from a chair.	Intensity
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?: concepts not addressed adequately.

5. 2011 Knee Society Score (2011 KSS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
OBJECTIVE KNEE INDICATORS (To be completed by surgeon)					
	ALIGNMENT				
1	Alignment: measured on AP standing Xray (Anatomic Alignment)			Neutral: 2-10 degrees valgus Varus: < 2 degrees valgus Valgus: > 10 degrees valgus	
	INSTABILITY				
2	Medial / Lateral Instability: measured in full extension			None (15 pts) Little or < 5 mm (10 pts) Moderate or 5 mm (5 pts) Severe or > 5 mm (0 pts)	
3	Anterior / Posterior Instability: measured at 90 degrees			None (10 pts) Moderate < 5 mm (5 pts) Severe > 5 mm (0 pts)	
	JOINT MOTION				
4	Range of motion (1 point for each 5 degrees)			Deductions Flexion Contracture: 1-5 degrees, 6-10 degrees 11-15 degrees , > 15 degrees Extensor: < 10 degrees, 10-20 degrees >20 degrees	
	(To be completed by patient)				
	Symptoms				
1	Pain with level walking	NA	b2 Sensory functions and pain <i>d4509 Walking, unspecified</i> ?	a number between “0, none“ and “10,severe”	Intensity
2	Pain with stairs or inclines	NA	b2 Sensory functions and pain <i>d451 Going up stairs OR d451 Going down stairs</i> ? <i>d4551 Climbing</i>	a number between “0, none“ and “10,severe”	Intensity
3	Does this knee feel "normal" to you?	NA	b1 Mental functions	Always, Sometimes, Never	Frequency
	Patient satisfaction				
1	Currently, how satisfied are you with the pain level of your knee while sitting?	NA	b2 Sensory functions and pain <i>d4103 Sitting OR d4153 Maintaining a sitting position</i> ?	Very Satisfied, Satisfied, Neutral Dissatisfied, Very Dissatisfied	Intensity

2	Currently, how satisfied are you with the pain level of your knee while lying in bed?	NA	b2 Sensory functions and pain <i>d4100 Lying down and getting up OR d4150 Maintaining a lying position?</i>	Very Satisfied, Satisfied, Neutral Dissatisfied, Very Dissatisfied	Intensity
3	Currently, how satisfied are you with your knee function while getting out of bed?	Appraisal	<i>nc or nd ?</i> d4100 Lying down and getting up	Very Satisfied, Satisfied, Neutral Dissatisfied, Very Dissatisfied	Intensity
4	Currently, how satisfied are you with your knee function while performing light household duties?	Appraisal	<i>nc or nd ?</i> d640 Doing housework	Very Satisfied, Satisfied, Neutral Dissatisfied, Very Dissatisfied	Intensity
5	Currently, how satisfied are you with your knee function while performing leisure recreational activities?	Appraisal	<i>nc or nd ?</i> <i>d9209 Recreation and leisure, unspecified ?</i>	Very Satisfied, Satisfied, Neutral Dissatisfied, Very Dissatisfied	Intensity
Patient expectation Compared to what you expected before your knee replacement:					
1	My expectations for pain relief were...	NA	b2 Sensory functions and pain	Too High- "I'm a lot worse than I thought" Too High- "I'm somewhat worse than I thought" Just Right- "My expectations were met" Too Low- "I'm somewhat better than I thought" Too Low- "I'm a lot better than I thought"	Intensity
2	My expectations for being able to do my normal activities of daily living were...	NA	nc (d230 Carrying out daily routine)	Too High- "I'm a lot worse than I thought" Too High- "I'm somewhat worse than I thought" Just Right- "My expectations were met" Too Low- "I'm somewhat better than I thought" Too Low- "I'm a lot better than I thought"	Intensity
3	My expectations for being able to do my leisure, recreational or sports activities were...	NA	<i>d9209 Recreation and leisure, unspecified ?</i> d9201 Sports	Too High- "I'm a lot worse than I thought" Too High- "I'm somewhat worse than I thought" Just Right- "My expectations were met" Too Low- "I'm somewhat better than I thought" Too Low- "I'm a lot better than I thought"	Intensity
Functional activities					
Walking and standing					
1	Can you walk without any aids (such as a cane, crutches or wheelchair)?	Descriptive	d4508 Other specified walking e1 Products and technology	Yes No	Confirmation or agreement
2	If no, which of the following aid(s) do you use?	Need or dependency	e1 Products and technology	wheelchair, walker, crutches, two canes, one crutch, one cane, knee sleeve / brace, other	Qualitative attributes
3	Do you use these aid(s) because of your knees?	Need or dependency	e1 Products and technology	Yes No	Confirmation or agreement
4	For how long can you stand (with or without aid) before sitting due to knee discomfort?	Descriptive	d4154 Maintaining a standing position	cannot stand, 0-5 minutes, 6-15 minutes, 16-30 minutes, 31-60 minutes, more than an hour	Duration

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5	For how long can you walk (with or without aid) before stopping due to knee discomfort?	Descriptive	d4508 Other specified walking	cannot walk, 0-5 minutes, 6-15 minutes, 16-30 minutes, 31-60 minutes, more than an hour	Duration
	STANDARD ACTIVITIES				
	How much does your knee bother you during each of the following activities?				
1	Walking on an uneven surface	Descriptive	d4502 Walking on different surfaces	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
2	Turning or pivoting on your leg	Descriptive	d4558 Other specified moving around	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
3	Climbing up or down a flight of stairs	Descriptive	d451 Going up stairs d451 Going down stairs	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
4	Getting up from a low couch or a chair without arms	Descriptive	d4104 Standing	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
5	Getting into or out of a car	Descriptive	d4701 Using private motorized transportation	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
6	Moving laterally (stepping to the side)	Descriptive	d4508 Other specified walking	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
	ADVANCED ACTIVITIES				
1	Climbing a ladder or step stool	Descriptive	d4551 Climbing	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
2	Carrying a shopping bag for a block	Descriptive	d4308 Lifting and carrying, other specified	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
3	Squatting	Descriptive	d4101 Squatting OR d4151 Maintaining a squatting position?	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
4	Kneeling	Descriptive	d4102 Kneeling OR d4152 Maintaining a kneeling position?	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
5	Running	Descriptive	d4552 Running	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
	Discretionary knee activities				
1	Please check 3 of the activities below that you consider most important to you. (Please do not write in additional activities)				
	Recreational Activities				
	Swimming	Descriptive	d9201 Sports /4554 Swimming	NA	NA
	Golfing (18 holes)	Descriptive	d9201 Sports	NA	NA
	Road Cycling (>30mins)	Descriptive	d4750 Driving human-powered transportation	NA	NA
	Gardening	Descriptive	d9200 Play d9204 Hobbies /d9203 Crafts / d9202 Arts and culture	NA	NA
	Bowling	Descriptive	d9201 Sports	NA	NA
	Racquet Sports (Tennis, Racquetball, etc.)	Descriptive	d9201 Sports	NA	NA

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	Distance Walking	Descriptive	d4501 Walking long distances	NA	NA
	Dancing / Ballet	Descriptive	d9201 Sports	NA	NA
	Stretching Exercises (stretching out your muscles)	Descriptive	d9201 Sports	NA	NA
	Workout and Gym Activities				
	Weight-lifting	Descriptive	d9201 Sports	NA	NA
	Leg Extensions	Descriptive	d9201 Sports	NA	NA
	Stair-Climber	Descriptive	d9201 Sports	NA	NA
	Stationary Biking / Spinning	Descriptive	d9201 Sports	NA	NA
	Leg Press	Descriptive	d9201 Sports	NA	NA
	Jogging	Descriptive	d4552 Running	NA	NA
	Elliptical Trainer	Descriptive	d9201 Sports	NA	NA
	Aerobic Exercises	Descriptive	d9201 Sports	NA	NA
	Please copy all 3 checked activities into the empty boxes below				
1	How much does your knee bother you during each of these activities?	Appraisal	NA	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity

nc: not covered; **nc:** not covered; **?:** concepts not addressed adequately

5.1. Adjusted 2011 KSS (2011 KSS-A)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Symptoms subscale					
1	Pain when walking on an even underground ?	NA	b2 Sensory functions and pain <i>d4509 Walking, unspecified ?</i>	a number between “0, none“ and “10,severe”	Intensity
2	Pain during intensive activities (e.g. climbing stairs, cycling, sports etc.)?	NA	b2 Sensory functions and pain <i>d451 Going up stairs OR d451 Going down stairs ?</i> d4750 Driving human-powered transportation d9201 Sports	a number between “0, none“ and “10,severe”	Intensity
3	How often do you experience pain in your knee?	NA	b2 Sensory functions and pain	always, daily, weekly, sometimes, never	Frequency
Satisfaction subscale					
How satisfied are you with the pain level of your knee while...					
1	sitting?	NA	b2 Sensory functions and pain <i>d4103 Sitting OR d4153 Maintaining a sitting position ?</i>	Not applicable, very dissatisfied, dissatisfied, neutral, satisfied, very satisfied	Intensity
2	lying in bed?	NA	b2 Sensory functions and pain <i>d4100 Lying down and getting up OR d4150 Maintaining a lying position?</i>	Not applicable, very dissatisfied, dissatisfied, neutral, satisfied, very satisfied	Intensity
3	Getting out of bed?	NA	b2 Sensory functions and pain d4100 Lying down and getting up	Not applicable, very dissatisfied, dissatisfied, neutral, satisfied, very satisfied	Intensity
4	Performing light household duties?	NA	b2 Sensory functions and pain d640 Doing housework	Not applicable, very dissatisfied, dissatisfied, neutral, satisfied, very satisfied	Intensity
Expectation subscale					
My expectations for...					

1	Pain relief were...	NA	b2 Sensory functions and pain	No not at all, yes a little, yes somewhat, yes moderate, yes a lot	Intensity
2	Being able to do my normal activities of daily living were...	NA	nc (d230 Carrying out daily routine)	No not at all, yes a little, yes somewhat, yes moderate, yes a lot	Intensity
3	My expectations for being able to do my leisure, recreational or sports activities were...	NA	d9209 Recreation and leisure, unspecified [?] d9201 Sports	No not at all, yes a little, yes somewhat, yes moderate, yes a lot	Intensity
Functional Activity subscale					
Walking & Standing					
1	Which of the following aid(s) do you use ?	Need or dependency	e1 Products and technology	none, brace/bandage, one cane, two canes, crutches/walker, wheelchair	Qualitative attributes
2	For how long can you stand...		d4154 Maintaining a standing position	cannot stand, 0-5 minutes, 6-15 minutes, 16-30 minutes, 31-60 minutes, more than an hour	Duration
3	How long can you walk...		d4509 Walking, unspecified [?]	cannot walk, 0-5 minutes, 6-15 minutes, 16-30 minutes, 31-60 minutes, more than an hour	Duration
Standard Activities					
How much does your knee bother you during each of the following activities?					
1	Walking on a uneven underground	Descriptive	d4502 Walking on different surfaces	no bother, slight, moderate, severe, very severe, impossible, not applicable	Intensity
2	Putting on or taking of socks/shoes	Descriptive	d5402 Putting on footwear d5403 Taking off footwear	no bother, slight, moderate, severe, very severe, impossible, not applicable	Intensity
3	Climbing up or down a flight of stairs	Descriptive	d451 Going up stairs d451 Going down stairs	no bother, slight, moderate, severe, very severe, impossible, not applicable	Intensity
4	Getting up from a low couch or a chair without arms	Descriptive	d4104 Standing	no bother, slight, moderate, severe, very severe, impossible, not applicable	Intensity
ADVANCED ACTIVITIES					
How much does your knee bother you during each of the following activities?					
1	Bending down or picking something up from the floor	Descriptive	d4105 Bending d4300 Lifting a light object OR d4300 Lifting a heavy object [?]	no bother, slight, moderate, severe, very severe, impossible, not applicable	Intensity
2	Domestic activities	Descriptive	d640 Doing housework	no bother, slight, moderate, severe, very severe, impossible, not applicable	Intensity
3	Hobbies (e.g. distance walking, gardening, cycling, swimming etc.)	Descriptive	d4501 Walking long distances d9200 Play d9204 Hobbies /d9203 C rafts / d9202 Arts and culture	no bother, slight, moderate, severe, very severe, impossible, not applicable	Intensity

			d4750 Driving human-powered transportation d9201 Sports /4554 Swimming		
4	Kneeling	Descriptive	d4102 Kneeling OR d4152 Maintaining a kneeling position [?]	no bother, slight, moderate, severe, very severe, impossible, not applicable	Intensity

nc: not covered; **?:** concepts not addressed adequately.

5.2. Knee Society Score-Short form (KSS-S)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
SYMPTOMS					
1	Pain with level walking	NA	b2 Sensory functions and pain <i>d4509 Walking, unspecified</i> ?	a number between “0, none“ and “10,severe”	Intensity
2	Pain with stairs or inclines	NA	b2 Sensory functions and pain <i>d451 Going up stairs OR d451 Going down stairs</i> ? d4551 Climbing	a number between “0, none“ and “10,severe”	Intensity
3	Does this knee feel "normal" to you?	NA	b1 Mental functions	Always, Sometimes, Never	Frequency
PATIENT SATISFACTION					
1	Currently, how satisfied are you with your knee function while performing light household duties?	Descriptive	<i>nd or nc</i> ? d640 Doing housework	Very Satisfied, Satisfied, Neutral Dissatisfied, Very Dissatisfied	Intensity
FUNCTIONAL ACTIVITIES					
1	For how long can you walk (with or without aid) before stopping due to knee discomfort?		d4508 Other specified walking	cannot walk, 0-5 minutes, 6-15 minutes, 16-30 minutes, 31-60 minutes, more than an hour	Duration
STANDARD ACTIVITIES					
How much does your knee bother you during each of the following activities?					
1	Walking on an uneven surface	Descriptive	d4502 Walking on different surfaces	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
2	Climbing up or descending a flight of stairs	Descriptive	d451 Going up stairs d451 Going down stairs	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
3	Getting up from a low couch or a chair without arms	Descriptive	d4104 Standing	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
4	Running	Descriptive	d4552 Running	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity
DISCRETIONARY KNEE ACTIVITIES					
1	Many people consider the following activities important. Of these activities, which one is the most important to you? (Please do not write in additional activities)				
	Swimming	Descriptive	d9201 Sports /4554 Swimming	NA	NA
	Golfing (18 holes)	Descriptive	d9201 Sports	NA	NA
	Road Cycling (>30mins)	Descriptive	d4750 Driving human-powered transportation	NA	NA

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	Gardening	Descriptive	d9200 Play d9204 Hobbies /d9203 Crafts / d9202 Arts and culture	NA	NA
	Bowling	Descriptive	d9201 Sports	NA	NA
	Racquet Sports (Tennis, Racquetball, etc.)	Descriptive	d9201 Sports	NA	NA
	Distance Walking	Descriptive	d4501 Walking long distances	NA	NA
	Dancing / Ballet	Descriptive	d9201 Sports	NA	NA
	Stretching Exercises (stretching out your muscles)	Descriptive	d9201 Sports	NA	NA
	Weight-lifting	Descriptive	d9201 Sports	NA	NA
	Leg Extensions	Descriptive	d9201 Sports	NA	NA
	Stair-Climber	Descriptive	d9201 Sports	NA	NA
	Stationary Biking / Spinning	Descriptive	d9201 Sports	NA	NA
	Leg Press	Descriptive	d9201 Sports	NA	NA
	Jogging	Descriptive	d4552 Running	NA	NA
	Elliptical Trainer	Descriptive	d9201 Sports	NA	NA
	Aerobic Exercises	Descriptive	d9201 Sports	NA	NA
1	How much does your knee bother you during the activity checked above?	Appraisal	NA	no bother, slight, moderate, severe, very severe, cannot do (because of knee), I never do this	Intensity

nc: not covered; **nd:** not definable; **?:** concepts not addressed adequately.

6. Knee Injury and Osteoarthritis Outcome Score (KOOS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
I	Symptoms: Answer these questions thinking of your knee symptoms during the last week.				
S1	Do you have swelling in your knee?	NA	s7 Structures related to movement	Never, Rarely, Sometimes, Often, Always	Frequency
S2	Do you feel grinding, hear clicking, or any other type of noise when your knee moves?	NA	s7 Structures related to movement	Never, Rarely, Sometimes, Often, Always	Frequency
S3	Does your knee catch or hang up when moving?	NA	b7 Neuromusculoskeletal and movement-related functions	Never, Rarely, Sometimes, Often, Always	Frequency
S4	Can you straighten your knee fully?	NA	b7 Neuromusculoskeletal and movement-related functions	Never, Rarely, Sometimes, Often, Always	Frequency
S5	Can you bend your knee fully?	NA	b7 Neuromusculoskeletal and movement-related functions	Never, Rarely, Sometimes, Often, Always	Frequency
S6	How severe is your knee joint stiffness after first wakening in the morning?	NA	b7 Neuromusculoskeletal and movement-related functions	Never, Rarely, Sometimes, Often, Always	Intensity
S7	How severe is your knee joint stiffness after sitting, lying, or resting later in the day?	NA	b7 Neuromusculoskeletal and movement-related functions d4153 Maintaining a sitting position d4150 Maintaining a lying position	Never, Rarely, Sometimes, Often, Always	Intensity
II	Pain				
P1	How often do you experience knee pain?	NA	b2 Sensory functions and pain	Never, Monthly, Weekly, Daily, Always	Frequency
	What amount of knee pain have you experienced the last week during the following activities?				
P2	Twisting/pivoting on your knee	NA	b2 Sensory functions and pain d4558 Other specified moving around	None, Mild, Moderate, Severe, Extreme	Intensity
P3	Straightening knee fully	NA	b2 Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe, Extreme	Intensity
P4	Bending knee fully	NA	b2 Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe, Extreme	Intensity
P5	Walking on flat surface	NA	b2 Sensory functions and pain d4508 Other specified walking	None, Mild, Moderate, Severe, Extreme	Intensity

P6	Going up or down stairs	NA	b2 Sensory functions and pain d451 Going up stairs d451 Going down stairs	None, Mild, Moderate, Severe, Extreme	Intensity
P7	At night while in bed	NA	b2 Sensory functions and pain	None, Mild, Moderate, Severe, Extreme	Intensity
P8	Sitting or lying	NA	b2 Sensory functions and pain <i>d4103 Sitting OR d4153 Maintaining a sitting position ?</i> <i>d4100 Lying down and getting up OR d4150 Maintaining a lying position ?</i>	None, Mild, Moderate, Severe, Extreme	Intensity
P9	Standing upright	NA	b2 Sensory functions and pain <i>d4104 Standing OR d4154 Maintaining a standing position ?</i>	None, Mild, Moderate, Severe, Extreme	Intensity
III	Function, daily living This section describes your ability to move around and to look after yourself. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your knee.				
A1	Descending stairs	Descriptive	d451 Going down stairs	None, Mild, Moderate, Severe, Extreme	Intensity
A2	Ascending stairs	Descriptive	d451 Going up stairs	None, Mild, Moderate, Severe, Extreme	Intensity
A3	Rising from sitting	Descriptive	d4104 Standing	None, Mild, Moderate, Severe, Extreme	Intensity
A4	Standing	Descriptive	d4154 Maintaining a standing position	None, Mild, Moderate, Severe, Extreme	Intensity
A5	Bending to the floor/pick up an object	Descriptive	d4105 Bending <i>d4300 Lifting a light object OR d4300 Lifting a heavy object ?</i>	None, Mild, Moderate, Severe, Extreme	Intensity
A6	Walking on a flat surface	Descriptive	d4508 Other specified walking	None, Mild, Moderate, Severe, Extreme	Intensity
A7	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, Mild, Moderate, Severe, Extreme	Intensity
A8	Going shopping	Descriptive	d620 Acquisition of goods and services	None, Mild, Moderate, Severe, Extreme	Intensity
A9	Putting on socks/stockings	Descriptive	d5402 Putting on footwear	None, Mild, Moderate, Severe, Extreme	Intensity
A10	Rising from bed	Descriptive	d4100 Lying down and getting up	None, Mild, Moderate, Severe, Extreme	Intensity
A11	Taking off socks/stockings	Descriptive	d5403 Taking off footwear	None, Mild, Moderate, Severe, Extreme	Intensity
A12	Lying in bed (turning over, maintaining knee position)	Descriptive	d4150 Maintaining a lying position d4107 Rolling over	None, Mild, Moderate, Severe, Extreme	Intensity
A13	Getting in/out of bath	Descriptive	d5101 Washing whole body	None, Mild, Moderate, Severe, Extreme	Intensity

A14	Sitting	Descriptive	<i>d4103 Sitting OR d4153 Maintaining a sitting position[?]</i>	None, Mild, Moderate, Severe, Extreme	Intensity
A15	Getting on/off toilet	Descriptive	d530 Toileting	None, Mild, Moderate, Severe, Extreme	Intensity
A16	Heavy domestic duties (moving heavy boxes, scrubbing floors, etc)	Descriptive	d640 Doing housework d4308 Lifting and carrying, other specified	None, Mild, Moderate, Severe, Extreme	Intensity
A17	Light domestic duties (cooking, dusting, etc)	Descriptive	d640 Doing housework nc (d630 Preparing meals)	None, Mild, Moderate, Severe, Extreme	Intensity
IV	Function, sports and recreational activities This section describes your ability to be active on a higher level. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your knee.				
SP1	Squatting	Descriptive	<i>d4101 Squatting OR d4151 Maintaining a squatting position[?]</i>	None, Mild, Moderate, Severe, Extreme	Intensity
SP2	Running	Descriptive	d4552 Running	None, Mild, Moderate, Severe, Extreme	Intensity
SP3	Jumping	Descriptive	d4553 Jumping	None, Mild, Moderate, Severe, Extreme	Intensity
SP4	Twisting/pivoting on your injured knee	NA	d4558 Other specified moving around	None, Mild, Moderate, Severe, Extreme	Intensity
SP5	Kneeling	Descriptive	<i>d4102 Kneeling OR d4152 Maintaining a kneeling position[?]</i>	None, Mild, Moderate, Severe, Extreme	Intensity
V	Quality of Life				
Q1	How often are you aware of your knee problem?	NA	nc (b110 Consciousness functions)	Never, Monthly, Weekly, Daily, Constantly	Frequency
Q2	Have you modified your life style to avoid activities potentially damaging to your knee?	NA	nc (d570 Looking after one's health)	Not at all, Mildly, Moderately, Severely, Extremely	Intensity
Q3	How much are you troubled with lack of confidence in your knee?	NA	b1 Mental functions	Not at all, Mildly, Moderately, Severely, Extremely	Intensity
Q4	In general, how much difficulty do you have with your knee?	NA	<i>nc or nd[?]</i>	None, Mild, Moderate, Severe, Extreme	Intensity

nd: not definable; **nc:** not covered; **?:** concepts not addressed adequately.

6.1. KOOS-12

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
	Pain				
1	How often do you experience knee pain?	NA	b2 Sensory functions and pain	Never, Monthly, Weekly, Daily, Always	Frequency
	What amount of knee pain have you experienced the last week during the following activities?				
2	Walking on flat surface	NA	b2 Sensory functions and pain d4508 Other specified walking	None, Mild, Moderate, Severe, Extreme	Intensity
3	Going up or down stairs	NA	b2 Sensory functions and pain d451 Going up stairs d451 Going down stairs	None, Mild, Moderate, Severe, Extreme	Intensity
4	Sitting or lying	NA	b2 Sensory functions and pain <i>d4103 Sitting OR d4153 Maintaining a sitting position[?]</i> <i>d4100 Lying down and getting up OR d4150 Maintaining a lying position[?]</i>	None, Mild, Moderate, Severe, Extreme	Intensity
	Function, daily living This section describes your ability to move around and to look after yourself. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your knee.				
5	Rising from sitting	Descriptive	d4104 Standing	None, Mild, Moderate, Severe, Extreme	Intensity
6	Standing	Descriptive	d4154 Maintaining a standing position	None, Mild, Moderate, Severe, Extreme	Intensity
7	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, Mild, Moderate, Severe, Extreme	Intensity
8	Twisting/pivoting on your injured knee	NA	d4558 Other specified moving around	None, Mild, Moderate, Severe, Extreme	Intensity
	Quality of Life				
9	How often are you aware of your knee problem?	NA	nc (b110 Consciousness functions)	Never, Monthly, Weekly, Daily, Constantly	Frequency
10	Have you modified your life style to avoid activities potentially damaging to your knee?	NA	nc (d570 Looking after one's health)	Not at all, Mildly, Moderately, Severely, Extremely	Intensity
11	How much are you troubled with lack of confidence in your knee?	NA	b1 Mental functions	Not at all, Mildly, Moderately, Severely, Extremely	Intensity
12	In general, how much difficulty do you have with your knee?	NA	nc or nd [?]	None, Mild, Moderate, Severe, Extreme	Intensity

nc: not covered; nd: not definable; ?: concepts not addressed adequately.

6.2.KOOS-PS

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
III	Function, daily living This section describes your ability to move around and to look after yourself. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your knee.				
1	Rising from sitting	Descriptive	d4104 Standing	None, Mild, Moderate, Severe, Extreme	Intensity
2	Bending to the floor	Descriptive	d4105 Bending	None, Mild, Moderate, Severe, Extreme	Intensity
3	Putting on socks/stockings	Descriptive	d5402 Putting on footwear	None, Mild, Moderate, Severe, Extreme	Intensity
4	Rising from bed	Descriptive	d4100 Lying down and getting up	None, Mild, Moderate, Severe, Extreme	Intensity
5	Squatting	Descriptive	<i>d4101 Squatting OR d4151 Maintaining a squatting position[?]</i>	None, Mild, Moderate, Severe, Extreme	Intensity
6	Twisting/pivoting on your injured knee	NA	d4558 Other specified moving around	None, Mild, Moderate, Severe, Extreme	Intensity
7	Kneeling	Descriptive	<i>d4102 Kneeling OR d4152 Maintaining a kneeling position[?]</i>	None, Mild, Moderate, Severe, Extreme	Intensity

?: concepts not addressed adequately.

6.3.KOOS-JR

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
I	Symptoms: Answer these questions thinking of your knee symptoms during the last week.				
S1	How severe is your knee joint stiffness after first wakening in the morning?	NA	b7 Neuromusculoskeletal and movement-related functions	Never, Rarely, Sometimes Often, Always	Intensity
II	Pain What amount of knee pain have you experienced the last week during the following activities?				
P1	Twisting/pivoting on your knee	NA	b2 Sensory functions and pain d4558 Other specified moving around	None, Mild, Moderate, Severe Extreme	Intensity
P2	Straightening knee fully	NA	b2 Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe Extreme	Intensity
P3	Going up or down stairs	NA	b2 Sensory functions and pain d451 Going up stairs d451 Going down stairs	None, Mild, Moderate, Severe Extreme	Intensity
P4	Standing upright	NA	b2 Sensory functions and pain <i>d4104 Standing OR d4154 Maintaining a standing position[?]</i>	None, Mild, Moderate, Severe Extreme	Intensity
III	Function, daily living This section describes your ability to move around and to look after yourself. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your knee.				
A1	Rising from sitting	Descriptive	d4104 Standing	None, Mild, Moderate, Severe Extreme	Intensity
A2	Bending to the floor/pick up an object	Descriptive	d4105 Bending <i>d4300 Lifting a light object/d4300 Lifting a heavy object[?]</i>	None, Mild, Moderate, Severe Extreme	Intensity

?: concepts not addressed adequately.

7. Kujala Anterior Knee Pain Scale (AKPS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
	For each question, circle the latest choice (letter), which corresponds to your knee symptoms.				
1	Limp	NA	b7 Neuromusculoskeletal and movement-related functions	None, Slight or periodical, Constant	Frequency
2	Support	NA	b7 Neuromusculoskeletal and movement-related functions	Full support without pain, Painful, Weight bearing impossible	Intensity
3	Walking	Descriptive	<i>d4509 Walking, unspecified[?]</i>	Unlimited, More than 2 km , 1-2 km, Unable	Duration
4	Stairs	Descriptive	<i>d451 Going up stairs OR d451 Going down stairs[?]</i>	No difficulty, Slight pain when descending, Pain both when descending and ascending, Unable	Intensity
5	Squatting	Descriptive	<i>d4101 Squatting OR d4151 Maintaining a squatting position[?]</i>	No difficulty, Repeated squatting painful, Painful each time, Possible with partial weight bearing, Unable	Intensity
6	Running	Descriptive	d4552 Running	No difficulty, Pain after more than 2 km, Slight pain from start, Severe pain, Unable	Intensity
7	Jumping	Descriptive	d4553 Jumping	No difficulty, Slight difficulty, Constant pain Unable	Intensity
8	Prolonged sitting with the knees flexed	Descriptive	d4153 Maintaining a sitting position	No difficulty, Pain after exercise, Constant pain, Pain forces to extend knees temporarily Unable	Intensity
9	Pain	NA	b2 Sensory functions and pain	None, Slight and occasional, Interferes with sleep, Occasionally severe, Constant and severe	Frequency
10	Swelling	NA	s7 Structures related to movement	None, After severe exertion, After daily activities, Every evening, Constant	Frequency
11	Abnormal painful kneecap (patellar) movements (subluxations)	NA	b7 Neuromusculoskeletal and movement-related functions	None, Occasionally in sports activities Occasionally in daily activities, At least one documented dislocation, More than two dislocations	Frequency
12	Athrophy of thigh	NA	s7 Structures related to movement	None, Slight, Severe	Intensity
13	Flexion deficiency	NA	b7 Neuromusculoskeletal and movement-related functions	None, Slight, Severe	Intensity

?: concepts not addressed adequately.

8. Lille Score

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
	For each question, please tick the option that best describes your knee symptoms during the last month.				
1	Rate the stability of your knee	NA	b7 Neuromusculoskeletal and movement-related functions	-Stable, never gives way -Gives way during sports -Gives way occasionally during daily activities -Gives way often during daily activities -A single episode of patello-femoral dislocation -Two or more episodes of patello-femoral dislocation	Frequency
2	Rate your knee pain	NA	b2 Sensory functions and pain	-None -Mild, occasional, related to weather changes -Moderate during activities -Severe during activities -Severe and permanent	Intensity
3	Rate your ability to walk (consider only limitations related to your knee):	Descriptive	<i>d4509 Walking, unspecified[?]</i>	-Normal, no limitation -No limitation when on level ground, pain on uneven terrain -Limited walking but more than 1.5 km or 15 minutes -Limited walking and less than 1.5 km or 15 minute -Very difficult	Intensity
4	Rate the swelling of your knee	NA	s7 Structures related to movement	-None -After strenuous activities -After daily activities -Every morning -Permanently swollen	Frequency
5	Rate locking of your knee	NA	b7 Neuromusculoskeletal and movement-related functions	-None -Catching episodes without locking -Occasional locking -Frequent locking	Frequency
6	Rate your ability to go up and down stairs (consider only limitations related to your knee):	Descriptive	d451 Going up stairs d451 Going down stairs	-No limitation -2 floors without pain -2 floors but with pain -<2 floors -Unable to go up/down stairs	Intensity
7	Rate your ability to run (consider only limitations related to your knee):	Descriptive	d4552 Running	-No limitation -I am able to run but I never do. -Limited -Unable to run.	Intensity
8	Rate your ability to squat (consider only limitations related to your knee):	Descriptive	<i>d4101 Squatting OR d4151 Maintaining a squatting position[?]</i>	-No limitation -Slight discomfort -Limited: moderate discomfort -Severely limited: severe discomfort -Unable to kneel.	Intensity

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9	Rate your ability to kneel (consider only limitations related to your knee):	Descriptive	<i>d4102 Kneeling OR d4152 Maintaining a kneeling position?</i>	-No limitation -Slight discomfort -Limited: moderate discomfort -Severely limited: severe discomfort -Unable to squat.	Intensity
10	Rate your ability to carry out your daily activities (consider only limitations related to your knee):	Descriptive	nc (d230 Carrying out daily routine)	-No limitation -Slight or occasional discomfort -Moderate or frequent discomfort -Severe impairment	Intensity
11	Rate your ability to carry out your occupational and sports activities (consider only limitations related to your knee):	Descriptive	d850 Remunerative employment d9201 Sports	- No limitation Slight or occasional discomfort - Moderate discomfort and occupation requiring heavy physical work/competition sports -Moderate discomfort and occupation requiring moderate physical work/regular leisure sports - Moderate discomfort and sedentary occupation/occasional sports -Unable to work or engage in sports	Intensity
12	Do you take analgesics for pain in your knee?	NA	e1 Products and technology b2 Sensory functions and pain	-Yes -No	Confirmation or agreement

nc: not covered; ?: concepts not addressed adequately.

9. Oxford knee score (OKS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
1	How would you describe the pain you usually have in your knee?	NA	b2- Sensory functions and pain	None, Very mild, Mild, Moderate, Severe	Intensity
2	Have you had any trouble washing and drying yourself (all over) because of your knee?	Descriptive	d5101 Washing whole body d5102 Drying oneself	No trouble, Very little trouble, Moderate trouble, Extreme difficulty, Impossible to do	Intensity
3	Have you had any trouble getting in and out of the car or using public transport because of your knee? (With or without a stick)	Descriptive	d4701 Using private motorized transportation. d4702 Using public motorized transportation	No trouble, Very little trouble, Moderate trouble, Extreme difficulty, Impossible to do	Intensity
4	For how long are you able to walk before the pain in your knee becomes severe? (With or without a stick)	Descriptive	d4508 Other specified walking	No pain/more than 30minutes, 16 to 30 minutes, 5 to 15 minutes, Around the house only, Not at all/pain severe when walking	Intensity
5	After a meal (sat at a table), how painful has it been for you to stand up from a chair because of your knee?	NA	b2- Sensory functions and pain d4104 Standing	Not at all painful, Slightly painful, Moderately painful, Very painful, Unbearable	Intensity
6	Have you been limping when walking, because of your knee?	NA	b7 Neuromusculoskeletal and movement-related functions d4509 Walking, unspecified [?]	Rarely/ never, Sometimes, or just at first, Often, not just at first, Most of the time, All of the time	Frequency
7	Could you kneel down and get up again afterwards?	Descriptive	d4102 Kneeling	Yes, easily, With little difficulty, With moderate difficulty, With extreme difficulty No, impossible	Intensity
8	Are you troubled by pain in your knee at night in bed?	NA	b2- Sensory functions and pain	No nights, Only 1 or 2 nights, Some nights, Most nights, Every night	Frequency
9	How much has pain from your knee interfered with your usual work? (including housework)	Descriptive	b2- Sensory functions and pain uc (d230 Carrying out daily routine) d640 Doing housework	Not at all, A little bit, Moderately, Greatly, Totally	Intensity
10	Have you felt that your knee might suddenly 'give way' or let you down?	NA	b7 Neuromusculoskeletal and movement-related functions	Rarely/ never, Sometimes, or just at first, Often, not just at first, Most of the time, All of the time	Frequency
11	Could you do household shopping on your own?	Descriptive	d620 Acquisition of goods and services	Yes, easily, With little difficulty, With moderate difficulty, With extreme difficulty, No, impossible	Intensity
12	Could you walk down a flight of stairs?	Descriptive	d451 Going down stairs	Yes, easily, With little difficulty, With moderate difficulty, With extreme difficulty, No, impossible	Intensity

nc: not covered; ?: concepts not addressed adequately.

10. Oxford knee score_activity and participation (OKS-APQ)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
	Please consider these statements thinking about the past 4 weeks				
1	It is a problem for me to do activities (e.g. sports, dancing, walking) to the level I want, because of my knee.	Descriptive	<i>nc or nd</i> ? d9201 Sports <i>d4509 Walking, unspecified</i> ?	Strongly agree, Tend to agree Neither agree nor disagree, Tend to disagree Strongly disagree	Intensity
2	It is a problem for me to carry heavy things (e.g. items at work, shopping or a child), because of my knee.	Descriptive	d4308 Lifting and carrying, other specified	Strongly agree, Tend to agree Neither agree nor disagree, Tend to disagree Strongly disagree	Intensity
3	I need to modify my work or everyday activities, because of my knee	Descriptive	<i>d850 Remunerative employment OR</i> <i>d855 Non-remunerative employment</i> ? nc (d230 Carrying out daily routine)	Strongly agree, Tend to agree Neither agree nor disagree, Tend to disagree Strongly disagree	Intensity
4	I need to plan carefully before going out for the day because of my knee (e.g. taking painkillers, using a knee brace or checking that there will be places to sit down).	NA	nc (b1641 Organization and planning)	Strongly agree, Tend to agree Neither agree nor disagree, Tend to disagree Strongly disagree	Intensity
5	It is a problem for me to fully take part in activities with friends and family, because of my knee.	Descriptive	d910 Community Life/ d9205 Socializing	Strongly agree, Tend to agree Neither agree nor disagree, Tend to disagree Strongly disagree	Intensity
6	It is a problem for me to walk at the pace I would like, because of my knee.	Descriptive	d4508 Other specified walking	Strongly agree, Tend to agree Neither agree nor disagree, Tend to disagree Strongly disagree	Intensity
7	It is a problem for me to twist or turn, as my knee may give way or be painful.	Descriptive	d4558 Other specified moving around	Strongly agree, Tend to agree Neither agree nor disagree, Tend to disagree Strongly disagree	Intensity
8	It is a problem for me that I need to take longer to do everyday activities, because of my knee	Descriptive	nc (d230 Carrying out daily routine)	Strongly agree, Tend to agree Neither agree nor disagree, Tend to disagree Strongly disagree	Intensity

nc: not covered; **?:** concepts not addressed adequately.

11. Patient Administered Questionnaires (PAQ)-Knee

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
1	Have you had knee pain within the last 3 months	NA	b2 Sensory functions and pain	Left knee, Right knee No: Yes: Location: Front,Back, Inner, Outer Severity: Mild, Moderate, Severe, Excruciating Frequency: Rarely, Occasionally, Frequently, Always	Confirmation or agreement Intensity Frequency
2	Do you hear any sounds coming from your knee? (such as clicking, snapping)	NA	s7 Structures related to movement	No: Yes: Is the sound from your: Left knee, right knee , Both knee Is sound associated with pain No, Yes	Confirmation or agreement
3	How much difficulty do you have with the following activities? Please check one box for each activity				
	Putting on socks/shoes	Descriptive	d5402 Putting on footwear	None, slight, moderate, great, unable	intensity
	Personal care (such as toilet, bathing)	Descriptive	nc (d598 Other specified Self-care) d5101 Washing whole body d530 Toileting	None, slight, moderate, great, unable	intensity
	Household activities (such as cleaning)	Descriptive	d640 Doing housework	None, slight, moderate, great, unable	intensity
	Getting in and out of a car	Descriptive	d4701 Using private motorized transportation	None, slight, moderate, great, unable	intensity
	Kneeling	Descriptive	d4102 Kneeling OR d4152 Maintaining a kneeling position?	None, slight, moderate, great, unable	intensity
	Squatting	Descriptive	d4101 Squatting OR d4151 Maintaining a squatting position?	None, slight, moderate, great, unable	intensity
	Sitting cross-legged	Descriptive	d4103 Sitting OR d4153 Maintaining a sitting position?	None, slight, moderate, great, unable	intensity
4	How much assistance do you need with going up and down stairs	Need or dependency	e1 Products and technology d451 Going up stairs d451 Going down stairs	None, slight, moderate, great, None, Can/crutch/banister, crutches, walker/someone's assistance, unable	Qualitative attributes intensity

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5	How far can you walk?	Descriptive	d4500 Walking short distances d4501 Walking long distances	unlimited, more than 10 blocks, 4-10 blocks, 1-3 blocks, housebound	intensity
6	How often do you participate in recreational/sports activities? Please check one box for each activity				
	Walking more than 1 mile	Descriptive	d4501 Walking long distances	Never, rarely, occasionally, frequently, always	frequency
	Running	Descriptive	d4552 Running	Never, rarely, occasionally, frequently, always	frequency
	Swimming	Descriptive	d9201 Sports /4554 Swimming	Never, rarely, occasionally, frequently, always	frequency
	Gym workout	Descriptive	d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
	Tennis	Descriptive	d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
	Golf	Descriptive	d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
	Gardening	Descriptive	d9200 Play d9204 Hobbies /d9203 Crafts /d9202 Arts and culture	Never, rarely, occasionally, frequently, always	frequency
	Biking	Descriptive	d4750 Driving human-powered transportation	Never, rarely, occasionally, frequently, always	frequency
	Skiing	Descriptive	d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
	Other	NA	NA	NA	NA
7	How often does your affected knee influence or prohibit the performance of recreational/sports activities?	Descriptive	d9209 Recreation and leisure, unspecified [?] d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
8	How often does your affected knee influence your social activities?	Descriptive	d910 Community Life /d9205 Socializing	Never, rarely, occasionally, frequently, always	frequency
9	How often does your knee pain influence your sense of well-being?	NA	b2 Sensory functions and pain b1 Mental functions	Never, rarely, occasionally, frequently, always	frequency
10	Please rate your degree of satisfaction with your ability to use your knee?	NA	nc or nd [?]	a number between “0, unsatisfied “ and “10, fully satisfied”	intensity

nc: not covered; nd: not definable; ?: concepts not addressed adequately.

12. Patient's Knee Implant Performance Questionnaire (PKIP)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
	The questions below ask about ways in which your knee replacement is working with your body to improve your performance. Please select only one answer for each question The following questions should be answered thinking of your knee replacement during the last week.				
1	How often are you aware of your knee?	NA	nc (b110 Consciousness functions)	Never Rarely Sometimes Often Always	Frequency
2	The following questions should be answered thinking of your knee replacement during the last week				
	Overall, how satisfied are you with how your replacement knee feels when doing everyday activities?	Appraisal	b1 Mental functions nc (d230 Carrying out daily routine)	Very Dissatisfied Dissatisfied A little Dissatisfied A little Satisfied Satisfied Very Satisfied	Intensity
3	Choose a number between “0, Not at all confident “ and “10, Very confident” that describes how confident you feel about your knee when performing activities such as...				
	...going up stairs?	Descriptive	b1 Mental functions d451 Going up stairs	a number between “0, Not at all confident “ and “10, Very confident”	Intensity
	...kneeling on your knee?	Descriptive	b1 Mental functions <i>d4102 Kneeling OR d4152 Maintaining a kneeling position ?</i>	a number between “0, Not at all confident “ and “10, Very confident”	Intensity
	...going down stairs?	Descriptive	b1 Mental functions d451 Going down stairs	a number between “0, Not at all confident “ and “10, Very confident”	Intensity
	...getting in/out of a car?	Descriptive	b1 Mental functions d4701 Using private motorized transportation	a number between “0, Not at all confident “ and “10, Very confident”	Intensity
	...sitting down on a toilet?	Descriptive	b1 Mental functions d530 Toileting	a number between “0, Not at all confident “ and “10, Very confident”	Intensity
	...walking on an uneven surface (such as a bumpy/broken sidewalk, sloping surface, etc.)?	Descriptive	b1 Mental functions d4502 Walking on different surfaces	a number between “0, Not at all confident “ and “10, Very confident”	Intensity

	...getting up from a toilet?	Descriptive	b1 Mental functions d530 Toileting	a number between “0, Not at all confident “ and “10, Very confident”	Intensity
4					
	How often do you feel confident about your knee when performing your day-to-day activities?		b1 Mental functions nc (d230 Carrying out daily routine)	Never Rarely Sometimes Often Always	Frequency
5	Choose a number between “0, Not at all stable “ and “10, Very stable” that describes how physically stable your knee feels when doing activities such as...				
	...going up stairs?	Descriptive	b7 Neuromusculoskeletal and movement-related functions d451 Going up stairs	a number between “0, Not at all stable “ and “10	Intensity
	... walking up a hill/ ramp/incline?	Descriptive	b7 Neuromusculoskeletal and movement-related functions d4551 Climbing	a number between “0, Not at all stable “ and “10	Intensity
	... going down stairs?	Descriptive	b7 Neuromusculoskeletal and movement-related functions d451 Going down stairs	a number between “0, Not at all stable “ and “10	Intensity
	... going down a hill/ ramp/decline?	Descriptive	b7 Neuromusculoskeletal and movement-related functions d4551 Climbing	a number between “0, Not at all stable “ and “10	Intensity
	... walking on slippery surfaces (such as wet grass, rainy streets, etc.)?	Descriptive	b7 Neuromusculoskeletal and movement-related functions d4502 Walking on different surfaces	a number between “0, Not at all stable “ and “10	Intensity
	... getting out of a car after driving or riding long distances?	Descriptive	b7 Neuromusculoskeletal and movement-related functions d4701 Using private motorized transportation	a number between “0, Not at all stable “ and “10	Intensity
6					
	How often does your knee feel physically stable when performing your day-to-day activities?	Descriptive	b7 Neuromusculoskeletal and movement-related functions nc (d230 Carrying out daily routine)	Never Rarely Sometimes Often Always	Frequency
7	Choose a number between “0, Never “ and “10, Always” that describes how often you modify or change the way you do activities such as...				
	... bending down to the floor (to pick up an object, reach an item in a low cabinet, etc.)?	Descriptive	nc (d230 Carrying out daily routine)	a number between “0, Never “ and “10, Always”	Frequency

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			d4105 Bending		
	... putting on your shoes?	Descriptive	nc (d230 Carrying out daily routine) d5402 Putting on footwear	a number between “0, Never “ and “10, Always”	Frequency
	... going up stairs?	Descriptive	nc (d230 Carrying out daily routine) d451 Going up stairs	a number between “0, Never “ and “10, Always”	Frequency
	... going downstairs?	Descriptive	nc (d230 Carrying out daily routine) d451 Going down stairs	a number between “0, Never “ and “10, Always”	Frequency
	... getting in and out of a car?	Descriptive	nc (d230 Carrying out daily routine) d4701 Using private motorized transportation	a number between “0, Never “ and “10, Always”	Frequency
8					
	To what degree does your knee allow you to do the activities you want to do now?	NA	nc (d298 other specified general tasks and demands)	Not at all, Slightly, Moderately Very, Completely	Intensity
9					
	Overall, how satisfied are you with how your knee functions?	Appraisal	nd or nc?	Very Dissatisfied Dissatisfied A little Dissatisfied A little Satisfied Satisfied Very Satisfied	Intensity

nc: not covered; **nd:** not definable; **?:** concepts not addressed adequately.

13. PROMIS R -Plus-Osteoarthritis of the Knee (OAK)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please respond to each question or statement by marking one box per row.					
Anger					
1	In the past 7 days... I felt frustrated by limitations caused by my knee	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
Anxiety					
1	In the past 7 days... I worried about falling	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
2	In the past 7 days... I worried about my knee(s) giving out	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
3	In the past 7 days... I worried about losing my independence	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
Depression					
1	In the past 7 days, I withdrew from other people	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
2	In the past 7 days, I felt lonely	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
3	In the past 7 days, I felt depressed	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
4	In the past 7 days, I felt unhappy	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
Life satisfaction					
1	In the past 7 days... I am able to enjoy life	NA	b1 Mental functions	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
Fatigue					
1	In the past 7 days, how often did you experience extreme exhaustion?	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
2	In the past 7 days, how often did you feel tired even when you hadn't done anything?	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
3	In the past 7 days, how often were you bothered by your fatigue?	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
4	In the past 7 days, how often did you have to push yourself to get things done because of your fatigue?	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
5	In the past 7 days, how often did your fatigue make you feel less alert?	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency

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			nc (b140 Attention functions)		
6	In the past 7 days, how often were you too tired to leave the house?	NA	b1 Mental functions <i>nc or nd ?</i>	Never, Rarely, Sometimes, Often, Always	Frequency
7	During the past 7 days: I have to limit my social activity because I am tired	NA	b1 Mental functions d910 Community Life/ d9205 Socializing	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
8	During the past 7 days: I feel fatigued	NA	b1 Mental functions	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
Pain intensity					
1	In the past 7 days... how often did you have knee pain?	NA	b2 Sensory functions and pain	Never, Rarely, Sometimes, Often, Always	Frequency
2	In the past 7 days... how much pain did you feel when you tried to straighten your leg?	NA	b2 Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe, Very Severe	Intensity
3	In the past 7 days... how much pain did you feel when you tried to bend your knee?	NA	b2 Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe, Very Severe	Intensity
Pain interference					
1	In the past 7 days, how much did pain interfere with your enjoyment of life?	NA	b2 Sensory functions and pain b1 Mental functions	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
2	In the past 7 days, how much did pain interfere with your close personal relationships?	Descriptive	b2 Sensory functions and pain d910 Community Life/ d9205 Socializing	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
3	In the past 7 days, how much did pain interfere with your day to day activities?		b2 Sensory functions and pain nc (d230 Carrying out daily routine)	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
4	In the past 7 days, how much did pain interfere with your ability to workssk (include work at home)?	Descriptive	b2 Sensory functions and pain <i>d850 Remunerative employment OR d855 Non-remunerative employment ?</i> d640 Doing housework	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity

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5	In the past 7 days, how much did pain interfere with your ability to participate in social activities?	Descriptive	b2 Sensory functions and pain d910 Community Life/ d9205 Socializing	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
6	In the past 7 days, how much did pain interfere with your ability to remember things?	NA	b2 Sensory functions and pain nc (b144 Memory functions)	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
7	In the past 7 days, how irritable did you feel because of pain?	NA	b2 Sensory functions and pain b1 Mental functions	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
8	In the past 7 days, how often did pain prevent you from walking more than 1 mile?	Descriptive	b2 Sensory functions and pain d4501 Walking long distances	Never, Rarely, Sometimes, Often, Always	Intensity
9	In the past 7 days... how much did knee pain limit your daily activities?	Descriptive	b2 Sensory functions and pain nc (d230 Carrying out daily routine)	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
10	In the past 7 days... how much did knee pain interfere with your walking?	Descriptive	b2 Sensory functions and pain d4509 Walking, unspecified [?]	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
11	In the past 7 days... how much did knee pain interfere with going up stairs?	Descriptive	b2 Sensory functions and pain d451 Going up stairs	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
12	In the past 7 days... how much did knee pain interfere with going down stairs?		b2 Sensory functions and pain d451 Going down stairs	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
13	In the past 7 days... how often did knee pain make you feel depressed?	NA	b2 Sensory functions and pain b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Intensity
Physical function					
1	Are you able to go for a walk of at least 15 min?	Descriptive	d4501 Walking long distances	Without any difficulty, With a little difficulty, With some difficulty, With much difficulty, Unable to do	Intensity
2	Are you able to stand unsupported for 10 min?	Descriptive	d4154 Maintaining a standing position	Without any difficulty, With a little difficulty, With some difficulty, With much difficulty, Unable to do	Intensity
3	Are you able to walk a block (about 100 m) on flat ground?	Descriptive	d4500 Walking short distances	Without any difficulty, With a little difficulty, With some difficulty, With much difficulty, Unable to do	Intensity
4	Are you able to run 100 yards (100 m)?	Descriptive	d4552 Running	Without any difficulty, With a little difficulty, With some	Intensity

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				difficulty, With much difficulty, Unable to do	
5	Are you able to walk at a normal speed?	Descriptive	d4508 Other specified walking	Without any difficulty, With a little difficulty, With some difficulty, With much difficulty, Unable to do	Intensity
6	Are you able to sit on and get up from the toilet?	Descriptive	d530 Toileting	Without any difficulty, With a little difficulty, With some difficulty, With much difficulty, Unable to do	Intensity
7	Does your health now limit you in walking more than a mile (1.6 km)?	Descriptive	d4501 Walking long distances	Not at all, Very little, Somewhat, Quite a lot, Cannot do	Intensity
8	Does your health now limit you in climbing one flight of stairs?	Descriptive	<i>d451 Going up stairs OR d451 Going up stairs ?</i>	Not at all, Very little, Somewhat, Quite a lot, Cannot do	Intensity
9	Are you able to straighten your knee?	Descriptive	b7 Neuromusculoskeletal and movement-related functions	Without any difficulty, With a little difficulty, With some difficulty, With much difficulty, Unable to do	Intensity
10	Are you able to bend your knee?	Descriptive	b7 Neuromusculoskeletal and movement-related functions	Without any difficulty, With a little difficulty, With some difficulty, With much difficulty, Unable to do	Intensity
11	Does your knee condition limit you in walking on uneven ground?	Descriptive	d4502 Walking on different surfaces	Not at all, Very little, Somewhat, Quite a lot, Cannot do	Intensity
12	I use a cane, walker, or other support to prevent a fall	NA	e3 Support and relationships	Never, Rarely, Sometimes, Often, Always	Frequency
13	My concern about falling limits the things I can do	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
Sleep disturbance					
1	In the past 7 days, my sleep was restful	NA	b1 Mental functions	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
2	In the past 7 days, my sleep was restless	NA	b1 Mental functions	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
3	In the past 7 days, my sleep quality was...	NA	b1 Mental functions	Very poor, Poor, Fair, Good, Very good	
4	In the past 7 days, I got enough sleep	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
5	In the past 7 days, it was easy for me to fall asleep	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
6	In the past 7 days, I had trouble sleeping	NA	b1 Mental functions	Never, Rarely, Sometimes, Often, Always	Frequency
Symptoms					
1	In the past 7 days... did you feel stiffness in your knee(s) when standing up after a period of rest?	NA	b7 Neuromusculoskeletal and movement-related functions	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity

2	In the past 7 days... did you have swelling in or around your knee?	NA	s7 Structures related to movement	Never, Rarely, Sometimes, Often, Always	Frequency
Ability to participate in social roles and activities					
1	I have to limit social activities at home	Descriptive	d910 Community Life /d9205 Socializing	Never, Rarely, Sometimes, usually, Always	Frequency
2	I have to limit social activities outside my home	Descriptive	d910 Community Life /d9205 Socializing	Never, Rarely, Sometimes, usually, Always	Frequency
3	I have trouble participating in recreational activities with others	Descriptive	d9209 Recreation and leisure, unspecified [?]	Never, Rarely, Sometimes, usually, Always	Frequency
4	I have trouble accomplishing my usual work (include work at home)	Descriptive	nc (d230 Carrying out daily routine) d640 Doing housework	Never, Rarely, Sometimes, usually, Always	Frequency
5	I have trouble doing everything for work that I want to do (include work at home)	Descriptive	nc (d230 Carrying out daily routine) d640 Doing housework	Never, Rarely, Sometimes, usually, Always	Frequency
6	I have trouble doing all the leisure activities with others that I want to do	Descriptive	d9209 Recreation and leisure, unspecified [?]	Never, Rarely, Sometimes, usually, Always	Frequency
7	I have trouble doing all of the work that is really important to me (include work at home)	Descriptive	nc (d230 Carrying out daily routine) d640 Doing housework	Never, Rarely, Sometimes, usually, Always	Frequency
8	I have trouble doing all of the work that I feel I should do (include work at home)	Descriptive	nc (d230 Carrying out daily routine) d640 Doing housework	Never, Rarely, Sometimes, usually, Always	Frequency
Independence					
1	In the past 7 days... were you dependent on others to get things done?	Descriptive	nc (d2202 Undertaking multiple tasks independently)	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
2	In the past 7 days... I was satisfied with my ability to be independent	Descriptive	nc (d2202 Undertaking multiple tasks independently)	Not at all, A little bit, Somewhat, Quite a bit, Cannot do	Intensity
3	Does your knee condition limit you in doing things that make you feel independent?	Descriptive	nc (d2202 Undertaking multiple tasks independently)	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
Satisfaction with social roles and activities					
1	I am satisfied with my ability to socialize with friends	Descriptive	d910 Community Life /d9205 Socializing	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
2	I am satisfied with my ability to do things for my family	Descriptive	d910 Community Life /d9205 Socializing	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity

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3	I am satisfied with how much work I can do (include work at home)	Descriptive	<i>d850 Remunerative employment OR d855 Non-remunerative employment</i> ? d640 Doing housework	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
4	I am satisfied with my ability to do the work that is really important to me (include work at home)	Descriptive	nc (d230 Carrying out daily routine) d640 Doing housework	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
5	I am satisfied with my current level of social activity	Descriptive	d910 Community Life /d9205 Socializing	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
6	I am satisfied with my ability to participate in family activities	Descriptive	d910 Community Life /d9205 Socializing	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
7	I am satisfied with my ability to do things for fun outside my home	Descriptive	d9208 Other specified recreation and leisure	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
8	I am satisfied with my ability to do household chores/tasks	Descriptive	d640 Doing housework	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
9	In the past 7 days... I am satisfied with my ability to do the activities that are important to me	Descriptive	nc (d230 Carrying out daily routine)	Not at all, A little bit, Somewhat, Quite a bit, Very much	Intensity
Social isolation					
1	I feel left out	NA	b1 Mental functions	Never, Rarely, Sometimes, Usually, Always	Frequency
2	I feel isolated from others	NA	b1 Mental functions	Never, Rarely, Sometimes, Usually, Always	Frequency

nc: not covered; nd: not definable; ?: concepts not addressed adequately.

14. WOMAC-Total knee arthroplasty function short forms

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please circle the appropriate rating for each item.					
<i>RATE YOUR DIFFICULTY WHEN...</i>					
1	Descending stairs	Descriptive	d451 Going down stairs	None, slight, moderate, severe, extreme	Intensity
2	Ascending stairs	Descriptive	d451 Going up stairs	None, slight, moderate, severe, extreme	Intensity
3	Rising from sitting	Descriptive	d4104 Standing	None, slight, moderate, severe, extreme	Intensity
4	Standing	Descriptive	d4154 Maintaining a standing position	None, slight, moderate, severe, extreme	Intensity
5	Bending to floor	Descriptive	d4105 Bending	None, slight, moderate, severe, extreme	Intensity
6	Walking on even floor	Descriptive	d4508 Other specified walking	None, slight, moderate, severe, extreme	Intensity
7	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, slight, moderate, severe, extreme	Intensity

Outcome measure tools used after THA**1. Core Outcome Measures Index (COMI)-hip**

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
1	“How would you describe the pain you usually had from your hip? (last 4 weeks)	NA	b2 Sensory functions and pain	Likert scale from 0 (none) to 4 (severe)	Intensity
2	During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?	Descriptive	<i>nc or nd</i> [?] <i>d850 Remunerative employment OR d855 Non-remunerative employment</i> [?] d640 Doing housework	Likert scale from 1 (not at all) to 5 (extremely)	Intensity
3	If you had to spend the rest of your life with the hip symptoms you have right now, how would you feel about it?	NA	b1 Mental functions	Likert scale from 1 (very dissatisfied) to 5 (very satisfied)	Intensity
4	How would you rate your quality of life?	Appraisal	<i>nc or nd</i> [?]	Likert scale from 1 (very poor) to 5 (very good)	Intensity
5	During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?	Descriptive	<i>nc or nd</i> [?] b1 Mental functions d910 Community Life/ d9205 Socializing	Likert scale from 1 (all of the time) to 5 (none of the time)	Intensity
6	How much has pain from your hip interfered with your usual work (including housework)?	Descriptive	b2 Sensory functions and pain <i>nc</i> (d230 Carrying out daily routine) d640 Doing housework	Likert scale from 0 (none) to 4 (severe)	Intensity

nc: not covered; **nd:** not definable; **?:** concepts not addressed adequately.

2. Self-reported Harris Hip Score

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
1	Please describe any pain in your hip	NA	b2 Sensory functions and pain	-No pain -Slight pain or occasional pain -Mild, no effect on ordinary activity, pain after unusual activity, uses aspirin or similar medication -Moderate pain that requires pain medicine stronger than aspirin/similar medications. I'm active but have had to make modifications and/or give up some activities because of pain -Marked or severe pain that limits activity and requires pain medicine frequently -Totally disabled—wheelchair or bed ridden	Intensity
2	Amount and type of support used	Need or dependency	e1 Products and technology	None Cane for long walks Cane all the time 2 canes 1 crutch 2 crutches or walker Unable to walk	Qualitative attributes
3	Limp. This should be judged at the end of a long walk using the type of support chosen in	NA	b7 Neuromusculoskeletal and movement-related functions	None Slight Moderate Severe	Intensity
4	Distance that you can walk. This should be judged with the aid of a support if you use one	Descriptive	d4500 Walking short distances d4501 Walking long distances	Unlimited 5–6 blocks 1–4 blocks In the house only Unable to walk	Intensity
5	Climbing stair	Descriptive	<i>d451 Going up stairs OR d451 Going up stairs ?</i>	Normally Need a banister or cane or crutch Must put both feet on each step/severe trouble climbing stairs Unable to climb stairs	Qualitative attributes
6	Shoes and socks	Descriptive	d5402 Putting on footwear	Can put on socks and tie a shoe easily Can put on socks and tie a shoe with difficulty Cannot put on socks and shoes	Intensity
7	Sitting	Descriptive	d4153 Maintaining a sitting position	Comfortable in any chair Comfortable only in high chair, or can sit comfortably for only 0.5 hour Cannot sit for 0.5 hour because of pain	Intensity

?: concepts not addressed adequately.

2.1. Modified Harris Hip Score

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
1	Pain	NA	b2 Sensory functions and pain	None or ignores it Slight, occasional Mild pain, rarely moderate Moderate pain Marked pain Totally disabled, pain in bed	Intensity
2	Limp	NA	b7 Neuromusculoskeletal and movement-related functions	None , Slight , Moderate, Severe	Intensity
3	Support	NA	e1 Products and technology	None, Cane, long walks, Cane, most of the time, One crutch, Two canes, Two crutches, Not able to walk	Qualitative attributes
4	Distance walked	Descriptive	d4500 Walking short distances d4501 Walking long distances	Unlimited, Six blocks , Two to three blocks Indoors only, Bed and chair	Intensity
5	Stairs	Descriptive	<i>d451 Going up stairs OR d451 Going up stairs?</i>	Normally without railing Normally with railing In any manner Unable to do	Qualitative attributes
6	Put on shoes and socks	Descriptive	d5402 Putting on footwear	With ease With difficulty Unable	Intensity
7	Sitting	Descriptive	d4153 Maintaining a sitting position	Ordinary chair for 1 h High chair for 1 h Unable to sit in any chair	Frequency
8	Enter public transportation	Descriptive	d4702 Using public motorized transportation	Able to use Unable to use	Confirmation or agreement

?: concepts not addressed adequately.

3. Hip dysfunction and Osteoarthritis Outcome Score (HOOS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Instructions: This survey asks for your opinion about your hip and helps us understand how well you are able to complete your usual activities. Answer each question by ticking the appropriate box (only one box for each question). If you are uncertain about how to answer a question, please give the best answer you can.					
I	Symptoms: Answer these questions thinking of your hip symptoms and difficulties in the last week.				
S1	Do you feel grinding, hear clicking, or any other type of noise from your hip?	NA	s7 Structures related to movement	Never, Rarely, Sometimes, Often, Always	Frequency
S2	Difficulties spreading legs wide apart	NA	b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe, Extreme	Intensity
S3	Difficulties to stride out when walking	NA	b7 Neuromusculoskeletal and movement-related functions <i>d4509 Walking, unspecified</i> ?	None, Mild, Moderate, Severe Extreme	Intensity
Stiffness is a sensation of restriction or slowness in the ease with which you move your hip joint.					
S4	How severe is your hip joint stiffness after first wakening in the morning?	NA	b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe, Extreme	Intensity
S5	How severe is your hip joint stiffness after sitting, lying, or resting later in the day?	NA	b7 Neuromusculoskeletal and movement-related functions d4153 Maintaining a sitting position d4150 Maintaining a lying position	None, Mild, Moderate, Severe, Extreme	Intensity
II	Pain				
P1	How often is your hip painful?	NA	b2 Sensory functions and pain	Never, Monthly, Weekly, Daily, Always	Frequency
What amount of hip pain have you experienced the last week during the following activities?					
P2	Straightening your hip fully	NA	b2 Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe, Extreme	Intensity
P3	Bending your hip fully	NA	b2 Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe, Extreme	Intensity
P4	Walking on flat surface	NA	b2 Sensory functions and pain	None, Mild, Moderate, Severe, Extreme	Intensity

			d4508 Other specified walking		
P5	Going up or down stairs	NA	b2 Sensory functions and pain d451 Going up stairs d451 Going down stairs	None, Mild, Moderate, Severe, Extreme	Intensity
P6	At night while in bed	NA	b2 Sensory functions and pain	None, Mild, Moderate, Severe, Extreme	Intensity
P7	Sitting or lying	NA	b2 Sensory functions and pain <i>d4103 Sitting OR d4153 Maintaining a sitting position?</i> <i>d4100 Lying down and getting up OR d4150 Maintaining a lying position?</i>	None, Mild, Moderate, Severe, Extreme	Intensity
P8	Standing upright	NA	b2 Sensory functions and pain <i>d4104 Standing OR d4154 Maintaining a standing position?</i>	None, Mild, Moderate, Severe, Extreme	Intensity
P9	Walking on a hard surface (asphalt, concrete, etc.)	NA	b2 Sensory functions and pain d4502 Walking on different surfaces	None, Mild, Moderate, Severe, Extreme	Intensity
P10	Walking on an uneven surface	NA	b2 Sensory functions and pain d4502 Walking on different surfaces	None, Mild, Moderate, Severe, Extreme	Intensity
III	Function, daily living This section describes your ability to move around and to look after yourself. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your hip.				
A1	Descending stairs	Descriptive	d451 Going down stairs	None, Mild, Moderate, Severe, Extreme	Intensity
A2	Ascending stairs	Descriptive	d451 Going up stairs	None, Mild, Moderate, Severe, Extreme	Intensity
A3	Rising from sitting	Descriptive	d4104 Standing	None, Mild, Moderate, Severe, Extreme	Intensity
A4	Standing	Descriptive	d4154 Maintaining a standing position	None, Mild, Moderate, Severe, Extreme	Intensity
A5	Bending to the floor/pick up an object	Descriptive	d4105 Bending <i>d4300 Lifting a light object OR d4300 Lifting a heavy object ?</i>	None, Mild, Moderate, Severe, Extreme	Intensity

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A6	Walking on a flat surface	Descriptive	d4508 Other specified walking	None, Mild, Moderate, Severe, Extreme	Intensity
A7	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, Mild, Moderate, Severe, Extreme	Intensity
A8	Going shopping	Descriptive	d620 Acquisition of goods and services	None, Mild, Moderate, Severe, Extreme	Intensity
A9	Putting on socks/stockings	Descriptive	d5402 Putting on footwear	None, Mild, Moderate, Severe, Extreme	Intensity
A10	Rising from bed	Descriptive	d4100 Lying down and getting up	None, Mild, Moderate, Severe, Extreme	Intensity
A11	Taking off socks/stockings	Descriptive	d5403 Taking off footwear	None, Mild, Moderate, Severe, Extreme	Intensity
A12	Lying in bed (turning over, maintaining knee position)	Descriptive	d4150 Maintaining a lying position d4107 Rolling over	None, Mild, Moderate, Severe, Extreme	Intensity
A13	Getting in/out of bath	Descriptive	d5101 Washing whole body	None, Mild, Moderate, Severe, Extreme	Intensity
A14	Sitting	Descriptive	<i>d4103 Sitting OR d4153 Maintaining a sitting position?</i>	None, Mild, Moderate, Severe, Extreme	Intensity
A15	Getting on/off toilet	Descriptive	d530 Toileting	None, Mild, Moderate, Severe, Extreme	Intensity
A16	Heavy domestic duties (moving heavy boxes, scrubbing floors, etc)	Descriptive	d640 Doing housework d4308 Lifting and carrying, other specified	None, Mild, Moderate, Severe, Extreme	Intensity
A17	Light domestic duties (cooking, dusting, etc)	Descriptive	d640 Doing housework nc (d630 Preparing meals)	None, Mild, Moderate, Severe, Extreme	Intensity
IV	Function, sports and recreational activities This section describes your ability to be active on a higher level. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your hip.				
SP1	Squatting	Descriptive	<i>d4101 Squatting OR d4151 Maintaining a squatting position?</i>	None, Mild, Moderate, Severe, Extreme	Intensity
SP2	Running	Descriptive	d4552 Running	None, Mild, Moderate, Severe, Extreme	Intensity
SP3	Twisting/pivoting on loaded leg	NA	d4558 Other specified moving around	None, Mild, Moderate, Severe, Extreme	Intensity
SP4	Walking on uneven surface	Descriptive	d4502 Walking on different surfaces	None, Mild, Moderate, Severe, Extreme	Intensity
V	Quality of Life				
Q1	How often are you aware of your hip problem?	NA	nc (b110 Consciousness functions)	Never, Monthly, Weekly, Daily, Constantly	Frequency

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Q2	Have you modified your life style to avoid activities potentially damaging to your hip?	NA	nc (d570 Looking after one's health)	Not at all, Mildly, Moderately, Severely, Extremely	Intensity
Q3	How much are you troubled with lack of confidence in your hip?	NA	b1 Mental functions	Not at all, Mildly, Moderately, Severely, Extremely	Intensity
Q4	In general, how much difficulty do you have with your hip?	NA	<i>nc or nd</i> [?]	None, Mild, Moderate, Severe, Extreme	Intensity

nc: not covered; **nd:** not definable; **?:** concepts not addressed adequately.

3.1 Hip dysfunction and Osteoarthritis Outcome Score (HOOS)-12

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Instructions: This questionnaire asks for your views about your hip. Answer every question by marking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can.					
I	Pain				
P1	How often is your hip painful?	NA	b2 Sensory functions and pain	Never, Monthly, Weekly, Daily, Always	Frequency
What amount of hip pain have you experienced the last week during the following activities?					
P2	Walking on flat surface	NA	b2 Sensory functions and pain d4508 Other specified walking	None, Mild, Moderate, Severe Extreme	Intensity
P3	Going up or down stairs	NA	b2 Sensory functions and pain d451 Going up stairs d451 Going down stairs	None, Mild, Moderate, Severe Extreme	Intensity
P4	Sitting or lying	NA	b2 Sensory functions and pain <i>d4103 Sitting OR d4153 Maintaining a sitting position?</i> <i>d4100 Lying down and getting up OR d4150 Maintaining a lying position?</i>	None, Mild, Moderate, Severe Extreme	Intensity
II	Function, daily living The following questions concern your physical function. By this we mean your ability to move around and to look after yourself. For each of the following activities please indicate the degree of difficulty you have experienced in the last week to your hip.				
A1	Rising from sitting	Descriptive	d4104 Standing	None, Mild, Moderate, Severe Extreme	Intensity
A2	Standing	Descriptive	d4154 Maintaining a standing position	None, Mild, Moderate, Severe Extreme	Intensity
A3	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, Mild, Moderate, Severe Extreme	Intensity
A4	Walking on uneven surface	Descriptive	d4502 Walking on different surfaces	None, Mild, Moderate, Severe Extreme	Intensity
III	Quality of Life				

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Q1	How often are you aware of your hip problem?	NA	nc (b110 Consciousness functions)	Never, Monthly, Weekly Daily, Constantly	Frequency
Q2	Have you modified your life style to avoid activities potentially damaging to your hip?	NA	nc (d570 Looking after one's health)	Not at all, Mildly, Moderately Severely, Extremely	Intensity
Q3	How much are you troubled with lack of confidence in your hip?	NA	b1 Mental functions	Not at all, Mildly, Moderately Severely, Extremely	Intensity
Q4	In general, how much difficulty do you have with your hip?	NA	nc or nd [?]	None, Mild, Moderate Severe, Extreme	Intensity

nc or nd: not covered or not definable; **?:** concepts not addressed adequately.

3.2 Hip dysfunction and Osteoarthritis Outcome Score (HOOS)-PS

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Instructions: This survey asks for your view about your hip. This information will help us keep track of how well you are able to perform different activities. Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can so that you answer all the questions. The following questions concern your level of function in performing usual daily activities and higher-level activities. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your hip problem.					
1	Descending stairs	Descriptive	d451 Going down stairs	None, Mild, Moderate, Severe Extreme	Intensity
2	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, Mild, Moderate, Severe Extreme	Intensity
3	Sitting	Descriptive	<i>d4103 Sitting OR d4153 Maintaining a sitting position?</i>	None, Mild, Moderate, Severe Extreme	Intensity
4	Running	Descriptive	d4552 Running	None, Mild, Moderate, Severe Extreme	Intensity
5	Jumping	Descriptive	d4553 Jumping	None, Mild, Moderate, Severe Extreme	Intensity
6	Twisting/pivoting on loaded leg	NA	d4558 Other specified moving around	None, Mild, Moderate, Severe Extreme	Intensity

?: concepts not addressed adequately.

3.3 Hip dysfunction and Osteoarthritis Outcome Score (HOOS)-JR

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Instructions: This survey asks for your opinion about your hip and helps us understand how well you are able to complete your usual activities. Answer each question by ticking the appropriate box (only one box for each question). If you are uncertain about how to answer a question, please give the best answer you can.					
I	Pain				
What amount of hip pain have you experienced the last week during the following activities?					
P1	Going up or down stairs	NA	b2 Sensory functions and pain d451 Going up stairs d451 Going down stairs	None, Mild, Moderate, Severe Extreme	Intensity
P2	Walking on an uneven surface	NA	b2 Sensory functions and pain d4502 Walking on different surfaces	None, Mild, Moderate, Severe Extreme	Intensity
III	Function, daily living This section describes your ability to move around and to look after yourself. For each of the following activities, please indicate the degree of difficulty you have experienced in the last week due to your hip.				
A1	Rising from sitting	Descriptive	d4104 Standing	None, Mild, Moderate, Severe Extreme	Intensity
A2	Bending to the floor/pick up an object	Descriptive	d4105 Bending d4300 Lifting a light object OR d4300 Lifting a heavy object ?	None, Mild, Moderate, Severe Extreme	Intensity
A3	Lying in bed (turning over, maintaining knee position)	Descriptive	d4150 Maintaining a lying position d4107 Rolling over	None, Mild, Moderate, Severe Extreme	Intensity
A4	Sitting	Descriptive	d4103 Sitting OR d4153 Maintaining a sitting position?	None, Mild, Moderate, Severe Extreme	Intensity

?: concepts not addressed adequately.

4. Hip Outcome Score (HOS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please answer every question with one response that most closely describes your condition within the past week. If the activity in question is limited by something other than your hip mark not applicable (N/A).					
Because of your hip how much difficulty do you have with:					
1	Standing for 15 minutes	Descriptive	d4154 Maintaining a standing position	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
2	Getting into and out of an average car	Descriptive	d4701 Using private motorized transportation	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
3	Walking up steep hills	Descriptive	d4551 Climbing	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
4	Walking down steep hills	Descriptive	d4551 Climbing	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
5	Going up 1 flight of stairs	Descriptive	d451 Going up stairs	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
6	Going down 1 flight of stairs	Descriptive	d451 Going down stairs	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
7	Stepping up and down curbs	Descriptive	d4551 Climbing	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
8	Deep squatting	Descriptive	<i>d4101 Squatting OR d4151 Maintaining a squatting position?</i>	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
9	Getting into and out of a bath tub	Descriptive	d5101 Washing whole body	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
10	Walking initially	Descriptive	d4508 Other specified walking	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity

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11	Walking approximately 10 minutes	Descriptive	d4500 Walking short distances	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
12	Walking 15 minutes or greater	Descriptive	d4501 Walking long distances	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
13	Twisting/pivoting on involved leg	Descriptive	d4558 Other specified moving around	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
14	Rolling over in bed	Descriptive	d4107 Rolling over	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
15	Light to moderate work (standing, walking)	Descriptive	<i>nc or nd</i> [?] <i>d4104 Standing OR</i> <i>d4154 Maintaining a standing</i> <i>position</i> [?] <i>d4509 Walking, unspecified</i> [?]	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
16	Heavy work (push/pulling, climbing, carrying)	Descriptive	<i>nc or nd</i> [?] nc (d4450 Pulling, d4451 Pushing) d4551 Climbing <i>d4309 Lifting and carrying,</i> <i>unspecified</i> [?]	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
17	Recreational activities	Descriptive	<i>d9209 Recreation and leisure,</i> <i>unspecified</i> [?]	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
If you participate in a sport or exercise activity, please fill out the Sports Subscale. If you do not please stop here.					
Sports Subscale					
Because of your hip how much difficulty do you have with:					
18	Running one mile	Descriptive	d4552 Running	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
19	Jumping	Descriptive	d4553 Jumping	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity

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20	Swinging objects like a golf club	Descriptive	d9201 Sports	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
21	Landing	Descriptive	d4553 Jumping	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
22	Starting and stopping quickly	Descriptive	b7 Neuromusculoskeletal and movement-related functions	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
23	Cutting/lateral movements	Descriptive	d4558 Other specified moving around	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
24	Low impact activities like fast walking	Descriptive	d9201 Sports d4508 Other specified walking	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
25	Ability to perform activity with your normal technique	Descriptive	d9201 Sports	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity
26	Ability to participate in your desired sport as long as you would like	Descriptive	d9201 Sports	No Difficulty at all, Some Difficulty , Moderate Difficulty, Extreme Difficulty, Unable , N/A	Intensity

nc or nd: not covered or not definable; **?:** concepts not addressed adequately.

5. Hip and Groin Outcome Score (HAGOS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
INSTRUCTIONS: This questionnaire asks for your view about your hip and/or groin problem. The questions should be answered considering your hip and/or groin function during the past week. This information will help us keep track of how you feel, and how well you are able to do your usual activities. Answer every question by ticking the appropriate box. Tick only one box for each question. If a question does not pertain to you or you have not experienced it in the past week please make your “best guess” as to which response would be the most accurate.					
I	Symptoms: These questions should be answered considering your hip and/or groin symptoms and difficulties during the past week .				
S1	Do you feel discomfort in your hip and/or groin?	NA	b1 Mental functions	Never, Rarely, Sometimes Often, Always	Frequency
S2	Do you hear clicking or any other type of noise from your hip and/or groin?	NA	s7 Structures related to movement	Never, Rarely, Sometimes Often, Always	Frequency
S3	Do you have difficulties stretching your legs far out to the side?	NA	b7 Neuromusculoskeletal and movement-related functions	Never, Rarely, Sometimes Often, Always	Frequency
S4	Do you have difficulties taking full strides when you walk?	NA	b7 Neuromusculoskeletal and movement-related functions <i>d4509 Walking, unspecified</i> [?]	Never, Rarely, Sometimes Often, Always	Frequency
S5	Do you experience sudden twinging/stabbing sensations in your hip and/or groin?	NA	b2 Sensory functions and pain	Never, Rarely, Sometimes Often, Always	Frequency
II	Stiffness The following questions concern the amount of stiffness you have experienced during the past week in your hip and/or groin. Stiffness is a sensation of restriction or slowness in the ease with which you move your hip and/or groin.				
S6	How severe is your hip and/or groin stiffness after first awakening in the morning?	NA	b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe Extreme	Intensity
S7	How severe is your hip and/or groin stiffness after sitting, lying or resting later in the day?	NA	b7 Neuromusculoskeletal and movement-related functions d4153 Maintaining a sitting position	None, Mild, Moderate, Severe Extreme	Intensity

			d4150 Maintaining a lying position		
	Pain				
P1	How often is your hip and/or groin painful?	NA	b2 Sensory functions and pain	Never, Monthly, Weekly, Daily, Always	Frequency
P2	How often do you have pain in areas other than your hip and/or groin that you think may be related to your hip and/or groin problem?	NA	b2 Sensory functions and pain	Never, Monthly, Weekly, Daily, Always	Frequency
The following questions concern the amount of pain you have experienced during the past week in your hip and/or groin. What amount of hip and/or groin pain have you experienced during the following activities?					
P3	Straightening your hip fully	NA	b2 Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe Extreme	Intensity
P4	Bending your hip fully	NA	b2 Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe Extreme	Intensity
P5	Walking up or down stairs	NA	b2 Sensory functions and pain d451 Going up stairs d451 Going down stairs	None, Mild, Moderate, Severe Extreme	Intensity
P6	At night while in bed	NA	b2 Sensory functions and pain	None, Mild, Moderate, Severe Extreme	Intensity
P7	Sitting or lying	NA	b2 Sensory functions and pain <i>d4103 Sitting OR d4153 Maintaining a sitting position?</i> <i>d4100 Lying down and getting up OR d4150 Maintaining a lying position?</i>	None, Mild, Moderate, Severe Extreme	Intensity
P8	Standing upright	NA	b2 Sensory functions and pain <i>d4104 Standing OR d4154 Maintaining a standing position?</i>	None, Mild, Moderate, Severe Extreme	Intensity

P9	Walking on a hard surface (asphalt, concrete, etc.)	NA	b2 Sensory functions and pain d4502 Walking on different surfaces	None, Mild, Moderate, Severe Extreme	Intensity
P10	Walking on an uneven surface	NA	b2 Sensory functions and pain d4502 Walking on different surfaces	None, Mild, Moderate, Severe Extreme	Intensity
III	Function, daily living The following questions concern your physical function. For each of the following activities please indicate the degree of difficulty you have experienced in the past week due to your hip and/or groin problem.				
A1	Walking up stairs	Descriptive	d451 Going up stairs	None, Mild, Moderate, Severe Extreme	Intensity
A2	Bending down, e.g. to pick something up from the floor	Descriptive	d4105 Bending <i>d4300 Lifting a light object OR d4300 Lifting a heavy object ?</i>	None, Mild, Moderate, Severe Extreme	Intensity
A3	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, Mild, Moderate, Severe Extreme	Intensity
A4	Lying in bed (turning over or maintaining the same hip position for a long time)	Descriptive	d4150 Maintaining a lying position d4107 Rolling over	None, Mild, Moderate, Severe Extreme	Intensity
A5	Heavy domestic duties (moving heavy boxes, scrubbing floors, etc.)	Descriptive	d640 Doing housework d4308 Lifting and carrying, other specified	None, Mild, Moderate, Severe Extreme	Intensity
IV	Function, sports and recreational activities The following questions concern your physical function when being active on a higher level. The questions should be answered thinking of what degree of difficulty you have experienced during the last week due to your hip.				
SP1	Squatting	Descriptive	<i>d4101 Squatting d4151 Maintaining a squatting position?</i>	None, Mild, Moderate, Severe, Extreme	Intensity
SP2	Running	Descriptive	d4552 Running	None, Mild, Moderate, Severe, Extreme	Intensity

SP3	Twisting/pivoting on your injured hip	NA	d4558 Other specified moving around	None, Mild, Moderate, Severe, Extreme	Intensity
SP4	Walking on uneven surface	Descriptive	d4502 Walking on different surfaces	None, Mild, Moderate, Severe, Extreme	Intensity
SP5	Running as fast as you can	Descriptive	d4552 Running	None, Mild, Moderate, Severe, Extreme	Intensity
SP6	Bringing the leg forcefully forward and/or out to the side, such as in kicking, skating etc.	Descriptive	d9201 Sports nc (d4351 Kicking)	None, Mild, Moderate, Severe, Extreme	Intensity
SP7	Sudden explosive movements that involve quick footwork, such as accelerations, decelerations, change of directions etc.	Descriptive	d4558 Other specified moving around	None, Mild, Moderate, Severe, Extreme	Intensity
SP8	Situations where the leg is stretched into an outer position (such as when the leg is placed as far away from the body as possible)	NA	b7 Neuromusculoskeletal and movement-related functions	None, Mild, Moderate, Severe, Extreme	Intensity
	Participation in physical activities The following questions are about your ability to participate in your preferred physical activities. Physical activities include sporting activities as well as all other forms of activity where you become slightly out of breath. When you answer these questions consider to what degree your ability to participate in physical activities during the past week has been affected by your hip and/or groin problem.				
PA1	Are you able to participate in your preferred physical activities for as long as you would like?	NA	nc (d298 other specified general tasks and demands)	Always, Often, Sometimes, Rarely, Never	Frequency
PA2	Are you able to participate in your preferred physical activities at your normal performance level?	NA	nc (d298 other specified general tasks and demands)	Always, Often, Sometimes, Rarely, Never	Frequency
V	Quality of Life				
Q1	How often are you aware of your hip and/or groin problem?	NA	nc (b110 Consciousness functions)	Never, Monthly, Weekly Daily, Constantly	Frequency
Q2	Have you modified your life style to avoid potentially damaging activities to your hip and/or groin?	NA	nc (d570 Looking after one's health)	Not at all, Mildly, Moderately Severely, Extremely	Intensity
Q3	In general, how much difficulty do you have with your hip and/or groin?	NA	nd or nc?	None, Mild, Moderate, Severe, Extreme	Intensity
Q4	Does your hip and/or groin problem affect your mood in a negative way?	NA	b1 Mental functions	Never, Monthly, Weekly Daily, Constantly	Frequency
Q5	Do you feel restricted due to your hip and/or groin problem?	NA	b1 Mental functions	Never, Monthly, Weekly Daily, Constantly	Frequency

nc: not covered; nd: not definable; ?: concepts not addressed adequately.

6. Mayo Hip Score

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Part1: Clinical assessment score					
1	Pain	NA	b2- Sensory functions and pain	None, Slight or occasional, Moderate, Severe	Intensity
Function					
2	Distance walked	Descriptive	d4501 Walking long distances	≥10 blocks, 6 blocks, 1-3 blocks, Indoors, Unable to walk	Intensity
3	Support aids	NA	e1 Products and technology	None, Occasional use of a cane, Full-time use of a cane/crutch, two canes or crutches, Walker, Unable to walk	Qualitative attributes
4	Mobility and muscle power in and out of car	Descriptive	d4701 Using private motorized transportation	With ease, With difficulty, Unable	Intensity
5	Foot care	NA	nc (d520 Caring for body parts)	Unable, With difficulty, Unable	Intensity
6	Limp	NA	b7 Neuromusculoskeletal and movement-related functions	None, Slight, Severe	Intensity
7	Ability to climb stairs	Descriptive	d451 Going up stairs OR d451 Going up stairs?	Normal, Holding rail, One step at a time, Unable	Qualitative attributes
Part 2, Roentgenographic Assessment					
1	Acetabulum			Incomplete bone-cement lucent line Comple, Incomplete bone-cement lucent line, Complete line since surgery 51 mm, Progressive line since surgery 51 mm, Complete or progressive line >1 mm in any one zone, Component migration	
2	Femur			Incomplete bone-cement lucent line Complete line since surgery: ≤1 mm Progressive line since surgery: ≤1 mm Complete or progressive line: >1 mm in any one zone Subsidence: ≤2 mm, >2 mm Prosthesis-cement lucent line: ≤1 mm 1-2 mm, ≥2 mm	

nc: not covered ; ?: concepts not addressed adequately.

7. Oxford Hip score (OHS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
1	How would you describe the pain you usually have from your hip?	NA	b2- Sensory functions and pain	None, Very mild, Mild, Moderate, Severe	Intensity
2	Have you had any trouble with washing and drying yourself (all over) because of your hip?	Descriptive	d5101 Washing whole body d5102 Drying oneself	No trouble, Very little trouble Moderate trouble, Extreme difficulty, Impossible to do	Intensity
3	Have you had any trouble getting in and out of a car or using public transport because of your hip? (whichever you tend to use)	Descriptive	d4701 Using private motorized transportation. d4702 Using public motorized transportation	No trouble, Very little trouble Moderate trouble, Extreme difficulty, Impossible to do	Intensity
4	Have you been able to put on a pair of socks, stocking or tights?	Descriptive	d5402 Putting on footwear	Yes, easily; with little difficulty; with moderate difficulty; with extreme difficulty; No, impossible	Intensity
5	Could you do household shopping on your own?	Descriptive	d620 Acquisition of goods and services	Yes, easily, With little difficulty, With moderate difficulty, With extreme difficulty, No, impossible	Intensity
6	For how long are you able to walk before the pain from your hip becomes severe? (with or without a stick)	Descriptive	d4508 Other specified walking	No pain/more than 30minutes 16 to 30 minutes, 5 to 15 minutes, Around the house only, Not at all/pain severe when walking	Frequency
7	Have you been able to climb a flight of stairs?	Descriptive	<i>d451 Going up stairs OR d451 Going up stairs ?</i>	Yes, easily, With little difficulty, With moderate difficulty, With extreme difficulty No, impossible	Intensity
8	After a meal (sat at a table), how painful has it been for you to stand up from a chair because of your hip?	NA	b2- Sensory functions and pain d4104 Standing	Not at all painful; Slightly painful; Moderately painful; Very painful; Unbearable	Intensity
9	Have you been limping when walking, because of your hip?	NA	b7 Neuromusculoskeletal and movement-related functions <i>d4509 Walking, unspecified ?</i>	Rarely/ never; Sometimes, or just at first; Often, not just at first; Most of the time; All of the time	Frequency
10	Have you had any sudden, severe pain - 'shooting', 'stabbing' or 'spasms' - from the affected hip?	NA	b2- Sensory functions and pain b7 Neuromusculoskeletal and movement-related functions	No days, Only 1 or 2 days, Some days, Most days, Every day	Frequency
11	How much has pain from your hip interfered with your usual work (including housework)?	Descriptive	b2- Sensory functions and pain un (d230 Carrying out daily routine) d640 Doing housework	Not at all, A little bit, Moderately, Greatly, Totally	Intensity
12	Have you been troubled by pain from your hip in bed at night?	NA	b2- Sensory functions and pain	No nights, Only 1 or 2 nights; Some nights, Most nights; Every night	Frequency

nc: not covered; ?: concepts not addressed adequately.

8. Patient Administered Questionnaire (PAQ)-Hip

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
1	Have you had hip pain within the last 3 months	NA	b2 Sensory functions and pain	Left hip, Right hip No Yes: Location: buttock, Groin, thigh, side, lower back Severity: Mild, Moderate, Severe, Excruciating Frequency: Rarely, Occasionally, Frequently, Always	Confirmation or agreement Intensity Frequency
2	How often do you limp?	NA	b7 Neuromusculoskeletal and movement-related functions	Never, rarely, Occasionally, Frequently, Always Because of your: Left Hip, Right Hip, Both Hips	Frequency
3	How much difficulty do you have with the following activities? Please check one box for each activity				
	Putting on socks/shoes	Descriptive	d5402 Putting on footwear	None, slight, moderate, great, unable	intensity
	Personal care (such as toilet, bathing)	Descriptive	nc (d598 Other specified self-care) d5101 Washing whole body d530 Toileting	None, slight, moderate, great, unable	intensity
	Household activities (such as cleaning)	Descriptive	d640 Doing housework	None, slight, moderate, great, unable	intensity
	Getting in and out of a car	Descriptive	d4701 Using private motorized transportation	None, slight, moderate, great, unable	intensity
4	How much assistance do you need with going up and down stairs	Need or dependency Descriptive	e1 Products and technology d451 Going up stairs d451 Going down stairs	None, Can/crutch/banister, crutches, walker/someone's assistance, unable	Qualitative attributes intensity
5	How far can you walk?	Descriptive	d4500 Walking short distances d4501 Walking long distances	unlimited, more than 10 blocks, 4-10 blocks, 1-3 blocks, housebound	intensity
6	How often do you participate in recreational/sports activities? Please check one box for each activity				
	Walking more than 1 mile	Descriptive	d4501 Walking long distances	Never, rarely, occasionally, frequently, always	frequency
	Running	Descriptive	d4552 Running	Never, rarely, occasionally, frequently, always	frequency

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	Swimming	Descriptive	d9201 Sports /4554 Swimming	Never, rarely, occasionally, frequently, always	frequency
	Gym workout	Descriptive	d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
	Tennis	Descriptive	d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
	Golf	Descriptive	d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
	Gardening	Descriptive	d9200 Play d9204 Hobbies/d9203 Crafts / d9202 Arts and culture	Never, rarely, occasionally, frequently, always	frequency
	Biking	Descriptive	d4750 Driving human-powered transportation	Never, rarely, occasionally, frequently, always	frequency
	Skiing	Descriptive	d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
	Other	NA	NA	NA	NA
7	How often does your affected hip influence or prohibit the performance of recreational/sports activities?	Descriptive	<i>d9209 Recreation and leisure, unspecified</i> ? d9201 Sports	Never, rarely, occasionally, frequently, always	frequency
8	How often does your affected hip influence your social activities?	Descriptive	d910 Community Life /d9205 Socializing	Never, rarely, occasionally, frequently, always	frequency
9	How often does your knee pain influence your sense of well-being?	NA	b2 Sensory functions and pain b1 Mental functions	Never, rarely, occasionally, frequently, always	frequency
10	Please rate your degree of satisfaction with your ability to use your knee?	NA	<i>nd or nc</i> ?	a number between “0, unsatisfied “ and “10, fully satisfied”	intensity

nc or nd: not covered or not definable; **?:** concepts not addressed adequately.

9. WOMAC-Total hip arthroplasty function short forms

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please circle the appropriate rating for each item.					
<i>RATE YOUR DIFFICULTY WHEN...</i>					
1	Ascending stairs	Descriptive	d451 Going up stairs	None, slight, moderate, severe, extreme	Intensity
2	Rising from sitting	Descriptive	d4104 Standing	None, slight, moderate, severe, extreme	Intensity
3	Standing	Descriptive	d4154 Maintaining a standing position	None, slight, moderate, severe, extreme	Intensity
4	Bending to floor	Descriptive	d4105 Bending	None, slight, moderate, severe, extreme	Intensity
5	Walking on even floor	Descriptive	d4508 Other specified walking	None, slight, moderate, severe, extreme	Intensity
6	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, slight, moderate, severe, extreme	Intensity
7	Putting on socks	Descriptive	d5402 Putting on footwear	None, slight, moderate, severe, extreme	Intensity
8	Doing heavy domestic duties (moving furniture)	Descriptive	d640 Doing housework d4308 Lifting and carrying, other specified nc (d4450 Pulling, d4451 Pushing)	None, slight, moderate, severe, extreme	Intensity

Outcome measure tools used after THA and TKA

1. American Academy of Orthopaedic Surgeons (AAOS) Hip and Knee Core Scale/ Hip and Knee Outcomes Questionnaire/ MODEMS (Musculoskeletal Outcomes Data Evaluation and Management System) Hip/Knee Core scale

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please answer the following questions for the hip/knee being treated or followed up. If it is BOTH hips/knees, please answer the questions for your worse side. All questions are about how you have felt, on average, during the past week . If you are being treated for an injury that happened <u>less than</u> one week ago, please answer for the period since your injury.					
1	During the <u>past week</u> , how stiff was your hip/knee? (Circle one response.)	NA	b7 Neuromusculoskeletal and movement-related functions	Not at all, Mildly, Moderately, Very, Extremely	Intensity
2	During the <u>past week</u> , how swollen was your hip/knee? (Circle one response.)	NA	s7 Structures related to movement	Not at all, Mildly, Moderately, Very, Extremely	Intensity
The following instructions are for questions 3-5. During the past week , please tell us about how painful your hips/knees were during the following activities. (Circle ONE response on each line that best describes your average ability for each joint.)					
3	Walking on flat surfaces? Right Hip, Left Hip, Right Knee, Left Knee	Descriptive	d4508 Other specified walking	Not painful, Mildly painful, Moderately painful, Very painful, Extremely painful, Could not do because of hip/knee pain, Could not do for other reasons	Intensity
4	Going up or down stairs? Right Hip, Left Hip, Right Knee, Left Knee	Descriptive	d451 Going up stairs d451 Going down stairs	Not painful, Mildly painful, Moderately painful, Very painful, Extremely painful, Could not do because of hip/knee pain, Could not do for other reasons	Intensity
5	Lying in bed at night? Right Hip, Left Hip, Right Knee, Left Knee	Descriptive	d4150 Maintaining a lying position	Not painful, Mildly painful, Moderately painful, Very painful, Extremely painful, Could not do because of hip/knee pain, Could not do for other reasons	Intensity
6	Which of the following statements best describes your ability to get around most of the time during the <u>past week</u> ? (Circle one response.)	NA	e1 Products and technology	I did not need support or assistance at all., I mostly walked without support or assistance., I mostly used one cane or crutch to help me get around., I mostly used two canes, two crutches or a walker to help me get around., I used a wheelchair., I mostly used other supports or someone else had to help me get around., I was unable to get around at all.	Qualitative attributes
7	How difficult was it for you to put on or take off socks/stockings during the <u>past week</u> ? (Circle one response.)	Descriptive	d5402 Putting on footwear d5403 Taking off footwear	Not at all difficult, Slightly difficult, Moderately difficult, Very difficult, Extremely difficult, Cannot do it at all	Intensity

2. *Forgotten Joint Score (FJS)*

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
A healthy joint is not something you are aware of in everyday life. However, even the smallest problems can raise one's awareness of a joint. This means that you think of your joint or have your attention drawn to it. The following questions concern how often you are aware of your affected knee joint in everyday life. Please choose the most appropriate answer for each question. Are you aware of your knee joint...					
1	... in bed at night?	Descriptive	nc (b110 Consciousness functions)	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
2	... when you are sitting on a chair for more than one hour?	Descriptive	nc (b110 Consciousness functions) d4153 Maintaining a sitting position	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
3	... when you are walking for more than 15 minutes?	Descriptive	nc (b110 Consciousness functions) d4501 Walking long distances	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
4	... when you are taking a bath/shower?	Descriptive	nc (b110 Consciousness functions) d5101 Washing whole body	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
5	... when you are traveling in a car?	Descriptive	nc (b110 Consciousness functions) d4701 Using private motorized transportation	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
6	... when you are climbing stairs?	Descriptive	nc (b110 Consciousness functions) <i>d451 Going up stairs OR d451 Going down stairs?</i>	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
7	... when you are walking on uneven ground?	Descriptive	nc (b110 Consciousness functions) d4502 Walking on different surfaces	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
8	... when you are standing up from a low-sitting position?	Descriptive	nc (b110 Consciousness functions) d4104 Standing	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
9	... when you are standing for long periods of time?	Descriptive	nc (b110 Consciousness functions) d4154 Maintaining a standing position	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
10	... when you are doing housework or gardening?	Descriptive	nc (b110 Consciousness functions) d640 Doing housework d9200 Play d9204 Hobbies/d9203 Crafts / d9202 Arts and culture	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
11	... when you are taking a walk/hiking?	Descriptive	nc (b110 Consciousness functions) <i>d4509 Walking, unspecified?</i> d9201 Sports	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
12	... when you are doing your favorite sport?	Descriptive	nc (b110 Consciousness functions) d9201 Sports	Never, Almost never, Seldom, Sometimes, Mostly	Intensity

nc: not covered; ?: concepts not addressed adequately.

2.1 Modified Forgotten Joint Score (MFJS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
A healthy joint is not something you are aware of in everyday life. However, even the smallest problems can raise one's awareness of a joint. This means that you think of your joint or have your attention drawn to it. The following questions concern how often you are aware of your affected knee joint in everyday life. Please choose the most appropriate answer for each question.					
Are you aware of your knee joint...					
1	... in bed at night?	Descriptive	nc (b110 Consciousness functions)	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
2	... when you are sitting on a chair for more than one hour?	Descriptive	nc (b110 Consciousness functions) d4153 Maintaining a sitting position	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
3	... when you are walking for more than 15 minutes?	Descriptive	nc (b110 Consciousness functions) d4501 Walking long distances	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
4	... when you are taking a bath/shower?	Descriptive	nc (b110 Consciousness functions) d5101 Washing whole body	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
5	... when you are traveling in a car?	Descriptive	nc (b110 Consciousness functions) d4701 Using private motorized transportation	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
6	... when you are climbing stairs?	Descriptive	nc (b110 Consciousness functions) <i>d451 Going up stairs OR d451 Going down stairs?</i>	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
7	... when you are walking on uneven ground?	Descriptive	nc (b110 Consciousness functions) d4502 Walking on different surfaces	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
8	... when you are squatting/crouching?	Descriptive	nc (b110 Consciousness functions) <i>d4101 Squatting or d4151 Maintaining a squatting position?</i>	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
9	... when you are standing for long periods of time?	Descriptive	nc (b110 Consciousness functions) d4154 Maintaining a standing position	Never, Almost never, Seldom, Sometimes, Mostly	Intensity
10	... when you are doing housework/gardening or the most strenuous activity you do around the home?	Descriptive	nc (b110 Consciousness functions) d640 Doing housework d9200 Play d9204 Hobbies/d9203 Crafts / d9202 Arts and culture	Never, Almost never, Seldom, Sometimes, Mostly	Intensity

nc: not covered; ?: concepts not addressed adequately.

2.2 Joint Awareness Score (JAS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Do you notice or think about your joint...					
1	... when you are taking a bath/shower?	Descriptive	nc (b110 Consciousness functions) d5101 Washing whole body	Never/rarely, Occasionally/infrequently, Frequently, NA I don't do this	Intensity
2	... when getting in and out of a car?	Descriptive	nc (b110 Consciousness functions) d4701 Using private motorized transportation	Never/rarely, Occasionally/infrequently, Frequently, NA I don't do this	Intensity
3	... when standing up from a low-sitting position?	Descriptive	nc (b110 Consciousness functions) d4104 Standing	Never/rarely, Occasionally/infrequently, Frequently, NA I don't do this	Intensity
4	... when you are walking on uneven ground for more than 15 minutes?	Descriptive	nc (b110 Consciousness functions) d4502 Walking on different surfaces	Never/rarely, Occasionally/infrequently, Frequently, NA I don't do this	Intensity
5	... when doing gardening, yard work, or snow removal?	Descriptive	nc (b110 Consciousness functions) d9200 Play d9204 Hobbies/d9203 Crafts / d9202 Arts and culture d640 Doing housework	Never/rarely, Occasionally/infrequently, Frequently, NA I don't do this	Intensity
6	... when longer walk or hike (more than half an hour)?	Descriptive	nc (b110 Consciousness functions) d4501 Walking long distances d9201 Sports	Never/rarely, Occasionally/infrequently, Frequently, NA I don't do this	Intensity

nc: not covered

2 Lower extremity functional scale (LEFS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
We are interested in knowing whether you are having any difficulty at all with the activities listed below <u>because of your lower limb problem</u> for which you are currently seeking attention. Please provide an answer for each activity. Today, <u>do you</u> or <u>would you</u> have any difficulty at all with:					
1	Any of your usual work, housework, or school activities.	Descriptive	<i>d850 Remunerative employment OR</i> <i>d855 Non-remunerative employment ?</i> d640 Doing housework nc (d820 School education)	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
2	Your usual hobbies, recreational or sporting activities.	Descriptive	d9200 Play d9204 Hobbies /d9203 Crafts / d9202 Arts and culture <i>d9209 Recreation and leisure, unspecified ?</i> d9201 Sports	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
3	Getting into or out of the bath.	Descriptive	d5101 Washing whole body	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
4	Walking between rooms.	Descriptive	d4500 Walking short distances	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
5	Putting on your shoes or socks	Descriptive	d5402 Putting on footwear	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
6	Squatting.	Descriptive	<i>d4101 Squatting or d4151 Maintaining a squatting position ?</i>	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
7	Lifting an object, like a bag of groceries from the floor	Descriptive	<i>d4300 Lifting a light object OR d4300 Lifting a heavy object ?</i>	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
8	Performing light activities around your home	Descriptive	d640 Doing housework	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity

9	Performing heavy activities around your home.	Descriptive	d640 Doing housework	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
10	Getting into or out of a car.	Descriptive	d4701 Using private motorized transportation	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
11	Walking 2 blocks.	Descriptive	d4500 Walking short distances	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
12	Walking a mile	Descriptive	d4501 Walking long distances	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
13	Going up or down 10 stairs (about 1 flight of stairs).	Descriptive	d451 Going up stairs d451 Going down stairs	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
14	Standing for 1 hour.	Descriptive	d4154 Maintaining a standing position	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
15	Sitting for 1 hour	Descriptive	d4153 Maintaining a sitting position	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
16	Running on even ground.	Descriptive	d4552 Running	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
17	Running on uneven ground.	Descriptive	d4552 Running	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
18	Making sharp turns while running fast.	Descriptive	d4558 Other specified moving around	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
19	Hopping	Descriptive	d4553 Jumping	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity
20	Rolling over in bed	Descriptive	d4107 Rolling over	Extreme difficult or unable to perform activity, Quit bit of difficulty, Moderate difficulty, A little bit of difficulty, No Difficulty	Intensity

nc: not covered; ?: concepts not addressed adequately.

3 Lower Limb Functional Index (LLFI)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
PLEASE COMPLETE: Your leg/s may make it difficult to do some things you normally do. This list contains sentences people use to describe themselves with such problems. Think of yourself over the last few days.					
If an item describes you, mark the line. If not, leave it blank. If an item partly describes you – Use a Half (1/2) Mark					
1	I stay at home most of the time.	Descriptive	nc (d230 Carrying out daily routine)	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
2	I change position frequently for comfort.	Descriptive	<i>d4109 Changing basic body position, unspecified[?]</i>	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
3	I avoid heavy jobs (e.g., cleaning, lifting more than 5 kg or 10 lb, gardening).	Descriptive	nc (d298 Other specified general tasks and demands) d640 Doing housework d4300 Lifting a heavy object d9200 Play d9204 Hobbies /d9203 Crafts / d9202 Arts and culture	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
4	I rest more often.	Descriptive	nc (d230 Carrying out daily routine)	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
5	I get others to do things for me.	NA	e3 Support and relationships	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
6	I have the pain/problem almost all the time.	NA	b2 Sensory functions and pain	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
7	I have difficulty lifting and carrying (e.g., shopping bags up to 5 kg or 10 lb).	Descriptive	d4308 Lifting and carrying, other specified	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
8	My appetite is now different.	NA	b1 Mental functions	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
9	My walking or normal recreation or sporting activity is affected.	Descriptive	<i>d4509 Walking, unspecified[?]</i> <i>d9209 Recreation and leisure, unspecified[?]</i> d9201 Sports	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
10	I have difficulty with normal home or family duties and chores.	Descriptive	d640 Doing housework	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
11	I sleep less well.	NA	b1 Mental functions	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
12	I need assistance with personal care (eg., washing, hygiene).	NA	e3 Support and relationships	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement

			nc (d598 Other specified self-care) <i>d5109 Washing oneself, unspecified</i> ?		
13	My regular daily activities (work, social contacts) are affected.	Descriptive	nc (d230 Carrying out daily routine) <i>d850 Remunerative employment OR d855 Non-remunerative employment</i> ? d910 Community Life/ d9205 Socializing	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
14	I am more irritable and/or bad tempered.	NA	b1 Mental functions	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
15	I feel weaker and/or stiffer.	NA	b1 Mental functions	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
16	My transport independence is affected (driving, public transport).	Descriptive	d4751 Driving motorized vehicles d4702 Using public motorized transportation	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
17	I have difficulty or need help with dressing (eg, trousers/pants/shoes and socks).	Descriptive	d540 Dressing	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
18	I have difficulty changing directions, twisting or turning.	Descriptive	d4558 Other specified moving around	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
19	I am unable to move as fast as I would wish.	Descriptive	nc (d498 Other specified mobility)	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
20	I have difficulty with prolonged or extended standing.	Descriptive	d4154 Maintaining a standing position	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
21	I have difficulty bending, squatting, and/or reaching down.	Descriptive	d4105 Bending <i>d4101 Squatting or d4151 Maintaining a squatting position</i> ?	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
22	I have difficulty with long or extended walks.	Descriptive	d4501 Walking long distances	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
23	I have difficulty with steps and stairs.	Descriptive	d4551 Climbing <i>d451 Going up stairs OR d451 Going down stairs</i> ?	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
24	I have difficulty with sitting for prolonged or extended times.	Descriptive	d4153 Maintaining a sitting position	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement
25	I have problems with my balance on uneven surfaces and/or with unaccustomed footwear.	NA	b7 Neuromusculoskeletal and movement-related functions	No (blank), Partly (1/2), Yes (mark)	Confirmation or agreement

nc: not covered; ?: related to the concepts not addressed adequately.

3.1 Lower Limb Functional Index-10 (LLFI-10)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
PLEASE COMPLETE ALL 4 PARTS - Each part has a separate score: -Your lower limb (leg) may make it difficult to do some things you normally do. This list contains sentences people use to describe themselves when they have such problems. Think of yourself now or over the last few days. -If an item describes you, mark the Box 'Partly' or 'Yes'. If an item does not describe you, Mark the Box 'NO'					
1	I avoid heavy jobs (eg, cleaning, lifting more than 5 kg or 10 lb, gardening).	Descriptive	nc (d298 Other specified general tasks and demands) d640 Doing housework d4300 Lifting a heavy object d9200 Play d9204 Hobbies /d9203 Crafts / d9202 Arts and culture	No Partly Yes	Confirmation or agreement
2	I have the pain/problem almost all the time.	NA	b2 Sensory functions and pain	No Partly Yes	Confirmation or agreement
3	I have difficulty lifting and carrying (e.g, shopping bags up to 5 kg or 10 lb).	Descriptive	d4308 Lifting and carrying, other specified	No Partly Yes	Confirmation or agreement
4	I have difficulty with normal home or family duties and chores.	Descriptive	d640 Doing housework	No Partly Yes	Confirmation or agreement
5	I sleep less well.	NA	b1 Mental functions	No Partly Yes	Confirmation or agreement
6	I need assistance with personal care (eg, washing, hygiene).	NA	e3 Support and relationships nc (d598 Other specified self-care) <i>d5109 Washing oneself, unspecified?</i>	No Partly Yes	Confirmation or agreement
7	My regular daily activities (work, social contacts) are affected.	Descriptive	nc (d230 Carrying out daily routine) <i>d850 Remunerative employment OR d855 Non-remunerative employment ?</i> d910 Community Life/ d9205 Socializing	No Partly Yes	Confirmation or agreement
8	I am unable to move as fast as I would wish.	Descriptive	nc (d498 other specified mobility)	No Partly Yes	Confirmation or agreement
9	I have difficulty with prolonged or extended standing.	Descriptive	d4154 Maintaining a standing position	No Partly Yes	Confirmation or agreement

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10	I have difficulty bending, squatting, and/or reaching down.	Descriptive	d4105 Bending <i>d4101 Squatting or d4151 Maintaining a squatting position</i> [?]	No Partly Yes	Confirmation or agreement
11	I have problems with my balance on uneven surfaces and/or with unaccustomed footwear.	NA	b7 Neuromusculoskeletal and movement-related functions	No Partly Yes	Confirmation or agreement

nc: not covered; ?: concepts not addressed adequately.

4 Lower Limb Task Questionnaire (LLTQ)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Activities of daily living section					
INSTRUCTIONS -Please rate your ability to do the following activities in the past 24 hours by circling the number below the appropriate response. -If you did not have the opportunity to perform an activity in the past 24 hours, please make your best estimate on which response would be the most accurate. -Please also rate how important each task is to you in your daily life according to the following scale: 1. Not important 2. Mildly important 3. Moderately important 4. Very important -Please answer all questions.					
1	Walk for 10 minutes	Descriptive	d4500 Walking short distances	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
2	Walk up or down 10 steps (1 flight)	Descriptive	d451 Going up stairs d451 Going down stairs	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
3	Stand for 10 minutes	Descriptive	d4154 Maintaining a standing position	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
4	Stand for a typical work day	Descriptive	d4154 Maintaining a standing position	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
5	Get on and off a bus	Descriptive	d4702 Using public motorized transportation	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
6	Get up from a lounge chair	Descriptive	d4104 Standing	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity

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7	Push or pull a heavy trolley	Descriptive	nc (d4450 Pulling, d4451 Pushing)	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
8	Get in and out of a car	Descriptive	d4701 Using private motorized transportation	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
9	Get out of bed in the morning	Descriptive	d4100 Lying down and getting up	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
10	Walk across a slope	Descriptive	d4502 Walking on different surfaces	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity

Recreational activities section

INSTRUCTIONS

-Please rate your ability to do the following activities in the past 24 hours by circling the number below the appropriate response.
 -If you did not have the opportunity to perform an activity in the past 24 hours, please make your best estimate on which response would be the most accurate.
 -Please also rate how important each task is to you in your daily life according to the following scale: 1. Not important 2. Mildly important 3. Moderately important 4. Very important
 -Please answer all questions.

1	Jog for 10 minutes	Descriptive	d4552 Running	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
2	Pivot or twist quickly while walking	Descriptive	d4558 Other specified moving around <i>d4509 Walking, unspecified ?</i>	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
3	Jump for distance	Descriptive	d4553 Jumping	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
4	Run fast/sprint	Descriptive	d4552 Running	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable	Intensity

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				Not important, Mildly important, Moderately important, Very important	
5	Stop and start moving quickly	Descriptive	b7 Neuromusculoskeletal and movement-related functions	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
6	Jump upwards and land	Descriptive	d4553 Jumping	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
7	Kick a ball hard	Descriptive	nc (d4351 Kicking)	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
8	Pivot or twist quickly while running	Descriptive	d4558 Other specified moving around d4552 Running	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
9	Kneel on both knees for 5 minutes	Descriptive	d4152 Maintaining a kneeling position	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity
10	Squat to the ground/floor	Descriptive	d4101 Squatting	No difficulty, Mild difficulty, Moderate difficulty, severe difficulty, unable Not important, Mildly important, Moderately important, Very important	Intensity

nc: not covered ; ?: concepts not addressed adequately.

5 Lysholm score

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
This questionnaire has been designed to give your Physical Therapist information as to how your knee pain has affected your ability to manage everyday life. Below are common complaints that people frequently have with their knee problems. Please answer every section and mark only ONE box which best describes your condition at this moment.					
1	Limp	NA	b7 Neuromusculoskeletal and movement-related functions	I have no limp when I walk. I have a slight or periodical limp when I walk. I have a severe and constant limp when I walk.	Intensity
2	Support	NA	e1 Products and technology	I do not use a cane or crutches. I use a cane or crutches with some weight-bearing. Putting weight on my hurt leg is impossible	Qualitative attributes
3	Locking	NA	b7 Neuromusculoskeletal and movement-related functions	I have no locking and no catching sensations in my knee. I have catching sensations but no locking sensations in my knee. My knee locks occasionally. My knee locks frequently. My knee feels locked at this moment.	Frequency
4	Instability	NA	b7 Neuromusculoskeletal and movement-related functions	My knee never gives way. My knee rarely gives way only during athletics or other vigorous activities. My knee frequently gives way during athletics or other vigorous activities and in turn, I am unable to participate in these activities. My knee often gives way during daily activities. My knee gives way every step I take.	Frequency
5	Pain	NA	b2 Sensory functions and pain	I have no pain in my knee. I have intermittent or slight pain in my knee during vigorous activities. I have marked pain in my knee during vigorous activities. I have marked pain in my knee during or after walking more than 1 mile. I have marked pain in my knee during or after walking less than 1 mile. I constant pain in my knee.	Intensity
6	Swelling	NA	s7 Structures related to movement	I have no swelling in my knee. I have swelling in my knee only after vigorous activities. I have swelling in my knee after ordinary activities. I have swelling constantly in my knee.	Frequency
7	Stair-climbing	Descriptive	d451 Going up stairs OR d451 Going up stairs [?]	I have no problems climbing stairs. I have slight problems climbing stairs. I can climb stairs only one at a time. Climbing stairs is impossible for me.	intensity
8	Squatting	Descriptive	d4101 Squatting or d4151 Maintaining a squatting position [?]	I have no problems squatting. I have slight problems squatting. I cannot squat beyond a 90 degree bend in my knee. Squatting is impossible because of my knee(s).	intensity

?: related to the concepts not addressed adequately.

6 Marx Scale

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please indicate how often you performed each activity in your healthiest and most active state, in the past year. Kindly put a (☑) mark on the appropriate space after each item.					
1	Running: running while playing a sport or jogging	Descriptive	d4552 Running	Less than one time in a month, One time in a month, One time in a week, 2 or 3 times in a week, 4 or more times in a week	Frequency
2	Cutting: changing directions while running	Descriptive	d4558 Other specified moving around	Less than one time in a month, One time in a month, One time in a week, 2 or 3 times in a week, 4 or more times in a week	Frequency
3	Deceleration: coming to a quick stop while running	Descriptive	b7 Neuromusculoskeletal and movement-related functions	Less than one time in a month, One time in a month, One time in a week, 2 or 3 times in a week, 4 or more times in a week	Frequency
4	Pivoting: turning your body with your foot planted while playing sport; For example: skiing, skating, kicking, throwing, hitting a ball (golf, tennis, squash), etc.	Descriptive	d9201 Sports nc (d4351 Kicking)	Less than one time in a month, One time in a month, One time in a week, 2 or 3 times in a week, 4 or more times in a week	Frequency

nc: not covered

7 Osteoarthritis Knee and Hip Quality of Life (OAKHQOL)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please read the following instructions carefully: The following statements are about alterations in your quality of life brought about by you hip or knee osteoarthritis. The information you provide will help in understanding what it is like for you living day-to-day with your arthritis. Tick the box that best describes your own situation, ranging from: “not at all” to “a great deal”, “never” to “all the time” “not at all” to “unbearable” “not at all” to “very much agree” According to statements. There are no right or wrong answers. For each statement, please tick only one box. Read these statements one by one carefully, thinking about your quality of life DURING THE LAST FOUR WEEKS. Tick the box that best describes how things are for you with your arthritis:					
1	I have difficulty walking	Descriptive	d4509 Walking, unspecified [?]	a number between “0, Not at all” and “10, a great deal”	Intensity
2	I have difficulty bending down or straightening up	Descriptive	d4105 Bending	a number between “0, Not at all” and “10, a great deal”	Intensity
3	I have difficulty carrying heavy things	Descriptive	d4308 Lifting and carrying, other specified	a number between “0, Not at all” and “10, a great deal”	Intensity
4	I have difficulty going down stairs	Descriptive	d451 Going down stairs	a number between “0, Not at all” and “10, a great deal”	Intensity
5	I have difficulty climbing stairs	Descriptive	d451 Going up stairs OR d451 Going up stairs [?]	a number between “0, Not at all” and “10, a great deal”	Intensity
6	I have difficulty taking a bath	Descriptive	d5101 Washing whole body	a number between “0, Not at all” and “10, a great deal”	Intensity
7	I have difficulty getting dressed (socks, tights, shoes, etc.)	Descriptive	d540 Dressing	a number between “0, Not at all” and “10, a great deal”	Intensity

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8	I have difficulty cutting my toe-nails	Descriptive	nc (d5204 Caring for toenails)	a number between “0, Not at all” and “10, a great deal”	Intensity
9	I have difficulty staying in the same position for a long time (sitting, standing, not moving, etc.)	Descriptive	d4159 <i>Maintaining a body position, unspecified</i> ? d4153 Maintaining a sitting position d4154 Maintaining a standing position	a number between “0, Not at all” and “10, a great deal”	Intensity
10	I have difficulty getting in and out of a car	Descriptive	d4701 Using private motorized transportation	a number between “0, Not at all” and “10, a great deal”	Intensity
11	I have difficulty using public transport (bus, train, subway, etc.)	Descriptive	d4702 Using public motorized transportation	a number between “0, Not at all” and “10, a great deal” Not applicable	Intensity
12	I have difficulty doing my job/professional activities	Descriptive	d850 Remunerative employment	a number between “0, Not at all” and “10, a great deal” I don not work	Intensity
13	I have to pace myself	Descriptive	nc (d230 Carrying out daily routine)	a number between “0, Not at all” and “10, a great deal”	Intensity
14	My spirits are low because of the pain	NA	b1 Mental functions b2 Sensory functions and pain	a number between “0, Not at all” and “10, a great deal”	Intensity
15	I take more time to do things	Descriptive	nc (d230 Carrying out daily routine)	a number between “0, Not at all” and “10, a great deal”	Intensity
16	I worry about being dependent on others	NA	b1 Mental functions e3 Support and relationships	a number between “0, Not at all” and “10, a great deal”	Intensity
17	I worry about being disabled	NA	b1 Mental functions <i>nd or nc ?</i>	a number between “0, Not at all” and “10, a great deal”	Intensity
18	I feel embarrassed when people look at me	NA	b1 Mental functions	a number between “0, Not at all” and “10, a great deal”	Intensity
19	I am anxious	NA	b1 Mental functions	a number between “0, Not at all” and “10, a great deal”	Intensity
20	I am depressed	NA	b1 Mental functions	a number between “0, Not at all” and “10, a great deal”	Intensity
21	I feel my family life is being affected	Descriptive	nc (d760 Family relationships)	a number between “0, Not at all” and “10, a great deal”	Intensity
22	I feel my relationship with my partner is being affected	Descriptive	d770 Intimate relationships	a number between “0, Not at all” and “10, a great deal” Not applicable	Intensity
23	I feel my sexual relationship is being affected	Descriptive	d770 Intimate relationships	a number between “0, Not at all” and “10, a great deal”	Intensity

				No sexual activity in the last four weeks	
24	I have difficulty staying in the same position for a long time (sitting, standing, not moving, etc.)	Descriptive	d4159 <i>Maintaining a body position, unspecified</i> ? d4153 Maintaining a sitting position d4154 Maintaining a standing position	a number between “0, Never“ and “10, all the time”	Frequency
25	I need a walking stick/cane or crutches to walk	Need or dependency	e1 Products and technology	a number between “0, Never“ and “10, all the time”	Frequency
26	I have pain (describe frequency)	NA	b2 Sensory functions and pain	a number between “0, Never“ and “10, all the time”	Frequency
27	I have pain (describe intensity)	NA	b2 Sensory functions and pain	a number between “0, Not at all“ and “10, unbearable”	Intensity
28	I need help for things like housework and shopping, etc.	Need or dependency	e3 Support and relationships d640 Doing housework d620 Acquisition of goods and services	a number between “0, Not at all“ and “10, a great deal”	Intensity
29	I feel older than my age	NA	b1 Mental functions	a number between “0, Not at all“ and “10, very much agree”	Intensity
30	I am able to plan projects for the long term	Descriptive	nc (b1642 Time management)	a number between “0, Not at all“ and “10, very much agree”	Intensity
31	I get out of the house as much as I like	Descriptive	nc (d498 other specified mobility)	a number between “0, Not at all“ and “10, very much agree”	Intensity
32	I entertain at home as much as I like	Descriptive	d9209 <i>Recreation and leisure, unspecified</i> ?	a number between “0, Not at all“ and “10, very much agree”	Intensity
33	I have difficulty getting to sleep or getting back to sleep because of pain	NA	b1 Mental functions b2 Sensory functions and pain	a number between “0, Never“ and “10, all the time”	Frequency
34	I wake up because of pain	NA	b1 Mental functions b2 Sensory functions and pain	a number between “0, Never“ and “10, all the time”	Frequency
35	I wonder what will become of me	NA	b1 Mental functions	a number between “0, Never“ and “10, all the time”	Frequency
36	I am irritable or aggressive	NA	b1 Mental functions	a number between “0, Never“ and “10, all the time”	Frequency
37	I feel I annoy those close to me	NA	b1 Mental functions	a number between “0, Never“ and “10, all the time”	Frequency
38	I am worried about the side-effects of my treatment	NA	b1 Mental functions	a number between “0, Not at all“ and “10, A great deal”	Intensity
39	I can talk to others about the difficulties I have due to my arthritis as much as I like	Descriptive	nc (d350 Conversation)	a number between “0, Not at all“ and “10, Very much agree”	Intensity
40	I feel others understand the difficulties I have because of my arthritis	NA	e3 Support and relationships	a number between “0, Not at all“ and “10, Very much agree”	Intensity
41	I am embarrassed to ask for help if I need it	NA	b1 Mental functions	a number between “0, Not at all“ and “10, A great deal”	Intensity

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42	I feel supported by people close to me (partner, family, etc.)	NA	e3 Support and relationships	a number between “0, Not at all” and “10, A great deal”	Intensity
43	I feel supported by those around me (friends, neighbours, colleagues at work, etc.)	NA	e3 Support and relationships	a number between “0, Not at all” and “10, A great deal”	Intensity

nc or nd: not covered or not definable; **?:** concepts not addressed adequately.

8 Oxford Arthroplasty Early Change Score (OACS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Don't spend too long on any one question. Your first choice of response is typically the right one. Please answer ALL questions. This questionnaire asks about your health today compared to before your operation. Thinking about the state of your health before the operation, how would you rate: Please place an X in the appropriate box.					
1	Your ability to stand compared to before the operation?	NA	<i>d4104 Standing or d4154 Maintaining a standing position?</i>	Much worse, Worse, The same, Better, Much better	Intensity
2	Your ability to walk compared to before the operation?	Descriptive	<i>d4509 Walking, unspecified?</i>	Much worse, Worse, The same, Better, Much better	Intensity
3	Your ability to walk upstairs compared to before the operation?	Descriptive	d451 Going up stairs	Much worse, Worse, The same, Better, Much better	Intensity
4	Your ability to walk down stairs compared to before the operation?	Descriptive	d451 Going down stairs	Much worse, Worse, The same, Better, Much better	Intensity
5	Your strength compared to before the operation?	NA	b7 Neuromusculoskeletal and movement-related functions	Much worse, Worse, The same, Better, Much better	Intensity
6	How comfortable you feel when sitting compared to before the operation?	Descriptive	b1 Mental functions <i>d4103 Sitting OR d4153 Maintaining a sitting position?</i>	Much worse, Worse, The same, Better, Much better	Intensity
7	Your pain in the affected area compared to before the operation?	NA	b2 Sensory functions and pain	Much worse, Worse, The same, Better, Much better	Intensity
8	Your pain in the affected area when walking as compared to before the operation?	NA	b2 Sensory functions and pain <i>d4509 Walking, unspecified?</i>	Much worse, Worse, The same, Better, Much better	Intensity
9	Your appetite as compared to before the operation?	NA	b1 Mental functions	Much worse, Worse, The same, Better, Much better	Intensity
10	Your mood compared to before the operation?	NA	b1 Mental functions	Much worse, Worse, The same, Better, Much better	Intensity
11	Your energy level compared to before the operation?	NA	b1 Mental functions	Much worse, Worse, The same, Better, Much better	Intensity
12	Your sleep as compared to before the operation?	NA	b1 Mental functions	Much worse, Worse, The same, Better, Much better	Intensity
13	How you feel overall compared to before the operation?	NA	b1 Mental functions	Much worse, Worse, The same, Better, Much better	Intensity
14	Your pain when trying to sleep compared to before the operation?	NA	b2 Sensory functions and pain b1 Mental functions	Much worse, Worse, The same, Better, Much better	Intensity

?: concepts not addressed adequately.

9 Oxford Arthroplasty Early Recovery Score (OARS)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Don't spend too long on any one question. Your first choice of response is typically the right one. Please answer ALL questions. This questionnaire asks about your health <u>today</u>. How much do you agree with these statements? Please place an X in the appropriate box.					
1	I've felt unwell	NA	<i>nc or nd</i> [?]	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
2	I've felt tired	NA	b1 Mental functions	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
3	I've felt faint	NA	<i>nc or nd</i> [?]	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
4	It's been painful in the affected area	NA	b2 Sensory functions and pain	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
5	I've had pain at night in the affected area	NA	b2 Sensory functions and pain	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
6	The affected area has felt swollen	NA	s7 Structures related to movement	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
7	I've had difficulty getting into bed	Descriptive	d4100 Lying down and getting up	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
8	I've not been able to stand	Descriptive	<i>d4104 Standing or d4154 Maintaining a standing position</i> [?]	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
9	I've not been able to walk	Descriptive	<i>d4509 Walking, unspecified</i> [?]	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
10	I've not slept well	NA	b1 Mental functions	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
11	I've found it difficult to sleep	NA	b1 Mental functions	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
12	I've not been able to sleep due to the pain in the affected area	NA	b1 Mental functions b2 Sensory functions and pain	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
13	I've felt sick	NA	<i>nc or nd</i> [?]	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity
14	I've lost my appetite	NA	b1 Mental functions	Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree	Intensity

nc or nd: not covered or not definable; **?:** concepts not addressed adequately.

10 Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please circle the appropriate rating for each item.					
RATE YOUR PAIN WHEN...					
1	Walking	NA	b2 Sensory functions and pain <i>d4509 Walking, unspecified[?]</i>	None, slight, moderate, severe, extreme	Intensity
2	Climbing stairs	NA	b2 Sensory functions and pain <i>d451 Going up stairs OR d451 Going up stairs[?]</i>	None, slight, moderate, severe, extreme	Intensity
3	Sleeping at night	NA	b2 Sensory functions and pain b1 Mental functions	None, slight, moderate, severe, extreme	Intensity
4	Resting	NA	b2 Sensory functions and pain	None, slight, moderate, severe, extreme	Intensity
5	Standing	NA	b2 Sensory functions and pain <i>d4104 Standing OR d4154 Maintaining a standing position[?]</i>	None, slight, moderate, severe, extreme	Intensity
RATE YOUR STIFFNESS IN THE...					
6	Morning	NA	b7 Neuromusculoskeletal and movement-related functions	None, slight, moderate, severe, extreme	Intensity
7	Evening	NA	b7 Neuromusculoskeletal and movement-related functions	None, slight, moderate, severe, extreme	Intensity
RATE YOUR DIFFICULTY WHEN...					
8	Descending stairs	Descriptive	d451 Going down stairs	None, slight, moderate, severe, extreme	Intensity
9	Ascending stairs	Descriptive	d451 Going up stairs	None, slight, moderate, severe, extreme	Intensity
10	Rising from sitting	Descriptive	d4104 Standing	None, slight, moderate, severe, extreme	Intensity
11	Standing	Descriptive	d4154 Maintaining a standing position	None, slight, moderate, severe, extreme	Intensity
12	Bending to floor	Descriptive	d4105 Bending	None, slight, moderate, severe, extreme	Intensity

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13	Walking on even floor	Descriptive	d4508 Other specified walking	None, slight, moderate, severe, extreme	Intensity
14	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, slight, moderate, severe, extreme	Intensity
15	Going shopping	Descriptive	d620 Acquisition of goods and services	None, slight, moderate, severe, extreme	Intensity
16	Putting on socks	Descriptive	d5402 Putting on footwear	None, slight, moderate, severe, extreme	Intensity
17	Rising from bed	Descriptive	d4100 Lying down and getting up	None, slight, moderate, severe, extreme	Intensity
18	Taking off socks	Descriptive	d5403 Taking off footwear	None, slight, moderate, severe, extreme	Intensity
19	Lying in bed	Descriptive	<i>d4100 Lying down and getting up OR d4150 Maintaining a lying position?</i>	None, slight, moderate, severe, extreme	Intensity
20	Getting in/out of bath	Descriptive	d5101 Washing whole body	None, slight, moderate, severe, extreme	Intensity
21	Sitting	Descriptive	<i>d4103 Sitting or d4153 Maintaining a sitting position?</i>	None, slight, moderate, severe, extreme	Intensity
22	Getting on/off toilet	Descriptive	d530 Toileting	None, slight, moderate, severe, extreme	Intensity
23	Doing light domestic duties (cooking, dusting)	Descriptive	d640 Doing housework nc (d630 Preparing meals)	None, slight, moderate, severe, extreme	Intensity
24	Doing heavy domestic duties (moving furniture)	Descriptive	d640 Doing housework d4308 Lifting and carrying, other specified nc (d4450 Pulling, d4451 Pushing)	None, slight, moderate, severe, extreme	Intensity

nc: not covered; ?: concepts not addressed adequately.

10.1 Hirsch- Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please circle the appropriate rating for each item.					
<i>RATE YOUR PAIN WHEN...</i>					
1	Walking	NA	b2 Sensory functions and pain <i>d4509 Walking, unspecified[?]</i>	None, slight, moderate, severe, extreme	Intensity
2	Climbing stairs	NA	b2 Sensory functions and pain <i>d451 Going up stairs OR d451 Going down stairs[?]</i>	None, slight, moderate, severe, extreme	Intensity
3	Resting	NA	b2 Sensory functions and pain	None, slight, moderate, severe, extreme	Intensity
<i>RATE YOUR DIFFICULTY WHEN...</i>					
4	Descending stairs	Descriptive	d451 Going down stairs	None, slight, moderate, severe, extreme	Intensity
5	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, slight, moderate, severe, extreme	Intensity
6	Rising from bed	Descriptive	d4100 Lying down and getting up	None, slight, moderate, severe, extreme	Intensity
7	Lying in bed	Descriptive	<i>d4100 Lying down and getting up OR d4150 Maintaining a lying position[?]</i>	None, slight, moderate, severe, extreme	Intensity
8	Doing light domestic duties (cooking, dusting)	Descriptive	d640 Doing housework nc (d630 Preparing meals)	None, slight, moderate, severe, extreme	Intensity

nc: not covered; ?: concepts not addressed adequately.

10.2 Whitehouse- Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please circle the appropriate rating for each item.					
<i>RATE YOUR PAIN WHEN...</i>					
1	Walking	NA	b2 Sensory functions and pain <i>d4509 Walking, unspecified[?]</i>	None, slight, moderate, severe, extreme	Intensity
2	Climbing stairs	NA	b2 Sensory functions and pain <i>d451 Going up stairs OR d451 Going up stairs[?]</i>	None, slight, moderate, severe, extreme	Intensity
3	Sleeping at night	NA	b2 Sensory functions and pain b1 Mental functions	None, slight, moderate, severe, extreme	Intensity
4	Resting	NA	b2 Sensory functions and pain	None, slight, moderate, severe, extreme	Intensity
5	Standing	NA	b2 Sensory functions and pain <i>d4104 Standing OR d4154 Maintaining a standing position[?]</i>	None, slight, moderate, severe, extreme	Intensity
<i>RATE YOUR DIFFICULTY WHEN...</i>					
6	Ascending stairs	Descriptive	d451 Going up stairs	None, slight, moderate, severe, extreme	Intensity
7	Rising from sitting	Descriptive	d4104 Standing	None, slight, moderate, severe, extreme	Intensity
8	Walking on even floor	Descriptive	d4508 Other specified walking	None, slight, moderate, severe, extreme	Intensity
9	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, slight, moderate, severe, extreme	Intensity
10	Putting on socks	Descriptive	d5402 Putting on footwear	None, slight, moderate, severe, extreme	Intensity
11	Rising from bed	Descriptive	d4100 Lying down and getting up	None, slight, moderate, severe, extreme	Intensity
12	Sitting	Descriptive	<i>d4103 Sitting or d4153 Maintaining a sitting position[?]</i>	None, slight, moderate, severe, extreme	Intensity

nc: not covered; ?: concepts not addressed adequately.

10.3 Tubach- Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please circle the appropriate rating for each item.					
<i>RATE YOUR DIFFICULTY WHEN...</i>					
1	Descending stairs	Descriptive	d451 Going down stairs	None, slight, moderate, severe, extreme	Intensity
2	Ascending stairs	Descriptive	d451 Going up stairs	None, slight, moderate, severe, extreme	Intensity
3	Rising from sitting	Descriptive	d4104 Standing	None, slight, moderate, severe, extreme	Intensity
4	Walking on even floor	Descriptive	d4508 Other specified walking	None, slight, moderate, severe, extreme	Intensity
5	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, slight, moderate, severe, extreme	Intensity
6	Going shopping	Descriptive	d620 Acquisition of goods and services	None, slight, moderate, severe, extreme	Intensity
7	Putting on socks	Descriptive	d5402 Putting on footwear	None, slight, moderate, severe, extreme	Intensity
8	Getting on/off toilet	Descriptive	d530 Toileting	None, slight, moderate, severe, extreme	Intensity

10.4 WOMAC-short form

Item	Superscription	Perspectives adopted in information	ICF category of main concept	Item response	Category of response option
Please circle the appropriate rating for each item.					
RATE YOUR PAIN WHEN...					
1	Walking	NA	b2 Sensory functions and pain <i>d4509 Walking, unspecified</i> ?	None, slight, moderate, severe, extreme	Intensity
2	Climbing stairs	NA	b2 Sensory functions and pain <i>d451 Going up stairs OR d451 Going up stairs</i> ?	None, slight, moderate, severe, extreme	Intensity
3	Resting	NA	b2 Sensory functions and pain	None, slight, moderate, severe, extreme	Intensity
RATE YOUR DIFFICULTY WHEN...					
4	Descending stairs	Descriptive	d451 Going down stairs	None, slight, moderate, severe, extreme	Intensity
5	Ascending stairs	Descriptive	d451 Going up stairs	None, slight, moderate, severe, extreme	Intensity
6	Rising from sitting	Descriptive	d4104 Standing	None, slight, moderate, severe, extreme	Intensity
7	Walking on even floor	Descriptive	d4508 Other specified walking	None, slight, moderate, severe, extreme	Intensity
8	Getting in/out of car	Descriptive	d4701 Using private motorized transportation	None, slight, moderate, severe, extreme	Intensity
9	Going shopping	Descriptive	d620 Acquisition of goods and services	None, slight, moderate, severe, extreme	Intensity
10	Putting on socks	Descriptive	d5402 Putting on footwear	None, slight, moderate, severe, extreme	Intensity
11	Getting on/off toilet	Descriptive	d530 Toileting	None, slight, moderate, severe, extreme	Intensity

?: concepts not addressed adequately.

CHAPTER 4: Systematic Review and Content Analysis of PBTs (Manuscript 4)

Relationship of Manuscript 4 to the Dissertation

In this chapter, I present the manuscript of a systematic review and content analysis of performance-based tests (PBTs) (Study 4). Although various PBTs are available to objectively assess function, it is still uncertain which of these tests best capture the important aspects of functioning after hip or knee arthroplasty. There is a need to analyze and compare existing PBTs to gain a thorough understanding of their activity components. Therefore, the objective of this study is to identify PBTs currently used in hip or knee arthroplasty and link their activity components to the International Classification of Functioning, Disability and Health (ICF) core set for osteoarthritis (OA). The results identified 28 PBTs, including both single and multiple activity tests used after hip or knee arthroplasty. These tests covered 15 categories of the ICF OA core set for activity and participation but did not address 34 other categories. This content analysis offers a comprehensive view of the variety and scope of activity components assessed by each test. It forms the basis for analyzing outcome measures based on the key activities in Study 6, thereby informing the selection of patient-centered outcome measures.

This manuscript has been submitted for publication in the Journal of Evaluation in Clinical Practice and is formatted as per the journal requirements. However, the numbering of tables and figures was adjusted to align with the formatting of this dissertation. Also, the acronym "PBT" for "performance-based test" has been used to align with this dissertation. The submitted version of the manuscript which is currently under review is presented in this chapter.

Manuscript 4: Performance-based outcome measures after hip or knee arthroplasty: A systematic review and content analysis using the International Classification of Functioning, Disability and Health (ICF)

Abstract

Rational: One of the important considerations to select the appropriate outcome measures is determining if the tool is relevant to patients. Despite the availability of various performance-based tests (PBTs) to objectively assess function, it is unknown which PBTs best capture important aspects of function after hip or knee arthroplasty.

Aims and objectives: Our systematic review aimed to identify the existing PBTs used in hip or knee arthroplasty and link the activity component of each test to the modified International Classification of Functioning, Disability and Health (ICF) core set for osteoarthritis (OA).

Methods: We searched four databases from inception until April 2024. A performance-based test was included if an individual performs one or more activities, evaluated by an assessor and resulted in a numerical value. Two reviewers independently screened and extracted data and assessed the included PBTs.

Results: From 449 studies included in this review, we identified 28 PBTs which covered 15 categories of OA core set activity and participation. The categories of d4500:walking short distances, d4104:standing and d4103:sitting were the most frequently used, employed in 14, 10, and 10 PBTs, respectively. However, 34 categories of activity and participation were not found in any PBTs. A-test (“A” like Activity or Assessment) had the widest coverage covering 10 out of 49 core set categories. Four PBTs covered four activity and participation categories, one covered three categories, ten covered two categories and 12 covered one category.

Conclusion: Our ICF-based content analysis revealed that the existing PBTs covered certain OA core set activity and participation categories, but overlooked multiple categories. This

analysis can serve as a guide for researchers and clinicians in selecting suitable PBTs or a battery of tests to assess function following hip or knee arthroplasty.

Keywords: Hip or knee arthroplasty; Outcome measures; ICF framework

Introduction

Hip or knee arthroplasty is an effective treatment in relieving pain, improving function, and enhancing quality of life in patients with end-stage osteoarthritis (OA) who do not respond to conservative treatments.^{1,2} Traditionally, outcome measures after hip or knee arthroplasty were focused on complications and implant survival.^{3,4} However, the assessment of function outcomes has become increasingly important in evaluating the success of these procedures due to the advancements in surgical techniques, postoperative care pathways, advent of bundled payment and patients who are more physically active.³⁻⁵

Evaluating function is complex due to its representation of multidimensional constructs.⁶ Key considerations when evaluating function outcomes include understanding different types of outcome measures, choosing the appropriate outcome measure tool and identifying various components of each outcome measure tool.⁷ Function can be evaluated through patient-reported outcome measures (PROMs) or PBTs. PROMs assess more subjective aspects and offer insight into the patient's perception of their ability to perform tasks, while PBTs are more objective and evaluate the patient's ability to perform a set of movements or tasks and usually assessed by timing, counting, or distance methods.⁶ Evidence indicates a weak correlation between performance-based measures and PROMs, as they evaluate different aspects of function. PROMs have been shown to be more influenced by pain compared to performance measures, as patients' perceptions of their function abilities are strongly affected by their pain level.^{8,9} Both PROMs and PBTs are considered complementary to assess functional status rather than competing.^{10,11}

Despite existing various PBTs and their critical role to assess function, it is unknown which PBTs best assess postoperative recovery. This uncertainty may explain the considerable variability in the types of PBTs used in clinical practice and research.¹² One of the critical

considerations to select the appropriate PBTs is determining if the tool is relevant to patients.⁷

Content analysis of the PBTs can provide information regarding the most relevant components of a specified construct for a target audience and context.¹³ The International Classification of Functioning, Disability and Health (ICF), developed in 2001, offers a comprehensive and standardized framework to depict health and health-related states, including body function and structure, activity, and participation.¹⁴ The ICF core set for patients with OA was developed to improve the applicability of the ICF which includes over 1450 categories.¹⁵ This core set lists ICF categories which represent common functional issues in patients with advanced OA undergoing hip or knee arthroplasty.^{16,17}

Using ICF as an external framework can offer valuable insights for analyzing the activity components of PBTs to select the appropriate one to use after hip or knee arthroplasty.¹⁴ To our knowledge, an assessment of the content of PBTs used after hip or knee arthroplasty based on the of ICF has yet to be carried out. Therefore, the objective of this systematic review was to identify the existing PBTs used in hip or knee arthroplasty due to OA and link the activity components of each test to the modified ICF core set for OA.

Methods

We conducted this systematic review following the Cochrane reviews methodology¹⁸ and reported it based on the guidelines presented in Preferred Reporting Items for Systematic Review and Meta-analysis Protocols (PRISMA).¹⁹ The protocol was registered on PROSPERO (CRD42023395420).

Eligibility criteria

We used the SPIDER framework (sample, phenomenon of interest, design, evaluation, research type) to specify inclusion and exclusion criteria.²⁰

Sample: We included studies involving participants, aged 18 years and older, who underwent primary elective hip or knee arthroplasty, including total joint arthroplasty, uni-compartmental knee arthroplasty, and hip resurfacing or hemi-arthroplasty due to OA. We excluded studies with patients who underwent hip or knee arthroplasty for other conditions, such as rheumatoid arthritis, dysplasia, trauma, fracture, had revision or bilateral procedures.

Phenomenon of interest: The phenomenon of interest is a performance-based test to assess function following hip or knee arthroplasty. It was defined as a test in which the individual performs one or more activities, evaluated by an assessor which the ability of performing the activities or the quality of the performance, such as timing, counting or distance methods are measured. The PBTs were excluded if they: 1) were used to evaluate impairment (e.g. balance, strength) or health-related quality of life (HRQoL); 2) required the use of costly or non-portable equipment; 3) were based on clinical judgement without providing a defined score; 4) their psychometric properties were evaluated and reported only prior to 2008, given the introduction of Outcome Measures in Rheumatology (OMERACT) standards that year.²¹ There were no limitations on the publication period during screening.

Design: We included any study designs that: 1) focused on developing PBTs for assessing function after hip or knee arthroplasty; 2) evaluated psychometric properties, including reliability (internal consistency, reliability, and measurement error/agreement), validity (content, construct, and criterion validity), and responsiveness; 3) compared the psychometric properties of different PBTs. We excluded all types of reviews, editorials, and commentaries. Studies, such as randomized control trials that used PBTs only to assess outcomes were excluded.

Evaluation: The content of included PBTs was evaluated by linking their activity components with the modified core set for OA, following the ICF linking rules developed by

Cieza et al.²² It includes 10 linking rules designed to link health status measures to the ICF. Rules 1–3 include becoming familiar with the ICF, identifying the primary purpose of the instrument and relevant concepts for linkage to the ICF. Rules 4-5 include identifying the perspective adopted within specific information and categorizing response options. Lastly, rules 6–10 focus on linking concepts to the most appropriate ICF category or specifying their content if a direct linkage to the ICF is not feasible. The ICF follows a hierarchical structure, with the first level consisting of chapters. Each chapter contains second-level categories, followed by more detailed third-level categories. For example, in the component "activity and participation", the hierarchy can be illustrated as follows: (1) first-level chapter: d4, "mobility"; (2) second-level category: d450, "walking"; (3) third-level category: d4500, "walking short distances". We used the third-level category for the linking process in our review.

Since the ICF core set for OA has not been validated specifically for patients undergoing arthroplasty, we established its content validity in a previous study.²³ This involved conducting cognitive think-aloud interviews with patients who underwent hip or knee arthroplasty. Through this process, we refined the core set, resulting in 49 second and third-level ICF categories after excluding, adding and modifying some categories. Detailed categories of the modified ICF core set for OA can be found in Appendix A.

Research type and other: We included studies published in peer-reviewed journals, as well as unpublished materials such as grey literature (e.g., governmental reports and clinical practice guidelines) and theses. Full-text articles in any language were eligible as long as they could be translated by our research team, including English, French, and Persian.

Data sources and search strategy

Four databases, including CINAHL, Medline, Embase, and CENTRAL were searched from inception until April 2024. Collaborating with an experienced medical librarian, we adapted the search strategy for each database using four main concepts, including target population, measurement instrument, construct, and measurement properties based on the recommendation by consensus-based standards for the selection of health measurement instrument (COSMIN).²⁴ We used a measurement properties precise search filter outlined by Terwee et al.²⁵ The full search strategy for all databases is outlined in Appendix B. The reference lists and the bibliographies of relevant review studies and included studies were searched manually by the first author (MK) to identify additional relevant studies that the electronic search may have missed.

Data management and selection process

After executing the search strategy and importing the search results into Zotero reference management software²⁶ and the Covidence web-based platform for systematic reviews,²⁷ duplicate studies were removed. The title and abstract were screened by two pairs of independent reviewers (MK, FA, SA, PR, AD) according to prespecified inclusion criteria. The full text of the remaining studies was then screened by the same independent reviewers. We contacted the corresponding authors for additional data or to clarify study details if necessary. Any discrepancy between reviewers was resolved through discussion or consultation with a senior researcher (SP).

Data collection and items

Two reviewers initially piloted two studies to ensure consistency and accuracy of extraction and made necessary revisions. One reviewer extracted data from the included studies using a predetermined data extraction form, and a second independent reviewer verified the

extraction for accuracy. Any disagreements in the extracted data were resolved through discussion until a consensus was reached. Data on the following items was extracted: 1) study characteristics, including title, authors list, journal, country of study, and year of publication, study aim, design, and sample size; 2) study population, including demographic characteristics (e.g., age, sex, type of surgery, duration after surgery, etc.); 3) information on PBTs, including name, year of development, target population during development, PBTs activity component, scoring (e.g. timing, distance, etc.) and interpretation of the score. We contacted the corresponding author if further information was required.

Content analysis of PBTs and ICF linking procedure

Two coders (MK, FA), who had sufficient knowledge with the modified ICF core set for OA and the ICF linking rules, independently evaluated each activity component of PBTs by linking each activity component to the modified ICF core set for OA. Initially, the coders identified the primary concepts within each activity component of the performance-based test and then linked them to third level categories of the modified ICF core set for OA. Each performance-based test could be linked to one or more core set categories, depending on the number of activity components contained in that test. To ensure accuracy, consensus between the two coders was sought. In cases where consensus was not reached, disagreements were resolved through discussion with a senior researcher (SP).

Whenever an activity component of a performance-based test could not be linked to a core set category, it was categorized as "other specified" if the activity component could only be linked to the first level category of the core set but was not represented by a third level category.

Moreover, we employed the Mann-Whitney U test to make two comparisons regarding the coverage of ICF categories by PBTs: 1) between PBTs specifically developed for hip or knee

arthroplasty and those intended for other health conditions, 2) between PBTs designed for lower extremity conditions, including hip or knee arthroplasty, and those designed for patients with other health conditions.

Results

Study selection

The initial database search yielded 22,842 articles, from which 13,895 titles and abstracts were screened after removing duplicates. In the final phase, the full texts of 575 studies were reviewed, resulting in the inclusion of 432 studies. In addition, 17 additional articles were identified from the reference lists of included articles or through citation tracking. After extracting the included studies, we excluded five PBTs from analysis. The PRISMA diagram depicts the study selection process (Figure 4.1).

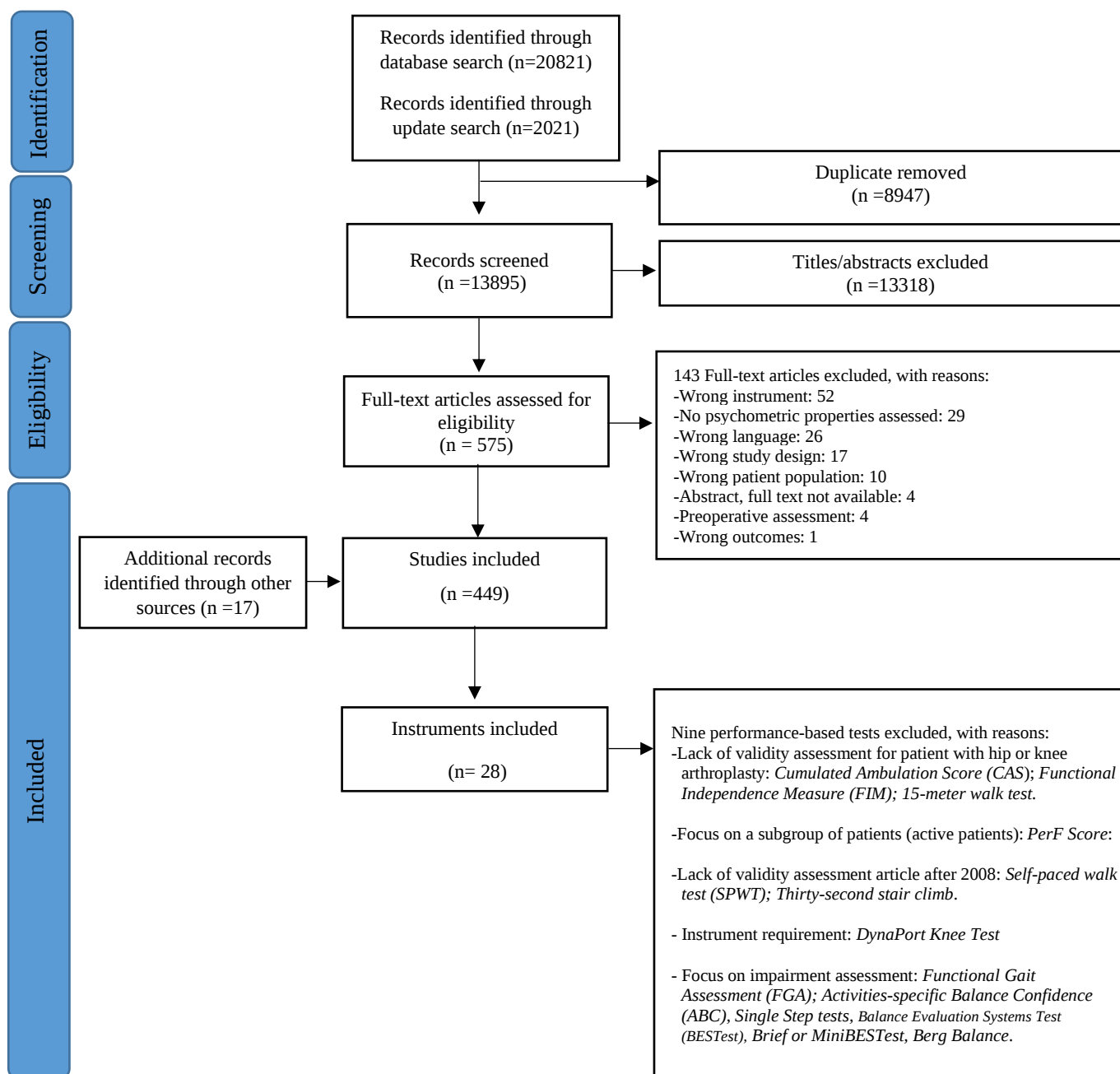


Figure 4.1 Flowchart of study screening and selection

PBTs characteristics

Twenty-eight PBTs were included in our review for content analysis. The full names and acronyms and major characteristics of these tests are outlined in Table 4.1. They were developed between 1982 and 2019 for a range of target populations, including elderly (n=7), hip or knee

arthroplasty (n=6), OA (n=5), stroke (n=3), hip fracture (n=2), lower extremity weakness (n=2), lower extremity amputation (n=1), anterior cruciate ligament reconstruction (n=1), mobility disability (n=1), chronic heart failure (n=1), and chronic respiratory disease (n=1). The tests specifically developed for patients undergoing hip or knee arthroplasty are the Iowa Level of Assistance Scale (ILAS), A-test (“A” like Activity or Assessment), Kneeling Test, Four-Step Stair Climb Test (4SCT), Stair Climb Test (SCT) and 30-Minute Walk Test (30MWT)).

The scoring method among the tests encompassed: 1) total time for activity completion (n=14); 2) number of activity repetitions within a specified time (n=2); 3) maximum distance achieved (n=5); 4) walking speed measurement (n=5); 5) assessment of pain and discomfort level (n=1); 6) evaluation of assistance required (n=2) and 7) assessment of ability level to perform an activity (n=3). Various equipment parameters are required to conduct these tests, including walkway lengths, stair numbers and heights, stopwatches and measuring tapes (Table 4.2).

ICF-based content assessment

The linking results of the concepts across the 28 tests are presented in Tables 4.1, and 4.2. These tests covered 15 out of the 49 activity and participation categories of the OA core set. The categories of d4500:walking short distances, d4103:sitting and d4104:standing were the most frequently covered, employed in 14, 10 and 10 tests respectively. However, eight of the 15 categories were used in only one test, including d4100:lying down and getting up, d4107:rolling over, d4153:maintaining a sitting position, d4154:maintaining a standing position, d530:toileting (all covered only by A-test), d4102:kneeling (covered by kneeling test), d4501:walking long distances (covered by 30MWT), and d4551:climbing (covered by step test). Thirty-five activity and participation categories were not covered in any tests. One body function and structure

category (balance) was assessed in one test (SPPB) and one environmental factor (level of therapist support) was included in three tests (ILAS, mILAS, A-test).

The tests can be grouped into two categories based on their coverage of ICF categories: single activity tests (n=12) and multi-activity tests (n=16). Among the three stair tests, one was single activity and three were multi-activity. These tests vary in the number of stairs (ranging from 4 to 12), direction of movements (ascend or descend), or incorporating turning movement. Among the eleven walking tests, seven were single activity and four were multi-activity. These tests vary in several aspects including distance walked (short or long distances) and incorporating obstacles, direction changes or incorporating turning movement. All three chair stand tests were multi-activity and covered for the component of sitting and standing. All three step tests were single activity and covered climbing or walking around obstacles. The kneeling tests were single activity, whereas the floor sitting-rising test was multi-activity. The multi-activity tests covered 12 activities overall, with the majority covering sitting, standing and walking short distances. Other activities covered were lying down, getting up, rolling over, maintaining sitting or standing, toileting, going up and down stairs.

Regarding the activity and participation coverage, the A-test had the widest coverage covering 10 core set categories. It was followed by ILAS, mILAS, L Test, and TUG, each covering 4 categories, and SPPB which covered three categories. Ten tests covered two categories and 12 tests covered only one category (Table 4.2).

Table 4.3 presents the results of the comparisons of ICF category coverage by PBTs. The analysis revealed that the coverage between patients who underwent hip or knee arthroplasty and those with other health conditions was not significant ($P=0.4$). However, it indicated that tests specifically developed for lower extremity conditions, including arthroplasty, OA, hip fracture,

lower extremity weakness, lower amputation, anterior cruciate ligament reconstruction, had a higher coverage of ICF categories($P=0.03$).

Table 4.1. Characteristics of the included PBTs and their linking to modified ICF core set for OA.

Performance-based test/ Development year	Target population	Activity Theme	Description	Measurement concept	Equipment Required	scoring	ICF Linking
Walking tests							
2-Minute Walk Test (2MWT)/1982 ²⁸	People with chronic respiratory disease	Walking	The participant is instructed to walk as safely and as far as possible at a comfortable speed within a span of 2 minutes, along a defined space, such as a hallway, using any walking aid they might normally use. The participant should pivot briskly around a cone and continue in the opposite direction without stopping, walking back and forth between the two cones.	Functional exercise capacity	Stopwatch Walking space (30-m long)	Total distance in meters during a minute walk is measured	d4500 Walking short distances d4558 Other specified moving around
6-Minute Walk Test (6MWT)/1985 ²⁹	Patients with chronic heart failure	Walking	The participant is instructed to walk as safely and as far as possible at a comfortable speed within a span of 6 minutes, along a defined space, such as a hallway, using any walking aid they might normally use. The participant should pivot briskly around a cone and continue in the opposite direction without stopping, walking back and forth between the two cones.	Functional exercise capacity	Stopwatch Walking space (30-m long)	Total distance in meters during a minute walk is measured	d4500 Walking short distances d4558 Other specified moving around
30-Minutes Walk Test (30MWT)/2013 ³⁰	Patient with total knee arthroplasty	Walking	The participant is instructed to walk as safely and as far as possible at a comfortable speed within a span of 30 minutes, along a defined space, such as a hallway, using any walking aid they might normally use. The participant should pivot briskly around a cone and continue in the opposite direction without stopping, walking back and forth between the two cones.	Functional exercise capacity	Stopwatch Walking space (200 m long)	Total distance in meters during a minute walk is measured	d4501 Walking long distances d4558 Other specified moving around
4-Meter Walk Test (4MWT)/2006 ³¹	Elderly	Walking	The participant is instructed to walk as quickly but as safely as possible, without running, along a 4-meter walkway, using any walking aid they might normally use.	Walking speed	Stopwatch Walking space	Walking speed is measured in meter per second (m/s)	d4500 Walking short distances
8-Foot Timed Walk (8FTW)/1994 ³²	Elderly	Walking	The participant is instructed to walk as safely and at a comfortable speed within 8 feet (2.44 meters), along a defined space, such as a hallway, using any walking aid they might normally use.	Functional exercise capacity	Stopwatch Walking space	Time	d4500 Walking short distances
10-Meter Walk Test (10MWT)/1987 ³³	Patient with stroke	Walking	The participant is instructed to walk as quickly but as safely as possible, without running, along a 10-meter walkway, using any walking aid they might normally use.	Walking speed	Stopwatch Walking space	Walking speed is measured in meter per second (m/s)	d4500 Walking short distances
20-Meter Walk (2MWT) test/2009 ³⁴	Patient with osteoarthritis	Walking	The participant is instructed to walk as quickly but as safely as possible, without running, along a 20-meter walkway, using any walking aid they might normally use.	Walking speed	Stopwatch Walking space	Walking speed is measured in meter per second (m/s)	d4500 Walking short distances

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Performance-based test/ Development year	Target population	Activity Theme	Description	Measurement concept	Equipment Required	scoring	ICF Linking
50-Foot Timed Walk (50FTW)/1996 ³⁵	Patient with knee osteoarthritis	Walking	The participant is instructed to walk as safely and at a comfortable speed within 50 feet (nearly 15.24 meters), along a defined space, such as a hallway, using any walking aid they might normally use.	Functional exercise capacity	Stopwatch Walking space	Time	d4500 Walking short distances
Figure of 8 Walk Test (F8WT)/2010 ³⁶	Elderly with mobility disability	Walking	The participant is instructed to stand in the middle of two cones (1.5m apart) and walk following a figure-of-8 pattern around the cones safely and at a comfortable speed, and ended at the starting position.	Walking ability	Stopwatch Walking space	Time Number of steps Smoothness	d4503 Walking around obstacles
40-m Fast-Paced Walking Test (40m FPWT)/2011 ³⁷	Patient with osteoarthritis	Walking	Participants walk as quickly but as safely as possible, without running, along a 10-meter walkway, turn around, return, and repeat the sequence for a total distance of 40 meters.	Walking time	Stopwatch Walking space	Walking speed is measured in meters/ second (m/s)	d4500 Walking short distances d4503 Walking around obstacles
3-Meter Backward Walk Test (3MBW)/2019 ³⁸	Elderly	Walking backward	The participant is instructed to walk backward for a distance of 3 meters as quickly but as safely as possible, without running. Looking behind is permitted during the test.	Balance and proprioception	Stopwatch Walking space	Time	d4508 Other specified walking
Chair stand tests							
30-s Chair Stand Test (30-s CST)/1999 ³⁹	Elderly	Sit to stand movement	The participant is instructed to stand up from a sitting position without using their hands until hips and knees are fully extended, then return to a complete seated position and repeat for 30s as quickly as possible but in a safe manner.	Lower extremity strength	Stopwatch Chair	Number of repetitions completed to stand movement (up and down represents one stand) within 30s.	d4103 Sitting d4104 Standing
Five Times Sit-to-Stand Test (5xSST)/1995 ⁴⁰	Patients with lower extremity weakness	Sit to stand movement	The participant is instructed to stand up from a sitting position without using their hands until hips and knees are fully extended, then return to a complete seated position and repeat for 5 times as quickly as possible but in a safe manner.	Lower extremity strength	Stopwatch Chair	Time	d4103 Sitting d4104 Standing
Sit to Stand Test (STS)/1985 ⁴¹	Patients with lower extremity weakness	Sit to stand movement	The participant is instructed to stand up from a sitting position without using their hands until hips and knees are fully extended, then return to a complete seated position and repeat for 10 times as quickly as possible but in a safe manner.	Lower extremity strength	Stopwatch Chair	Time	d4103 Sitting d4104 Standing
Stair tests							
Stair Climb Test (SCT)/ 1995 ⁴²	Patient with osteoarthritis	Stair climbing	The participant is instructed to ascend and descend the flight of stairs (9-12 stairs) as quickly as possible but in a safe manner.	Physical function	Stopwatch 9-12 step stairs	Time of stair climbing	d451 Going up stairs d451 Going down stairs d4558 Other specified moving around

Performance-based test/ Development year	Target population	Activity Theme	Description	Measurement concept	Equipment Required	scoring	ICF Linking
Four-step Stair Climb Test (4SCT)/2002 ⁴³	Patient underwent arthroplasty	Stair climbing	The participant is instructed to ascend and descend four flights of stairs as quickly as possible but in a safe manner.	Physical function	Stopwatch 4 step stairs	Time of stair climbing	d451 Going up stairs d451 Going down stairs d4558 Other specified moving around
Stair Test Up (ascend) (STUp)/2010 ⁴⁴	Patient underwent knee arthroplasty	Stair climbing	The participant is instructed to ascend the flight of stairs (9-12 stairs) as quickly as possible but in a safe manner.	Physical function	Stopwatch 9-12 step stairs	Time of stair climbing	d451 Going up stairs
Step tests							
Step Test/1996 ⁴⁵	Stroke patients	Step climbing	The participant is instructed to step one foot onto and then off a block as quickly as possible but in a safe manner within 15s.	Dynamic balance and locomotor function	Stopwatch One step	Number of repetitions completed steps within 15s.	d4551 Climbing
Four Square Step Test (FSST)/ 2002 ⁴⁶	Elderly	Stepping over obstacles	The participant is instructed to step forwards, backwards and sideways in a clockwise direction, then counterclockwise over four single-point canes placed on the floor in a cross-configuration as quickly as possible but in a safe manner.	Dynamic balance and locomotor function	Stopwatch Two canes	Time	d4503 Walking around obstacles
Modified Four Step Square Test (mFSST)/2016 ⁴⁷	Stroke patients	Stepping over obstacles	In the modifications the tapes are used instead of the canes.	Dynamic balance and locomotor function	Stopwatch Tape	Time	d4558 Other specified moving around
Other tests							
Assessment or Activity Test (A-test)/2008 ⁴⁸	Patients with hip fracture or underwent total hip arthroplasty due to osteoarthritis	Changing basic body position Maintaining body position Walking Going up and down stairs Toileting	Assesses ten basic activities: 1. Transfer from supine to side lying 2. Transfer from supine to sitting position, 3. Transfer from sitting to standing 4. Standing 5. Back to bed 6. Walking with aids 7. Use of toilet 8. Sitting on chair 9. Walking up- and down stairs 10. Endurance while walking	Functional recovery during early rehabilitation	Stopwatch Chair Walking space Stairs	Each activity is scored from 0 to 5. Activity 1-9: (0: patient didn't perform activity, 1. patient was absolutely dependent of therapist help, 2. patient performed activity with little therapist help, 3. patient needed therapist' verbal suggestion while performing activity, 4. patient performed activity independently but insecurely, 5. patient performed activity independently and securely) Activity 10: (didn't walk, walked 5 meters, walked 15 meters, walked 50 meters, walked 100 meters, walked more than 100 meters)	4107 Rolling over d4103 Sitting d4104 Standing d4154 Maintaining a standing position d4100 Lying down and getting up d4508 Other specified walking d530 Toileting d4153 Maintaining a sitting position 451 Going up and down stairs d4500 Walking short distances e3 support and relationships

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Performance-based test/ Development year	Target population	Activity Theme	Description	Measurement concept	Equipment Required	scoring	ICF Linking
						Total score ranges from 0 to 50 points. Lower score indicates inability to perform any activity with the help of the therapists.	
Iowa Level of Assistance Scale (ILAS)/1994 ⁴⁹	Patient underwent knee or hip arthroplasty	Changing basic body position Climbing stairs Walking	It assesses the four main activities, including: 1. Transfer from the supine position to sitting 2. Transfer from sitting to the standing position 3. Walking 4.57m 4. Climbing up and down 3 stairs And walking speed over a 13.4m distance.	Early functional recovery Walking speed	Stopwatch Walking space Stairs	Each of the four main activities is scored on an ordinal scale from 0 (independent) to 6 (activity is not achieved). <i>0. fully independent and secure</i> <i>1. Nearby supervision is required</i> <i>2. One point of contact is necessary for the safe performance of the activity.</i> <i>3. Two points of contact are necessary (by one or two persons)</i> <i>4. need full assistance</i> <i>5. Attempted activity but failed at maximal assistance.</i> <i>6- activity is not achieved.</i> And walking speed. <i>0 - Ambulates 44 feet in 20 s or less</i> <i>1 - Ambulates 44 feet in 21 to 30 s</i> <i>2 - Ambulates 44 feet in 31 to 40 s</i> <i>3 - Ambulates 44 feet in 41 to 50 s</i> <i>4 - Ambulates 44 feet in 51 to 60 s</i> <i>5 - Ambulates 44 feet in 61 to 70 s</i> <i>6 - Unable to make distance or exceeds 70 s</i>	d4103 Sitting d4104 Standing 451 Going up and down stairs d4500 Walking short distances e3 support and relationships
Modified Iowa Level of Assistance Scale (mILAS)/2016 ⁵⁰	Patient with hip fracture	Changing basic body position Climbing stairs Walking	It assesses the five main activities, including: 1. Transfer from the supine position to sitting 2. Transfer from sitting to the standing position 3. Walking 4.57m 4. Climbing up and down stairs And distanced walking.	Early functional recovery	Walking space Stairs	Each of the four main activities is scored on an ordinal scale from 0 (independent) to 6 (activity is not achieved). <i>0. fully independent and secure</i> <i>1. Nearby supervision is required</i> <i>2. One point of contact is necessary for the safe performance of the activity.</i> <i>3. Two points of contact are necessary (by one or two persons)</i> <i>4. need full assistance</i> <i>5. Attempted activity but failed at maximal assistance.</i> <i>6. activity is not achieved.</i> And walking distance <i>0: >40 m; 1: 26-40 m; 2: 10-25 m, 3: 5-9 m; 4: 3-4 m; 5: 2 m, 6: <2m.</i>	d4103 Sitting d4104 Standing d451 Going up and down stairs d4500 Walking short distances e3 support and relationships

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Performance-based test/ Development year	Target population	Activity Theme	Description	Measurement concept	Equipment Required	scoring	ICF Linking
Short Physical Performance Battery (SPPB)/1994 ³²	Elderly	Walking Changing basic body position	It includes balance tests (tandem, semi-tandem, and side-by-side stands), a 4-m walking test, and a five-repetition sit-stand test.	Physical function and dynamic balance	Stopwatch Chair Walking space	The timed results for each test are recorded and adjusted based on predefined cut-point to produce a score ranging from 0 (worst performance) to 4 (best performance). The total score of SPPB ranges from 0 to 12.	b755 Involuntary movement reaction functions d4103 Sitting d4104 Standing d4500 Walking short distances
Timed Up and Go (TUG)/1991 ⁵¹	Frail Elderly	Walking Sitting Standing Turning around	The participant is instructed to rise from a chair, walk 3 m as quickly but as safely as possible, without running, turn around, come back to the chair, and sit down.	Physical function and dynamic balance	Stopwatch Chair Walking space	Time	d4103 Sitting d4104 Standing d4500 Walking short distances d4558 Other specified moving around
L Test (<i>an extended variation of the TUG</i>)/2005 ⁵²	Individuals with lower limb amputation	Walking Sitting Standing Turning around	The participant is instructed to rise from a chair, walk 3 m as quickly but as safely as possible, without running, turn right, walk for 7 m, turn around and walk back 7m along the same path, turn left, walk back 3m and come back to the chair, and sit down. (This test involves four turns with a total distance of 20m).	Physical function	Stopwatch Chair Walking space	Time	d4103 Sitting d4104 Standing d4500 Walking short distances d4558 Other specified moving around
Kneeling Test/2019 ⁵³	Asymptomatic knees, patient with osteoarthritis, underwent total knee arthroplasty or anterior cruciate ligament reconstruction	kneeling	The participant is instructed to kneel with the knee at 90° and 110°, on three surfaces (soft, firm and hard). The participant is asked to rate their level of discomfort using a visual analogue scale (0–10).	kneeling tolerance	No instrument needed	Total score ranges from 0 to 10 points. Lower score indicates no pain or discomfort, and higher score indicates being intolerable pain or an inability to kneel.	d4102 Kneeling
Floor Sitting-Rising Test (SRT)/1999 ⁵⁴	Not mentioned	Floor Sitting-Rising Test	The participant is instructed to sit and then rise from the floor, using the minimum support that is needed.	Physical function	No instrument needed	One point is deducted each time the participant utilizes their hands (placing hands on the floor while sitting or pushing with hands on knees during rising) or legs (using the lateral leg to push up or kneeling on one or both knees to stand) to complete the task. A half point is deducted for any visible loss of balance during the maneuver. The final score is the combined scores for sitting and rising, with a maximum achievable score of 10.	d4103 Sitting d4104 Standing

Table 4.2 Number of categories of modified ICF core set for OA represented in PBTs used after hip or knee arthroplasty.

PBTs	d4100 Lying down/ getting up	d4102 Kneeling	d4103 Sitting	d4104 Standing	d4107 Rolling over	d4153 Maintaining a sitting position	d4154 Maintaining a standing position	d4500 Walking short distances	d4501 Walking long distances	d4503 Walking around obstacles	d4508 Other specified walking	d451 Going up and down stairs	d4551 Climbing	d4558 Other specified moving around	d530 Toileting	b715: Stability of joint functions	e3: Support and relationships
Single-activity																	
F8WT										✓							
FSST										✓							
mFSST														✓			
Kneeling Test		✓															
3MBWT											✓						
4MWT								✓									
8FTW								✓									
10MWT								✓									
20MWT								✓									
50FTW								✓									
STUp												✓					
Step Test													✓				
Multi-activity																	
A-test	✓		✓	✓	✓	✓	✓	✓			✓	✓			✓		✓
ILAS			✓	✓				✓				✓					✓
mILAS			✓	✓				✓				✓					✓
SPPB			✓	✓				✓								✓	
TUG			✓	✓				✓						✓			
L Test			✓	✓				✓						✓			
2MWT								✓						✓			
30-s CST			✓	✓													
30MWT									✓					✓			
40m FPWT								✓						✓			
4 SCT												✓		✓			
5xSST			✓	✓										✓			
6MWT								✓						✓			
SCT												✓		✓			
STS			✓	✓													
SRT			✓	✓													

10MWT: 10-meter walk Test; **20MWT:** 20-meter walk Test; **2MWT:** 2-minute walk Test; **30MWT:** 30-minutes walk Test; **30-s CST:** 30-s chair stand Test; **3MBWT:** 3-m backward walk Test; **40m FPWT:** 40-m fast-paced walking Test; **4MWT:** 4-meter walk Test; **4 SCT:** Four-step stair climb Test; **50FTW:** 50-Foot Timed Walk Test; **5xSST:** Five Times Sit-to-Stand Test; **6MWT:** 6-minute walk Test; **8FTW:** 8-Foot Timed Walk Test; **A-test:** “A” like Activity or Assessment; **F8WT:** Figure of 8 Walk Test; **FSST:** Four Square Step Test; **ILAS:** Iowa Level of Assistance Scale; **mFSST:** Modified Four Step Square Test; **mILAS:** Modified ILAS; **SCT:** Stair Climb Test; **SPPB:** Short Physical Performance Battery; **SST:** Single-step Test; **STS:** Sit to stand Test; **STUp:** Stair Test Up [ascend]; **SRT:** Floor sitting-rising Test; **TUG:** Timed up and go.

Table 4.3 Comparing the coverage of PBTs between tests specifically designed for arthroplasty patients and those designed for other health conditions.

ICF Chapters/Categories	F8WT	FSST	mFSST	Kneeling Test	3MBWT	4MWT	8FTW	10MWT	20MWT	50FTW	STUp	Step Test	A-test	ILAS	mILAS	SPPB	TUG	L Test	2MWT	30-s CST	30MWT	40m FPWT	4 SCT	5xSST	6MWT	SCT	STS	SRT	P-Value [†] Arthroplasty patients vs. patients with other health conditions	P-Value [†] Patients with lower extremities conditions vs. patients with general health conditions
Number of activity and participation categories	1	1	1	1	1	1	1	1	1	1	1	1	10	4	4	3	4	4	2	2	2	2	2	2	2	2	2	2	0.4	0.03
Specifically developed for patients undergoing arthroplasty				✓?							✓		✓	✓							✓		✓							
Specifically developed for patients with lower extremity conditions				✓						✓	✓		✓	✓	✓			✓	✓		✓	✓	✓	✓		✓	✓			

? = Involvement of patient underwent arthroplasty with another group of patients (such as patients with osteoarthritis or patients scheduled for arthroplasty); ; †= P-value obtained from Mann-Whitney U test; A p-value < 0.05 was considered statistically significant

10mWT: 10-meter walk Test; **20mWT:** 20-meter walk Test; **2MWT:** 2-minute walk Test; **30mWT:** 30-minutes walk Test; **30-s CST:** 30-s chair stand Test; **3mBWT:** 3-m backward walk Test; **40m FPWT:** 40-m fast-paced walking Test; **4mWT:** 4-meter walk Test; **4 SCT:** Four-step stair climb Test; **50FTW:** 50-Foot Timed Walk Test; **5xSST:** Five Times Sit-to-Stand Test; **6MWT:** 6-minute walk Test; **8FTW:** 8-Foot Timed Walk Test; **A-test:** “A” like Activity or Assessment; **F8WT:** Figure of 8 Walk Test; **FSST:** Four Square Step Test; **ILAS:** Iowa Level of Assistance Scale; **mFSST:** Modified Four Step Square Test; **mILAS:** Modified ILAS; **SCT:** Stair Climb Test; **SPPB:** Short Physical Performance Battery; **SST:** Single-step Test; **STS:** Sit to stand Test; **STUp:** Stair Test Up [ascend]; **SRT:** Floor sitting-rising Test; **TUG:** Timed up and go.

Discussion

In our review, we identified 28 PBTs used after hip or knee arthroplasty and linked the component of each test to the modified ICF core set for OA. By employing the ICF as a framework to evaluate the content of existing PBTs, clinicians can ensure they select the appropriate performance-based test or battery of tests to assess the most pertinent aspects for their patients. Moreover, our content analysis revealed gaps in the current assessments, guiding the development or modification of PBTs. This approach can prevent the development of duplicate tests and redirect attention towards aspects important to patients but not addressed by existing tests.

Of the 49 activity and participation categories of the core set, only 15 categories were covered by the existing PBTs used after hip or knee arthroplasty. Thus, some activity and participation categories such as walking on uneven ground, and putting on shoes or socks deemed important by patients undergoing arthroplasty⁵⁵ were not captured by existing PBTs. One possible reason is that among the 28 included PBTs, only six were specifically developed for patients undergoing hip or knee arthroplasty and five for lower limb OA, all of which were multi-activity tests with broader coverage of the ICF OA coreset. So, there is a possibility that some patient priorities related to arthroplasty or OA were overlooked. In addition, the findings indicated that patients with lower extremity conditions had higher coverage than those with general conditions, suggesting that PBTs should be specifically designed and utilized for particular patient groups when intended for use in those populations. It is noteworthy that assessing certain activities, such as washing the whole body or doing housework, may be challenging in a clinical setting.

Clinicians may choose a test based on clinical objectives. If the goal is to capture different activities, clinicians might decide to use a combination of single-activity PBTs or select multi-activity PBTs. However, the time required to conduct multiple PBTs may limit their practicality. Computer adaptive testing (CAT) has been proposed as a solution to improve the precision and efficiency of outcome measures.⁵⁶ CAT involves estimating patients' function and tailoring outcome measures administration based on each patient's performance level.⁵⁷ For instance, if a patient does not achieve a high score in the one PBT, CAT recognizes not to administer additional PBTs. This approach can alleviate the administrative burden with minimal compromise in precision. Future research is warranted to explore the feasibility of implementing this approach for PBTs.^{57,58}

Clinicians and researchers with expertise in developing instruments aiming to assess the domains not covered by the existing PBTs may choose to modify existing PBTs or develop new ones. To select the appropriate performance test, future research should first identify the activities that need assessment following arthroplasty. The initial step is to determine which activities are important to patients.⁵⁹ This will help clinicians decide which performance-based tests to utilize and whether a single test or multiple tests should be employed. Also, as patients progress in their recovery, their function may evolve, necessitating different performance tests at various stages. However, it remains unclear which tests would be appropriate at different time points. Thus, further research is needed to explore the activities that matter most to patients and to select the relevant tests accordingly.

The majority of PBTs were only linked to activity and participation components of the core set. The SPPB was the only PBT also assessing an impairment (balance). Since impairments are not activity and participation concepts, instrument developers should be cautious to avoid

mixing the two concepts. Since impairments can impact activity performance after arthroplasty,^{59,60} it is essential to assess and address impairments once activity issues have been identified.

The assessment of function is based on two dimensions: 1) capacity, which refers to one's ability to perform tasks, and 2) performance, which reflects actual real-world task execution. All included PBTs assess capacity by evaluating an individual's ability to complete tasks or actions in a standardized setting.⁶¹ However, the extent to which capacity translates into performance can be influenced by environmental factors (e.g. home environment, use of mobility aids or caregiver support).^{62,63} Therefore, it has been suggested to consider the circumstances in which the activity is assessed, to determine to what extent circumstances reflect the patient's current environment. If there is correspondence, the measure then assesses performance. Otherwise, the measure reflects capacity. Thus, the difference between capacity and performance on an activity can provide guidance on adjusting the individual's environment to improve performance.⁶⁴ Further research is needed to determine the applicability of tests assessing capacity in real-world settings and to develop tests that better reflect the patient's environment. PROMs might be one way to measure perceived performance in a current environment.⁶⁵ Using a combination of PROMs and PBTs have been recommended to comprehensively assess function following hip or knee arthroplasty.^{10,11} Given that environmental factors can potentially impact function following arthroplasty,⁶² it might be worth considering whether environmental factors should be integrated in PBTs for a more comprehensive evaluation. Among the included PBTs, ILAS, mILAS and A-test evaluated environmental factors. The level of support from the assessor when performing the activities was assessed and could be considered a proxy for caregiver support when performing the same activities at home.

Another essential criterion influencing the selection of appropriate PBTs is their psychometric properties. Previous studies have evaluated the psychometric properties of some PBTs.^{66,67} However, certain aspects of psychometric properties of some included PBTs are lacking, particularly in the acute and subacute phases where most recovery happens after hip or knee arthroplasty.⁶⁸ Moreover, challenges associated with conducting PBTs in person include constraints on clinician and patient time, equipment availability, and the necessity for patients to travel.^{69–71} Despite the growing use of telerehabilitation after arthroplasty,⁷² there is limited evidence on the psychometric properties and feasibility of applying PBTs in virtual settings. Conducting these PBTs in a patient's home environment may offer better reflection of performance, reduce required resources and improve test accessibility. However, ensuring patients safety is one of the most important challenges and assessments should address this.⁷³ Further research is needed to investigate the feasibility, safety and psychometric properties of virtual PBTs.

Another consideration in selecting the appropriate PBT is its ability to be accomplished. This means that the inability to complete the PBT results in the absence of a score, posing a challenge to score interpretation. For instance, many of the included walking tests are set to a specific distance and measured by time or speed. To address this challenge, it has been recommended to use PBTs that are set to a specific time or measured by the distance or repetitions performed.⁶

Limitations

We excluded the PBTs that required substantial resources and costs. This allowed us to focus on PBTs feasible to conduct in most settings, whether in research or clinical practice. Despite conducting a thorough search using precise search criteria and synonyms, in

collaboration with an experienced clinical librarian and providing a comprehensive list of PBTs used after hip or knee arthroplasty, it's also possible that we may have missed PBTs published in other languages that we did not include in this review.

Conclusion

Our ICF-based content analysis of the 28 identified PBTs showed that 16 activities were covered by the PBTs used after hip or knee arthroplasty. Some activity and participation categories deemed important from the patients' perspective were not captured. The PBTs focus on functional capacity rather than assessing the performance. Our analysis guides professionals in identifying PBTs that best align with their clinical aims. In addition, it may facilitate the further development of the PBTs by identifying concepts that have yet to be incorporated.

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Competing interests

Authors have no conflict of interests to declare.

References

1. Jüni P, Reichenbach S, Dieppe P. Osteoarthritis: rational approach to treating the individual. *Best pract Res Clin Rheumatol*. 2006;20(4):721-740.
2. Liu XW, Zi Y, Xiang LB, Wang Y. Total hip arthroplasty: areview of advances, advantages and limitations. *Int. J Clin Exp Med*. 2015;8(1):27.
3. Halawi MJ. Outcome Measures in Total Joint Arthroplasty: Current Status, Challenges, and Future Directions. *Orthopedics*. 2015;38(8).
4. Vajapey SP, Morris J, Spitzer AI, Glassman AH, Greco NJ, Li M. Outcome reporting patterns in total knee arthroplasty: a systematic review. *J Clin Orthop Trauma*. 2020;11:S464-71.
5. Boonstra MC, Schwering PJ, De Waal Malefijt MC, Verdonchot N. Sit-to-stand movement as a performance-based measure for patients with total knee arthroplasty. *Phys Ther*. 2010;90(2):149-156.

6. Dobson F, Hinman RS, Roos EM, et al. OARSI recommended performance-based tests to assess physical function in people diagnosed with hip or knee osteoarthritis. *Osteoarthr Cartil.* 2013;21(8):1042-1052.
7. Suk M, Norvell DC, Hanson B, Dettori JR, Helfet D. Evidence-based orthopaedic surgery: what is evidence without the outcomes? *J Am Acad Orthop Surg.* 2008;16(3):123-129.
8. Stratford PW, Kennedy DM. Performance measures were necessary to obtain a complete picture of osteoarthritic patients. *J Clin Epidemiol.* 2006;59(2):160-167.
9. Stratford PW, Kennedy DM, Woodhouse LJ. Performance measures provide assessments of pain and function in people with advanced osteoarthritis of the hip or knee. *Phys Ther.* 2006;86(11):1489-1496.
10. Bolink S, Grimm B, Heyligers IC. Patient-reported outcome measures versus inertial performance-based outcome measures: a prospective study in patients undergoing primary total knee arthroplasty. *The Knee.* 2015;22(6):618-623.
11. Capin JJ, Bade MJ, Jennings JM, Snyder-Mackler L, Stevens-Lapsley JE. Total knee arthroplasty assessments should include strength and performance-based functional tests to complement range-of-motion and patient-reported outcome measures. *Phys Ther.* 2022;102(6):pzac033.
12. McAuley C, Westby MD, Hoens A, et al. A Survey of Physiotherapists' Experience Using Outcome Measures in Total Hip and Knee Arthroplasty. *Physiother Can.* 2014;66(3):274-285.
13. MacDermid JC. ICF Linking and cognitive interviewing are complementary methods for optimizing content validity of outcome measures: an integrated methods review. *Front Rehabil Sci.* 2021;2:702596.
14. Organization WH. World Health Organization international classification of functioning, disability and health. *Geneva: World Health Organization.* Published online 2001.
15. Dreinhofer K, Stucki G, Ewert T, et al. ICF Core Sets for osteoarthritis. *J Rehabil Med-Suppl.* 2004;(44):75-80.
16. Alviar MJ, Olver JH, Brand C, Hale T, Khan F. Do patient-reported outcome measures used in assessing outcomes in rehabilitation after hip and knee arthroplasty capture issues relevant to patients? Results of a systematic review and ICF linking process. *Journal Rehabil Med.* 2011;43(5):374-381.
17. Pisoni C, Giardini A, Majani G, Maini M. International Classification of Functioning, Disability and Health (ICF) core sets for osteoarthritis. A useful tool in the follow-up of patients after joint arthroplasty. *Eur J Phys Rehabil Med.* 2008;44(4):377-385.
18. Higgins JP, Thomas J, Chandler J, et al. *Cochrane Handbook for Systematic Reviews of Interventions.* John Wiley & Sons; 2019.

19. Liberati A. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *Ann Intern Med.* 2009;151(4):W.
20. Cooke A, Smith D, Booth A. Beyond PICO: The SPIDER Tool for Qualitative Evidence Synthesis. *Qual Health Res.* 2012;22(10):1435-1443.
21. Riddle DL, Stratford PW, Singh JA, Strand CV. Variation in outcome measures in hip and knee arthroplasty clinical trials: a proposed approach to achieving consensus. *J Rheumatol.* 2009;36(9):2050-2056.
22. Cieza A, Fayed N, Bickenbach J, Prodinger B. Refinements of the ICF Linking Rules to strengthen their potential for establishing comparability of health information. *Disabil Rehabil.* 2019;41(5):574-583.
23. Karimijashni M, Westby M, Ramsay T, Beaulé PE, Poitras S. Development and content validation of a questionnaire identifying patients' functional priorities and abilities after hip or knee arthroplasty. *Disabil Rehabil.* 2024 Aug 16:1-5.
24. Prinsen CAC, Mokkink LB, Bouter LM, et al. COSMIN guideline for systematic reviews of patient-reported outcome measures. *Qual Life Res.* 2018;27(5):1147-1157.
25. Terwee CB, Jansma EP, Riphagen II, De Vet HCW. Development of a methodological PubMed search filter for finding studies on measurement properties of measurement instruments. *Qual Life Res.* 2009;18(8):1115-1123.
26. Zotero | Your personal research assistant [Internet]. [cited 2024 May 9]. Available from: <https://www.zotero.org/>
27. Covidence [Internet]. [cited 2024 May 9]. Covidence - Better systematic review management. Available from: <https://www.covidence.org/>
28. RJ B. Two-, six-, and 12-minute walking test in respiratory disease. *Br Med J.* 1982;284:1607-1608.
29. Guyatt GH, Sullivan MJ, Thompson PJ, et al. The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure. *CMAJ.* 1985;132(8):919.
30. Ko V, Naylor JM, Harris IA, Crosbie J, Yeo AE. The six-minute walk test is an excellent predictor of functional ambulation after total knee arthroplasty. *BMC Musculoskelet Disord.* 2013;14(1):145.
31. Perera S, Mody SH, Woodman RC, Studenski SA. Meaningful Change and Responsiveness in Common Physical Performance Measures in Older Adults. *J Am Geriatr Soc.* 2006;54(5):743-749.

32. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol*. 1994;49(2):M85-M94.
33. Wade DT, Wood VA, Heller A, Maggs J. Walking after stroke. Measurement and recovery over the first 3 months. *Scand J Rehabil Med*. 1987;19(1):25-30.
34. Nevitt, Michael, David Felson, and Gayle Lester. "The osteoarthritis initiative." *Protocol for the cohort study 1* (2006): 2.
35. Schilke JM, Johnson GO, Housh TJ, O'Dell JR. Effects of muscle-strength training on the functional status of patients with osteoarthritis of the knee joint. *Nurs Res*. 1996;45(2):68-72.
36. Hess RJ, Brach JS, Piva SR, VanSwearingen JM. Walking skill can be assessed in older adults: validity of the Figure-of-8 Walk Test. *Phys Ther*. 2010;90(1):89-99.
37. Wright AA, Cook CE, Baxter GD, Dockerty JD, Abbott JH. A Comparison of 3 Methodological Approaches to Defining Major Clinically Important Improvement of 4 Performance Measures in Patients With Hip Osteoarthritis. *J Orthop Sports Phys Ther*. 2011;41(5):319-327.
38. Carter V, Jain T, James J, Cornwall M, Aldrich A, De Heer HD. The 3-m backwards walk and retrospective falls: diagnostic accuracy of a novel clinical measure. *J Geriatr Phys Ther*. 2019;42(4):249-255.
39. Jones CJ, Rikli RE, Beam WC. A 30-s Chair-Stand Test as a Measure of Lower Body Strength in Community-Residing Older Adults. *Res Q Exerc Sport*. 1999;70(2):113-119.
40. Bohannon RW. Sit-to-Stand Test for Measuring Performance of Lower Extremity Muscles. *Percept Mot Skills*. 1995;80(1):163-166.
41. Csuka M, McCarty DJ. Simple method for measurement of lower extremity muscle strength. *Am J Med*. 1985;78(1):77-81.
42. Rejeski WJ, Ettinger Jr WH, Schumaker S, James P, Burns R, Elam JT. Assessing performance-related disability in patients with knee osteoarthritis. *Osteoarthr Cartil*. 1995;3(3):157-167.
43. Parent E, Moffet H. Comparative responsiveness of locomotor tests and questionnaires used to follow early recovery after total knee arthroplasty. *Arch Phys Med Rehabil*. 2002;83(1):70-80.
44. Almeida GJ, Schroeder CA, Gil AB, Fitzgerald GK, Piva SR. Interrater reliability and validity of the stair ascend/descend test in subjects with total knee arthroplasty. *Arch Phys Med Rehabil*. 2010;91(6):932-8.
45. Hill KD. A New Test of Dynamic Standing Balance for Stroke Patients: Reliability, Validity and Comparison with Healthy Elderly. *Physiother Can*. 1996;48(4):257-262.

46. Dite W, Temple VA. A clinical test of stepping and change of direction to identify multiple falling older adults. *Arch Phys Med Rehabil*. 2002;83(11):1566-1571.
47. Roos MA, Reisman DS, Hicks GE, Rudolph KS. Development of the modified four square step test and its reliability and validity in people with stroke. *J Rehabil Res Dev*. 2016;53(3):403.
48. Vukomanović A, \DJurović A, Popović Z, Pejović V. The A-test: assessment of functional recovery during early rehabilitation of patients in an orthopedic ward-content, criterion and construct validity. *Vojnosanit pregl*. 2014;71(8):715-722.
49. Shields RK, Leo KC, Miller B, Dostal WF, Barr R. An acute care physical therapy clinical practice database for outcomes research. *Phys Ther*. 1994;74(5):463-470.
50. Elings J, Van Der Sluis G, Goldbohm RA, et al. Development of a Risk Stratification Model for Delayed Inpatient Recovery of Physical Activities in Patients Undergoing Total Hip Replacement. *J Orthop Sports Phys Ther*. 2016;46(3):135-143.
51. Podsiadlo D, Richardson S. The Timed “Up & Go”: A Test of Basic Functional Mobility for Frail Elderly Persons. *J American Geriatrics Society*. 1991;39(2):142-148.
52. Deathe AB, Miller WC. The L test of functional mobility: measurement properties of a modified version of the timed “up & go” test designed for people with lower-limb amputations. *Phys Ther*. 2005;85(7):626-635.
53. Calvert ND, Smith A, Kuster L, et al. The kneeling test is a valid method of assessing kneeling tolerance. *Knee Surg Sports Traumatol Arthrosc*. 2019;27(11):3705-3712.
54. de Araujo CG. [Sit-up test: presentation of an evaluation procedure in exercise and sports medicine] [Portuguese]. *Rev Bras Med Esporte* 1999;5:179-82.
55. Rastogi R, Davis AM, Chesworth BM. A cross-sectional look at patient concerns in the first six weeks following primary total knee arthroplasty. *Health Qual Life Outcomes*. 2007;5(1):48.
56. Cella D, Gershon R, Lai JS, Choi S. The future of outcomes measurement: item banking, tailored short-forms, and computerized adaptive assessment. *Qual Life Res*. 2007;16:133-141.
57. Jette AM, Haley SM. Contemporary measurement techniques for rehabilitation outcomes assessment. *J Rehabil Med*. 2005;37(6):339-345.
58. Hart DL, Mioduski JE, Stratford PW. Simulated computerized adaptive tests for measuring functional status were efficient with good discriminant validity in patients with hip, knee, or foot/ankle impairments. *J Clin Epidemiol*. 2005;58(6):629-638.
59. Loyd BJ, Jennings JM, Judd DL, et al. Influence of Hip Abductor Strength on Functional Outcomes Before and After Total Knee Arthroplasty: Post Hoc Analysis of a Randomized Controlled Trial. *Phys Ther*. 2017;97(9):896-903

60. Swinkels A, Allain TJ. Physical performance tests, self-reported outcomes, and accidental falls before and after total knee arthroplasty: an exploratory study. *Physiother Theory Pract*. 2013;29(6):432-442.
61. Wang TJ. Concept analysis of functional status. *Int J Nurs Stud*. 2004;41(4):457-462.
62. Jette DU, Hunter SJ, Burkett L, et al. Physical therapist management of total knee arthroplasty. *Phys Ther*. 2020;100(9):1603-1631.
63. Barsoum WK, Murray TG, Klika AK, et al. Predicting patient discharge disposition after total joint arthroplasty in the United States. *J Arthroplasty*. 2010;25(6):885-892
64. Young NL, Williams JI, Yoshida KK, Bombardier C, Wright JG. The context of measuring disability: does it matter whether capability or performance is measured?. *J Clin Epidemiol*. 1996;49(10):1097-1101.
65. Lemmens RJ, Timmermans AA, Janssen-Potten YJ, Smeets RJ, Seelen HA. Valid and reliable instruments for arm-hand assessment at ICF activity level in persons with hemiplegia: a systematic review. *BMC Neurol*. 2012;12:21.
66. Özden F, Tümtürk İ. Physical Performance-Based Outcome Measures in Total Hip Arthroplasty Patients: COSMIN-Based Systematic Review. *Phys Occup Ther Geriatr*. 2023;41(3):415-431.
67. Özden F, Tümtürk İ. Performance-Based Outcome Measures in Total Knee Arthroplasty: A Systematic Review. *Phys Occup Ther Geriatr*. 2022;40(3):241-260.
68. Mizner RL, Petterson SC, Clements KE, Zeni JA Jr, Irrgang JJ, Snyder-Mackler L. Measuring functional improvement after total knee arthroplasty requires both performance-based and patient-report assessments: a longitudinal analysis of outcomes. *J Arthroplasty*. 2011;26(5):728-737.
69. Swinkels RA, van Peppen RP, Wittink H, Custers JW, Beurskens AJ. Current use and barriers and facilitators for implementation of standardised measures in physical therapy in the Netherlands. *BMC Musculoskelet Disord*. 2011;12:106.
70. Duncan EA, Murray J. The barriers and facilitators to routine outcome measurement by allied health professionals in practice: a systematic review. *BMC Health Serv Res*. 2012;12:96
71. Razmjou H, Denis S, Robarts S, et al. Virtual performance measure in osteoarthritis: An innovative transformation of patient care. *Osteoarthr Cartil Open*. 2023;5(4):100410
72. Brennan DM, Mawson S, Brownsell S. Telerehabilitation: enabling the remote delivery of healthcare, rehabilitation, and self management. *Stud Health Technol Inform*. 2009;145:231-248.
73. Shahrestanaki SK, Rafii F, Najafi Ghezeljeh T, Farahani MA, Majdabadi Kohne ZA. Patient safety in home health care: a grounded theory study. *BMC Health Serv Res*. 2023;23(1):467

Appendices (Study 4)

Appendix A. Modified ICF core set for OA for patients undergoing hip or knee arthroplasty

Activity and Participation (ICF code/category title) - 39 third level categories +7 second level categories - 49 third and second level categories	Body functions and structure (ICF code/category title) - 4 first level categories	Environmental factor (ICF code/category title) - 5 first level categories
d4 Mobility (First level chapter)	b1 Mental functions (First level chapter)	e1 Products and technology (First level chapter)
d410 Changing basic body position (Second-level category) (Third-level category) d4100 Lying down and getting up d4101 Squatting d4102 Kneeling d4103 Sitting d4104 Standing d4105 Bending d4106 Shifting the body's centre of gravity d4107 Rolling over (8 third level) <i>d4108 Other specified changing basic body position</i> <i>d4109 Changing basic body position, unspecified</i>	b2 Sensory functions and pain	e2 Natural environment and human-made changes to environment
	b7 Neuromusculoskeletal and movement-related functions	e3 Support and relationships
	s7 Structures related to movement	e4 Attitudes
d415 Maintaining a body position (Second-level category) (Third-level category) d4150 Maintaining a lying position d4151 Maintaining a squatting position d4152 Maintaining a kneeling position d4153 Maintaining a sitting position d4154 Maintaining a standing position (5 third level) <i>d4158 Maintaining a body position, other specified</i>		e5 Services, systems and policies

<i>d4159 Maintaining a body position, unspecified</i> d430 Lifting and carrying objects (<u>Second-level category</u>) (<u>Third-level category</u>) d4300 Lifting a light object d4300 Lifting a heavy object d4301 Carrying in the hands d4302 Carrying in the arms d4303 Carrying on shoulders and back d4305 Putting down objects <i>(6 third level)</i> <i>d4308 Lifting and carrying, other specified</i> <i>d4309 Lifting and carrying, unspecified</i> d450 Walking (<u>Second-level category</u>) (<u>Third-level category</u>) d4500 Walking short distances d4501 Walking long distances d4502 Walking on different surfaces d4503 Walking around obstacles <i>(4 third level)</i> <i>d4508 Other specified walking</i> <i>d4509 Walking, unspecified</i> d451 Going up stairs d451 Going down stairs <i>(2 second level)</i> d455 Moving around (<u>Second-level category</u>) (<u>Third-level category</u>) d4551 Climbing d4553 Jumping <i>(2 third level)</i>		
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<i>d4558 Other specified moving around</i> <i>d4559 Moving around, unspecified</i> d470 Using transportation (Second-level category) (Third-level category) d4701 Using private motorized transportation d4702 Using public motorized transportation <i>(2 third level)</i> <i>d4708 Other specified using transportation</i> <i>d4709 Using transportation, unspecified</i> d475 Driving (Second-level category) (Third-level category) d4750 Driving human-powered transportation d4751 Driving motorized vehicles <i>(2 third level)</i> <i>d4758 Other specified driving</i> <i>d4759 Driving, unspecified</i> d5 Self-care (First level chapter) d510 Washing oneself (Second-level category) (Third-level category) d5100 Washing body parts d5101 Washing whole body d5102 Drying oneself <i>(3 third level)</i> <i>d5108 Other specified washing oneself</i> <i>d5109 Washing oneself, unspecified</i> d530 Toileting (Second-level category) <i>(1 second level)</i> d540 Dressing (Second-level category) (Third-level category)		
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d5400 Putting on clothes d5401 Taking off clothes d5402 Putting on footwear d5403 Taking off footwear <i>(4 third level)</i> <i>d5408 Other specified dressing</i> <i>d5409 Dressing, unspecified</i> d6 Domestic life d620 Acquisition of goods and services (<u>Second-level category</u>) <i>(1 second level)</i> d640 Doing housework (<u>Second-level category</u>) <i>(1 second level)</i> d660 Assisting others (<u>Second-level category</u>) <i>(1 second level)</i> d7 Interpersonal interactions and relationships d770 Intimate relationships (<u>Second-level category</u>) <i>(1 second level)</i> d8 Major life areas d850 Remunerative employment (<u>Second-level category</u>) <i>(1 second level)</i> d855 Non-remunerative employment (<u>Second-level category</u>) <i>(1 second level)</i> d9 Community, social and civic life d910 Community Life(<u>Second-level category</u>)/ d9205 Socializing (<u>Third-level category</u>) <i>(1 third/second level)</i>		
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d920 Recreation and leisure (Second-level category) (Third-level category) d9200 Play d9204 Hobbies /d9203 Crafts / d9202 Arts and culture d9201 Sports/ d4554 Swimming d4552 Running <i>(3 third level)</i> <i>d9208 Other specified recreation and leisure</i> <i>d9209 Recreation and leisure, unspecified</i>		
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Appendix B. Search Strategy

Ovid Medline

- 1 arthroplasty, replacement, hip/ or arthroplasty, replacement, knee/
- 2 hip prosthesis/ or knee prosthesis/
- 3 (knee* adj3 (replace* or implant* or arthroplast* or prosth*)) .ti,ab,kf.
- 4 (hip* adj3 (replace* or implant* or arthroplast* or prosth* or resurfac*)) .ti,ab,kf.
- 5 or/1-4
- 6 physical performance measure* .ti,ab,kf.
- 7 (objective adj3 (test* or instrument* or measure* or method* or evaluation* or disability or function or assessment*)) .ti,ab,kf.
- 8 Gait Analysis/
- 9 (gait adj3 (analys* or evaluation)) .ti,ab,kf.
- 10 ((performance or performance-based or performance based or observational or observational-based) adj3 (test* or measure* or instrument* or method* or index or indices or assessment* or evaluation* or analys*)) .ti,ab,kf.
- 11 (Observed adj3 (disability or function)) .ti,ab,kf.
- 12 Walk Test/
- 13 (walk* adj3 test*) .ti,ab,kf.
- 14 "Task Performance and Analysis"/
- 15 or/6-14
- 16 (physical function* or physical activity or physical activities or physical performance* or functional activity or functional activities or functional performance* or performance* or function* or activity limitation* or functional limitation* or disability or disabilities) .ti,ab,kf.
- 17 exp physical functional performance/
- 18 "Activities of Daily Living"/
- 19 Motor Activity/
- 20 or/16-19
- 21 15 and 20
- 22 Patient Reported Outcome Measures/
- 23 Patient Outcome Assessment/
- 24 patient outcome assessment* .ti,ab,kf.
- 25 (patient centred outcome* or patient centered outcome*) .ti,ab,kf.

- 26 patient reported outcome*.ti,ab,kf.
- 27 (Health and (index* or indices or profile* or status)).ti,ab,kf.
- 28 ((patient or self or carer or proxy) and (report or reported or reporting or rated or rating or ratings or based or assessed or assessment or assessments)).ti,ab,kf.
- 29 (PROMS or PROM).ti,ab,kf.
- 30 (((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) and (outcome or outcomes or instrument or instruments or measure or measures or questionnaire or questionnaires or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab,kf.
- 31 or/22-30
- 32 21 or 31
- 33 instrumentation.fs.
- 34 Validation Study.pt.
- 35 exp reproducibility of results/
- 36 reproducib*.ti,ab.
- 37 exp psychometrics/
- 38 (psychometr or clinimetr* or clinometr*).ti,ab.
- 39 exp observer variation/
- 40 observer variation.ti,ab.
- 41 exp discriminant analysis/
- 42 (reliab* or valid* or coefficient or internal consistency).ti,ab.
- 43 (cronbach* and (alpha or alphas)).ti,ab.
- 44 (item correlation? or item selection? or item reduction?).ti,ab.
- 45 (agreement or precision or imprecision or precise values).ti,ab,kf.
- 46 test-retest.ti,ab.
- 47 (test and retest).ti,ab.
- 48 (reliab* and (test or retest)).ti,ab.
- 49 (stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intra-observer or intertechnician or intertechnician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or inter-assay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa* or coefficient of variation).ti,ab.

- 50 repeatab*.ti,ab,kf.
- 51 ((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab,kf.
- 52 (generaliza* or generalisa* or concordance).ti,ab.
- 53 (intraclass and correlation*).ti,ab.
- 54 (discriminative or known group or factor analysis or factor analyses or factor structure* or dimensionality or subscale* or multitrait scaling analys* or item discriminant or interscale correlation or interscale correlations).ti,ab.
- 55 ((error or errors) and (measure* or correlat* or evaluat* or accuracy or accurate or precision or mean)).ti,ab.
- 56 (individual variability or interval variability or rate variability or variability analysis).ti,ab.
- 57 (uncertainty and (measurement or measuring)).ti,ab.
- 58 (standard error of measurement or sensitiv* or responsive*).ti,ab.
- 59 (limit and detection).ti,ab.
- 60 (minimal detectable concentration or interpretab*).ti,ab.
- 61 (small* and (real or detectable) and (change or difference)).ti,ab.
- 62 (meaningful change or minimal important change or minimal important difference or minimally important change or minimally important difference or minimal detectable change or minimal detectable difference or minimally detectable change or minimally detectable difference or minimal real difference or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.
- 63 or/33-62
- 64 5 and 32 and 63
- 65 (address or biography or comment or directory or editorial or festschrift or lecture or legal case or legislation or letter or news or congress or consensus development conference or consensus development conference, nih or review or systematic review or scientific integrity review).pt.
- 66 64 not 65
- 67 exp animals/ not exp humans/
- 68 66 not 67
- 69 65 or 67
- 70 64 not 69

Embase

- 1 hip replacement/ or hip arthroplasty/ or total hip replacement/
- 2 knee replacement/ or knee arthroplasty/ or total knee arthroplasty/
- 3 hip prosthesis/ or knee prosthesis/
- 4 (knee* adj3 (replace* or implant* or arthroplast* or prosth*)).ti,ab,kw.
- 5 (hip* adj3 (replace* or implant* or arthroplast* or prosth* or resurfac*)).ti,ab,kw.
- 6 or/1-5
- 7 physical performance measure*.ti,ab,kw.
- 8 (objective adj3 (test*or instrument* or measure* or method* or evaluation* or disability or function or assessment*)).ti,ab,kw.
- 9 Gait Analysis/
- 10 (gait adj3 (analys* or evaluation)).ti,ab,kw.
- 11 ((performance or performance-based or performance based or observational or observational-based) adj3 (test* or measure* or instrument* or method* or index or indices or assessment* or evaluation* or analys*)).ti,ab,kw.
- 12 (Observed adj3 (disability or function)).ti,ab,kw.
- 13 exp walk test/
- 14 (walk* adj3 test*).ti,ab,kw.
- 15 "Task Performance and Analysis"/
- 16 or/7-15
- 17 (physical function* or physical activity or physical activities or physical performance* or functional activity or functional activities or functional performance* or performance* or function* or activity limitation* or functional limitation* or disability or disabilities).ti,ab,kw.
- 18 exp physical performance/
- 19 daily life activity/
- 20 motor activity/
- 21 or/17-20
- 22 16 and 21
- 23 exp patient-reported outcome/
- 24 patient outcome assessment/
- 25 patient outcome assessment*.ti,ab,kw.
- 26 (patient centred outcome* or patient centered outcome*).ti,ab,kw.

- 27 patient reported outcome*.ti,ab,kw.
- 28 (Health and (index* or indices or profile* or status)).ti,ab,kw.
- 29 ((patient or self or carer or proxy) and (report or reported or reporting or rated or rating or ratings or based or assessed or assessment or assessments)).ti,ab,kw.
- 30 (PROMS or PROM).ti,ab,kw.
- 31 (((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) and (outcome or outcomes or instrument or instruments or measure or measures or questionnaire or questionnaires or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab,kw.
- 32 or/23-31
- 33 22 or 32
- 34 exp validation study/
- 35 exp reproducibility/
- 36 reproducib*.ti,ab.
- 37 exp psychometry/
- 38 (psychometr or clinimetr* or clinometr*).ti,ab.
- 39 exp observer variation/
- 40 observer variation.ti,ab.
- 41 exp discriminant analysis/
- 42 (reliab* or valid* or coefficient or internal consistency).ti,ab.
- 43 (cronbach* and (alpha or alphas)).ti,ab.
- 44 (item correlation or item correlations or item selection or item selections or item reduction or item reductions).ti,ab.
- 45 (agreement or precision or imprecision or precise values).ti,ab,kw.
- 46 test-retest.ti,ab.
- 47 (test and retest).ti,ab.
- 48 (reliab* and (test or retest)).ti,ab.
- 49 (stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intra-observer or intertechnician or intertechnician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or inter-assay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa* or coefficient of variation).ti,ab.

- 50 repeatab*.ti,ab,kw.
- 51 ((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab,kw.
- 52 (generaliza* or generalisa* or concordance).ti,ab.
- 53 (intraclass and correlation*).ti,ab.
- 54 (discriminative or known group or factor analysis or factor analyses or factor structure* or dimensionality or subscale* or multitrait scaling analys* or item discriminant or interscale correlation or interscale correlations).ti,ab.
- 55 ((error or errors) and (measure* or correlat* or evaluat* or accuracy or accurate or precision or mean)).ti,ab.
- 56 (individual variability or interval variability or rate variability or variability analysis).ti,ab.
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- 57 (uncertainty and (measurement or measuring)).ti,ab.
- 58 (standard error of measurement or sensitiv* or responsive*).ti,ab.
- 59 (limit and detection).ti,ab.
- 60 (minimal detectable concentration or interpretab*).ti,ab.
- 61 (small* and (real or detectable) and (change or difference)).ti,ab.
- 62 (meaningful change or minimal important change or minimal important difference or minimally important change or minimally important difference or minimal detectable change or minimal detectable difference or minimally detectable change or minimally detectable difference or minimal real difference or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.
- 63 or/34-62
- 64 6 and 33 and 63
- 65 (Conference Abstract or Conference Review or Editorial or Erratum or Letter or Note or review).pt.
- 66 64 not 65
- 67 exp animal/ not exp human/
- 68 66 not 67

Cochrane Central Register of Controlled Trials

- 1 arthroplasty, replacement, hip/ or arthroplasty, replacement, knee/
- 2 hip prosthesis/ or knee prosthesis/

- 3 (knee* adj3 (replace* or implant* or arthroplast* or prosth*)).ti,ab.
- 4 (hip* adj3 (replace* or implant* or arthroplast* or prosth* or resurfac*)).ti,ab.
- 5 or/1-4
- 6 physical performance measure*.ti,ab.
- 7 (objective adj3 (test* or instrument* or measure* or method* or evaluation* or disability or function or assessment*)).ti,ab.
- 8 (Observed adj3 (disability or function)).ti,ab.
- 9 gait analysis/
- 10 (gait adj3 (analys* or evaluation)).ti,ab.
- 11 ((performance or performance-based or performance based or observational or observational-based) adj3 (test* or measure* or instrument* or method* or index or indices or assessment* or evaluation* or analys*)).ti,ab.
- 12 Walk Test/
- 13 (walk* adj3 test*).ti,ab.
- 14 "Task Performance and Analysis"/
- 15 or/6-14
- 16 (physical function* or physical activity or physical activities or physical performance* or functional activity or functional activities or functional performance* or performance* or function* or activity limitation* or functional limitation* or disability or disabilities).ti,ab.
- 17 exp physical functional performance/
- 18 "Activities of Daily Living"/
- 19 motor activity/
- 20 or/16-19
- 21 15 and 20
- 22 patient reported outcome measures/
- 23 Patient Outcome Assessment/
- 24 patient outcome assessment*.ti,ab.
- 25 (patient centred outcome* or patient centered outcome*).ti,ab.
- 26 patient reported outcome*.ti,ab.
- 27 (Health and (index* or indices or profile* or status)).ti,ab.
- 28 ((patient or self or carer or proxy) adj3 (report* or apprais* or rate* or rating* or based or assessed or assessment* or evaluate or response*)).ti,ab.

- 29 (PROMS or PROM).ti,ab.
- 30 ((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) and (outcome or outcomes or instrument or instruments or measure or measures or questionnaire or questionnaires or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab.
- 31 or/22-30
- 32 21 or 31
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- 34 validation studies as topic/
- 35 exp "reproducibility of results"/
- 36 reproducib*.ti,ab.
- 37 psychometrics/
- 38 (psychometr or clinimetr* or clinometr*).ti,ab.
- 39 observer variation/
- 40 observer variation.ti,ab.
- 41 Discriminant Analysis/
- 42 (reliab* or valid* or coefficient or internal consistency).ti,ab.
- 43 (cronbach* and (alpha or alphas)).ti,ab.
- 44 (item correlation? or item selection? or item reduction?).ti,ab.
- 45 (agreement or precision or imprecision or precise values).ti,ab.
- 46 test-retest.ti,ab.
- 47 (test and retest).ti,ab.
- 48 (reliab* and (test or retest)).ti,ab.
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- 50 repeatab*.ti,ab.
- 51 ((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab.
- 52 (generaliza* or generalisa* or concordance).ti,ab.

- 53 (intraclass and correlation*).ti,ab.
- 54 (discriminative or known group or factor analysis or factor analyses or factor structure* or dimensionality or subscale* or multitrait scaling analys* or item discriminant or interscale correlation or interscale correlations).ti,ab.
- 55 ((error or errors) and (measure* or correlat* or evaluat* or accuracy or accurate or precision or mean)).ti,ab.
- 56 (individual variability or interval variability or rate variability or variability analysis).ti,ab.
- 57 (uncertainty and (measurement or measuring)).ti,ab.
- 58 (standard error of measurement or sensitiv* or responsive*).ti,ab.
- 59 (limit and detection).ti,ab.
- 60 (minimal detectable concentration or interpretab*).ti,ab.
- 61 (small* and (real or detectable) and (change or difference)).ti,ab.
- 62 (meaningful change or minimal important change or minimal important difference or minimally important change or minimally important difference or minimal detectable change or minimal detectable difference or minimally detectable change or minimally detectable difference or minimal real difference or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.
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- 65 (address or biography or comment or directory or editorial or festschrift or lecture or legal case or legislation or letter or news or congress or consensus development conference or consensus development conference, nih or review or systematic review or scientific integrity review).pt.
- 66 64 not 65
- 67 exp animals/ not exp humans/
- 68 66 not 67

CHAPTER 5: Survey of Functional Activities (Manuscript 5)

Relationship of Manuscript 5 to the Dissertation

This manuscript presents a cross-sectional survey study involving patients who underwent hip or knee arthroplasty (Study 5). Despite the growing interest in adopting a more patient-centered approach to care and outcome assessment, there remains a limited understanding of patients' functional needs after hip or knee arthroplasty. Therefore, this study aimed to identify key functional activities from the patient's perspective within two weeks, at six, 13, and 26 weeks post hip or knee arthroplasty. It surveyed 632 patients who underwent hip or knee arthroplasty using the questionnaire developed and validated in Study 2. The findings revealed that key functional activities varied over time and showed slight differences between hip and knee arthroplasty. Furthermore, there was a decline in the number of important functional activities patients had difficulty performing over time. The study also identified activities that were not considered key based on patients' perspectives. The results of this study provide a basis for selecting patient-centered outcome measures in Study 6.

This manuscript has been prepared for submission. The numbering of tables and figures has been adjusted to align with the formatting of this dissertation.

Manuscript 5: Which functional activities matters most to the patients during the first six months after hip or knee arthroplasty: a cross-sectional study

Abstract

Background: Understanding what matters most to patients can help clinicians plan healthcare more responsive to patients' needs after orthopedic surgery. This study aimed to explore key functional activities from patients' perspectives at different timepoints during the first six months after hip or knee arthroplasty.

Methods: A cross-sectional study was conducted at The Ottawa Hospital in Ottawa, Canada. Patients who underwent hip or knee arthroplasty due to osteoarthritis (OA) were recruited. A self-report questionnaire based on the activity and participation components of the International Classification of Functioning, Disability, and Health (ICF) core set for osteoarthritis was developed and validated.

Results: A total of 632 patients participated, including 334 hip arthroplasty patients and 298 knee arthroplasty patients. Patients identified 26 key functional activities and 22 non-key functional activities within 2 weeks, at six, 13, and 26 weeks post-arthroplasty. Patients highlighted different key activities across various stages following hip or knee arthroplasty, with a decline in the number of key activities over time. During the acute recovery phase, patients focused on simpler activities such as walking short distances and self-care, progressing to more advanced activities like squatting and walking long distances as recovery advanced. The findings revealed slight differences in key activities between patients undergoing hip and knee arthroplasty. Rising from a chair within two weeks, socializing at six weeks, going up or down stairs at 13 and 26 weeks postoperative were key after knee arthroplasty, but not after hip arthroplasty.

Conclusion: The study identified how patients' perspective on key activities changed over different recovery stages following hip or knee arthroplasty. Understanding what matters most to patients enables clinicians to assess outcomes more accurately as well as adapt interventions that align with patients' needs in order to optimize time to recovery.

Keywords: knee and hip arthroplasty, osteoarthritis, functional priorities

Introduction

Knee and hip osteoarthritis (OA) are the most common form of joint disease and leading cause of pain and disability.^{1,2} Once conservative treatments fail to control the symptoms, joint arthroplasty is recommended for advanced hip and knee OA.²⁻⁴ The demand for hip or knee arthroplasty surgeries have increased over the past decades.^{5,6} A recent study forecasted a rise in hip or knee arthroplasty, projecting 791,760 knee arthroplasty and 433,372 hip arthroplasty surgeries annually in the United States by 2030, respectively.⁷ However, 10% to 30% of patients report little or no improvement after hip or knee arthroplasty.^{2,3} Identifying patients with suboptimal outcomes after hip or knee arthroplasty is challenging due to the lack of consensus on its definition.⁴ Ensuring that outcome assessment aligns with patients' priorities could be key to identifying patients at risk or not optimally recovering and optimal management of outcomes after hip or knee arthroplasty

Over the past two decades, there has been increasing interest in adopting a more patient-centered approach to assessing treatment outcomes.⁸ Thus, understanding the aspects of care that are important to the patients, and those of lesser importance, is crucial. This knowledge enables healthcare providers to accurately evaluate outcomes and prioritize interventions, thereby enhancing healthcare responsiveness to patients' preferences and needs. Ultimately, this approach aims to improve patients satisfaction and enhance the overall quality and value of healthcare.^{9,10} Outcome measures that are not informed by patient perspectives risk failing to adequately reflect their concerns and needs, thus compromising the patient-centered outcome assessment.⁸ It is essential for patients to be actively involved in the development of outcome measures to ensure that the operationalization of items reflects patient perspectives.^{8,11} However, previous reviews have indicated that patient involvement in the development process of the tools has been

limited.^{11,12} Determining the patient centeredness of existing tools to assess outcomes after hip or knee arthroplasty remains unclear.¹³

While patients' expectations and goals before surgery have been extensively investigated in the literature,^{14–17} there is still little understanding of which activities patients undergoing hip or knee arthroplasty prioritize at different time points after surgery. Preoperative information is insufficient for several reasons :1) response shift may occur after arthroplasty, which is a change in self-evaluation because of changes in internal standards, values, and the conceptualization of function after treatment.¹⁸ Previous studies have shown that patients might revise their functional priorities and expectations and redefine treatment success after hip or knee arthroplasty because their functional status and perception of functional health may change;^{19,20} 2) up to half of patients have overly optimistic attitudes on potential postoperative outcomes which can lead to dissatisfaction after arthroplasty;¹⁷ and 3) preoperative patient expectations tend to focus only on long-term goals.^{19,20} A comprehensive understanding of patient priorities at different time points after hip or knee arthroplasty is needed. Therefore, the aim of this study is to determine key functional activities based on patient perspectives within 2 weeks, at 6, 13, and 26 weeks after hip or knee arthroplasty.

Methods

We conducted a cross-sectional survey and was reported based on the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline.²¹ The rationale for choosing this research design is to efficiently reach a large sample in a specific period of time.^{22,23} This study received ethics approval from the Ottawa Health Sciences Network Research Ethics Board (20230252-01H), and the University of Ottawa Board of Ethics (H-06-23-9425).

Survey questionnaire

In a previous study,²⁴ we developed a self-administered questionnaire based on activity and participation components of the International Classification of Functioning, Disability and Health (ICF) core set for OA and established its face and content validity. This process resulted in 49 questions on functional activities in the following 12 domains: changing basic body position, maintaining a body position, lifting and carrying objects, walking, moving around, using transportation, driving, washing oneself, toileting, dressing, remunerative employment, and recreation and leisure.

Setting and participants

We conducted this study within the orthopedic division at The Ottawa Hospital in Ottawa, Canada, an academic-affiliated institution in an urban setting with a high volume of arthroplasty procedures. The recruitment timing in this study was selected based on recovery pattern after arthroplasty. Within two weeks after hip or knee arthroplasty captures acute recovery. Approximately six weeks postoperative addresses the first post-acute recovery since most adverse events usually occur within 30 days after arthroplasty,^{25,26} and most patients can be considered stable between 4 to 6 weeks after hip or knee arthroplasty. The assessments at 12 and 26 weeks were selected to capture the majority of functional recovery.^{27,28}

Participants were adults (18 years or older) who underwent primary elective hip or knee arthroplasty, including total joint arthroplasty, uni-compartmental knee arthroplasty, and hip resurfacing or hemi-arthroplasty due to OA, had surgery one, six, 13, or 26 weeks prior, spoke English, and gave consent to participate in this study. Participants with hearing or speech impairments were included if the research team member (MK) received their consent as it was not required to communicate orally to fill out the questionnaire. Participants who underwent hip

or knee arthroplasty for reasons other than primary OA, who had severe cognitive impairment, were unable to read and did not have any support (family member, friend, or caregiver) to read the documents were excluded.

Sampling and Recruitment

We used in-person and telephone-based recruitment strategies. The patients were recruited during postoperative in-clinic visits with orthopedic surgeons at The Ottawa Hospital or by phone calls. The study used two nonprobability sampling methods, including convenience sampling and purposive sampling. First, patients were recruited using convenience sampling in the first three months of recruitment.²⁹ After three months of recruitment, the characteristics of the participants at each time point was compared with the Canadian population (age and gender),³⁰ patients at The Ottawa Hospital who underwent hip or knee arthroplasty over the past two years (caregiver support, comorbidities, walking aids), or with findings from relevant research (BMI). This comparison aimed to determine which demographic characteristic was under or overrepresented. In the case of significant differences with the population, purposive sampling was selected for patient recruitment to ensure representativeness. To identify and recruit individuals with underrepresented characteristics, we reviewed patient charts at The Ottawa Hospital. This method allowed us to specifically target and include patients whose characteristics were underrepresented in our sample.

Data collection

After agreeing to participate in this study, the participants had the option to complete the questionnaire either in-person (paper) or online (email). Implied consent was obtained from participants by responding to the survey. For the in-person option, participants were given the choice to receive either a paper version of the questionnaire and consent form physically during

their appointments with their orthopedic surgeons or to have them sent by mail. The email contained an embedded link to the survey which directed the interested participants to the implied consent form and survey questions. The Ottawa Hospital REDCap software platform was used to develop the online survey.³¹ In order to increase response rates, non-responders were contacted by a research team member (MK) via telephone approximately 5 and 10 days after receiving the questionnaire.³² To identify the non-responders, a research team member (MK) used the participant IDs. The survey could be completed over several sessions and allowed participants to review their answers before the final submission.

In addition, preoperative data including Oxford Knee Score (OKS), Oxford Hip Score (OHS) score, American Society of Anesthesiologists physical status classification (ASA) score and surgical approach were collected from patient charts in Epic and ConEHR. ConEHR is part of the Orthopaedic Surgery Division's Continuous Quality Improvement program based within The Ottawa Hospital.

Sample Size

With a margin of error of 8% and a confidence level of 90% based on number of patients underwent hip or knee arthroplasty at The Ottawa Hospital across six months, it was estimated that 76 hip arthroplasty and 72 knee arthroplasty participants for each time period would be representative of the respective patients population at The Ottawa Hospital.³³ We consider the sample size of patients underwent hip or knee arthroplasty over six months to be aligned with the follow-up period.

Data analysis

We used the Statistical Package for Social Sciences (IBM SPSS, version 28) to analyze data. Descriptive analyses were used to calculate response rates and participants demographics,

such as age, gender, ethnicity, having a caregiver, preoperative function (defined as OKS or OHS³⁴), postoperative pain (defined as visual analog scale (VAS) score ^{35,36}), body mass index (BMI), and comorbidities (defined ASA score ³⁷). All continuous variables were expressed as means and standard deviations, and categorical variables were reported as frequency and percentage.

With the questionnaire, participants rated each functional activity on four point scales according to its current importance to them and ability to do it.^{38,39} The importance of the activity was dichotomized into: not important (not important, slightly important) and important (important, very important), and ability into: little difficulty (easily, with little difficulty) and a lot of difficulty (with a lot of difficulty, unable to do).

Two research team members (MK and FA) independently coded the open-ended question asking about other important activities with NVivo 12 qualitative data analysis software (QSR International Inc., Burlington, MA, USA).⁴⁰ If a response could align with one of the 49 activities of the questionnaire, it was compared with the corresponding questionnaire response. If there were discrepancies, the coders updated the response accordingly. If a code did not correspond to any of the 49 activities, the coders defined a new code and grouped them to identify uncovered key activities. Two coders met regularly to peer-review the coding process, and discuss interpretations until reaching a consensus.⁴¹

To identify key functional activities, a threshold of 75% of participants assessing the activity as important was used, consistent with previous studies.^{42,43} Also, a threshold of 15% of participants having difficulty doing the activity was used based on average percentage of patients reporting poor postoperative outcomes, including function or satisfaction.⁴⁴⁻⁵¹ In addition, we conducted chi-square analyses to compare the importance and difficulty of each

activity at each time point between hip and knee arthroplasty. If an activity met the thresholds in one procedure and there was no statistically significant percentage difference between hip and knee, we categorized that activity as key for both procedures. A p-value < 0.05 was considered statistically significant.

Results

Between November 2023 and March 2024, 840 eligible patients were approached and invited to participate in this study. Of these, 298 patients who underwent hip arthroplasty and 334 knee arthroplasty completed the questionnaire, resulting in a response rate of 85.4% and 84.9 % for hip and knee arthroplasty respectively. In the last two months of recruitment, we purposely recruited the participants based on age, gender and BMI, aiming to ensure a representative sample of the population. The detailed participant recruitment process is presented in Figure 5.1.

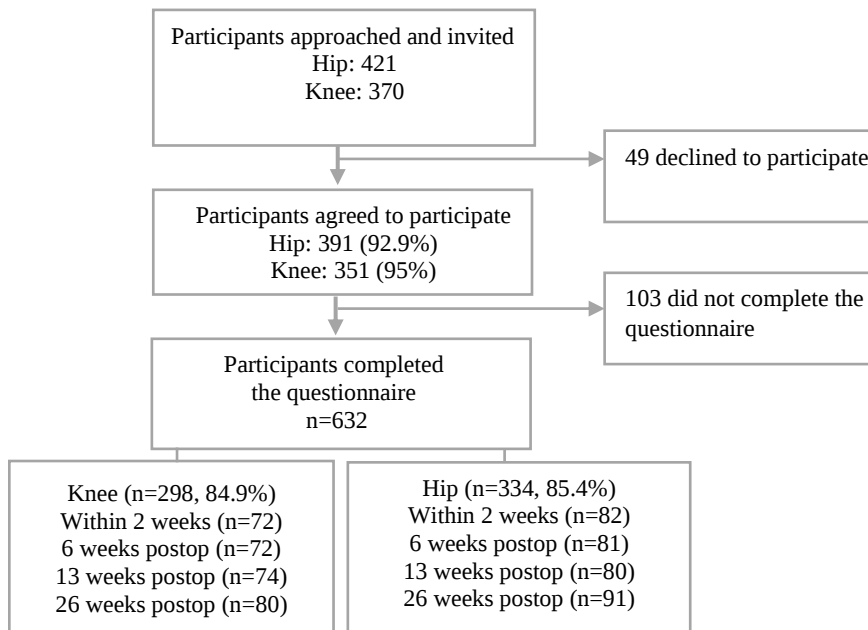


Figure 5.1 Flowchart of participants recruitment

Participants Characteristics

Detailed characteristics of the patients at different time points after hip and knee arthroplasty are presented in Appendix A and B, respectively. Patients did not differ significantly across time periods following hip or knee arthroplasty, except in pain levels, use of walking aids, and precautions after hip arthroplasty, which may reflect improvements in recovery over time. When comparing hip and knee arthroplasty, patients who underwent knee arthroplasty were older, had higher BMI, higher preoperative Oxford score, experienced more pain, and had more contralateral knee joint problems. Appendix C provides a detailed comparison of the demographic characteristics of patients undergoing hip and knee arthroplasty.

Key functional activities after hip or knee arthroplasty

Table 5.1 to 5.4 present percentages of importance and difficulty for the 49 functional activities. The results demonstrated different key functional activities across different time points after arthroplasty.

Key functional activities within 2 weeks after hip or knee arthroplasty

During the first two weeks after hip or knee arthroplasty, 14 key functional activities were identified for both procedures, with the addition of rising from a chair after knee arthroplasty. These activities were related to categories of self-care (n=7), changing and holding a body position (n=5), moving around (n=2), and walking (n=1) (Table 5.1, 5.5).

Key functional activities at 6 weeks after hip or knee arthroplasty

Patients identified 15 key functional activities six weeks after hip or knee arthroplasty, with the additional activity of socializing after knee arthroplasty. These activities encompassed categories of changing and holding a body position (n=4), self-care (n=3), lifting and carrying objects (n=2), moving around (n=2), domestic life (n=2), walking (n=1), community, social and civic life (n=1) (Table 5.2, 5.5).

Key functional activities at 13 weeks after hip or knee arthroplasty

Patients identified seven key functional activities 13 weeks after hip or knee arthroplasty, with the additional activity of going down stairs after knee arthroplasty. The activities were related to categories of changing and holding a body position (n=3), walking (n=2), lifting and carrying objects (n=1), moving around (n=1), and self-care (n=1) (Table 5.3, 5.5).

Key functional activities at 26 weeks after hip or knee arthroplasty

Patients identified four key functional activities at 26 weeks after hip or knee arthroplasty. These activities were related to categories of walking (n=2) activity changing and holding a body position (n=1) and lifting and carrying objects (n=1). Furthermore, two additional activities (going up stairs, going down stairs) were identified after knee arthroplasty (Table 5.4, 5.5).

Differences in key activities across the four-time points

Key activities varied across four different time points, with some activities common across various phases. Within the first two weeks after hip or knee arthroplasty, patients identified eight key activities that were not key at later time points, including lying down in bed and getting up, rolling over, rising from a chair, walking short distances, washing the whole body, drying the body, putting on and taking off clothes. However, seven key activities identified within the first two weeks after surgery did remain key in later stages of recovery, including holding a sitting position, holding a standing position, going up stairs, going down stairs, washing lower body parts, putting on footwear, and taking off footwear. As recovery progressed, nine activities that were not identified as key within the first two weeks postoperatively emerged as key six weeks and beyond, including squatting, bending, putting down objects, carrying in the arms, walking on different surfaces, driving, going shopping,

doing housework, and socializing. Conversely, holding a sitting position, holding a standing position, and putting on footwear were key at 2, 6 and 13 weeks but not at 26 weeks. Eight activities were key only six weeks after surgery, including bending, putting down objects, carrying in the arms, driving, going shopping, doing housework and socializing. Finally, lifting heavy objects from the floor and walking long distances were key only at 13 and 26 weeks after surgery.

Other functional activities from qualitative analysis

After qualitative analysis of the open-ended questions from 191 participants, we identified 56 responses that did not match the 49 activities listed in our questionnaire. Five new activities following hip or knee arthroplasty were identified, including d6506:taking care of animals, d650:caring for household objects (vehicle maintenance), d4558:other specified moving around (getting into and out of boats or pool), d5202:caring for hair, and d170:writing. In addition, patients highlighted impairments including b134:sleep functions, b1:mental function (stress management, having a clear mind), b130:energy and drive functions, b710:mobility of joint functions, and b760:control of voluntary movement functions (balance). Table 5.6 provides the reporting frequency of these activities. However, none of them were identified as key activities since they did not meet the thresholds.

Non-key functional activities

The findings indicated that 22 out of 49 activities were not key at any time after hip or knee arthroplasty. Table 5.7 lists these activities.

Table 5.1 Importance and difficulty of key activities for hip and knee arthroplasty within two weeks.

Activity	Within 2 weeks postoperative			
	Importance%_Hip	Importance%_Knee	Difficulty%_Hip	Difficulty%_Knee
Changing and holding a body position				
Lying down in bed and getting up	96.3	96.9	14.6	20.3
Rolling over	76.8	87.3	27.1	35.9
Hold a lying position during the day	62.2	64.1	22	27
Squatting down	60	52.4	41.5*	76.6
Hold a squatting position	41.9	44.4	54.3*	76.6
Kneeling down on the ground	32.6	32.8	54.9*	95.3
Hold a kneeling position	27.2	26.6	50*	93.7
Sitting on a chair	90.3*	98.5	4.9*	14.1
Hold a sitting position	86.3*	92.2	22	42.2
Rising from a chair	92.6	92.2	11*	26.5
Hold a standing position	82.6	81	39	47.6
Bending over or to the side	65.1	70.3	36.6	40.6
Shifting the body from side to side	61.7	70.3	25.6	31.3
Lifting and carrying objects				
Lifting a light object from the floor	61.7	64.1	37.8	37.5
Lifting a heavy object from the floor	27.6	29.7	51.2*	74.6
Putting down objects on the floor	38.8	43.8	39.5*	50
Carrying in the hands	57.6	56.2	31.7	42.2
Carrying in the arms	46.3	48.4	41.9	50.1
Carrying on shoulders or back	22.2	20.6	22	21.9
Walking				
Walking short distances	78	75	20.7	37.5
Walking long distances	39.5	31.3	57.3	64.1
Walking on different surfaces	51.9	37.5	43.9	60.9
Walking around obstacles	48.1	42.8	28	40.6
Moving around				
Going up stairs	79	64.1	28*	46.9
Going down stairs	81	65.6	30.5*	46.9
Going up a curb or step	72.5	67.2	13.5*	29.7
Jumping	11.1	12.5	59.8	81.3
Moving around using transportation				
Getting in and out of a car	67.1	68.8	33.3	46.9
Using public transportation	12.6	7.8	16*	40.6
Biking	16.1	15.7	42.7	60.9
Driving vehicle	51.2	49.2	45.1	61
Self-care				
Washing lower body parts	91.4	89.1	56.1	42.2
Washing whole body	96.3	92	33.3	29.7
Drying your body	96.3	92.2	30.5	21.9
Going to the toilet	100	98.5	14.6	14.1
Putting on clothes	95	90.7	31.7	20.6
Taking off clothes	96.3	93.6	19.5	18.8
Putting on footwear	82.7	82.5	59.7	46.9
Taking off footwear	83.9	84.1	42.6*	29.7
Domestic life and Intimate relationships				

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Going shopping	31.7	25	39*	64.1
Doing housework	53.1	45.4	52.4	66.7
Assisting others	28.1	23.5	38.3	50
Sexual relationships	38.4	33.8	53.8	63.9
Employment				
Paid job	25.1	25.1	37.8	35.9
Unpaid work	18.5	21.9	41.5	48.4
Community, social and civic life				
Socializing /Participating in community life	56.1	54.7	48.8	64.1
Sports	45	37.5	66.7*	87.5
Running/jogging	14.8	3.1	70.8	81
Hobbies/play/Crafts/Arts/culture	64.6	46.9	34.2	48.5

* Difference between hip and knee is significant ($p < 0.05$). Bold numbers indicate key activities.

Table 5.2 Importance and difficulty of key activities for hip and knee arthroplasty at six weeks.

	6 weeks postoperative			
Activity	Importance%_Hip	Importance%_Knee	Difficulty%_Hip	Difficulty%_Knee
Changing and holding a body position				
Lying down in bed and getting up	97.6	96.6	1.3	1.7
Rolling over	92.6	94.9	8.8	8.8
Hold a lying position during the day	50.7	68.4	13.8	15.5
Squatting down	80.3	79.3	15*	34.4
Hold a squatting position	53.8	53.4	30.1	47.4
Kneeling down on the ground	55.5	56.9	34.5*	74.2
Hold a kneeling position	45	55.2	32.1*	75.9
Sitting on a chair	100	100	0	1.7
Hold a sitting position	96.3	98.3	9.8	20.7
Rising from a chair	97.5	98.3	4.9	8.6
Hold a standing position	93.8	98.3	11.1	17.2
Bending over or to the side	93.9	94.9	16	8.6
Shifting the body from side to side	73.8	75.4	5	5.2
Lifting and carrying objects				
Lifting a light object from the floor	82.7	94.9	11.3	5.2
Lifting a heavy object from the floor	64.2	65.6	32.1	33.3
Putting down objects on the floor	77.8	79.3	20	6.9
Carrying in the hands	88.8	94.8	13.5	13.8
Carrying in the arms	86.4	84.5	16.1	13.8
Carrying on shoulders or back	56.8*	39.6	4.9	3.4
Walking				
Walking short distances	96.3	96.5	11.1	5.2
Walking long distances	72.9	70.7	32.5	32.8
Walking on different surfaces	81.4	81.1	25.9	31
Walking around obstacles	82.3	75.9	11.1	8.6
Moving around				
Going up stairs	93.8	89.6	16	22.4
Going down stairs	93.9	89.6	15*	27.6
Going up a curb or step	92.6	96.5	4.9	12.1
Jumping	22.2	27.6	30.8	46.5
Moving around using transportation				
Getting in and out of a car	96.3	96.6	3.7	13.8
Using public transportation	20.9	10.4	7.4	5.2
Biking	30.8	34.5	19.7*	29.3
Driving vehicle	87.6	94.7	7.4	15.5
Self-care				
Washing lower body parts	95.1	96.5	22.2	8.6
Washing whole body	97.5	100	1.2	8.6
Drying your body	96.3	98.3	3.7	5.2
Going to the toilet	100	98.2	0	5.2
Putting on clothes	100	100	2.5	5.2
Taking off clothes	98.7	100	2.5	5.2
Putting on footwear	100	98.3	23.4	13.7
Taking off footwear	100	98.2	19.8	10.5
Domestic life and Intimate relationships				
Going shopping	77.8	75.9	11.3	20.6

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Doing housework	87.6	89.6	22.6	13.7
Assisting others	46.2	55.2	9.8	17.2
Sexual relationships	55.1	42.9	12.8	17.8
Employment				
Paid job	39.7	29.3	10.2	15.5
Unpaid work	32.6	39.7	13.6	17.2
Community, social and civic life				
Socializing/Participating in community life	81.5	80.7	6.1*	25.9
Sports	57.5	55.1	50.6	51.8
Running/jogging	18.8	20.6	38.8*	51.7
Hobbies/play/Crafts/Arts/culture	67.9*	77.2	9.9	6.8

* Difference between hip and knee is significant ($p < 0.05$). Bold numbers indicate key activities.

Table 5.3 Importance and difficulty of key activities for hip and knee arthroplasty at 13 weeks.

	13 weeks postoperative			
Activity	Importance%_Hip	Importance%_Knee	Difficulty%_Hip	Difficulty%_Knee
Changing and holding a body position				
Lying down in bed and getting up	95	95.9	0	2.7
Rolling over	91.3	90.5	2.5	2.7
Hold a lying position during the day	56.3	65.2	13.8	20.9
Squatting down	83.8	84.9	15.1	19.2
Hold a squatting position	58.8	70.4	23.8	35.6
Kneeling down on the ground	72.2	60.3	40*	63.9
Hold a kneeling position	59.5	54.8	23.8*	65.7
Sitting on a chair	95.1	95.8	0	0
Hold a sitting position	91	95.9	8.8	16.4
Rising from a chair	94.9	95.9	7.5	4.2
Hold a standing position	95	90.4	6.3	16.4
Bending over or to the side	88.6	89	10.1	6.8
Shifting the body from side to side	75.1	79.5	2.5	2.7
Lifting and carrying objects				
Lifting a light object from the floor	91.3	87.7	6.3	4.1
Lifting a heavy object from the floor	71.3	76.7	28.8	24.6
Putting down objects on the floor	83.8	85	8.8	8.2
Carrying in the hands	91.3	87.6	2.5	4.1
Carrying in the arms	82.5	82	7.6	10.9
Carrying on shoulders or back	56.3	47.2	6.3	2.8
Walking				
Walking short distances	96.3	95.9	1.3	2.7
Walking long distances	79.5	83.6	21.8	21.9
Walking on different surfaces	85	82.2	17.5	15.1
Walking around obstacles	83.8	79.4	7.6	6.8
Moving around				
Going up stairs	93.8	94.5	6.3	11.1
Going down stairs	95.1	94.5	6.3*	20.5
Going up a curb or step	93.8	91.8	5	4.1
Jumping	28.8	22.2	23.8	41.1
Moving around using transportation				
Getting in and out of a car	97.6	97.3	5	6.8
Using public transportation	28.8	24.7	2.6	4.2
Biking	40.1	52	8.8	13.6
Driving vehicle	89.9	93.2	5.1	0
Self-care				
Washing lower body parts	98.7	95.8	10.1	4.1
Washing whole body	98.8	95.9	2.5	0
Drying your body	98.7	93.1	1.3	0
Going to the toilet	98.8	95.9	2.5	0
Putting on clothes	98.7	97.2	1.3	0
Taking off clothes	98.8	95.8	0	0
Putting on footwear	96.3	97.2	16.3	5.5
Taking off footwear	97.5	95.8	10.1	6.8
Domestic life and Intimate relationships				
Going shopping	80.1	79.5	5.1	5.5
Doing housework	88.8	91.7	15.1	6.9

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Assisting others	52.5	60.3	5.1	5.5
Sexual relationships	48.7	45.9	7.8	15.1
Employment				
Paid job	38.5	27.8	6.3	6.9
Unpaid work	45	38.4	10	5.4
Community, social and civic life				
Socializing/Participating in community life	91.3	83.5	6.3	2.8
Sports	63.8	58.9	22.8	27.4
Running/jogging	20.2	21.9	29.1	35.6
Hobbies/play/Crafts/Arts/culture	77.6	79.4	10.1	11

*Difference between hip and knee is significant ($p < 0.05$). Bold numbers indicate key activities.

Table 5.4 Importance and difficulty of key activities for hip and knee arthroplasty at 26 weeks.

	26 weeks postoperative			
	Importance%_Hip	Importance%_Knee	Difficulty%_Hip	Difficulty%_Knee
Changing and holding a body position				
Lying down in bed and getting up	94.4	93.8	2.2	0
Rolling over	87.8	88.7	4.4	5.1
Hold a lying position during the day	51.1	56.2	8.8	13.8
Squatting down	86.5	79.8	18.7	22.6
Hold a squatting position	68.9	69.6	24.2	31.7
Kneeling down on the ground	70.8	61.2	22	70
Hold a kneeling position	58.9	56.9	19.8	63.8
Sitting on a chair	96.7	92.5	2.2	0
Hold a sitting position	92.2	92.5	9.9	6.3
Rising from a chair	95.5	88.8	4.4	6.3
Hold a standing position	95.5	88.8	8.8	11.3
Bending over or to the side	91	91.3	11	12.6
Shifting the body from side to side	75.9	77.6	5.5	3.8
Lifting and carrying objects				
Lifting a light object from the floor	94.4	91.3	4.4	6.3
Lifting a heavy object from the floor	81.1	81.3	16.5	18.8
Putting down objects on the floor	86.7	86	3.3	11.4
Carrying in the hands	93.3	92.5	6.6	8.8
Carrying in the arms	91.1	89.8	7.7	11.3
Carrying on shoulders or back	66.7	56.2	2.2	5.1
Walking				
Walking short distances	96.7	95.1	4.4	6.3
Walking long distances	82	81	14.4	20
Walking on different surfaces	88.9	90	13.3	24
Walking around obstacles	90.1	85.1	6.6	11.3
Moving around				
Going up stairs	97.8	92.4	7.7*	17.6
Going down stairs	97.8	93.8	4.4*	23.8
Going up a curb or step	95.5	90.1	5.5	12.7
Jumping	33.3	18.8	22	38.8
Moving around using transportation				
Getting in and out of a car	97.8	96.2	4.4	8.8
Using public transportation	27.7	25	2.2	5
Biking	46.7	39.2	7.7	15
Driving vehicle	94.4	90	2.2	5.1
Self-care				
Washing lower body parts	97.8	93.7	5.5	3.8
Washing whole body	97.7	96.2	4.4	3.8
Drying your body	97.8	96.2	3.3	1.3
Going to the toilet	100	96.3	1.1	2.5
Putting on clothes	100	96.3	5.5	2.5
Taking off clothes	100	96.3	4.4	1.3
Putting on footwear	97.8	95.1	7.7	12.6
Taking off footwear	97.8	94.8	6.6	8.9
Domestic life and Intimate relationships				
Going shopping	91.2	88.6	5.5	3.8

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Doing housework	95.6	94.9	6.6	8.8
Assisting others	63.8	65	5.5	8.8
Sexual relationships	69.3	53.1	11.3	16.5
Employment				
Paid job	53.9	44.7	7.7	5
Unpaid work	43.4	37.1	6.6	5.1
Community, social and civic life				
Socializing/Participating in community life	90.1	88.6	4.4	5
Sports	70.4	70	25.3	30
Running/jogging	17.8	20	34.1	49.3
Hobbies/play/Crafts/Arts/culture	82.4	74.4	3.3	7.6

* Difference between hip and knee is significant ($p < 0.05$). Bold numbers indicate key activities.

Table 5.5 Key functional activities at different time points after hip or knee arthroplasty.

Activity	2 weeks postop		6 weeks postop		13 weeks postop		26 weeks postop	
	Knee	Hip	Knee	Hip	Knee	Hip	Knee	Hip
Changing and holding a body position								
Lying down in bed and getting up	✓	✓						
Rolling over	✓	✓						
Squatting down			✓	✓	✓	✓	✓	✓
Hold a sitting position	✓	✓	✓	✓	✓	✓		
Rising from a chair	✓							
Hold a standing position	✓	✓	✓	✓	✓	✓		
Bending over or to the side			✓	✓				
Lifting and carrying objects								
Lifting a heavy object from the floor					✓	✓	✓	✓
Putting down objects on the floor			✓	✓				
Carrying in the arms			✓	✓				
Walking								
Walking short distances	✓	✓						
Walking long distances					✓	✓	✓	✓
Walking on different surfaces			✓	✓	✓	✓	✓	✓
Moving around								
Going up stairs	✓	✓	✓	✓			✓	
Going down stairs	✓	✓	✓	✓	✓		✓	
Moving around using transportation								
Driving vehicle			✓	✓				
Self-care								
Washing lower body parts	✓	✓	✓	✓				
Washing whole body	✓	✓						
Drying your body	✓	✓						
Putting on clothes	✓	✓						
Taking off clothes	✓	✓						
Putting on footwear	✓	✓	✓	✓	✓	✓		
Taking off footwear	✓	✓	✓	✓				
Domestic life								
Going shopping			✓	✓				
Doing housework			✓	✓				
Community, social and civic life								
Socializing/Participating in community life			✓					
Frequency of priorities at each time point	15	14	16	15	8	7	6	4

Table 5.6. Activities identified through qualitative analysis of open-ended questions

	Frequency
d6506:taking care of animals	20
b134:sleep functions	12
d4558:other specified moving around	10
b1:mental function	4
d650:caring for household objects	3
b710:mobility of joint functions	2
b130:energy and drive functions	2
d5202:caring for hair	2
b760:control of voluntary movement functions	1
d170:writing.	1

Table 5.7. Non-key activities after hip or knee arthroplasty

Non-priority activities
Changing and holding a body position
Hold a lying position during the day
Hold a squatting position
Kneeling down on the ground
Hold a kneeling position
Sitting on a chair
Shifting the body from side to side
Lifting and carrying objects
Lifting a light object from the floor
Carrying in the hands
Carrying on shoulders or back
Walking
Walking around obstacles
Moving around
Going up a curb or step
Jumping
Moving around using transportation
Getting in and out of a car
Using public transportation
Biking
Self-care
Going to the toilet
Domestic life and Intimate relationships
Assisting others
Sexual relationships
Employment
Paid job
Unpaid work
Community, social and civic life
Sports
Running/jogging
Hobbies/ play /Crafts/ Arts and culture

Discussion

This study identified key functional activities within the first two weeks, at six, 13 and 26 weeks after hip and knee arthroplasty. Our findings can enable healthcare professionals to tailor care plans to focus on what matters most to the patient at various stages of recovery, promoting patient-centered care. This approach can enhance the effectiveness of postoperative interventions, improve patient adherence to treatment, and ultimately optimize patient outcomes while reducing treatment burden.^{52,53} Patient-centered care is particularly important for individuals experiencing poor outcomes after hip or knee arthroplasty, where evidence for postoperative intervention is uncertain.⁵⁴ In addition, to ensure that interventions align with patient key activities, it is essential to incorporate patient-centered outcome measures. Our results can guide the selection of appropriate outcome measures to evaluate how well patient needs are addressed. Not taking into account patient needs may lead to clinicians missing important treatment outcomes.⁵⁵ Moreover, this study indicated that key functional activities vary over time, with limited differences between hip and knee arthroplasty. This information about patients' evolving experiences during recovery enable clinicians to anticipate recovery patterns, which can help manage patient expectations by providing realistic insights into recovery, potentially increasing satisfaction.⁵⁶

The findings highlighted that patients identify different key activities at various stages following hip or knee arthroplasty. When improvements were reached in some key activities, new needs in other key activities appeared. Not surprisingly, patients identified simpler key activities during the acute phase of recovery and shifted towards more advanced activities as they progressed. Initially, within the first 2 weeks after hip or knee arthroplasty, patients focused on basic mobility tasks (e.g. rolling over, holding a sitting position, walking short distances), self-

care tasks, and dressing. By 6 weeks, there was the shift towards activities requiring increased stability and mobility, such as walking on different surfaces and driving, aimed at regaining independence in daily activities. By 13 weeks, key activities advanced to more complex tasks such as walking long distances. Finally, at 26 weeks, key activities consolidated around more demanding tasks, such as squatting down, and lifting a heavy object from the floor. In addition, patients identified some activities as important, but challenging throughout the postoperative recovery such as holding a sitting and standing position, going up and down stairs, putting on footwear, squatting, and walking on different surfaces. Given that these activities are essential for daily living, postoperative rehabilitation should prioritize them throughout the recovery to improve performance. However, previous research indicates going up and down stair is infrequently incorporated into rehabilitation interventions,⁵⁷ and there is limited research available to determine the extent to which other activities are addressed in rehabilitation programs after hip or knee arthroplasty.

Our findings also reveal a decline in patients' key activities over time, indicating a decrease in the number of important functional activities they had difficulty performing. This suggests that arthroplasty procedures can restore a significant degree of function and enhance independence in the first three to six months after surgery, as demonstrated by previous research.^{28,58-60} However, patients identified six activities after knee arthroplasty and four after hip arthroplasty that were important to them but continued to experience difficulty at 26 weeks after arthroplasty. This is consistent with previous research reporting that 10-30% of patients experience persistent poor function after arthroplasty,⁶¹ with a higher proportion of patients reporting poor recovery after knee arthroplasty compared to hip arthroplasty.^{49,50} As previously noted, activities such as squatting, lifting heavy objects, walking long distances, walking on

different surfaces, and going up and down stairs also pose challenges in the early stages of recovery. These findings highlight the importance of implementing targeted rehabilitation strategies early in the recovery process to mitigate these challenges as patients progress. There was notable overlap in activities between knee and hip arthroplasty which aligns with previous research.⁶² Although this might suggest that similar postoperative rehabilitation interventions could be effective for both hip and knee arthroplasty patients due to similarity in key activities, the treatment strategies to address issues in these key activities may differ. For instance, while knee range of motion might limit going down stairs in patients who have undergone knee arthroplasty, muscle strength may be the limiting factor for those who have had hip arthroplasty. However, our findings revealed slight differences in key functional activities between patients undergoing hip and knee arthroplasty.^{63,64} Patients who underwent knee arthroplasty reported slightly more key activities that were important to them but also experienced greater difficulty performing them. This likely reflects poorer outcomes, as previous studies have shown that patients undergoing knee arthroplasty tend to experience worse outcomes compared to those undergoing hip arthroplasty.^{50,65} In addition, our findings revealed a trend of a slightly more decline in key functional activities over time following hip arthroplasty compared to knee arthroplasty, suggesting that patients undergoing hip arthroplasty may experience a faster recovery pattern, consistent with previous research.⁶⁴

Patients who underwent knee arthroplasty faced greater difficulties in socializing, which could be explained by the increased pain experienced after knee arthroplasty restricting participation in social activities.⁶⁶ Our findings also indicated that the difficulty of socializing decreased over time as pain levels decreased. Given that social isolation and loneliness are associated with negative health outcomes and well-being following arthroplasty, clinicians

should address this issue and associated factors.⁶⁷ Going down stairs at 13 and 26 weeks and going up stairs at 26 weeks were key after knee arthroplasty, with a trend towards the cut off for going up stairs at 13 weeks after knee surgery. These results are consistent with previous research showing that patients who underwent knee arthroplasty had less satisfaction in going up and down stairs compared to those who underwent hip arthroplasty.⁶⁸ This difficulty after knee arthroplasty may be attributed to the higher biomechanical functional demands placed on the knee joints and muscles during stair activities.⁶⁹ Also, our findings showed that patients after knee arthroplasty experienced greater difficulty in going down stairs, possibly due to higher ground reaction forces on knees joint when going down stairs compared to going up stairs.⁷⁰ Additionally, rising from a chair was identified as a key activity within the first two weeks following knee arthroplasty but not after hip arthroplasty. This difference between hip and knee arthroplasty may stem from several factors, such as limited range of motion and quadriceps weakness in patients undergoing knee arthroplasty which can significantly impact their ability to perform these activities.⁷¹

Patients identified 22 activities that were not key following hip or knee arthroplasty. This finding highlights the need to evaluate the content validity of outcome measures used after these procedures because several outcome measures assess non-key activities.⁷² Incorporating these items can compromise the content validity of these PROMs,⁷³ potentially leading to low completion rates, as patients may find irrelevant activities burdensome or important ones missing. Developing outcome measures that prioritize patient needs and eliminate less relevant items could enhance patient-centeredness, potentially reducing the burden on patients and increasing response rates.⁷⁴ An option to reduce less relevant items is using the PROMIS set of tools, which eliminate irrelevant items based on participants' responses through computer

adaptive testing algorithms based on item response theory. However, previous reviews have indicated limited direct patient involvement in the development or abbreviation process of outcome measurement tools. This can result in overlooking some patients' needs, as only patients can accurately identify which activities are pertinent to them.^{75,76,77} In our previous research, we evaluated the content of outcome measure instruments after hip or knee arthroplasty based on the ICF framework,⁷² and our findings highlight the importance of evaluation of these instruments on key activities identified in this study to determine patient-centeredness of outcome measures.

Comparing our findings with other studies is challenging because there are limited studies on the key functional activities across different time periods following hip or knee arthroplasty. One study explored patient concerns during the initial six weeks following knee arthroplasty,⁷⁸ with some concerns overlapping with our study, such as lying down in bed and putting on footwear within two weeks, and shopping and going up and down stairs at six weeks after knee arthroplasty. However, they conducted interviews with only 30 patients. Weiss et al.⁷⁹ examined patient priorities one year after knee arthroplasty, highlighting challenges in functional activities including kneeling, gardening, and squatting for patients. Another study highlighted that squatting was an important activity for patients, with more than half of patients expressing dissatisfaction with their ability to perform it one year after knee arthroplasty.⁸⁰ Additionally, another study reported that 29.5% of patients continued to experience difficulties with squatting one year after hip arthroplasty, indicating persistent challenges in this activity that remain important for patients.⁸¹ Thus, most activities identified in previous research align with our findings, indicating persistent challenges with these key activities.

Limitation

Our study had some limitations. While we believe our sample is representative of the hip and knee arthroplasty population regarding the patients' characteristics mentioned before since our study was conducted at one of Canada's largest joint arthroplasty centers with patients drawn from a broad geographic area, it is possible that patient priorities could vary across different settings. In addition, we recruited patients who underwent unilateral primary elective hip or knee arthroplasty for OA, thus our results may not be generalizable to those who underwent arthroplasty for other reasons or bilateral arthroplasty. Another limitation was that we focused solely on function as one of the primary goals patients aim to achieve through hip or knee arthroplasty. However, other aspects, such as reducing pain or other symptoms that may be important to patients following arthroplasty should be considered in future research. Despite this, assessing functional outcomes has gained increasing importance in evaluating the success of these procedures. This shift is driven by advancements in surgical techniques, postoperative care pathways, the introduction of bundled payment models, and the growing population of more physically active patients.

Conclusion

This study identified key functional activities that are important to patients, and which they had difficulty performing over the first 26 weeks after hip or knee arthroplasty. The findings indicated that these activities varied over time and differed between hip and knee arthroplasty surgeries, underscoring the need for tailored postoperative interventions at various stages and for each type of surgery. These results will help clinicians in selecting the appropriate outcomes measures based on patient needs following hip or knee arthroplasty. Moreover, understanding

what matters most to patients enables clinicians to better align interventions with patient needs which might improve outcomes for patients undergoing hip or knee arthroplasty.

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Conflict of interest

The authors do not report a potential conflict of interest

References

1. Domínguez-Navarro F, Igual-Camacho C, Silvestre-Muñoz A, Roig-Casasús S, Blasco JM. Effects of balance and proprioceptive training on total hip and knee replacement rehabilitation: a systematic review and meta-analysis. *Gait & posture*. 2018;62:68-74.
2. Papalia R, Campi S, Vorini F, et al. The role of physical activity and rehabilitation following hip and knee arthroplasty in the elderly. *Journal of Clinical Medicine*. 2020;9(5):1401.
3. Van Manen MD, Nace J, Mont MA. Management of primary knee osteoarthritis and indications for total knee arthroplasty for general practitioners. *Journal of Osteopathic Medicine*. 2012;112(11):709-715.
4. van Doormaal MC, Meerhoff GA, Vliet Vlieland TP, Peter WF. A clinical practice guideline for physical therapy in patients with hip or knee osteoarthritis. *Musculoskeletal Care*. 2020;18(4):575-595.
5. CJRR annual report: Hip and knee replacements in Canada | CIHI. Accessed September 27, 2022. <https://www.cihi.ca/en/cjrr-annual-report-hip-and-knee-replacements-in-canada>
6. Bandholm T, Wainwright TW, Kehlet H. Rehabilitation strategies for optimisation of functional recovery after major joint replacement. *Journal of experimental orthopaedics*. 2018;5(1):1-4.
7. Shichman I, Roof M, Askew N, et al. Projections and epidemiology of primary hip and knee arthroplasty in medicare patients to 2040-2060. *JBJS Open Access*. 2023;8(1):e22.

8. Trujols J, Portella MJ, Iraurgi I, Campins MJ, Siñol N, Cobos JPDL. Patient-reported outcome measures: Are they patient-generated, patient-centred or patient-valued? *Journal of Mental Health*. 2013;22(6):555-562.
9. Wensing M, Jung HP, Mainz J, Olesen F, Grol R. A systematic review of the literature on patient priorities for general practice care. Part 1: Description of the research domain. *Social science & medicine*. 1998;47(10):1573-1588.
10. Whitebird RR, Solberg LI, Ziegenfuss JY, et al. Personalized outcomes for hip and knee replacement: the patients point of view. *J Patient Rep Outcomes*. 2021;5(1):116. doi:10.1186/s41687-021-00393-z
11. Wiering B, De Boer D, Delnoij D. Patient involvement in the development of patient-reported outcome measures: a scoping review. *Health Expectations*. 2017;20(1):11-23.
12. Wang Y, Yin M, Zhu S, Chen X, Zhou H, Qian W. Patient-reported outcome measures used in patients undergoing total knee arthroplasty: a COSMIN systematic review. *Bone & Joint Research*. 2021;10(3):203-217.
13. Dowsey MM, Choong PF. The utility of outcome measures in total knee replacement surgery. *International journal of rheumatology*. 2013;2013.
14. Lützner C, Postler AE, Druschke D, Riedel R, Günther KP, Lange T. Ask patients what they expect! A survey among patients awaiting total hip arthroplasty in Germany. *The Journal of Arthroplasty*. 2022;37(8):1594-1601.
15. Lange T, Schmitt J, Kopkow C, Rataj E, Günther KP, Lützner J. What do patients expect from total knee arthroplasty? A Delphi consensus study on patient treatment goals. *The Journal of arthroplasty*. 2017;32(7):2093-2099.
16. Mancuso CA, Salvati EA, Johanson NA, Peterson MG, Charlson ME. Patients' expectations and satisfaction with total hip arthroplasty. *The Journal of arthroplasty*. 1997;12(4):387-396. Accessed June 1, 2024.
17. Noble PC, Conditt MA, Cook KF, Mathis KB. The John Insall Award: Patient expectations affect satisfaction with total knee arthroplasty. *Clinical Orthopaedics and Related Research (1976-2007)*. 2006;452:35-43.
18. Schwartz CE, Sprangers MA. *Adaptation to Changing Health: Response Shift in Quality-of-Life Research*. American Psychological Association; 2000.
19. Razmjou H, Yee A, Ford M, Finkelstein JA. Response shift in outcome assessment in patients undergoing total knee arthroplasty. *JBJS*. 2006;88(12):2590-2595.

20. Kim TK, Kwon SK, Kang YG, Chang CB, Seong SC. Functional disabilities and satisfaction after total knee arthroplasty in female Asian patients. *The Journal of arthroplasty*. 2010;25(3):458-464.
21. Von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. *International journal of surgery*. 2014;12(12):1495-1499.
22. Setia MS. Methodology series module 3: Cross-sectional studies. *Indian journal of dermatology*. 2016;61(3):261.
23. Thompson CB, Panacek EA. Research study designs: Non-experimental. *Air medical journal*. 2007;26(1):18-22.
24. Karimijashni M, Westby M, Ramsay T, Beaulé P, Poitras S. Development and content validation of a questionnaire identifying patients' functional priorities and abilities after hip or knee arthroplasty. *medRxiv*. Published online 2024:2024-03.
25. Maloy GC, Kammien AJ, Rubin LE, Grauer JN. Adverse Events After Total Hip Arthroplasty Are Not Sufficiently Characterized by 30 Day Follow-Up: A Database Study. *The Journal of Arthroplasty*. Published online 2022.
26. Bohl DD, Ondeck NT, Basques BA, Levine BR, Grauer JN. What is the timing of general health adverse events that occur after total joint arthroplasty? *Clinical Orthopaedics and Related Research*®. 2017;475(12):2952-2959.
27. Wiecek M, Rotonda C, Guillemin F, Rat AC. What Have We Learned About the Course of Clinical Outcomes After Total Knee or Hip Arthroplasty? *Arthritis Care & Research*. 2020;72(11):1519-1529.
28. Kennedy DM, Stratford PW, Riddle DL, Hanna SE, Gollish JD. Assessing recovery and establishing prognosis following total knee arthroplasty. *Physical therapy*. 2008;88(1):22-32.
29. Etikan I, Musa SA, Alkassim RS. Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics*. 2016;5(1):1-4.
30. CJRR annual report: Hip and knee replacements in Canada – Series | CIHI. Accessed June 13, 2024. <https://www.cihi.ca/en/cjrr-annual-report-hip-and-knee-replacements-in-canada-series>
31. Paulhus DL. Socially desirable responding on self-reports. *Encyclopedia of personality and individual differences*. 2017;1(5).

32. Burns KE, Duffett M, Kho ME, et al. A guide for the design and conduct of self-administered surveys of clinicians. *Cmaj*. 2008;179(3):245-252.
33. Kotrlik J, Higgins C. Organizational research: Determining appropriate sample size in survey research appropriate sample size in survey research. *Information technology, learning, and performance journal*. 2001;19(1):43.
34. Jenny JY, Diesinger Y. The Oxford Knee Score: compared performance before and after knee replacement. *Orthopaedics & Traumatology: Surgery & Research*. 2012;98(4):409-412.
35. Clement ND, Scott CE, Hamilton DF, MacDonald D, Howie CR. Meaningful values in the forgotten joint score after total knee arthroplasty: minimal clinical important difference, minimal important and detectable changes, and patient-acceptable symptom state. *The Bone & Joint Journal*. 2021;103(5):846-854.
36. Boonstra AM, Preuper HRS, Balk GA, Stewart RE. Cut-off points for mild, moderate, and severe pain on the visual analogue scale for pain in patients with chronic musculoskeletal pain. *Pain®*. 2014;155(12):2545-2550.
37. Bjorgul K, Novicoff WM, Saleh KJ. Evaluating comorbidities in total hip and knee arthroplasty: available instruments. *Journal of orthopaedics and traumatology*. 2010;11(4):203-209.
38. Mendonca D, Warren NA. Perceived and unmet needs of critical care family members. *Critical care nursing quarterly*. 1998;21(1):58-67.
39. Lei Chang. A Psychometric Evaluation of 4-Point and 6-Point Likert-Type Scales in Relation to Reliability and Validity. *Applied Psychological Measurement*. 1994;18(3):205-215.
40. Moretti F, van Vliet L, Bensing J, et al. A standardized approach to qualitative content analysis of focus group discussions from different countries. *Patient education and counseling*. 2011;82(3):420-428.
41. Hsieh HF, Shannon SE. Three Approaches to Qualitative Content Analysis. *Qual Health Res*. 2005;15(9):1277-1288. doi:10.1177/1049732305276687
42. Lützner C, Postler AE, Druschke D, Riedel R, Günther KP, Lange T. Ask Patients What They Expect! A Survey Among Patients Awaiting Total Hip Arthroplasty in Germany. *The Journal of Arthroplasty*.

43. Diamond IR, Grant RC, Feldman BM, et al. Defining consensus: a systematic review recommends methodologic criteria for reporting of Delphi studies. *Journal of clinical epidemiology*. 2014;67(4):401-409.
44. Wylde V, Hewlett S, Learmonth ID, Dieppe P. Persistent pain after joint replacement: prevalence, sensory qualities, and postoperative determinants. *PAIN®*. 2011;152(3):566-572.
45. Poitras S, Wood KS, Savard J, Dervin GF, Beaulé PE. Predicting early clinical function after hip or knee arthroplasty. *Bone & Joint Research*. 2015;4(9):145-151.
46. Nilsson AK, Petersson IF, Roos EM, Lohmander LS. Predictors of patient relevant outcome after total hip replacement for osteoarthritis: a prospective study. *Annals of the rheumatic diseases*. 2003;62(10):923-930.
47. Nilsson AK, Toksvig-Larsen S, Roos EM. Knee arthroplasty: are patients' expectations fulfilled?: A prospective study of pain and function in 102 patients with 5-year follow-up. *Acta Orthopaedica*. 2009;80(1):55-61.
48. Stephens MAP, Druley JA, Zautra AJ. Older adults' recovery from surgery for osteoarthritis of the knee: psychosocial resources and constraints as predictors of outcomes. *Health Psychology*. 2002;21(4):377.
49. Quintana JM, Escobar A, Arostegui I, et al. Health-related quality of life and appropriateness of knee or hip joint replacement. *Archives of internal medicine*. 2006;166(2):220-226.
50. Jones CA, Voaklander DC, Johnston DW, Suarez-Almazor ME. Health related quality of life outcomes after total hip and knee arthroplasties in a community based population. *The Journal of rheumatology*. 2000;27(7):1745-1752.
51. Núñez M, Núñez E, Del Val JL, et al. Health-related quality of life in patients with osteoarthritis after total knee replacement: factors influencing outcomes at 36 months of follow-up. *Osteoarthritis and cartilage*. 2007;15(9):1001-1007.
52. Holman H, Lorig K. Patients as partners in managing chronic disease: partnership is a prerequisite for effective and efficient health care. *Bmj*. 2000;320(7234):526-527.
53. Oates J, Weston WW, Jordan J. The impact of patient-centered care on outcomes. *Fam Pract*. 2000;49(9):796-804.
54. Karimijashni M, Yoo S, Barnes K, Poitras S. Pre- and Post-Operative Rehabilitation Interventions in Patients at Risk of Poor Outcomes Following Knee or Hip Arthroplasty:

- Protocol for Two Systematic Reviews. *Advances in Rehabilitation Science and Practice*. 2023;12:275363512311709.
55. Wright JG, Santaguida PL, Young N, Hawker GA, Schemitsch E, Owen JL. Patient preferences before and after total knee arthroplasty. *Journal of clinical epidemiology*. 2010;63(7):774-782.
 56. Salmon P, Hall GM, Peerbhoy D, Shenkin A, Parker C. Recovery from hip and knee arthroplasty: Patients' perspective on pain, function, quality of life, and well-being up to 6 months postoperatively. *Archives of physical medicine and rehabilitation*. 2001;82(3):360-366.
 57. Gavin JP, Immins T, Wainwright T. Stair negotiation as a rehabilitation intervention for enhancing recovery following total hip and knee replacement surgery. *International journal of orthopaedic and trauma nursing*. 2017;25:3-10.
 58. Kennedy DM, Stratford PW, Robarts S, Gollish JD. Using Outcome Measure Results to Facilitate Clinical Decisions the First Year After Total Hip Arthroplasty. *J Orthop Sports Phys Ther*. 2011;41(4):232-240.
 59. Lenguerrand E, Wylde V, Gooberman-Hill R, et al. Trajectories of pain and function after primary hip and knee arthroplasty: the ADAPT cohort study. *PloS one*. 2016;11(2):e0149306.
 60. Naylor JM, Harmer AR, Heard RC, Harris IA. Patterns of recovery following knee and hip replacement in an Australian cohort. *Australian Health Review*. 2009;33(1):124-135.
 61. Dumenci L, Perera RA, Keefe FJ, et al. Model-based pain and function outcome trajectory types for patients undergoing knee arthroplasty: a secondary analysis from a randomized clinical trial. *Osteoarthritis and cartilage*. 2019;27(6):878-884.
 62. Gandek B, Roos EM, Franklin PD, Ware Jr JE. Item selection for 12-item short forms of the Knee injury and Osteoarthritis Outcome Score (KOOS-12) and Hip disability and Osteoarthritis Outcome Score (HOOS-12). *Osteoarthritis and Cartilage*. 2019;27(5):746-753.
 63. Kennedy DM, Hanna SE, Stratford PW, Wessel J, Gollish JD. Preoperative function and gender predict pattern of functional recovery after hip and knee arthroplasty. *The Journal of arthroplasty*. 2006;21(4):559-566.
 64. Kennedy DM, Stratford PW, Hanna SE, Wessel J, Gollish JD. Modeling early recovery of physical function following hip and knee arthroplasty. *BMC Musculoskelet Disord*. 2006;7(1):100.

65. Wylde V, Blom AW, Whitehouse SL, Taylor AH, Pattison GT, Bannister GC. Patient-reported outcomes after total hip and knee arthroplasty: comparison of midterm results. *The Journal of arthroplasty*. 2009;24(2):210-216.
66. Wylde V, Beswick A, Bruce J, Blom A, Howells N, Gooberman-Hill R. Chronic pain after total knee arthroplasty. *EFORT open reviews*. 2018;3(8):461-470.
67. Rubio-Morales M, Miralles-Muñoz FA, Gonzalez-Parreño S, Ruiz-Lozano M, Lizaur-Utrilla A, Vizcaya-Moreno MF. A relevant number of patients do not increase their engagement in physical, social and leisure activities at the medium-term after total knee arthroplasty: a prospective cohort study. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2023;31(3):1011-1017.
68. Bourne RB, Chesworth B, Davis A, Mahomed N, Charron K. Comparing patient outcomes after THA and TKA: is there a difference? *Clinical Orthopaedics and Related Research®*. 2010;468(2):542-546.
69. Samuel D, Rowe P, Hood V, Nicol A. The biomechanical functional demand placed on knee and hip muscles of older adults during stair ascent and descent. *Gait & posture*. 2011;34(2):239-244.
70. Protopapadaki A, Drechsler WI, Cramp MC, Coutts FJ, Scott OM. Hip, knee, ankle kinematics and kinetics during stair ascent and descent in healthy young individuals. *Clinical biomechanics*. 2007;22(2):203-210.
71. Mizner RL, Snyder-Mackler L. Altered loading during walking and sit-to-stand is affected by quadriceps weakness after total knee arthroplasty. *Journal Orthopaedic Research*. 2005;23(5):1083-1090.
72. Alviar MJ, Olver J, Brand C, Hale T, Khan F. Do patient-reported outcome measures used in assessing outcomes in rehabilitation after hip and knee arthroplasty capture issues relevant to patients? Results of a systematic review and ICF linking process. *Journal of rehabilitation medicine*. 2011;43(5):374-381.
73. Terwee CB, Prinsen CAC, Chiarotto A, et al. COSMIN methodology for evaluating the content validity of patient-reported outcome measures: a Delphi study. *Qual Life Res*. 2018;27(5):1159-1170.
74. Rolstad S, Adler J, Rydén A. Response burden and questionnaire length: is shorter better? A review and meta-analysis. *Value in Health*. 2011;14(8):1101-1108.

75. Terwee CB, Prinsen CAC, Chiarotto A, et al. COSMIN methodology for evaluating the content validity of patient-reported outcome measures: a Delphi study. *Qual Life Res.* 2018;27(5):1159-1170.
76. Wiering B, de Boer D, Delnoij D. Patient involvement in the development of patient-reported outcome measures: a scoping review. *Health Expectations.* 2017;20(1):11-23.
77. Wang Y, Yin M, Zhu S, Chen X, Zhou H, Qian W. Patient-reported outcome measures used in patients undergoing total knee arthroplasty: a COSMIN systematic review. *Bone & Joint Research.* 2021;10(3):203-217.
78. Rastogi R, Davis AM, Chesworth BM. A cross-sectional look at patient concerns in the first six weeks following primary total knee arthroplasty. *Health Qual Life Outcomes.* 2007;5(1):48.
79. Weiss JM, Noble PC, Conditt MA, et al. What functional activities are important to patients with knee replacements? *Clinical Orthopaedics and Related Research®.* 2002;404:172-188.
80. Du H, Tang H, Gu JM, Zhou YX. Patient satisfaction after posterior-stabilized total knee arthroplasty: a functional specific analysis. *The Knee.* 2014;21(4):866-870.
81. Harada S, Hamai S, Gondo H, Higaki H, Ikebe S, Nakashima Y. Squatting after total hip arthroplasty: patient-reported outcomes and in vivo three-dimensional kinematic study. *The Journal of Arthroplasty.* 2022;37(4):734-741.

Appendix

Appendix A. Demographic characteristics of patients who underwent hip arthroplasty at different time points.

		Within 2 weeks postop (N=82)	6 weeks postop (N=81)	13 weeks postop (N=80)	26 weeks postop (N=91)	P-value
Surgery type	Total hip arthroplasty	66	70	73	82	-
	Hip resurfacing	16	11	7	9	-
Age Mean (SD) (range)		64.3 (10) (42-86)	64.9 (10.6) (41-87)	67.4 (9.9) (41-88)	64.6 (9.5) (42-86)	0.196
Sex (male, female)		(42,40)	(40,41)	(34,46)	(46,45)	0.66
Gender (man, woman)		(42,40)	(40,41)	(34,46)	(46,45)	0.66
BMI Mean (SD) (range)		28.1 (5.2) (17.3-42.7)	27.8 (5.3) (19.4-48.7)	27.6 (5.8) (16 -55.3)	28.8 (5.1) (19.2-45.9)	0.45
Preop OHS Mean (SD)		21.46 (8.5)	22.86 (9.4)	21.75 (9)	21.6 (9.4)	0.8
Ethnicity	White	78	77	72	83	0.34
	First Nation, Métis, Inuk(Inuit)	1	0	0	1	
	South Asian	0	0	1	0	
	Chinese	0	0	0	1	
	Black	0	1	1	1	
	Latin American	1	0	0	0	
	Arab	0	1	1	0	
	Japanese	0	0	0	1	
ASA score	Prefer not to say	2	2	3	4	0.62
	ASA=1	5	1	6	6	
	ASA=2	31	34	28	40	
	ASA=3	43	40	39	40	
	ASA=4	3	6	7	5	
Receiving precautions (Yes, No)		(77, 5)	(48, 31) *	(24, 55) *	(23, 67) *	<0.001
Pain Mean (SD)		38.04 (23.4)	19.05 (20.6)	15.96 (18.4)	15.64 (20.9)	<0.001
Problems in other joints (yes, no)		(34, 48)	(31, 50)	(22, 58)	(29, 62)	0.23
Problems in other joints	Right Hip (yes)	15 (18.3%)	13 (16%)	11 (13.8%)	14 (15.4%)	0.88
	Left hip (yes)	17 (20.7%)	14(17.3%)	16 (20%)	9 (9.9%)	0.2
	Right knee (yes)	19 (23.2%)	17 (21%)	19 (23.8%)	20 (22%)	0.97
	Left knee (yes)	17 (20.7%)	17 (21%)	18 (22.5%)	13 (14.3%)	0.53
	Right foot (yes)	4 (4.9%)	3 (3.7%)	5 (6.3%)	11 (12.1%)	0.13
	Left foot (yes)	5 (6.1%)	3 (3.7%)	2 (2.5%)	10 (11%)	0.09
	Low back (yes)	17 (20.7%)	19 (23.5%)	27 (33.8%)	31 (34.1%)	0.11
	Neck (yes)	5 (6.1%)	4 (4.9%)	8 (10%)	13 (14.3%)	0.13
Walking aids	Shoulder (yes)	10 (12.2%)	10 (12.3%)	15 (18.8%)	26 (28.6%)	0.015
	Wheelchair (yes)	3 (3.7%)	1 (1.2%)	0	0	0.1
	Walker (yes)	46 (56.1%)	15 (18.5%)	11(13.8%)	8 (8.8%)	<0.001
	Cane (yes)	37 (45.1%)	32 (39.5%)	27 (33.8%)	12 (13.2%)	<0.001
	Crutches (yes)	36 (43.9%)	9 (11.1%)	1 (1.3%)	1 (1.1%)	<0.001
	Scooter (yes)	0	1 (1.2%)	0	0	0.37
	Other walking aids (yes)	1 (1.2%)	4 (4.9%)	1 (1.3%)	2 (2.2%)	0.36
	No using aids (yes)	6 (7.3%)	37 (45.7%)	51 (63.7%)	74 (81.3%)	<0.001
Living with whom alone, family		12, 70	18, 63	17, 63	20, 71	0.57

Chapter 5: Survey of Functional Activities

Having family yes, no		69,12	65,13	63,16	73, 17	0.81
Dependency of others yes, no		12,70	13,68	12,680	23,68	0.2
Place of residence	House	68	68	65	75	0.95
	Apartment	12	12	13	14	
	Retirement home	1	0	1	0	
	Other	0	1	1	1	
Level of activity	Sedentary	18	16	16	17	
	Light physical	13	12	10	24	
	Heavy physical	7	6	3	6	
	Retired	44	47	49	44	

Appendix B. Demographic characteristics of patients who underwent knee arthroplasty at different time points.

		Within 2 weeks postop (N=72)	6 weeks postop (N=72)	13 weeks postop (N=74)	26 weeks postop (N=80)	P-value
Surgery Type	Total knee arthroplasty	71	67	66	75	-
	Unicompartmental knee arthroplasty	1	5	8	5	-
Age Mean (SD) (range)		67.5 (8.5) (50-83)	69 (8.6) (49-87)	69.47 (8.6) (44-90)	68.44 (8.5) (49-86)	0.57
Sex (male, female)		(36, 36)	(32, 40)	(34, 40)	(35, 45)	0.82
Gender (man, woman)		(36, 36)	(32, 40)	(34, 40)	(35, 45)	0.80
BMI Mean (SD) (range)		31.2 (5.3) (17.5-43.02)	29.9 (6.14) (21.60-47)	30.5 (6.7) (20.8-54.4)	31.1 (6.9) (20.53-54.9)	0.67
Preop OKS Mean (SD)		24.3 (8.2)	23.7 (7.8)	25.2 (6.9)	22.1 (7.4)	0.131
Ethnicity	White	56	48	67	74	0.062
	First Nation, Métis, Inuk(Inuit)	2	0	0	0	
	South Asian	1	4	2	1	
	Chinese	0	0	0	1	
	Filipino	1	0	0	0	
	Arab	2	0	0	0	
	Prefer not to say	2	6	5	2	
ASA score	ASA=1	0	1	3	3	0.7
	ASA=2	24	24	24	25	
	ASA=3	39	32	43	50	
	ASA=4	1	2	4	2	
Pain Mean (SD)		55.4 (21.5) (0-95)	36.3 (24.7) (0-95)	27.7 (23.3) (0-81)	23.5 (22) (0-85)	<0.001
Problems in other joints (yes, no)		(36, 28)	(40, 19)	(54, 20)	(61, 19)	0.06
Problems in other joints n (%)	Right Hip (yes)	11 (17.2%)	6 (10.2%)	10 (13.5%)	10 (12.5%)	0.71
	Left hip (yes)	3 (4.7%)	9 (15.2%)	11 (14.9%)	10 (12.5%)	0.22
	Right knee (yes)	15 (23.4%)	14 (23.7%)	19 (25.7%)	22 (27.5%)	0.94
	Left knee (yes)	20 (31.2%)	17 (28.8%)	22 (29.7%)	25 (31.2%)	0.99
	Right foot (yes)	4 (6.2%)	5 (8.5%)	7 (9.5%)	6 (7.5%)	0.91
	Left foot (yes)	3 (4.7%)	3 (5.1%)	7 (9.5%)	6 (7.5%)	0.66
	Low back (yes)	10 (15.6%)	12 (20.4%)	22 (29.7%)	20 (25%)	0.23
	Neck (yes)	3 (4.7%)	4 (6.8%)	7 (9.5%)	11 (13.8%)	0.26
	Shoulder (yes)	5 (7.8%)	8 (13.5%)	11 (14.9%)	16 (20%)	0.23
Walking aids						
Walking aids	Wheelchair (yes)	0	0	0	1 (1.2%)	0.48
	Walker (yes)	35 (54.7%)	7 (11.9%)	6 (8.1%)	6 (7.5%)	<0.001
	Cane (yes)	38 (59.4%)	21 (35.6%)	19 (25.7%)	13 (16.3%)	<0.001
	Crutches (yes)	15 (23.4%)	2 (3.4%)	0	0	<0.001
	Scooter (yes)	0	0	0	0	-
	Other walking aids (yes)	2 (3.1%)	2 (3.4%)	1 (1.4%)	4 (5%)	0.65
	No using aids (yes)	2(1.44%)	31 (52.5%)	52 (70.3 %)	59 (73.8%)	<0.001

Chapter 5: Survey of Functional Activities

Living with whom alone, family		13,51	13,46	17,57	17,63	.99
Having family yes, no		52, 11	46, 11	61, 13	68, 11	0.86
Dependency of others yes, no		5, 58*	4, 54	10, 64	14, 66	0.18
Place of residence	House	51	50	64	64	0.50
	Apartment	12	9	10	13	
	Retirement home	0	0	0	2	
	Other	0	0	0	1	
Level of activity	Sedentary	6	8	9	10	0.13
	Light physical	11	3	6	16	
	Heavy physical	9	5	4	6	
	Retired	37	40	54	46	

*Missing data

Appendix C. Demographic characteristics of patients who underwent hip or knee arthroplasty.

		Knee arthroplasty (298)	Hip arthroplasty (334)	P-value
Age (Mean (SD), (range))		68.6 (8.5) (44-90)	65.3 (10.0) (41-88)	0.001
Sex (male, female)		(137,161)	(162, 172)	0.63
Gender (man, woman)		(137,161)	(162, 172)	0.63
BMI (Mean (SD), Median (range))		30.8 (6.4) (17.5-54.9)	28.8(5.3) (16 -55.3)	0.003
OKS or OHS		23.8 (7.6)	21.9 (9.1)	0.011
Ethnicity	White	245	310	0.26
	First Nation, Métis, Inuk(Inuit)	2	2	
	South Asian	8	1	
	Chinese	1	1	
	Black	3	3	
	Filipino	1	0	
	Lati American	0	1	
	Arab	2	2	
	Japanese	0	1	
	Prefer not to say	14	8	
ASA score	ASA=1	7	18	0.02
	ASA=2	97	133	
	ASA=3	164	162	
	ASA=4	9	21	
Receiving Precautions (Yes, %)		-	141 (51.4%)	-
Pain (Mean (SD))		34. 6(25.7)	21. 9(22.7)	<0.001
Problems in other joints (Yes, No)		(191, 86)	(218, 116)	0.335
Problems in other joints	Right Hip (yes)	37(13.4%)	53(15.9%)	0.38
	Left hip (yes)	33(11.9%)	56(16.8%)	0.09
	Right knee (yes)	70 (25.3%)	75(22.5%)	0.41
	Left knee (yes)	84 (30.3%)	65(19.5%)	0.002
	Right foot (yes)	22(7.9%)	2 3(6.9%)	0.92
	Left foot (yes)	1 9(6.9%)	20(6 %)	0.66
	Low back (yes)	64(23.1%)	94(28.1 %)	0.16
	Neck (yes)	2 5(9%)	30(9%)	0.98
	Shoulder (yes)	40(14.4%)	61(18.3%)	0.20
Walking aids	Wheelchair (yes)	1(.4%)	4 (1.2%)	0.25
	Walker (yes)	54(19.5%)	80(24%)	0.2
	Cane (yes)	91 (32.9%)	108(32.3%)	0.89
	Crutches (yes)	17 (6.1%)	47 (14.1%)	0.001
	Scooter (yes)	0	1 (.3%)	0.36
	Other walking aids (yes)	9(3.2%)	8(2.4%)	0.52
	No using aids (yes)	1 44(52%)	1 68(50.3%)	0.68
Living with whom (alone, family)		(60,216)	(67,267)	0.61
Having family (yes,no)		(229,46)	(270,58)	0.76
Dependency of others (yes,no)		(33,242)	(60,274)	0.04
Place of residence	House	229	276	0.86
	Apartment	44	51	
	Retirement home	2	2	
	Other	1	3	
Level of activity	Sedentary, n (%)	33 (11.9%)	67 (20%)	0.011
	Light physical, n (%)	36 (13%)	59 (17.7%)	
	Heavy physical, n (%)	24 (8.7%)	22 (6.6%)	
	Retired, n (%)	177 (63.9%)	184 (55.1%)	

CHAPTER 6: Patient-Centered Content Analysis of Functional Outcome Measures (Manuscript 6)

Relationship of Manuscript 6 to the Dissertation

In this chapter, I present the manuscript on the patient-centered content analysis of outcome measures used after hip or knee arthroplasty (Study 6). Because of the growing emphasis on patient-centered care, there is a need to understand how well the existing outcome measures used after hip or knee arthroplasty reflect the patient's perspective and needs. Therefore, the objective of this study was to conduct a patient-centered content analysis of existing outcome measures used to assess function following hip or knee arthroplasty. This analysis was conducted by mapping the content analysis of 50 patient-reported outcome measures (PROMs) and 28 performance-based tests (PBTs) identified in studies 3 and 4 with the key activities identified at different time periods in Study 5. The results indicated that PROMs failed to capture more than half of the key functional activities or covered them inadequately across various stages of recovery. In addition, 17 out of 28 PBTs addressed less than half of the key activities at the early stage of recovery, and only one key activity was covered by a single PBT at later stages of recovery. This analysis also revealed varying degrees of coverage by outcome measures at different time points. These findings highlighted the need to address deficiencies in capturing key activities within the existing measures.

This manuscript has been prepared for submission. The numbering of tables and figures has been adjusted to fit the formatting of this dissertation.

Manuscript 6: Patient-centered content analysis of functional outcome measures after hip or knee arthroplasty

Abstract

Introduction: Although there has been increasing focus on patient-centered approaches in outcome evaluation, there is limited information on how well existing outcome measures used to assess function after hip or knee arthroplasty align with patients' perspectives. This study aimed to evaluate the content of these outcome measures to identify how well they cover the functional activities important to patients.

Methods: We assessed functional key activity coverage and coverage gaps of 50 patient-reported outcome measures (PROMs) and 28 performance-based tests (PBTs) at four time points (within two weeks, at six, 13 and 26 weeks) after arthroplasty. This analysis was based on 26 key activities identified by patients who underwent hip or knee arthroplasty. A key activity was defined as an activity that patients prioritized at a time point following surgery. We also documented the recall period for each PROM.

Results: The outcome measures showed varying degrees of coverage at different time points following hip or knee arthroplasty. PROMs failed to capture more than half of the key functional activities or covered them inadequately across various stages of recovery. All PROMs included between three to 33 non-key activities across four postoperative time points. PROMs had varying recall periods, with the previous week and four weeks being the most common. For PBTs, 17 out of 28 tests covered less than half of the key activities at two and six weeks, and only one PBT covered a key activity at 13 and 26 weeks after arthroplasty. Five key activities, including washing lower body parts, putting on clothes, taking off clothes, carrying objects, and placing objects on the floor were not covered by any outcome measures at any time points.

Discussion: Outcome measures used to assess function after hip or knee arthroplasty do not fully capture functional key activities that are important to patients. These findings highlight the need to more comprehensively address key activities in outcome measures used after arthroplasty. Researchers should take into account the evolving nature of function following arthroplasty when developing or refining these measures.

Introduction

Hip or knee arthroplasty is a successful surgical procedure for advanced osteoarthritis (OA) unresponsive to conservative treatment, aiming to alleviate pain, restore function, and enhance quality of life.¹ The demand for these procedures continues to rise, with projections suggesting that by 2030, annual hip and knee arthroplasties in the United States will exceed 433,372 and 791,760, respectively.² Consequently, continuous monitoring of patient outcomes after arthroplasty are crucial to improve practice and optimize patient outcomes.³ Furthermore, with advancements in prosthetic design and evolving demographics of arthroplasty patients who often are more physically active and have higher expectations for functional recovery, there is a growing emphasis on functional assessment.^{4,5}

Functional outcome assessment is commonly measured through either patient-reported outcome measures (PROMs) or performance-based tests (PBTs). PROMs are subjective, capturing patients' perceptions of activity and participation which would be challenging or impossible to measure otherwise. Performance-based outcome measures assess what a patient actually can do, providing a more objective measure of true functional capability rather than perceived performance. These two types of outcome measures capture different dimensions of physical function and provide complementary information.⁶⁻⁸

Despite the availability of several assessment instruments, there is uncertainty regarding the most appropriate ones for measuring the functional outcomes following hip or knee arthroplasty.⁹ Of utmost importance when selecting an appropriate outcome measure, is the extent to which it incorporates patients' perspectives and includes elements that are relevant to the target population.^{10,11} Failure to include patients' needs and concerns could mean that the outcome measure is completed by patients without actually reflecting their needs and concerns,

which may compromise the content validity.^{12,13} Low content validity can hinder appropriate assessment of interventions.¹¹

Despite a growing emphasis on developing a more patient-centered approach to evaluating outcomes over the past two decades,¹³ there has been limited research to date on how well current outcome measures used to evaluate function after knee or hip arthroplasty align with patient's perspectives and needs. Only one study mapped three outcome measures used after knee arthroplasty to patient concerns during the first six weeks postoperative, revealing gaps in addressing their concerns.¹⁴ However, given the variety of outcome measures used after hip or knee arthroplasty and considering that most functional recovery typically occurs within the first six months after arthroplasty,^{15–18} it is essential to map all outcome measures to patient needs during this initial post-operative period to select the most appropriate ones. To address this gap, we conducted a patient-centered content analysis of existing outcome measures used to assess function following hip or knee arthroplasty for OA, aiming to identify how well they cover the functional activities important to patients.

Methods

To conduct patient-centered content analysis, we drew upon findings from our previous research. In two systematic reviews, we identified 50 PROMs and 28 PBTs used after hip or knee arthroplasty. The PROMs were categorized into three groups: for knee arthroplasty, for hip arthroplasty, and for either procedure. In these two studies, we also assessed the content of each included outcome measure and developed mapping code lists based on the International Classification of Functioning, Disability and Health (ICF) core set for OA, modified to better align with patients undergoing hip or knee arthroplasty.¹⁹

To determine key functional activities from the patient's perspective (i.e. the activities that patients deemed important and challenging to perform) and non-key activities (i.e. the activities deemed unimportant or not challenging by patients), we conducted a cross-sectional survey, using a validated questionnaire containing 49 activity and participation questions.¹⁹ It involved 298 and 334 patients who underwent knee or hip arthroplasty respectively at The Ottawa Hospital in Ottawa, Canada. Four time periods were chosen to evaluate various stages of recovery after arthroplasty, including acute recovery (within two weeks postoperative), post-acute recovery (at six weeks postoperative) when most patients stabilize between 4 to 6 weeks after surgery, and two timepoints during the period of greatest functional recovery (13 and 26 weeks postoperative).^{15,20} We identified 26 key and 22 non-key functional activities at various time points following hip or knee arthroplasty, with slight differences between surgical procedures. Specifically, we identified 14, 15, 7, and 4 key functional activities within two weeks, at six, 13, and 26 weeks after hip or knee arthroplasty respectively. We focused on key activities common to both procedures to analyze the PROMs used after both procedures and PBTs. Detailed descriptions of these key activities are provided in Appendix A.

We conducted the patient-centered analysis by combining the findings from the abovementioned studies. This analysis aimed to evaluate how well current PROMs and PBTs address patients' perspectives and needs, and to identify less relevant items within these outcome measures. We followed COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) initiative terminology for content analysis of the outcome measures based on patients' perspective.²¹ We focused on two aspects of content analysis, including relevance (ensuring all items are pertinent to the construct of interest in a specific population) and comprehensiveness (ensuring no key aspects of the construct are missed). We also

documented the recall period for each PROM as part of the content validity assessment based on the COSMIN classification.

The key activities were categorized into two groups across the PROMs: those covered and those inadequately covered. The latter group includes activities that were assessed with other activities within a single PROM item. For example, an item that addresses "Putting on or taking off socks/shoes" encompasses two key activities, thereby covering multiple key activities in a single item. While both activities are covered, some patients might have difficulties with one of these tasks but not the other, leading to incomplete evaluation of their activities.

We assessed the coverage of key activities by counting the number of key activities adequately addressed by PROMs and PBTs at four time points after hip or knee arthroplasty. Proportions were also calculated as percentages, where higher percentages of matched key activities indicated greater coverage and relevance of the outcome measures.

The number of non-key elements across the PROMs was determined by summing the following categories: 1) covered by the modified ICF OA core set but not considered key after hip or knee arthroplasty; 2) not covered by the modified ICF OA core set and not considered key after hip or knee arthroplasty; 3) not adequately addressed; 4) related to ICF categories of body function and structure, or environmental factors. The details of these categories are described in appendix B.

Results

Knee-specific PROMs

Coverage within the first two weeks after surgery

Within the first two weeks after surgery, ten out of the 15 key activities were covered by the knee-specific PROMs. Among these PROMs, 15 covered at least one key activity while four PROMs did not. The most frequently covered key activities were "rising from a chair", "going

down stairs", and "going up stairs", with ten, six, and five PROMs capturing them respectively. "Washing lower body parts", "putting on clothes" and "taking off clothes" were not addressed in any PROMs (Appendix C). "Rolling over" and "drying the body" were addressed, but they were not covered adequately (Table 6.1). Regarding the coverage of key activities, the Knee Injury and Osteoarthritis Outcome Score (KOOS) had the widest coverage, addressing eight key activities (53.3%) (Table 6.2).

Coverage at 6 weeks after surgery

At six weeks after surgery, ten out of the 16 key activities were covered by the knee-specific PROMs. Among these PROMs, 14 covered at least one key activity, while five PROMs did not. The most frequently covered key activities were "holding a standing position", "going up stairs" and "going down stairs", with seven, five and five PROMs covering them respectively. "Squatting down", "carrying in the arms", "putting down objects on the floor", "driving vehicles", and "washing lower body parts" were not addressed in any PROMs (Table 6.1, Appendix C). Regarding the coverage of key activities, the KOOS had the widest coverage, addressing seven key activities (44%) (Table 6.2).

Coverage at 13 weeks after surgery

At 13 weeks after surgery, six out of the eight key activities were covered by the knee-specific PROMs. Among these PROMs, 15 covered at least one key activity, while four PROMs did not. The most frequently covered key activities were "holding a standing position" and "going down stairs", with seven and five PROMs covering them. "Squatting down" and "lifting a heavy object" were not addressed in any PROMs (Table 6.1, Appendix C). Regarding the coverage of key activities, the KOOS and Knee Outcome Survey Activities of Daily Living Scale (KOS-ADLS) had the widest coverage, addressing four key activities (50%) (Table 6.2).

Coverage at 26 weeks after surgery

At 26 weeks after surgery, four out of the six key activities were covered by the knee-specific PROMs. Among these PROMs, 11 covered at least one key activity, while eight PROMs did not. The most frequently covered key activities were "going down stairs" and "going up stairs", with six and seven PROMs covering them respectively. "Squatting down" and "lifting a heavy object" were not addressed in any PROMs (Table 1, Appendix C). Regarding the coverage of key activities, the Patient Administered Questionnaire-knee (PAQ-knee) had the widest coverage, addressing three key activities (50%) (Table 6.2).

Inadequate coverage across the four time points after knee arthroplasty

In terms of key activities addressed inadequately, the Adjusted 2011 Knee Society Score (2011 KSS-A) had the highest number across all four time points. The most frequent key activities not fully addressed were "going up and down stairs", with both activities combined in one item. All PROMs included at least two non-key elements, with KOOS and 2011 KSS having the highest number at all time points (Table 6.2, Appendix D). The most frequent non-key elements covered across the PROMs were "impairment (such as pain, stiffness or swelling)", "walking (unspecified)" and "kneeling".

Table 6.1 Coverage of key activities of specific PROMs used after knee arthroplasty.

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Key activities within 2 weeks																			
Lying down and getting up					1 [?]	1 [?]		1		1									
Rising from a chair		1	1	1	1	1	1	1	1	1	1			1 [?]					1
Rolling over								1 [?]											
Holding a sitting position		1		1				1 [?]				1							
Holding a standing position				1	1	1		1	1									1	1
Walking short distances																1 [?]		1	
Going up stairs		1	1	1	1 [?]	1 [?]	1 [?]	1+1 [?]	1 [?]		1 [?]		1 [?]			1 [?]	3 [?]	1 [?]	1
Going down stairs		1	1	1	1 [?]	1 [?]	1 [?]	1+1 [?]	1 [?]		1 [?]		1 [?]	1		1 [?]	3 [?]	1 [?]	1
Washing body parts																			
Washing whole body								1						1 [?]		1 [?]			
Drying body														1 [?]					
Putting on clothes																			
Taking off clothes																			
Putting on footwear						1 [?]		1		1						1	1 [?]		
Taking off footwear						1 [?]		1											
Key activities at 6 weeks postop																			
Squatting down																			
Bending over or to the side						1 [?]		1		1	1 [?]						1 [?]		1
Holding a sitting position		1		1				1 [?]				1							
Holding a standing position				1	1	1		1	1									1	1
Carrying in the arms																			
Putting down objects on the floor																			
Walking on different surfaces					1	1	1										2 [?]	1	
Going up stairs		1	1	1	1 [?]	1 [?]	1 [?]	1+1 [?]	1 [?]		1 [?]		1 [?]			1 [?]	3 [?]	1 [?]	1
Going down stairs		1	1	1	1 [?]	1 [?]	1 [?]	1+1 [?]	1 [?]		1 [?]		1 [?]	1		1 [?]	3 [?]	1 [?]	1
Driving vehicles																			
Washing lower body parts																			
Putting on footwear						1 [?]		1		1						1	1 [?]		
Taking off footwear						1 [?]		1											
Going shopping								1						1					
Doing housework	3 [?]		4 [?]		1 [?]	2	1 [?]	2 [?]						1 [?]		1		1+7 [?]	
Socializing/ Participating in community life															1	1		6+3 [?]	
Key activities at 13 weeks postop																			
Squatting																			
Holding a sitting position		1		1				1 [?]				1							
Holding a standing position				1	1	1		1	1									1	1
Lifting a heavy object from the floor																			
Walking long distances					1	1 [?]	1									1+1 [?]		2+1 [?]	
Walking on different surfaces					1	1	1										2 [?]	1	
Going up stairs		1	1	1	1 [?]	1 [?]	1 [?]	1+1 [?]	1 [?]		1 [?]		1 [?]			1 [?]	3 [?]	1 [?]	1
Going down stairs		1	1	1	1 [?]	1 [?]	1 [?]	1+1 [?]	1 [?]		1 [?]		1 [?]	1		1 [?]	3 [?]	1 [?]	1
Putting on footwear						1 [?]		1		1						1	1 [?]		
Key activities at 26 weeks postop																			
Squatting down																			
Lifting a heavy object from the floor																			
Walking long distances					1	1 [?]	1									1+1 [?]		2+1 [?]	
Walking on different surfaces					1	1	1										2 [?]	1	
Going up stairs		1	1	1	1 [?]	1 [?]	1 [?]	1+1 [?]	1 [?]		1 [?]		1 [?]			1 [?]	3 [?]	1 [?]	1
Going down stairs		1	1	1	1 [?]	1 [?]	1 [?]	1+1 [?]	1 [?]		1 [?]		1 [?]	1		1 [?]	3 [?]	1 [?]	1

?=key activity covered inadequately

The number indicates the time the activity was queried in the PROM.

COMI: Core Outcome Measures Index; **HSSP:** Hospital for Special Surgery Patellar score; **IKDC:** International Knee Documentation Committee; **KOS-ADLS:** Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS:** 2011 Knee Society Score; **2011 KSS-A:** Adjusted 2011 Knee Society Score; **KSS-S:** Short-form Knee Society Score; **KOOS:** Knee Injury and Osteoarthritis Outcome Score; **KOOS-12:** 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS:** Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR:** Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS:** Kujala Anterior Knee Pain Scale; **OKS:** Oxford knee score; **OKS-APQ:** Oxford knee score—activity and participation; **PAQ :** Patient Administered Questionnaire; **PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

Table 6.2 Number of key activities covered adequately, covered inadequately, and number of non-key elements covered in specific PROMs used after knee arthroplasty.

	COMI-knee	HSSP	IKDC	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Number of items	6	4	18	13	31	20	10	42	12	7	7	13	12	12	8	29	24	76	7
Within 2 weeks postop (15 key activity)																			
Number of key activities covered adequately (n %)	0	3 20%	3 20%	5 33.3 %	2 13.3%	2 13.3%	1 6.7%	8 53.3%	2 13.3%	3 20%	1 6.7%	1 6.7%	0	1 6.7%	0	1 6.7%	0	2 13.3%	4 26.7%
Number of key activities covered inadequately (n %)	0	1	0	0	3	5	2	3	2	0	2	0	2	3	0	4	3	2	0
Number of non-key elements covered	7	2	15	9	29	22	14	29	12	6	8	9	12	10	11	21	13	23	3
6 weeks postoperative (16 key activity)																			
Number of key activities covered inadequately (n %)	0	3 19%	2 12.5%	4 25%	2 12.5%	3 19%	1 6.3%	7 44%	1 6.3%	2 12.5%	0	1 6.3%	0	2 12.5%	0	3 19%	0	4 25%	4 25%
Number of key activities covered inadequately (n %)	1	0	1	0	3	5	3	4	2	0	3	0	2	1	0	2	5	4	0
Number of non-key elements covered	7	4	15	10	28	19	13	28	13	7	7	9	12	11	10	22	11	19	3
13 weeks postoperative (8 key activity)																			
Number of key activities covered adequately (n %)	0	3 37.5%	2 25%	4 50%	3 37.5%	2 25%	2 25%	4 50%	1 12.5%	1 12.5%	0	1 12.5%	0	1 12.5%	1 12.5%	3 37.5%	0	3 37.5%	3 37.5%
Number of key activities covered inadequately (n %)	0	0	0	0	2	4	2	3	2	0	2	0	2	0	0	2	4	3	0
Number of non-key elements covered	8	3	16	10	27	22	13	32	13	8	8	9	12	13	11	23	12	20	4
26 weeks postoperative (6 key activity)																			
Number of key activities covered adequately (n %)	0	2 33.3%	2 33.3%	2 33.3%	2 33.3%	1 16.7%	2 33.3%	0	0	0	0	1 16.7%	0	1 16.7%	0	3 50%	0	2 33.3%	2 33.3%
Number of key activities covered inadequately (n %)	0	0	0	0	2	3	2	2	2	0	2	0	2	0	0	1	3	3	0
Number of non-key elements covered	8	4	16	12	29	24	13	33	14	9	8	10	12	13	11	24	13	22	5

COMI: Core Outcome Measures Index; **HSSP:** Hospital for Special Surgery Patellar score; **IKDC:** International Knee Documentation Committee; **KOS-ADLS:** Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS:** 2011 Knee Society Score; **2011 KSS-A:** Adjusted 2011 Knee Society Score; **KSS-S:** Short-form Knee Society Score; **KOOS:** Knee Injury and Osteoarthritis Outcome Score; **KOOS-12:** 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS:** Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR:** Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS:** Kujala Anterior Knee Pain Scale; **OKS:** Oxford knee score; **OKS-APQ:** Oxford knee score—activity and participation; **PAQ :** Patient Administered Questionnaire; **PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

Hip-specific PROMs

Coverage within the first two weeks after surgery

Within the first two weeks after surgery, 11 out of 14 key activities were covered by the hip-specific PROMs. Among these PROMs, ten covered at least one key activity, while three PROMs did not. The most frequently covered key activities were "putting on footwear", "going up stairs", and "going down stairs", with six, four, and three PROMs covering them respectively. "Washing lower body parts", "putting on clothes" and "taking off clothes" were not addressed in any PROMs (Appendix C). "Drying the body" was addressed, but it was not covered adequately (Table 6.3). Regarding the coverage of key activities, the Hip disability and Osteoarthritis Outcome Score (HOOS) and Hip Outcome Score (HOS) had the widest coverage, addressing six key activities (42.9%) (Table 6.4).

Coverage at 6 weeks after surgery

At six weeks after surgery, ten out of 15 key activities were covered by the hip-specific PROMs. Among these PROMs, ten covered at least one key activity, while three PROMs did not. The most frequently covered key activities were "putting on footwear", "going up stairs" and "holding a standing position", with six, four and four PROMs covering them respectively. "Squatting down", "carrying in the arms", "putting down objects on the floor", "driving vehicles", and "washing lower body parts" were not addressed in any PROMs (Table 6.3, Appendix C). Regarding the coverage of key activities, the HOOS had the widest coverage, addressing seven key activities (46.7%) (Table 6.4).

Coverage at 13 weeks after surgery

At six weeks after surgery, five out of seven key activities were covered by the hip-specific PROMs. Among these PROMs, ten covered at least one key activity, while three

PROMs did not. The most frequently covered key activities were "putting on footwear" and "holding a standing position", with six and four PROMs covering them respectively. "Squatting down" and "lifting a heavy object" were not addressed in any PROMs (Table 6.3, Appendix C). Regarding the coverage of key activities, the HOOS had the widest coverage, addressing three key activities (42.9 %) (Table 6.4).

Coverage at 26 weeks after surgery

At 26 weeks after surgery, two out of four key activities were covered by the hip-specific PROMs. Among these PROMs, six covered at least one key activity, while seven PROMs did not. "Walking long distances" and "walking on different surfaces" were covered by three PROMs, while "squatting down" and "lifting a heavy object" were not addressed in any PROMs (Table 6.3, Appendix C). Regarding the coverage of key activities, six PROMs addressed one key activity (25%) (Table 6.4).

Inadequate coverage across the four time points after hip arthroplasty

In terms of key activities addressed inadequately, the HOOS and Hip and Groin Outcome Score (HAGOS) had the highest number. The most frequent key activities not addressed were "going up and down stairs" and "doing housework", with more than one key activity combined in one item. All PROMs included at least five non-key elements, with HOOS and HAGOS having the highest number in all time points (Table 6.4, Appendix E). The most frequent non-key elements covered across the PROMs were "impairment (such as pain, stiffness or swelling)" and "using private transportation".

Table 6.3 Coverage of key activities of specific PROMs used after hip arthroplasty.

ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Key activities within two weeks													
Lying down and getting up				1									
Rolling over				1 [?]			1 [?]	1	1 [?]				
Holding a sitting position		1	1	1 [?]					1 [?]				
Holding a standing position				1 [?]	1			1					1
Walking short distances		1 [?]	1 [?]					1				1 [?]	
Going up stairs				1+1 [?]	1 [?]		1 [?]	1	1+1 [?]			1 [?]	1
Going down stairs				1+1 [?]	1 [?]	1	1 [?]	1	1 [?]			1 [?]	
Washing lower body parts													
Washing whole body				1				1			1 [?]	1 [?]	
Drying oneself											1 [?]		
Putting on clothes													
Taking off clothes													
Putting on footwear		1	1	1							1	1	1
Taking off footwear				1									
Key activities at 6 weeks													
Squatting													
Bending				1 [?]			1 [?]		1 [?]				1
Holding a sitting position		1	1	1 [?]					1 [?]				
Holding a standing position				1	1			1					1
Carrying in the arms													
Putting down objects													
Walking on different surfaces				1+2 [?]	1		1 [?]		3 [?]				
Going up stairs				1+1 [?]	1 [?]		1 [?]	1	1+1 [?]			1 [?]	1
Going down stairs				1+1 [?]	1 [?]	1	1 [?]	1	1 [?]			1 [?]	
Driving vehicles													
Washing lower body parts													
Putting on footwear		1	1	1							1	1	1
Taking off footwear				1									
Going Shopping				1							1		
Doing housework	2 [?]			2 [?]					1 [?]		1 [?]	1	1 [?]
Key activities at 13 weeks													
Squatting													
Holding a sitting position		1	1	1 [?]					1 [?]				
Holding a standing position				1	1			1					1
Lifting a heavy object													
Walking long distances		1 [?]	1 [?]					1		1		1+1 [?]	
Walking on different surfaces				1+2 [?]	1		1 [?]		1+2 [?]				
Putting on footwear		1	1	1							1	1	1
Key activities at 26 weeks													
Squatting													
Lifting a heavy object													
Walking long distances		1 [?]	1 [?]					1		1		1+1 [?]	
Walking on different surfaces				1+2 [?]	1		1 [?]		1+2 [?]				

?=key activity covered inadequately

The number indicates the time the activity was queried in the PROM

COMI: Core Outcome Measures Index; **HHS:** Harris Hip Score; **HOOS:** Hip disability and Osteoarthritis Outcome Score; **HOS:** Hip Outcome Score; **HAGOS:** Hip and Groin Outcome Score; **OHS:** Oxford Hip score; **PAQ:** Patient Administered Questionnaire; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

Table 6.4 Number of key activities covered adequately, covered inadequately, and number of non-key elements covered in specific PROMs used after hip arthroplasty.

	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Number of items	6	5	8	40	12	6	6	37	37	7	12	26	8
Key activities within two weeks (14 key activities)													
Number of key activities covered adequately (n %)	0	2 14.3%	2 14.3%	6 42.9%	1 7.1%	1 7.1%	0	6 42.9%	1 7.1%	0	1 7.1%	1 7.1%	3 21.4%
Number of key activities covered inadequately (n %)	0	1	1	5	2	0	3	0	4	0	2	4	0
Coverage of non-key elements	8	6	7	28	13	6	9	18	27	8	12	16	7
Key activities at 6 weeks (15 key activities)													
Number of key activities covered adequately (n %)	0	2 13.3%	2 13.3%	7 46.7%	2 13.3%	1 6.7%	0	3 20%	1 6.7%	0	2 13.3%	2 13.3%	4 26.7%
Number of key activities covered inadequately (n %)	1	0	0	6	2	0	4	0	6	0	1	2	1
Coverage of non-key elements	7	7	8	26	12	6	8	21	25	8	12	17	5
Key activities at 13 weeks (7 key activities)													
Number of key activities covered adequately (n %)	0	2 28.6%	2 28.6%	3 42.9%	2 28.6%	0	0	2 28.6%	1 14.3%	1 14.3%	1 14.3%	2 28.6%	2 28.6%
Number of key activities covered inadequately (n %)	0	1	1	2	0	0	1	0	2	0	0	1	0
Coverage of non-key elements	8	6	7	32	14	7	11	22	29	7	14	19	8
Key activities at 26 weeks (4 key activities)													
Number of key activities covered adequately (n %)	0	0	0	1 25%	1 25%	0	0	1 25%	1 25%	1 25%	0	1 25%	0
Number of key activities covered inadequately (n %)	0	1	1	1	0	0	1	0	1	0	0	1	0
Coverage of non-key elements	8	8	9	33	15	7	11	22	29	7	15	20	10

COMI: Core Outcome Measures Index; HHS: Harris Hip Score; HOOS: Hip dysfunction and Osteoarthritis Outcome Score; HOS: Hip Outcome Score; HAGOS: Hip and Groin Outcome Score; OHS: Oxford Hip score; PAQ: Patient Administered Questionnaire; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

Hip or knee-specific PROMs

Coverage within the first two weeks after surgery

Within the first two weeks after surgery, ten hip or knee-specific PROMs adequately addressed ten out of the 14 key activities, while eight PROMs did not. The most frequently covered key activities were "holding a standing position" and "going down stairs", with six PROMs covering them. "Washing lower body parts", "drying body" and "putting on clothes" and "taking off clothes" were not addressed in any PROMs (Table 6.5, Appendix C). Regarding the coverage of key activities, WOMAC had the widest coverage, addressing five key activities (35.7%)(Table 6.6).

Coverage at six weeks after surgery

At six weeks after surgery, 11 hip or knee-specific PROMs adequately addressed ten out of the 16 key activities, while seven PROMs did not. The most frequently covered key activities were "going down stairs", with six PROMs covering it, followed by "going up stairs", "holding a standing position" and "putting on footwear", each covered by five PROMs. "Carrying in the arms", "putting down objects on the floor" and "washing lower body parts" were not addressed in any PROMs (Table 6.5, Appendix C). "Driving vehicles" was addressed but not covered adequately (Table 6.5). Regarding the coverage of key activities, the WOMAC had the widest coverage, addressing seven key activities (46.7%)(Table 6.6).

Coverage at 13 weeks after surgery

At 13 weeks after surgery, nine hip or knee-specific PROMs adequately covered six key activities, while ten PROMs did not. The most frequently covered key activities were "holding a standing position" and "putting on footwear", with five PROMs covering them (Table 6.5). "Lifting a heavy object" was addressed but not covered adequately. Regarding the coverage of

key activities, the Lower Extremity Functional Scale (LEFS) had the widest coverage, followed by Lower Limb Functional Index (LLFI) and Lower Limb Task Questionnaire (LLTQ) addressing four (57.1%), three (42.9%) and three (42.9%) key activities respectively (Table 6.6).

Coverage at 26 weeks after surgery

At 26 weeks after surgery, three hip or knee-specific PROMs adequately covered three out of the four key activities, while 15 PROMs did not. The activities "walking long distances", "walking on different surfaces" and "squatting" were covered by two, one and one PROMs respectively. "Lifting a heavy object" was addressed, but it was not covered adequately (Table 5). Regarding the coverage of key activities, LLTQ had the widest coverage, addressing two key activities (50%) (Table 6.6).

Inadequate coverage across the four time points after hip or knee arthroplasty

In terms of key activities addressed inadequately, the American Academy of Orthopaedic Surgeons (AAOS), Forgotten Joint Score (FJS), Modified Forgotten Joint Score (MFJS) and Osteoarthritis Knee and Hip Quality of Life (OAKHQOL) had the highest number. The most frequent key activity inadequately addressed was "doing housework". All PROMs included at least four non-key elements, with LLFI and OAKHQOL having the highest number at all time points (Table 6.6, Appendix F). The most frequent non-key elements covered across the PROMs were impairment "(pain, swelling, or stiffness)", "mental function (e.g. confidence, feelings of depression)", and "walking (unspecified)".

Table 6.5 Coverage of key activities of specific PROMs used after hip or knee arthroplasty.

ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Key activities within 2 weeks																		
Lying down and getting up								1					1	1	1	1		
Rolling over					1													
Holding a sitting position		1	1 [?]		1	1					2 [?]							
Holding a standing position		1	1 [?]		1	1	1	2			2 [?]			1				
Walking short distances					2			1										
Going up stairs	1 [?]				1 [?]			1 [?]				1		1		1	1	1
Going down stairs	1 [?]				1 [?]			1 [?]			1	1		1	1		1	1
Washing body parts																		
Washing whole body		1	1 [?]	1 [?]	1						1			1				
Drying oneself																		
Putting on clothes																		
Taking off clothes																		
Putting on footwear	1 [?]				1									1		1	1	1
Taking off footwear	1 [?]													1				
Key activities at 6 weeks postop																		
Squatting								1										
Bending						1	1 [?]				1			1				
Holding a sitting position		1 [?]	1 [?]		1	1					2 [?]							
Holding a standing position		1 [?]	1 [?]		1	1	1	2			2 [?]			1				
Carrying in the arms																		
Putting down objects																		
Walking on different surfaces		1 [?]	1 [?]	1 [?]				1										
Going up stairs	1 [?]				1 [?]			1 [?]				1		1		1	1	1
Going down stairs	1 [?]				1 [?]			1 [?]			1	1		1	1		1	1
Driving vehicles						1 [?]												
Washing lower body parts																		
Putting on footwear	1 [?]				1									1		1	1	1
Taking off footwear	1 [?]													1				
Going shopping											1 [?]			1			1	1
Doing housework		1 [?]	1 [?]	1 [?]	1+2 [?]	1+1 [?]	1+1 [?]				1 [?]			2 [?]	1 [?]			
Key activities at 13 weeks postop																		
Squatting								1										
Holding a sitting position		1 [?]	1 [?]		1	1					2 [?]							
Holding a standing position		1 [?]	1 [?]		1	1	1	2			2 [?]			1				
Lifting a heavy object						1 [?]	1 [?]											
Walking long distances		1 [?]	1 [?]	1 [?]	1	1												
Walking on different surfaces		1 [?]	1 [?]	1 [?]				1										
Putting on footwear	1 [?]				1									1		1	1	1
Key activities at 26 weeks postop																		
Squatting								1										
Lifting a heavy object						1 [?]	1 [?]											
Walking long distances		1 [?]	1 [?]	1 [?]	1	1												
Walking on different surfaces		1 [?]	1 [?]	1 [?]				1										

?=key activity covered inadequately

The number indicates the time the activity was queried in the PROM.

AAOS: American Academy of Orthopaedic Surgeons; **FJS:** Forgotten Joint Score; **MFJS:** Modified Forgotten Joint Score; **JAS:** Joint Awareness Score; **LEFS:** Lower extremity functional scale; **LLFI:** Lower Limb Functional Index; **LLFI-10:** Lower Limb Functional Index-10; **LLTQ:** Lower Limb Task Questionnaire; **OAKHQOL:** Osteoarthritis Knee and Hip Quality of Life; **OARS:** Oxford Arthroplasty Early Recovery Score; **OACS:** Oxford Arthroplasty Early Change Score; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index.

Table 6.6 Number of key activities covered adequately, covered inadequately, and number of non-key elements covered in specific PROMs used after hip or knee arthroplasty.

	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OARS	OACS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Number of items	7	12	10	6	20	25	10	20	8	4	43	14	14	24	8	12	8	11
Key activities within two weeks (14 key activities)																		
Number of key activities covered adequately (n %)	0	1 7.1%	0	0	3 21.4%	0	0	1 7.1%	0	0	2 14.3%	0	2 14.3%	5 35.7%	1 7.1%	2 14.3%	3 21.4%	3 21.4%
Number of key activities covered inadequately (n %)	4	0	1	1	2	0	0	2	0	0	0	0	0	0	0	0	0	0
Coverage of non-key elements	4	11	11	8	16	31	19	13	7	5	25	7	8	21	9	11	5	9
Key activities at 6 weeks (15 key activities)																		
Number of key activities covered adequately (n %)	0	0	0	0	4 26.7%	4 26.7%	2 13.3%	3 20%	0	0	2 13.3%	0	2 13.3%	7 46.7%	1 6.7%	2 13.3%	4 26.7%	4 26.7%
Number of key activities covered inadequately (n %)	4	4	4	2	3	2	2	2	0	0	4	0	0	1	1	0	0	0
Coverage of non-key elements	4	10	10	7	18	28	17	13	7	5	23	8	8	19	8	12	4	8
Key activities at 13 weeks (7 key activities)																		
Number of key activities covered adequately (n %)	0	0	0	0	4 57.1%	3 42.9%	1 14.3%	3 42.9%	0	0	0	0	0	2 28.6%	0	1 14.3%	1 14.3%	1 14.3%
Number of key activities covered inadequately (n %)	1	4	4	2	0	1	1	0	0	0	2	0	0	0	0	0	0	0
Coverage of non-key elements	7	12	12	7	20	32	20	16	7	5	28	7	8	22	9	10	7	9
Key activities at 26 weeks (4 key activities)																		
Number of key activities covered adequately (n %)	0	0	0	0	1 25%	1 25%	0	2 0.5%	0	0	0	0	0	0	0	0	0	0
Number of key activities covered inadequately (n %)	0	2	2	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Coverage of non-key elements	8	14	14	9	24	33	20	18	7	5	28	8	10	24	9	13	8	10

AAOS: American Academy of Orthopaedic Surgeons; FJS: Forgotten Joint Score; MFJS: Modified Forgotten Joint Score; JAS: Joint Awareness Score; LEFS: Lower extremity functional scale; LLFI: Lower Limb Functional Index; LLFI-10: Lower Limb Functional Index-10; LLTQ: Lower Limb Task Questionnaire; OAKHQOL: Osteoarthritis Knee and Hip Quality of Life; OARS: Oxford Arthroplasty Early Recovery Score; OACS: Oxford Arthroplasty Early Change Score; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

Recall period for PROMs used after hip or knee arthroplasty

The recall periods for the included PROMs are detailed in Appendix G. The PROMs varied in their recall periods, including previous two hours or today (n=4), previous 1-2 days (n=8), previous few days (n=1), previous week (n=14), previous four weeks or month (n=8), previous three months (n=3), and previous year (n=1). Additionally, eight PROMs used different recall periods for different domains. For example, the IKDC had a 4-week recall period for symptoms, a 1-week recall period for function, and no specified recall period for sport activities. Ten PROMs did not specify any recall periods.

PBTs used after hip or knee arthroplasty

Within the first two weeks after surgery, seven out of 14 key activities were covered by 18 PBTs, with "walking short distances" being the most commonly covered activity, included in 14 PBTs, followed by "going up stairs" and "going down stairs", covered by six and five PBTs respectively. At six weeks after surgery, four out of 15 key activities were covered by 6 PBTs, with "going up stairs" and "going down stairs" being the most frequently addressed activity, included in six and five PBTs respectively. Among seven key activities at 13 weeks and four key activities at 26 weeks after surgery, only "walking long distances" was covered by 30-minute Walk Test (30MWT). Eighteen key activities were not covered by any of the PBTs at any of the four time points. (Appendix H). In terms of coverage of key activities, the A-test had the highest coverage, covering seven key activities (50%) within two weeks and four key activities (26.7%) at six weeks after surgery. However, ten PBTs did not cover any key activities (Table 6.7).

Six PBTs, including 4-meter walk Test (4mWT), 8-Foot Timed Walk Test (8FTW), 10-meter walk Test (10mWT), 20-meter walk Test (20mWT), 50-Foot Timed Walk Test (50FTW), Stair Test Up (STUp) covered only key activities. However, other PBTs included at least one

non-key activities, with the A-test having the highest number of non-key concepts covering five non-key activities, followed by Iowa Level of Assistance Scale (ILAS), Modified ILAS (mILAS), Short Physical Performance Battery (SPPB), Timed up and go (TUG), and L Test, each covering three non-key activities. The most frequent non-key activities covered across the PBTs were "sitting on a chair" and "rising from a chair" (Appendix I).

Table 6.7 Key activities covered by PBTs at various time points after hip or knee arthroplasty

ICF Chapters/Categories	F8WT	FSST	mFSST	Kneeling Test	3mBWT	4mWT	8FTW	10mWT	20mWT	50FTW	STUp	Step Test	A-test	ILAS	mILAS	SPPB	TUG	L Test	2MWT	30-s CST	30mWT	40m FPWT	4 SCT	5xSST	6MWT	SCT	STS	SRT
Key activities within two weeks postoperative																												
Lying down and getting up													x															
Rolling over													x															
Holding a sitting position													x															
Holding a standing position													x															
Walking short distances						x	x	x	x	x			x	x	x	x	x	x	x			x				x		
Going up stairs											x		x	x	x								x				x	
Going down stairs													x	x	x								x				x	
Key activities at 6 weeks postoperative																												
Holding a sitting position													x															
Holding a standing position													x															
Going up stairs											x		x	x	x								x				x	
Going down stairs													x	x	x								x				x	
Key activities at 13 weeks postoperative																												
Walking long distances																						x						
Key activities at 26 weeks postoperative																												
Walking long distances																						x						

10mWT: 10-meter walk Test; **20mWT:** 20-meter walk Test; **2MWT:** 2-minute walk Test; **30mWT:** 30-minutes walk Test; **30-s CST:** 30-s chair stand Test; **3mBWT:** 3-m backward walk Test; **40m FPWT:** 40-m fast-paced walking Test; **4mWT:** 4-meter walk Test; **4 SCT:** Four-step stair climb Test; **50FTW:** 50-Foot Timed Walk Test; **5xSST:** Five Times Sit-to-Stand Test; **6MWT:** 6-minute walk Test; **8FTW:** 8-Foot Timed Walk Test; **A-test:** "A" like Activity or Assessment; **F8WT:** Figure of 8 Walk Test; **FSST:** Four Square Step Test; **ILAS:** Iowa Level of Assistance Scale; **mFSST:** Modified Four Step Square Test; **mILAS:** Modified ILAS; **SCT:** Stair Climb Test; **SPPB:** Short Physical Performance Battery; **SST:** Single-step Test; **STS:** Sit to stand Test; **STUp:** Stair Test Up [ascend]; **SRT:** Floor sitting-rising Test; **TUG:** Timed up and go.

Discussion

Our study evaluated how well existing outcome measures used following hip or knee arthroplasty address the key functional activities most important to patients within two weeks, at six, 13, and 26 weeks following surgery. Our analysis identified gaps in the coverage of key functional activities, inadequate representation of key functional activities, and inclusion of activities not relevant to patients. By understanding patients' perspectives on what best reflects their experiences and needs regarding functional recovery, researchers and clinicians can better select appropriate outcome measures for clinical and research purposes. In addition, the findings of our study may assist in developing new outcome measures or refining existing ones to provide a more comprehensive view of the patient's perspective on their functional recovery.

One of the main findings of this study is that the majority of current outcome measures used to assess function after hip or knee arthroplasty fail to capture more than half of the key functional activities at various stages of recovery. These missing activities may compromise the validity and responsiveness of the outcome measures.²² Given that outcome measures play a primary role in evaluating treatment efficacy, the limited comprehensiveness and relevance of the measures may result in inaccurate assessments of interventions.²³ Such inaccuracies could contribute to the overuse or underuse of healthcare services.²⁴ The failure of outcome measures to reflect patients' needs could partly explain the lack of consensus on defining poor outcomes,²⁵ leading to misclassification of patients as having suboptimal outcomes following arthroplasty and producing variable prevalence rates for poor outcomes.

All included PROMs covered between three to 33 non-key elements across four time periods. PROMs with the highest coverage also included many non-key elements. For instance, KOOS and HOOS, which had the highest coverage of key activities, also had the highest number

of non-key elements. Covering non-key elements may undermine internal consistency, structural validity, and interpretability of the PROM.²¹ Moreover, including a non-key elements can make the process of collecting outcome measures more burdensome.²⁶ Asking patients to answer irrelevant questions is likely to alienate them, leading to a perception that their views are not fully valued.²⁷ This can increase the likelihood of missing or inaccurate responses, and decrease the response rate.^{22,27}

Our findings also highlighted a notable gap in the coverage of key activities by PBTs, particularly during the later stages of recovery. Specifically, 17 out of 28 PBTs covered less than half of the key activities within two and at six weeks, and only one PBT covered one key activity at 13 and 26 weeks after arthroplasty. Combining PBTs with PROMs has been proposed as a way to achieve a more comprehensive assessment.^{8,28} This is because PROMs are subjective and can be influenced by internal factors (such as mood and expectations) and external factors (such as treatment context and socioeconomic status), which may affect patients' perception of their health improvements.²³ However, the limited coverage of key activities by PBTs diminishes the value of this combination, especially at 13 and 26 weeks after arthroplasty. Future research should focus on which combination of PBTs are necessary to comprehensively assess key activities for each time period.

One potential explanation for the lack of comprehensiveness and relevance in outcome measures is that most were not specifically developed for hip or knee arthroplasty. Our previous research revealed that only 28 out of 50 PROMs and five out of 28 PBTs were specifically developed for patients who underwent hip or knee arthroplasty. In addition, our previous study found that patients were involved in the development of 52% of PROMs used after hip or knee arthroplasty. Specifically, patients who underwent hip or knee arthroplasty were involved in 32%

of PROMs used for these procedures.²⁹ To ensure that outcome measures are relevant to the arthroplasty population and have adequate validity, they should be developed with direct patient input.²⁶ Engaging patients in the development process helps capture concepts that are important to them, may make the measures feel less burdensome and prevent a paternalistic approach driven by clinicians or researchers.³⁰ In our analysis, some PROMs inadequately addressed key activities by combining them with other key or non-key categories. For example, the 2011 KSS-A item "How much does your knee bother you during each of the following: climbing up or down a flight of stairs" includes two key activities. This complexity can make it challenging for patients to understand and respond appropriately, especially if they experience difficulties with some activities but not others. Therefore, involving patients in the development of outcome measures is paramount to understanding how respondents interpret and react to individual items.

Another key finding from our content analysis is different coverage of outcome measures at various stages of recovery, due to patients' changing views on key activities over time. For example, the PAQ-knee measure showed varying coverage: 6.7% at two weeks, 19% at six weeks, 37.5% at 13 weeks, and 50% at 26 weeks after knee arthroplasty. Early in recovery, patients tend to focus on simpler tasks and gradually shift towards more complex tasks as they progress. Using a PROM that emphasizes simpler activities during later recovery stages may increase the ceiling effects, whereas asking about advanced functional activities during the early recovery phase can increase the floor effects. These issues can limit the responsiveness of outcome measures, potentially leading to an overestimation or underestimation of patients' outcome.^{7,31} Although previous studies have examined ceiling and floor effects of PROMs, they have not compared these effects across early and later stages of recovery.³¹⁻³⁵ Therefore, a comparative analysis of ceiling and floor effects at different stages of recovery is recommended

to ensure their suitability over time. This variation in coverage of key activities raises questions about whether the appropriate tools are currently being used in clinical practice and research for each follow-up time point. Certain outcome measures, such as the Oxford Arthroplasty Early Recovery Score (OARS) and the ILAS, have been specifically developed for the early stages of recovery and may not be suitable for evaluating patients in later stages. This highlights the need for using different outcome measures tailored to various phases of the recovery process. Given the challenges associated with follow-up recovery with use of diverse outcome measures, future research should focus on assessing the feasibility of employing various outcome measures appropriate for different stages of recovery.

The implementation of Computerized Adaptive Testing (CAT) algorithm, which has gained popularity over the past few years, offers a promising solution for adapting to changes over time. It uses a dynamic approach to select questions from an item bank that best match a person's ability based on their previous answers. CAT can be given to each person multiple times across different stages of recovery. In this approach, each individual is less likely to see the same questions at the later stage of recovery as they did at the early stage. By tailoring questions to the patient's current condition, CAT improves the accuracy and relevance of the outcome measures.³⁵ The PROMIS set of tools offer item banks of generic measures by the implementation of CAT based on item response theory. The item banks should be representative of activities relevant to the target population to reduce the floor and ceiling effects and enhance applicability.³⁶ However, our content analysis of PROMIS-OAK showed significant gaps in coverage of key activities across four time points.

Content validity is the most important psychometric property of an outcome measure, influencing all other psychometric properties and practical considerations.²¹ Research indicated

that patients prefer outcome measures with relevant items, even if these measures are longer, compared to those that are shorter but contain irrelevant items.³⁷ It has been shown that if a PROM is abbreviated based on patients' perspectives, the higher response rates for the shorter version are likely due as much to its relevance as to its reduced length.³⁷ Therefore, shifting the focus from questionnaire length to content relevance can enhance response rates, as patients are more motivated to engage with questions they find relevant. Despite this, none of the modified shorter outcome measures developed from longer ones included in our analysis covered more than half of the key activities across the four time points. One possible explanation is that shorter outcome measures are often developed based on item reduction (e.g., factor analysis) rather than patient input.³⁷ In our previous study, we found that only three out of 18 modified PROMs were adjusted with input from patients underwent hip or knee arthroplasty.

Another factor to consider when selecting PROMs is the recall period, which directly impacts the reliability and validity of the outcome measures.³⁸ However, ten PROMs did not specify a recall period, and others had varying recall periods ranging from the previous two hours to the previous year. The recall period should be chosen based on the functional recovery rate and key activities important to the patients at different time periods after hip or knee arthroplasty. Function typically improves rapidly in the early phase following surgery, with notable weekly variations.^{15,20,39} Key activities also happen frequently during this period since they tend to be basic daily activities. Therefore, a recall period longer than one week may lead to less accurate responses during early recovery. Conversely, as recovery progresses, functional improvement continues but at a slower pace, with little weekly variation.^{15,20,39} In addition, key activities occur less frequently during this time since they are more advanced. Thus, a shorter recall period such as a day or week may not provide enough time for these key activities to

occur. Given the variability in recall periods among current PROMs used after hip or knee arthroplasty, further research is needed to determine and standardize the most appropriate recall period.

Another consideration is the inclusion of multi-dimensional outcome measures that were not specifically developed for assessing function. As a result, incorporating items such as pain and symptoms may impact the coverage of non-key elements of these measures in evaluating functional outcomes. Given that the primary aim of this study focused on functional outcome measures, the high coverage of non-key elements observed in these multi-dimensional outcome measures suggests that they may be less appropriate if the goal is solely to assess function. In addition, outcome measures with multiple subscales can raise concerns about multiplicity issues, which can improve type I error.⁴¹ Previous research has suggested using a hierarchical approach for administering these scales. The primary subscale should be assessed first, if issues arise, then the secondary endpoint should be evaluated, and so forth. If the first scale shows no issues, no further scales need to be tested.⁴¹

Limitation

One potential limitation of our study is the content analysis of outcome measures was based on a survey conducted at a single Canadian hospital. However, another study demonstrated similar results in the evolution of the activities deemed important by patients over the first six weeks following knee arthroplasty.¹⁴ Another limitation is the inclusion of only English language outcome measures. We limited the content analysis to the first six months following hip or knee arthroplasty in alignment with the results of our survey. Since rehabilitation and recovery can extend beyond this period for specific patients,⁴⁰ the coverage of outcome measures cannot be generalized to the longer-term following arthroplasty.

Conclusion

In summary, we could not identify an appropriate patient-centered outcome measure that offers high coverage, and low number of non-key elements at any single time point. Our content analysis highlights the need to address deficiencies in existing outcome measures to better capture the functional activities that are important to patients after hip or knee arthroplasty. In addition, researchers developing or modifying outcome measures should consider the evolving nature of function after arthroplasty.

References

1. Rat A, Guillemin F, Osnowycz G, et al. Total hip or knee replacement for osteoarthritis: Mid- and long-term quality of life. *Arthritis Care Res.* 2010;62(1):54-62. doi:10.1002/acr.20014
2. Shichman I, Roof M, Askew N, et al. Projections and epidemiology of primary hip and knee arthroplasty in medicare patients to 2040-2060. *JBJS Open Access.* 2023;8(1):e22. doi:10.2106/JBJS.OA.22.00112
3. Wylde V, Blom AW. Assessment of Outcomes after hip Arthroplasty. *HIP Int.* 2009;19(1):1-7. doi:10.1177/112070000901900101
4. Senden R, Grimm B, Meijer K, Savelberg H, Heyligers IC. The importance to including objective functional outcomes in the clinical follow up of total knee arthroplasty patients. *The Knee.* 2011;18(5):306-311. doi:10.1016/j.knee.2010.07.008
5. Halawi MJ. Outcome Measures in Total Joint Arthroplasty: Current Status, Challenges, and Future Directions. *Orthopedics.* 2015;38(8). doi:10.3928/01477447-20150804-55
6. Lyman S, Yin KL. Patient-reported outcome measurement for patients with total knee arthroplasty. *JAAOS-J Am Acad Orthop Surg.* 2017;25:S44-S47. doi:10.5435/JAAOS-D-16-00637
7. Hossain FS, Konan S, Patel S, Rodriguez-Merchan EC, Haddad FS. The assessment of outcome after total knee arthroplasty: are we there yet? *Bone Jt J.* 2015;97-B(1):3-9. doi:10.1302/0301-620X.97B1.34434
8. Bolink S, Grimm B, Heyligers IC. Patient-reported outcome measures versus inertial performance-based outcome measures: a prospective study in patients undergoing primary total knee arthroplasty. *The Knee.* 2015;22(6):618-623. doi:10.1016/j.knee.2015.04.002
9. Dowsey MM, Choong PFM. The Utility of Outcome Measures in Total Knee Replacement Surgery. *Int J Rheumatol.* 2013;2013:1-8. doi:10.1155/2013/506518
10. Abdellatif S, Hladkiewicz E, Lalu MM, Boet S, Gagne S, McIsaac DI. Patient prioritization of routine and patient-reported postoperative outcome measures: a prospective, nested cross-sectional study. *Can J Anesth Can Anesth.* 2022;69(6):693-703. doi:10.1007/s12630-022-02191-7

11. MacDermid JC. ICF Linking and cognitive interviewing are complementary methods for optimizing content validity of outcome measures: an integrated methods review. *Front Rehabil Sci.* 2021;2:702596. doi:10.3389/fresc.2021.702596
12. Wiering B, De Boer D, Delnoij D. Patient involvement in the development of patient-reported outcome measures: a scoping review. *Health Expect.* 2017;20(1):11-23. doi:10.1111/hex.12442
13. Trujols J, Portella MJ, Iraurgi I, Campins MJ, Siñol N, Cobos JPDL. Patient-reported outcome measures: Are they patient-generated, patient-centred or patient-valued? *J Ment Health.* 2013;22(6):555-562. doi:10.3109/09638237.2012.734653
14. Rastogi R, Davis AM, Chesworth BM. A cross-sectional look at patient concerns in the first six weeks following primary total knee arthroplasty. *Health Qual Life Outcomes.* 2007;5(1):48. doi:10.1186/1477-7525-5-48
15. Kennedy DM, Stratford PW, Riddle DL, Hanna SE, Gollish JD. Assessing recovery and establishing prognosis following total knee arthroplasty. *Phys Ther.* 2008;88(1):22-32. doi:10.2522/ptj.20070051
16. Kennedy DM, Stratford PW, Robarts S, Gollish JD. Using Outcome Measure Results to Facilitate Clinical Decisions the First Year After Total Hip Arthroplasty. *J Orthop Sports Phys Ther.* 2011;41(4):232-240. doi:10.2519/jospt.2011.3516
17. Lenguerrand E, Wylde V, Gooberman-Hill R, et al. Trajectories of pain and function after primary hip and knee arthroplasty: the ADAPT cohort study. *PloS One.* 2016;11(2):e0149306. doi:10.1371/journal.pone.0149306
18. Naylor JM, Harmer AR, Heard RC, Harris IA. Patterns of recovery following knee and hip replacement in an Australian cohort. *Aust Health Rev.* 2009;33(1):124-135. doi:10.1071/ah090124
19. Karimijashni M, Westby M, Ramsay T, Beaulé PE, Poitras S. Development and content validation of a questionnaire identifying patients' functional priorities and abilities after hip or knee arthroplasty. *Disabil Rehabil.* 2024 Aug 16:1-5.
20. Wieczorek M, Rotonda C, Guillemin F, Rat AC. What Have We Learned About the Course of Clinical Outcomes After Total Knee or Hip Arthroplasty? *Arthritis Care Res.* 2020;72(11):1519-1529. doi:10.1002/acr.24045
21. Terwee CB, Prinsen C, Chiarotto A, et al. COSMIN methodology for assessing the content validity of PROMs–user manual. *Amst VU Univ Med Cent.* Published online 2018:1159-1170.

22. Terwee CB, Prinsen CAC, Chiarotto A, et al. COSMIN methodology for evaluating the content validity of patient-reported outcome measures: a Delphi study. *Qual Life Res.* 2018;27(5):1159-1170. doi:10.1007/s11136-018-1829-0
23. Kluzek S, Dean B, Wartolowska KA. Patient-reported outcome measures (PROMs) as proof of treatment efficacy. *BMJ Evid-Based Med.* 2022;27(3):153-155. doi:10.1136/bmjebm-2020-111573
24. Kroenke K, Miksch TA, Spaulding AC, et al. Choosing and using patient-reported outcome measures in clinical practice. *Arch Phys Med Rehabil.* 2022;103(5):S108-S117. doi:10.1016/j.apmr.2020.12.033
25. Karimijashni M, Ramsay T, Beaulé PE, Poitras S. Strategies to Manage Poorer Outcomes After Hip or Knee Arthroplasty: A Narrative Review of Current Understanding, Unanswered Questions, and Future Directions. *Musculoskeletal Care.* 2024;22(3):e1921. doi:10.1002/msc.1921
26. Aiyegbusi OL, Roydhouse J, Rivera SC, et al. Key considerations to reduce or address respondent burden in patient-reported outcome (PRO) data collection. *Nat Commun.* 2022;13(1):6026. doi:10.1038/s41467-022-33826-4
27. Doward LC, Gnanasakthy A, Baker MG. Patient reported outcomes: looking beyond the label claim. *Health Qual Life Outcomes.* 2010;8(1):89. doi:10.1186/1477-7525-8-89
28. Capin JJ, Bade MJ, Jennings JM, Snyder-Mackler L, Stevens-Lapsley JE. Total knee arthroplasty assessments should include strength and performance-based functional tests to complement range-of-motion and patient-reported outcome measures. *Phys Ther.* 2022;102(6):pzac033. doi:10.1093/ptj/pzac033
29. Karimijashni M. Patient involvement in the development of patient-reported outcome measures after hip or knee arthroplasty: A Scoping Review. Published online August 9, 2024. doi:10.17605/OSF.IO/8D2FK
30. Aiyegbusi OL, Cruz Rivera S, Roydhouse J, et al. Recommendations to address respondent burden associated with patient-reported outcome assessment. *Nat Med.* 2024;30(3):650-659. doi:10.1038/s41591-024-02827-9
31. Eckhard L, Munir S, Wood D, et al. The ceiling effects of patient reported outcome measures for total knee arthroplasty. *Orthop Traumatol Surg Res.* 2021;107(3):102758. doi:10.1016/j.otsr.2020.102758
32. Lim CR, Harris K, Dawson J, Beard DJ, Fitzpatrick R, Price AJ. Floor and ceiling effects in the OHS: an analysis of the NHS PROMs data set. *BMJ Open.* 2015;5(7):e007765. doi:10.1136/bmjopen-2015-007765

33. Harris K, Lim CR, Dawson J, Fitzpatrick R, Beard DJ, Price AJ. The Oxford knee score and its subscales do not exhibit a ceiling or a floor effect in knee arthroplasty patients: an analysis of the National Health Service PROMs data set. *Knee Surg Sports Traumatol Arthrosc.* 2017;25:2736-2742. doi:10.1007/s00167-015-3788-0
34. Clement ND, Weir D, Holland JP, Gerrand CH, Deehan DJ. An overview and predictors of achieving the postoperative ceiling effect of the WOMAC score following total knee arthroplasty. *J Arthroplasty.* 2019;34(2):273-280. doi:10.1016/j.arth.2018.10.004
35. Hamilton DF, Giesinger JM, MacDonald DJ, Simpson AHRW, Howie CR, Giesinger K. Responsiveness and ceiling effects of the Forgotten Joint Score-12 following total hip arthroplasty. *Bone Jt Res.* 2016;5(3):87-91. doi:10.1302/2046-3758.53.2000480
36. Fries JF, Witter J, Rose M, Cella D, Khanna D, Morgan-DeWitt E. Item response theory, computerized adaptive testing, and PROMIS: assessment of physical function. *J Rheumatol.* 2014;41(1):153-158. doi:10.3899/jrheum.130813
37. Rolstad S, Adler J, Rydén A. Response burden and questionnaire length: is shorter better? A review and meta-analysis. *Value Health.* 2011;14(8):1101-1108. doi:10.1016/j.jval.2011.06.003
38. Stull DE, Leidy NK, Parasuraman B, Chassany O. Optimal recall periods for patient-reported outcomes: challenges and potential solutions. *Curr Med Res Opin.* 2009;25(4):929-942. doi:10.1185/03007990902774765
39. Kennedy DM, Stratford PW, Hanna SE, Wessel J, Gollish JD. Modeling early recovery of physical function following hip and knee arthroplasty. *BMC Musculoskelet Disord.* 2006;7(1):100. doi:10.1186/1471-2474-7-100
40. Westby MD, Backman CL. Patient and health professional views on rehabilitation practices and outcomes following total hip and knee arthroplasty for osteoarthritis: a focus group study. *BMC Health Serv Res.* 2010;10(1):119. doi:10.1186/1472-6963-10-119
41. Roos EM, Engelhart L, Ranstam J, et al. ICRS Recommendation Document: Patient-Reported Outcome Instruments for Use in Patients with Articular Cartilage Defects. *Cartilage.* 2011;2(2):122-136. doi:10.1177/1947603510391084

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Appendix H. Key activities not covered by any PBT for hip or knee arthroplasty

Appendix I. Non-key elements in PBTs after hip or knee arthroplasty

Appendix A. Key functional activities at different time points after hip or knee arthroplasty

Activity	2 weeks postop		6 weeks postop		13 weeks postop		26 weeks postop	
	Knee	Hip	Knee	Hip	Knee	Hip	Knee	Hip
Changing and holding a body position								
Lying down in bed and getting up	x	x						
Rolling over	x	x						
Squatting down			x	x	x	x	x	x
Hold a sitting position	x	x	x	x	x	x		
Rising from a chair	x							
Hold a standing position	x	x	x	x	x	x		
Bending over or to the side			x	x				
Lifting and carrying objects								
Lifting a heavy object from the floor					x	x	x	x
Putting down objects on the floor			x	x				
Carrying in the arms			x	x				
Walking								
Walking short distances	x	x						
Walking long distances					x	x	x	x
Walking on different surfaces			x	x	x	x	x	x
Moving around								
Going up stairs	x	x	x	x			x	
Going down stairs	x	x	x	x	x		x	
Moving around using transportation								
Driving vehicle			x	x				
Self-care								
Washing lower body parts	x	x	x	x				
Washing whole body	x	x						
Drying your body	x	x						
Putting on clothes	x	x						
Taking off clothes	x	x						
Putting on footwear	x	x	x	x	x	x		
Taking off footwear	x	x	x	x				
Domestic life								
Going shopping			x	x				
Doing housework			x	x				
Community, social and civic life								
Socializing/Participating in community life			x					
Frequency of priorities at each time point	15	14	16	15	8	7	6	4

Appendix B. Definition of non-key elements

Category		Description	Example
Categories covered by the modified ICF OA core set but not considered key after hip or knee arthroplasty		Categories covered by the modified ICF OA core set but not deemed key by patients after arthroplasty	"Getting in and out of a car " is an example of categories covered by the modified ICF OA core set but not deemed important by patients after hip or knee arthroplasty
Categories not covered by OA core set	<i>Other specified</i>	Categories linked to the first level category of the core set but not represented by a third level category	"Walking on flat surfaces" is an example of "other specified" concept that could not be linked to the third-level category.
	<i>Covered beyond OA core set</i>	Categories linked to a category beyond the core set	"Cooking" is an example of the not covered concept that can be linked to d630 (Preparing meals) that is beyond the coreset (d630 Preparing meals).
Categories not addressed adequately	<i>Unspecified</i>	Categories linked to the first level category but lacking sufficient information to link them to a third level category	Recreational activities" is an example of the unspecified category due to insufficient information
	<i>Not definable or covered by ICF</i>	Categories that were too vague or not covered by the ICF	"Quality of life" is an example of not definable concept
	<i>Question mark</i>	Categories linked to several categories of the core set	"Standing" is an example of question mark concept as it can include both changing and maintaining a standing position
Categories related to body function and structure, or environmental factors		Categories linked to ICF category of body function and structure, or environmental factors	"pain, swelling, or joint stiffness " is an example of body function and structure category. "Feeling support by people" is an example of environmental category

Appendix C. Key activities not covered by any PROMs for hip or knee arthroplasty

PROMs for knee arthroplasty
Washing lower body parts
Putting on clothes
Taking off clothes
Squatting down
Carrying in the arms
Putting down objects on the floor
Driving vehicles
Lifting a heavy object from the floor
PROMs for hip or knee arthroplasty
Washing lower body parts
Putting on clothes
Taking off clothes
Squatting down
Carrying in the arms
Putting down objects on the floor
Driving vehicles
Lifting a heavy object from the floor
PROMs for hip or knee arthroplasty
Washing lower body parts
Drying oneself
Putting on clothes
Taking off clothes
Carrying in the arms
Putting down objects on the floor

Appendix D. Non-key elements at different time points after knee arthroplastya. Number of non-key elements **within two weeks** after knee arthroplasty.

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Body functions and structure																			
Mental functions	1				1		1	1	1							1	9	29	
Sensory functions and pain	1	1	3	1	5	8	2	8	4		4	1	2	4		2		16	
Neuromusculoskeletal and movement-related functions / Structures related to movement			6	7				9			2	6	3	2		1	7	6	
Not covered by ICF coresets for OA								1	1						1		1	2	
Activity and Participation																			
Lying down in bed and getting up					1 ²	1 ²		1 ²	1 ²										
Squatting down			1 ²	1 ²	1 ²			1 ²		1 ²		1 ²	1 ²			1 ²			
Kneeling down on the ground			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²	1		1 ²	1 ²		
Sitting on a chair			1 ²		1 ²	1 ²			1 ²							1 ²			
Rising from a chair								1 ²			1 ²								
Bending over or to the side						1		1		1	1						1		1
Rolling over																			
Holding a lying position					1 ²	1 ²		2+1 ²	1 ²										
Holding a squatting position			1 ²	1 ²	1 ²			1 ²		1 ²		1 ²	1 ²			1 ²			
Holding a kneeling position			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²			1 ²	1 ²		
Holding a sitting position			1 ²		1 ²	1 ²		2 ²	1 ²							1 ²			
Holding a standing position								1 ²			1 ²								
Lifting a light object/ Lifting a heavy object						2 ²		2 ²			2 ²								
Lifting and carrying, other specified					1			1							1				
Walking short distances																1		1	
Walking long distances					1	1	1									2		3	
Walking on different surfaces					1	1	1										2	1	
Other specified walking				1	3		1	2	1					1	1			1	1
Walking, unspecified			4 ²	2 ²	1 ²	2 ²	1 ²					1 ²	1 ²	1 ²	1 ²			1 ²	
Going up stairs/ Going down stairs					2 ²	2 ²	2 ²					2 ²						2 ²	
Going up a curb or step					2		1										2		
Jumping			5					1				1							
Other specified moving around			4		1			2	1	1	1				1				
Getting in and out of a car					1			1	1					1		1	3		1
Using public transportation														1					
Driving vehicle					1	2	1									1			
Washing whole body																			
Going to the toilet								1								1	2	1	
Going shopping								1						1				8	
Doing housework	3		4		1	2	1	2						1		1		2	
Paid job	3 ²												1		1 ²			2 ²	
Unpaid work	3 ²														1 ²			2 ²	
Socializing/Participating in community life															1	1		9	
Play/Arts and culture/Crafts/Hobbies					1	1	1									1			
Sports/Swimming			5		14	3	13						1		1	6			
Running			5		2		2	1				1	1			1		1	
Other specified recreation and leisure																		1	
Recreation and leisure, unspecified	1 ²				2 ²	1 ²										2 ²		2 ²	

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Not covered by modified ICF coreset for OA Undertaking multiple tasks independently Carrying out daily routine other specified general tasks and demands Looking after one's health Other specified self-care Preparing meals School education	2		1	7	1	1		2	1				1	1	2	1	9	11	
Environmental factor																			
Products and technology					3	1							1			1			
Support and relationships																		1	
Not covered or not definable category	2	4			3			1	1						1	1	1		

? = concepts not addressed adequately.

COMI: Core Outcome Measures Index; **HSSP:** Hospital for Special Surgery Patellar score; **IKDC:** International Knee Documentation Committee; **KOS-ADLS:** Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS:** 2011 Knee Society Score; **2011 KSS-A:** Adjusted 2011 Knee Society Score; **KSS-S:** Knee Society Score- Short-form; **KOOS:** Knee Injury and Osteoarthritis Outcome Score; **KOOS-12:** 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS:** Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR:** Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS:** Kujala Anterior Knee Pain Scale; **OKS:** Oxford knee score; **OKS-APQ:** Oxford knee score—activity and participation; **PAQ:** Patient Administered Questionnaire; **PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

b. . Number of non-key elements **at six weeks** after knee arthroplasty.

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Body functions and structure																			
Mental functions	1				1		1	1	1							1	9	29	
Sensory functions and pain	1	1	3	1	5	8	2	8	4		4	1	2	4		2		16	
Neuromusculoskeletal and movement-related functions /Structures related to movement			6	7				9			2	6	3	2		1	7	6	
Not covered by ICF coreset for OA								1	1						1		1	2	
Activity and Participation																			
Lying down in bed and getting up					1+1 ²	1+1 ²		1+1 ²	1 ²	1									
Squatting down			1 ²	1 ²	1 ²			1 ²		1 ²		1 ²	1 ²			1 ²			
Kneeling down on the ground			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²	1		1 ²	1 ²		
Sitting on a chair			1 ²		1 ²	1 ²		2 ²	1 ²							1 ²			
Rising from a chair		1	1	1	1	1	1	1+1 ²	1	1	1+1 ²			1					1
Rolling over								1											
Holding a lying position					1 ²	1 ²		2+1 ²	1 ²										
Holding a squatting position			1 ²	1 ²	1 ²			1 ²		1 ²		1 ²	1 ²			1 ²			
Holding a kneeling position			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²			1 ²	1 ²		
Holding a sitting position			1 ²		1 ²	1 ²		2 ²	1 ²							1 ²			
Holding a standing position								1 ²			1 ²								
Lifting a light object/ Lifting a heavy object						2 ²		2 ²			2 ²								
Lifting and carrying, other specified					1			1							1				
Walking short distances																1		1	
Walking long distances					1	1	1									2		3	
Other specified walking				1	3		1	2	1					1	1			1	1
Walking, unspecified			4 ²	2 ²	1 ²	2 ²	1 ²					1 ²	1 ²	1 ²	1 ²			1 ²	
Going up stairs/ Going down stairs					2 ²	2 ²	2 ²					2 ²						2 ²	
Going up a curb or step					2		1										2		
Jumping			5					1				1							
Other specified moving around			4		1			2	1	1	1				1				
Getting in and out of a car					1			1	1					1		1	3		1
Using public transportation														1					
Driving vehicle					1	2	1									1			
Washing whole body								1						1		1			
Drying oneself														1					
Going to the toilet								1								1	2	1	
Paid job	3 ²												1		1 ²			2 ²	
Unpaid work	3 ²														1 ²			2 ²	
Play/Arts and culture/Crafts/ Hobbies					1	1	1									1			
Sports/Swimming			5		14	3	13						1		1	6			
Running			5		2		2	1				1	1			1		1	
Other specified recreation and leisure																		1	
Recreation and leisure, unspecified	1 ²				2 ²	1 ²										2 ²		2 ²	
Not covered by modified ICF coreset for OA	2		1	7	1	1		2	1				1	1	2	1	9	11	
Undertaking multiple tasks independently																			
Carrying out daily routine																			
Other specified general tasks and demands																			
Looking after one's health																			
Other specified self-care																			
Preparing meals																			

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OXS	OXS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
School education																			
Environmental factor																			
Products and technology					3	1							1			1			
Support and relationships																		1	
Not covered or not definable category	2	4			3			1	1						1	1	1		

? = concepts not addressed adequately.

COMI: Core Outcome Measures Index; **HSSP:** Hospital for Special Surgery Patellar score; **IKDC:** International Knee Documentation Committee; **KOS-ADLS:** Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS:** 2011 Knee Society Score; **2011 KSS-A:** Adjusted 2011 Knee Society Score; **KSS-S:** Knee Society Score- Short-form; **KOOS:** Knee Injury and Osteoarthritis Outcome Score; **KOOS-12:** 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS:** Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR:** Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS:** Kujala Anterior Knee Pain Scale; **OXS:** Oxford knee score; **OXS-APQ:** Oxford knee score—activity and participation; **PAQ** : Patient Administered Questionnaire; **PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

c. Number of non-key elements at 13 weeks after knee arthroplasty.

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Body functions and structure																			
Mental functions	1				1		1	1	1							1	9	29	
Sensory functions and pain	1	1	3	1	5	8	2	8	4		4	1	2	4		2		16	
Neuromusculoskeletal and movement-related functions / Structures related to movement			6	7				9			2	6	3	2		1	7	6	
Not covered by ICF coresets for OA								1	1						1		1	2	
Activity and Participation																			
Lying down in bed and getting up					1+1 ²	1+1 ²		1+1 ²	1 ²	1									
Squatting down			1 ²	1 ²	1 ²			1 ²		1 ²		1 ²	1 ²			1 ²			
Kneeling down on the ground			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²	1		1 ²	1 ²		
Sitting on a chair			1 ²		1 ²	1 ²		2 ²	1 ²							1 ²			
Rising from a chair		1	1	1	1	1	1	1+1 ²	1	1	1+1 ²			1					1
Bending over or to the side						1		1		1	1						1		1
Rolling over								1											
Holding a lying position					1 ²	1 ²		2+1 ²	1 ²										
Holding a squatting position			1 ²	1 ²	1 ²			1 ²		1 ²		1 ²	1 ²			1 ²			
Holding a kneeling position			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²			1 ²	1 ²		
Holding a sitting position			1 ²		1 ²	1 ²		2 ²	1 ²							1 ²			
Holding a standing position								1 ²			1 ²								
Lifting a light object/ Lifting a heavy object						2 ²		2 ²			2 ²								
Lifting and carrying, other specified					1			1							1				
Walking short distances																1		1	
Other specified walking				1	3		1	2	1					1	1			1	1
Walking, unspecified			4 ²	2 ²	1 ²	2 ²	1 ²					1 ²	1 ²	1 ²	1 ²			1 ²	
Going up stairs/ Going down stairs					2 ²	2 ²	2 ²					2 ²						2 ²	
Going up a curb or step					2		1										2		
Jumping			5					1				1							
Other specified moving around			4		1			2	1	1	1				1				
Getting in and out of a car					1			1	1					1		1	3		1
Using public transportation														1					
Driving vehicle					1	2	1									1			
Washing whole body								1						1		1			
Drying oneself														1					
Going to the toilet								1								1	2	1	
Taking off footwear						1		1											
Going shopping								1						1				8	
Doing housework	3		4		1	2	1	2						1		1		2	
Paid job	3 ²												1		1 ²			2 ²	
Unpaid work	3 ²														1 ²			2 ²	
Socializing/Participating in community life															1	1		9	
Play/Arts and culture/Crafts/Hobbies					1	1	1									1			
Sports/ Swimming			5		14	3	13						1		1	6			
Running			5		2		2	1				1	1			1		1	
Other specified recreation and leisure																		1	
Recreation and leisure, unspecified	1 ²				2 ²	1 ²										2 ²		2 ²	
Not covered by modified ICF coresets for OA	2		1	7	1	1		2	1				1	1	2	1	9	11	
Undertaking multiple tasks independently																			
Carrying out daily routine																			
Other specified general tasks and																			

Chapter 6: Patient-Centered Content Analysis

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OXS	OXS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
demands Looking after one's health Other specified self-care Preparing meals School education																			
Environmental factor																			
Products and technology					3	1							1			1			
Support and relationships																		1	
Not covered or not definable category	2	4			3			1	1						1	1	1		

? = concepts not addressed adequately.

COMI: Core Outcome Measures Index; **HSSP:** Hospital for Special Surgery Patellar score; **IKDC:** International Knee Documentation Committee; **KOS-ADLS:** Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS:** 2011 Knee Society Score; **2011 KSS-A:** Adjusted 2011 Knee Society Score; **KSS-S:** Knee Society Score- Short-form; **KOOS:** Knee Injury and Osteoarthritis Outcome Score; **KOOS-12:** 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS:** Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR:** Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS:** Kujala Anterior Knee Pain Scale; **OXS:** Oxford knee score; **OXS-APQ:** Oxford knee score—activity and participation; **PAQ :** Patient Administered Questionnaire; **PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

d. Number of non-key elements at 26 weeks after knee arthroplasty.

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Body functions and structure																			
Mental functions	1				1		1	1	1							1	9	29	
Sensory functions and pain	1	1	3	1	5	8	2	8	4		4	1	2	4		2		16	
Neuromusculoskeletal and movement-related functions / Structures related to movement			6	7				9			2	6	3	2		1	7	6	
Not covered by ICF coreset for OA								1	1						1		1	2	
Activity and Participation																			
Lying down in bed and getting up					1+1 ²	1+1 ²		1+1 ²	1 ²	1									
Squatting down			1 ²	1 ²	1 ²			1 ²		1 ²		1 ²	1 ²			1 ²			
Kneeling down on the ground			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²	1		1 ²	1 ²		
Sitting on a chair			1 ²		1 ²	1 ²		2 ²	1 ²							1 ²			
Rising from a chair		1	1	1	1	1	1	1+1 ²	1	1	1+1 ²			1					1
Bending over or to the side						1		1		1	1						1		1
Rolling over								1											
Holding a lying position					1 ²	1 ²		2+1 ²	1 ²										
Holding a squatting position			1 ²	1 ²	1 ²			1 ²		1 ²		1 ²	1 ²			1 ²			
Holding a kneeling position			1 ²	1 ²	1 ²	1 ²		1 ²		1 ²			1 ²			1 ²	1 ²		
Holding a sitting position		1	1 ²	1	1 ²	1 ²		1+2 ²	1 ²			1				1 ²			
Holding a standing position				1	1	1		1+1 ²	1		1 ²							1	1
Lifting a light object/Lifting a heavy object						2 ²		2 ²			2 ²								
Lifting and carrying, other specified					1			1							1				
Walking short distances																1		1	
Other specified walking				1	3		1	2	1					1	1			1	1
Walking, unspecified			4 ²	2 ²	1 ²	2 ²	1 ²					1 ²	1 ²	1 ²	1 ²			1 ²	
Going up stairs/Going down stairs					2 ²	2 ²	2 ²					2 ²						2 ²	
Going up a curb or step					2		1										2		
Jumping			5					1				1							
Other specified moving around			4		1			2	1	1	1				1				
Getting in and out of a car					1			1	1					1		1	3		1
Using public transportation														1					
Driving vehicle					1	2	1									1			
Washing whole body								1						1		1			
Drying oneself														1					
Toileting								1								1	2	1	
Putting on footwear						1		1		1						1	1		
Taking off footwear						1		1											
Going shopping								1						1				8	
Doing housework	3		4		1	2	1	2						1		1		2	
Paid job	3 ²												1		1 ²			2 ²	
Unpaid work	3 ²														1 ²			2 ²	
Socializing/Participating in community life															1	1		9	
Play/Arts and culture/ Crafts/ Hobbies					1	1	1									1			
Sports/Swimming			5		14	3	13						1		1	6			
Running			5		2		2	1				1	1			1		1	
Other specified recreation and leisure																		1	
Recreation and leisure, unspecified	1 ²				2 ²	1 ²										2 ²		2 ²	
Not covered by modified ICF coreset for OA	2		1	7	1	1		2	1				1	1	2	1	9	11	
Undertaking multiple tasks independently																			

Chapter 6: Patient-Centered Content Analysis

ICF Chapters/Categories	COMI-knee	HSSP	IKDS	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OXS	OXS-APQ	PAQ-Knee	PKIP	PROMIS-OAK	WOMAC-TKA short form
Carrying out daily routine other specified general tasks and demands Looking after one's health Other specified self-care Preparing meals School education																			
Environmental factor																			
Products and technology					3	1							1			1			
Support and relationships																		1	
Not covered or not definable category	2	4			3			1	1						1	1	1		

? = concepts not addressed adequately.

COMI: Core Outcome Measures Index; **HSSP:** Hospital for Special Surgery Patellar score; **IKDC:** International Knee Documentation Committee; **KOS-ADLS:** Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS:** 2011 Knee Society Score; **2011 KSS-A:** Adjusted 2011 Knee Society Score; **KSS-S:** Knee Society Score- Short-form; **KOOS:** Knee Injury and Osteoarthritis Outcome Score; **KOOS-12:** 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS:** Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR:** Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS:** Kujala Anterior Knee Pain Scale; **OXS:** Oxford knee score; **OXS-APQ:** Oxford knee score—activity and participation; **PAQ :** Patient Administered Questionnaire; **PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

Appendix E. Non-key elements at different time points after hip arthroplastya. Number of non-key elements **within two weeks** after hip arthroplasty

ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Body functions and structure													
Mental functions	2			1	1				3			1	
Sensory functions and pain	2	1	1	5	4		2		6	1	5	2	
Neuromusculoskeletal and movement-related functions / Structures related to movement		1	1	7				1	8	1	2	1	
Not covered by ICF coreset for OA				1	1				1				
Consciousness functions													
Activity and Participation													
Lying down in bed and getting up				1 ²	1 ²				1 ²				
Squatting down				1 ²				1 ²	1 ²				
Kneeling down on the ground						1 ²							
Sitting on a chair				2 ²	1 ²		1 ²		1 ²				
Rising from a chair				1+1 ²	1		1	1 ²	1 ²		1		1
Bending over or to the side				1			1		1				1
Holding a lying position				2+1 ²	1 ²		1		2+1 ²				
Holding a squatting position				1 ²				1 ²	1 ²				
Holding a sitting position				2 ²	1 ²	1 ²	1 ²		1 ²				
Holding a standing position				1 ²				1 ²	1 ²				
Lifting a light object/ Lifting a heavy object				2 ²			2 ²		2 ²				
Lifting and carrying, other specified				1					1				1
Lifting and carrying, unspecified								1 ²					
Walking long distances		1	1					1		1		2	
Walking on different surfaces				3	1		1		3				
Other specified walking				2	1			2			1		1
Walking, unspecified				1 ²				1 ²	1 ²		1 ²		
Going up stairs/ Going down stairs		2 ²	2 ²							2 ²	2 ²		
Going up a curb or step								4					
Jumping						1		2					
Other specified moving around				1		1		2	2				
Getting in and out of a car				1	1	1		1	1	1	1	1	1
Using public transportation			1								1		
Driving vehicle												1	
Going to the toilet				1								1	
Going shopping				1							1		
Doing housework	2			2					1		1	1	1
Paid job	1 ²												
Unpaid work	1 ²												
Socializing/Participating in community life	1											1	
Play/Arts and culture/Crafts/ Hobbies												1	
Sports/ Swimming								4	1			6	
Running				1		1		1	2			1	
Recreation and leisure, unspecified								1 ²				1 ²	
Not covered by modified ICF coreset for OA	1			2	1			1	4	1	1	1	1
Carrying out daily routine													
Other specified general tasks and demands													
Kicking													
Pulling, Pushing													
Caring for body parts													
Looking after one's health													
Preparing meals													

ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Environmental factor													
Products and technology		1	1							1		1	
Not covered or not definable category	3			1	1			2	1			1	

COMI: Core Outcome Measures Index; **HHS:** Harris Hip Score; **HOOS:** Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-12:** 12-item Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-JR:** Hip dysfunction and Osteoarthritis Outcome Score-Joint Replacement; **HOOS-PS:** Hip dysfunction and Osteoarthritis Outcome Score -Physical function short form; **HOS:** Hip Outcome Score; **HAGOS:** Hip and Groin Outcome Score; **OHS:** Oxford Hip score; **PAQ:** Patient Administered Questionnaire; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

b. Number of non-key elements **at six weeks** after hip arthroplasty

ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Body functions and structure													
Mental functions	2			1	1				3			1	
Sensory functions and pain	2	1	1	5	4		2		6	1	5	2	
Neuromusculoskeletal and movement-related functions /Structures related to movement		1	1	7				1	8	1	2	1	
Not covered by ICF coresets for OA Consciousness functions				1	1				1				
Activity and Participation													
Lying down in bed and getting up				1+1 ²	1 ²				1 ²				
Squatting down				1 ²				1 ²	1 ²				
Kneeling down on the ground						1 ²							
Sitting on a chair				2 ²	1 ²		1 ²		1 ²				
Rising from a chair				1+1 ²	1		1	1 ²	1 ²		1		1
Rolling over				1			1	1	1				
Holding a lying position				2+1 ²	1 ²		1		2+1 ²				
Holding a squatting position				1 ²				1 ²	1 ²				
Holding a sitting position				2 ²	1 ²	1 ²	1 ²		1 ²				
Holding a standing position				1 ²				1 ²	1 ²				
Lifting a light object/ Lifting a heavy object				2 ²			2 ²		2 ²				
Lifting and carrying, other specified				1					1				1
Lifting and carrying, unspecified								1 ²					
Walking short distances		1	1					1				1	
Walking long distances		1	1					1		1		2	
Other specified walking				2	1			2			1		1
Walking, unspecified				1 ²				1 ²	1 ²		1 ²		
Going up stairs/ Going down stairs		2 ²	2 ²							2 ²	2 ²		
Going up a curb or step								4					
Jumping						1		2					
Other specified moving around				1		1		2	2				
Going up a curb or step				1	1	1		1	1	1	1	1	1
Using public transportation			1								1		
Driving vehicle												1	
Washing whole body				1				1			1	1	
Drying oneself											1		
Going to the toilet				1								1	
Paid job	1 ²												
Unpaid work	1 ²												
Socializing/Participating in community life	1											1	
Play/Arts and culture/Crafts/Hobbies												1	
Sports/Swimming								4	1			6	
Running				1		1		1	2			1	
Recreation and leisure, unspecified								1 ²				1 ²	
Not covered by modified ICF coresets for OA Carrying out daily routine Other specified general tasks and demands Kicking Pulling, Pushing Caring for body parts Looking after one's health Preparing meals	1			2	1			1	4	1	1	1	1
Environmental factor													
Products and technology		1	1							1		1	
Not covered or not definable category	3			1	1			2	1			1	

COMI: Core Outcome Measures Index; **HHS:** Harris Hip Score; **HOOS:** Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-12:** 12-item Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-JR:** Hip dysfunction and Osteoarthritis Outcome Score-Joint Replacement; **HOOS-PS:** Hip dysfunction and Osteoarthritis Outcome Score -Physical function short form; **HOS:** Hip Outcome Score; **HAGOS:** Hip and Groin Outcome Score; **OHS:** Oxford Hip score; **PAQ:** Patient Administered Questionnaire; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

c. Number of non-key elements at 13 weeks after hip arthroplasty

ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Body functions and structure													
Mental functions	2			1	1				3			1	
Sensory functions and pain	2	1	1	5	4		2		6	1	5	2	
Neuromusculoskeletal and movement-related functions /Structures related to movement		1	1	7				1	8	1	2	1	
Not covered by ICF coreset for OA				1	1				1				
Consciousness functions													
Activity and Participation													
Lying down and getting up				1+1 ²	1 ²				1 ²				
Squatting				1 ²				1 ²	1 ²				
Kneeling						1 ²							
Sitting				2 ²	1 ²		1 ²		1 ²				
Standing				1+1 ²	1		1	1 ²	1 ²		1		1
Bending				1			1		1				1
Rolling over				1			1	1	1				
Holding a lying position				2+1 ²	1 ²		1		2+1 ²				
Holding a squatting position				1 ²				1 ²	1 ²				
Holding a sitting position				2 ²	1 ²	1 ²	1 ²		1 ²				
Holding a standing position				1 ²				1 ²	1 ²				
Lifting a light object/ Lifting a heavy object				2 ²			2 ²		2 ²				
Lifting and carrying, other specified				1					1				1
Lifting and carrying, unspecified								1 ²					
Walking short distances		1	1					1				1	
Other specified walking				2	1			2			1		1
Walking, unspecified				1 ²				1 ²	1 ²		1 ²		
Going up stairs/ Going down stairs		2 ²	2 ²	4	2	1	2	2	3	2 ²	2 ²	2	1
Going up a curb or step								4					
Jumping						1		2					
Other specified moving around				1		1		2	2				
Getting in and out of a car				1	1	1		1	1	1	1	1	1
Using public transportation			1								1		
Driving vehicle												1	
Washing whole body				1				1			1	1	
Drying oneself											1		
Going to the toilet				1								1	
Taking off footwear				1									
Going shopping				1							1		
Doing housework	2			2					1		1	1	1
Paid job	1 ²												
Unpaid work	1 ²												
Socializing/Participating in community life	1											1	
Recreation and leisure													
Play /Arts and culture/Crafts/ Hobbies												1	
Sports/ Swimming								4	1			6	
Running				1		1		1	2			1	
Recreation and leisure, unspecified								1 ²				1 ²	
Not covered by modified ICF coreset for OA	1			2	1			1	4	1	1	1	1
Carrying out daily routine													
Other specified general tasks and demands													
Kicking													
Pulling, Pushing													
Caring for body parts													

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ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Looking after one's health													
Preparing meals													
Environmental factor													
Products and technology		1	1							1		1	
Not covered or not definable category	3			1	1			2	1			1	

COMI: Core Outcome Measures Index; **HHS:** Harris Hip Score; **HOOS:** Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-12:** 12-item Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-JR:** Hip dysfunction and Osteoarthritis Outcome Score-Joint Replacement; **HOOS-PS:** Hip dysfunction and Osteoarthritis Outcome Score -Physical function short form; **HOS:** Hip Outcome Score; **HAGOS:** Hip and Groin Outcome Score; **OHS:** Oxford Hip score; **PAQ:** Patient Administered Questionnaire; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

d. Number of non-key elements at 26 weeks after hip arthroplasty

ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Body functions and structure													
Mental functions	2			1	1				3			1	
Sensory functions and pain	2	1	1	5	4		2		6	1	5	2	
Neuromusculoskeletal and movement-related functions /Structures related to movement		1	1	7				1	8	1	2	1	
Not covered by ICF coresets for OA Consciousness functions				1	1				1				
Activity and Participation													
Lying down in bed and getting up				1+1 ²	1 ²				1 ²				
Squatting down				1 ²				1 ²	1 ²				
Kneeling down on the ground						1 ²							
Sitting on a chair				2 ²	1 ²		1 ²		1 ²				
Rising from a chair				1+1 ²	1		1	1 ²	1 ²		1		1
Bending over or to the side				1			1		1				1
Rolling over				1			1	1	1				
Holding a lying position				2+1 ²	1 ²		1		2+1 ²				
Holding a squatting position				1 ²				1 ²	1 ²				
Holding a sitting position		1	1	1+2 ²	1 ²	1 ²	1 ²		1+1 ²				
Holding a standing position				1+1 ²	1			1+1 ²	1 ²				1
Lifting a light object/ Lifting a heavy object				2 ²			2 ²		2 ²				
Lifting and carrying, other specified				1					1				1
Lifting and carrying, unspecified								1 ²					
Walking short distances		1	1					1				1	
Other specified walking				2	1			2			1		1
Walking, unspecified				1 ²				1 ²	1 ²		1 ²		
Going up stairs/ Going down stairs		2 ²	2 ²	4	2	1	2	2	3	2 ²	2 ²	2	1
Going up a curb or step								4					
Jumping						1		2					
Other specified moving around				1		1		2	2				
Getting in and out of a car				1	1	1		1	1	1	1	1	1
Using public transportation			1								1		
Driving vehicle												1	
Washing whole body				1				1			1	1	
Drying oneself											1		
Going to the toilet				1								1	
Putting on footwear		1	1	1							1	1	1
Taking off footwear				1									
Going shopping				1							1		
Doing housework	2			2					1		1	1	1
Paid job	1 ²												
Unpaid work	1 ²												
Socializing/Participating in community life	1											1	
Play/Arts and culture/Crafts/Hobbies												1	
Sports/Swimming								4	1			6	
Running				1		1		1	2			1	
Recreation and leisure, unspecified								1 ²				1 ²	
Not covered by modified ICF coresets for OA Carrying out daily routine Other specified general tasks and demands Kicking Pulling, Pushing Caring for body parts	1			2	1			1	4	1	1	1	1

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ICF Chapters/Categories	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form
Looking after one's health													
Preparing meals													
Not covered or not definable category	3			1	1			2	1			1	

COMI: Core Outcome Measures Index; **HHS:** Harris Hip Score; **HOOS:** Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-12:** 12-item Hip dysfunction and Osteoarthritis Outcome Score; **HOOS-JR:** Hip dysfunction and Osteoarthritis Outcome Score-Joint Replacement; **HOOS-PS:** Hip dysfunction and Osteoarthritis Outcome Score -Physical function short form; **HOS:** Hip Outcome Score; **HAGOS:** Hip and Groin Outcome Score; **OHS:** Oxford Hip score; **PAQ:** Patient Administered Questionnaire; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

Appendix F. Non-key elements at different time points after hip or knee arthroplastya. Number of non-key elements **within two weeks** after hip or knee arthroplasty

ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Body functions and structure																		
Mental functions		12	10	6		4	1				14	7	5	1		1		
Sensory functions and pain						1	1		1		5	3	3	5	3	5		3
Neuromusculoskeletal and movement-related functions /Structures related to movement	2					1	1	1	4	1		1	1	2				
Not covered by ICF coreset for OA Time management											1							
Activity and Participation																		
Lying down in bed and getting up														1 ²	1 ²			
Squatting down			1 ²		1 ²	1 ²	1 ²	1	1 ²									
Sitting on a chair												1 ²		1 ²		1 ²		
Rising from a chair		1	1	1				1				1 ²	1 ²	1+1 ²		1+1 ²	1	1
Bending over or to the side						1	1				1			1				
Changing basic body position, unspecified						1 ²												
Holding a lying position	1													1 ²	1 ²			
Holding a squatting position			1 ²		1 ²	1 ²	1 ²		1 ²									
Holding a kneeling position								1										
Holding a sitting position												1 ²		1 ²		1 ²		
Holding a standing position												1 ²	1 ²	1 ²		1 ²		
Holding a body position, unspecified											2 ²							
Lifting a light object/ Lifting a heavy object					2 ²	1	1											
Lifting and carrying, other specified						1	1				1			1				
Walking long distances		1	1	1	1	1												
Walking on different surfaces		1	1	1				1										
Other specified walking	1													1		1	1	1
Walking, unspecified		1 ²				1 ²		1 ²			1 ²	2 ²	1 ²	1 ²	1 ²	1 ²		1 ²
Going up stairs/ Going down stairs		2 ²	2 ²			2 ²			2 ²		2 ²			2 ²	2 ²	2 ²		2 ²
Going up a curb or step						1												
Jumping					1			2										
Other specified moving around					1	1		2		1								
Getting in and out of a car		1	1	1	1			1			1			1	1	1	1	1
Using public transportation						1		1			1							
Driving vehicle						1												
Washing oneself, unspecified						1 ²	1 ²											
Going to the toilet														1			1	1
Dressing						1					1						1	1
Going shopping											1			1			1	1
Doing housework		1	1	1	3	2	2				1			2	1			
Intimate relationships											2							
Paid job					1 ²	1 ²	1 ²				1							
Unpaid work					1 ²	1 ²	1 ²											
Socializing/Participating in community life						1	1											
Play /Arts and culture/Crafts/ Hobbies		1	1	1	1	1	1											
Sports/Swimming		2		1	1	1				1								
Running					2			3		1								
Recreation and leisure, unspecified					1 ²	1 ²					1 ²							
Not covered by modified ICF coreset for OA Carrying out daily routine					1	5	4	2		1	6			2	1			

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ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Other specified general tasks and demands																		
Conversation																		
Kicking																		
Pulling, Pushing																		
Other specified mobility																		
Caring for toenails																		
Other specified self-care																		
Preparing meals																		
Family relationships																		
School education																		
Environmental factor																		
Products and technology	1								1		1							
Support and relationships						2	1				5							
Not covered or not definable category											1		3					

AAOS: American Academy of Orthopaedic Surgeons; **FJS:** Forgotten joint scale; **MFJS:** Modified Forgotten Joint Score; **JAS:** Joint Awareness Score; **LEFS:** Lower extremity functional scale; **LLFI:** Lower Limb Functional Index; **LLFI-10:** Lower Limb Functional Index-10; **LLTQ:** Lower Limb Task Questionnaire; **OAKHQOL:** Osteoarthritis Knee and Hip Quality of Life; **OARS:** Oxford Arthroplasty Early Recovery Score; **OACS:** Oxford Arthroplasty Early Change Score; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index.

b. Number of non-key elements at 6 weeks after hip or knee arthroplasty

ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Body functions and structure																		
Mental functions		12	10	6		4	1				14	7	5	1		1		
Sensory functions and pain						1	1		1		5	3	3	5	3	5		3
Neuromusculoskeletal and movement-related functions / Structures related to movement	2					1	1	1	4	1		1	1	2				
Not covered by ICF coresets for OA											1							
Time management																		
Activity and Participation																		
Lying down in bed and getting up								1					1	1+1 ²	1+1 ²	1		
Squatting down			1 ²		1 ²	1 ²	1 ²		1 ²									
Sitting on a chair												1 ²		1 ²		1 ²		
Rising from a chair		1	1	1				1				1 ²	1 ²	1+1 ²		1+1 ²	1	1
Rolling over					1													
Changing basic body position, unspecified						1 ²												
Holding a lying position	1													1 ²	1 ²			
Holding a squatting position			1 ²		1 ²	1 ²	1 ²		1 ²									
Holding a kneeling position								1										
Holding a sitting position												1 ²		1 ²		1 ²		
Holding a standing position												1 ²	1 ²	1 ²		1 ²		
Holding a body position, unspecified											2 ²							
Lifting a light object/ Lifting a heavy object					2 ²	1	1											
Lifting and carrying, other specified						1	1				1			1				
Walking short distances					2			1										
Walking long distances		1	1	1	1	1												
Other specified walking	1													1		1	1	1
Walking, unspecified		1 ²				1 ²		1 ²			1 ²	2 ²	1 ²	1 ²	1 ²	1 ²		1 ²
Going up stairs/ Going down stairs		2 ²	2 ²			2 ²			2 ²		2 ²			2 ²	2 ²	2 ²		2 ²
Going up a curb or step						1												
Jumping					1			2										
Other specified moving around					1	1		2		1								
Getting in and out of a car		1	1	1	1			1			1			1	1	1	1	1
Using public transportation						1		1			1							
Washing whole body		1	1	1	1						1			1				
Washing oneself, unspecified						1 ²	1 ²											
Going to the toilet														1			1	1
Dressing						1					1							
Intimate relationships											2							
Paid job					1 ²	1 ²	1 ²				1							
Unpaid work					1 ²	1 ²	1 ²											
Socializing/Participating in community life						1	1											
Play /Arts and culture/Crafts/ Hobbies		1	1	1	1	1	1											
Sports/Swimming		2		1	1	1				1								
Running					2			3		1								
Recreation and leisure, unspecified					1 ²	1 ²					1 ²							
Not covered by modified ICF coresets for OA					1	5	4	2		1	6			2	1			
Carrying out daily routine																		
Other specified general tasks and demands																		
Conversation																		
Kicking																		
Pulling, Pushing																		
Other specified mobility																		
Caring for toenails																		

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ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Other specified self-care Preparing meals Family relationships School education																		
Environmental factor																		
Products and technology	1								1		1							
Support and relationships						2	1				5							
Not covered or not definable category											1		3					

AAOS: American Academy of Orthopaedic Surgeons; **FJS:** Forgotten joint scale; **MFJS:** Modified Forgotten Joint Score; **JAS:** Joint Awareness Score; **LEFS:** Lower extremity functional scale; **LLFI:** Lower Limb Functional Index; **LLFI-10:** Lower Limb Functional Index-10; **LLTQ:** Lower Limb Task Questionnaire; **OAKHQOL:** Osteoarthritis Knee and Hip Quality of Life; **OARS:** Oxford Arthroplasty Early Recovery Score; **OACS:** Oxford Arthroplasty Early Change Score; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index.

c. Number of non-key elements at 13 weeks after hip or knee arthroplasty

ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Body functions and structure																		
Mental functions		12	10	6		4	1				14	7	5	1		1		
Sensory functions and pain						1	1		1		5	3	3	5	3	5		3
Neuromusculoskeletal and movement-related functions / Structures related to movement	2					1	1	1	4	1		1	1	2				
Not covered by ICF coresets for OA Time management											1							
Activity and Participation																		
Lying down in bed and getting up								1					1	1+1 ²	1+1 ²	1		
Squatting down			1 ²		1 ²	1 ²	1 ²		1 ²									
Sitting on a chair												1 ²		1 ²		1 ²		
Rising from a chair		1	1	1				1				1 ²	1 ²	1+1 ²		1+1 ²	1	1
Bending over or to the side						1	1				1			1				
Rolling over					1													
Changing basic body position, unspecified						1 ²												
Holding a lying position	1													1 ²	1 ²			
Holding a squatting position			1 ²		1 ²	1 ²	1 ²		1 ²									
Holding a kneeling position								1										
Holding a sitting position		1	1		1	1					2							
Holding a standing position		1	1		1	1	1	2			2			1				
Holding a body position, unspecified											2 ²							
Lifting a light object/ Lifting a heavy object						1	1											
Lifting and carrying, other specified						1	1				1			1				
Walking short distances					2			1										
Other specified walking	1													1		1	1	1
Walking, unspecified		1 ²				1 ²		1 ²			1 ²	2 ²	1 ²	1 ²	1 ²	1 ²		1 ²
Going up stairs/ Going down stairs	2	2 ²	2 ²		2	2 ²		2	2 ²		1+2 ²	2		2+2 ²	1+2 ²	1+2 ²	2	2+2 ²
Going up a curb or step						1												
Jumping					1			2										
Other specified moving around					1	1		2		1								
Getting in and out of a car		1	1	1	1			1			1			1	1	1	1	1
Using public transportation						1		1			1							
Driving vehicle						1												
Washing whole body		1	1	1	1						1			1				
Washing oneself, unspecified						1 ²	1 ²											
Going to the toilet														1			1	1
Dressing						1					1							
Taking off footwear	1													1				
Going shopping											1			1			1	1
Doing housework		1	1	1	3	2	2				1			2	1			
Intimate relationships											2							
Paid job					1 ²	1 ²	1 ²				1							
Unpaid work					1 ²	1 ²	1 ²											
Socializing/Participating in community life						1	1											
Play /Arts and culture/Crafts/ Hobbies		1	1	1	1	1	1											
Sports/Swimming		2		1	1	1				1								
Running					2			3		1								
Recreation and leisure, unspecified					1 ²	1 ²					1 ²							
Not covered by modified ICF coresets for OA Carrying out daily routine Other specified general tasks and demands Conversation					1	5	4	2		1	6			2	1			

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ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Kicking Pulling, Pushing Other specified mobility Caring for toenails Other specified self-care Preparing meals Family relationships School education																		
Environmental factor																		
Products and technology	1								1		1							
Support and relationships						2	1				5							
Not covered or not definable category											1		3					

AAOS: American Academy of Orthopaedic Surgeons; **FJS:** Forgotten joint scale; **MFJS:** Modified Forgotten Joint Score; **JAS:** Joint Awareness Score; **LEFS:** Lower extremity functional scale; **LLFI:** Lower Limb Functional Index; **LLFI-10:** Lower Limb Functional Index-10; **LLTQ:** Lower Limb Task Questionnaire; **OAKHQOL:** Osteoarthritis Knee and Hip Quality of Life; **OARS:** Oxford Arthroplasty Early Recovery Score; **OACS:** Oxford Arthroplasty Early Change Score; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index.

d. Number of non-key elements at 26 weeks after hip or knee arthroplasty

ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Body functions and structure																		
Mental functions		12	10	6		4	1				14	7	5	1		1		
Sensory functions and pain						1	1		1		5	3	3	5	3	5		3
Neuromusculoskeletal and movement-related functions / Structures related to movement	2					1	1	1	4	1		1	1	2				
Not covered by ICF coresets for OA Time management											1							
Activity and Participation																		
Lying down in bed and getting up								1					1	1+1 ²	1+1 ²	1		
Squatting down			1 ²		1 ²	1 ²	1 ²	1	1 ²									
Sitting on a chair												1 ²		1 ²		1 ²		
Rising from a chair		1	1	1				1				1 ²	1 ²	1+1 ²		1+1 ²	1	1
Bending over or to the side						1	1				1			1				
Rolling over					1													
Changing basic body position, unspecified						1 ²												
Holding a lying position	1													1 ²	1 ²			
Holding a squatting position			1 ²		1 ²	1 ²	1 ²		1 ²									
Holding a kneeling position								1										
Holding a sitting position		1	1		1	1					2	1 ²		1 ²		1 ²		
Holding a standing position		1	1		1	1	1	2			2	1 ²	1 ²	1+1 ²		1 ²		
Holding a body position, unspecified											2 ²							
Lifting a light object/ Lifting a heavy object					2 ²	1	1											
Lifting and carrying, other specified						1	1				1			1				
Walking																		
Walking short distances					2			1										
Walking long distances		1	1	1	1	1												
Walking on different surfaces		1	1	1				1										
Other specified walking	1													1		1	1	1
Walking, unspecified		1 ²				1 ²		1 ²			1 ²	2 ²	1 ²	1 ²	1 ²	1 ²		1 ²
Going up stairs/ Going down stairs	2	2 ²	2 ²		2	2 ²		2	2 ²		1+2 ²	2		2+2 ²	1+2 ²	1+2 ²	2	2+2 ²
Going up a curb or step						1												
Jumping					1			2										
Other specified moving around					1	1		2		1								
Getting in and out of a car		1	1	1	1			1			1			1	1	1	1	1
Using public transportation						1		1			1							
Driving vehicle						1												
Washing whole body		1	1	1	1						1			1				
Washing oneself, unspecified						1 ²	1 ²											
Going to the toilet														1			1	1
Dressing						1					1							
Putting on footwear	1				1									1		1	1	1
Taking off footwear	1													1				
Going shopping											1			1			1	1
Doing housework		1	1	1	3	2	2				1			2	1			
Intimate relationships											2							
Paid job					1 ²	1 ²	1 ²				1							
Unpaid work					1 ²	1 ²	1 ²											
Socializing/Participating in community life						1	1											
Play /Arts and culture/Crafts/ Hobbies		1	1	1	1	1	1											
Sports/Swimming		2		1	1	1				1								
Running					2			3		1								
Recreation and leisure, unspecified					1 ²	1 ²					1 ²							

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ICF Chapters/Categories	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OACS	OARS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form
Not covered by modified ICF coreset for OA Carrying out daily routine Other specified general tasks and demands Conversation Kicking Pulling, Pushing other specified mobility Caring for toenails Other specified self-care Preparing meals Family relationships School education					1	5	4	2		1	6			2	1			
Environmental factor																		
Products and technology	1								1		1							
Support and relationships						2	1				5							
Not covered or not definable category											1		3					

AAOS: American Academy of Orthopaedic Surgeons; **FJS:** Forgotten joint scale; **MFJS:** Modified Forgotten Joint Score; **JAS:** Joint Awareness Score; **LEFS:** Lower extremity functional scale; **LLFI:** Lower Limb Functional Index; **LLFI-10:** Lower Limb Functional Index-10; **LLTQ:** Lower Limb Task Questionnaire; **OAKHQOL:** Osteoarthritis Knee and Hip Quality of Life; **OARS:** Oxford Arthroplasty Early Recovery Score; **OACS:** Oxford Arthroplasty Early Change Score; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index.

Appendix G. The recall period of included the PROMs used after hip or knee arthroplasty.

Instrument / Abbreviation	Recall period
PROMs after knee arthroplasty	
Core Outcome Measures Index-Knee/ COMI-Knee	Previous week for pain, quality of life, function Previous 4 weeks for disability
Hospital for Special Surgery Patellar score/ HSSP	Not specific recall period
International Knee Documentation Committee/ IKDC	4 weeks for symptoms. Previous week for function. Not defined for sports activities.
Knee Outcome Survey Activities of Daily Living Scale/ KOS-ADLS	1–2 days
2011 Knee Society Score/ 2011 KSS	Not specific recall period
Adjusted 2011 KSS/ 2011 KSS-A	Not specific recall period
Short-form Knee Society Score/ Short-form KSS	Not specific recall period
Knee Injury and Osteoarthritis Score/ KOOS	Previous week for pain, symptoms, Function/ADL, and sport/recreation subscales. Not defined for QoL subscale.
12-item short forms Knee Injury and Osteoarthritis Score/ KOOS-12	Previous week for pain, Function/ADL, and sport/recreation subscales. Not defined for QoL subscale.
Knee Injury and Osteoarthritis Score Physical function Short form / KOOS-PS	Previous week
Knee Injury and Osteoarthritis Score Joint Replacement / KOOS-JR	Previous week
Kujala Anterior Knee Pain Scale/ AKPS	Not specific recall period
Lille Score	Previous month
Oxford knee score/ OKS	Previous 4 weeks
Oxford knee score—activity and participation/ OKS-APQ	Previous 4 weeks
Patient Administered Questionnaire-Knee/ PAQ- Knee	Not specific recall period
Patient's Knee Implant Performance Questionnaire/ PKIP	Previous week
PROMIS R-Plus-Osteoarthritis of the Knee/ OAK	Previous week for the below domains: Anger, Anxiety, Depression, Life satisfaction, Fatigue, Pain intensity, Pain interference, Sleep disturbance, Symptoms, Independence, Satisfaction with social roles and activities (for 1 item)
WOMAC-Total knee arthroplasty function short forms	Previous 48 hours
PROMs after hip arthroplasty	
Core Outcome Measures Index-Knee/ COMI-Hip	Previous 4 weeks for pain, function, disability
Self-reported Harris Hip score/Self-reported HHS	Not specific recall period
Modified Harris score/ HHS	Not specific recall period
Hip dysfunction and Osteoarthritis Outcome Score/ HOOS	Previous week for pain, symptoms, Function/ADL, and sport/recreation subscales. Not defined for QoL subscale.
12-item Hip dysfunction and Osteoarthritis Outcome Score/ HOOS-12	Previous week for pain, Function/ADL, subscales. Not defined for QoL subscale.
Hip dysfunction and Osteoarthritis Outcome Score Physical function short form/ HOOS-PS	Previous week
Hip dysfunction and Osteoarthritis Outcome Score Joint Replacement/ HOOS-JR	Previous week
Hip Outcome Score/ HOS	Previous week
Hip and Groin Outcome Score/ HAGOS	Previous week
Mayo Hip Score	Not specific recall period
Oxford Hip score/ OHS	Previous 4 week
Patient Administered Questionnaire-Hip/ PAQ-Hip	3 months for question related to pain. Not specific recall period for other questions.
WOMAC-Total hip arthroplasty function short forms	Previous 48 hours

PROMs after Hip or knee arthroplasty	
American Academy of Orthopaedic Surgeons (AAOS) Hip and Knee Core Scale/ Hip and Knee Outcomes Questionnaire	Previous week
Lower extremity functional scale/ LEFS	Today
Lower Limb Functional Index/ LLFI	Last few days
Lower Limb Functional Index-10/ LLFI-10	Last few days
Lower Limb Task Questionnaire/ LLTQ	Previous 2 hours
Lysholm score	Not specific recall period
Marx Activity Rating Scale	Previous year
Osteoarthritis Knee and Hip Quality of Life/ OAKHQOL	Previous four weeks
Oxford Arthroplasty Early Recovery Score/ OARS	Today
Oxford Arthroplasty Early Change Score/ OACS	Today compared before surgery
Western Ontario and McMaster Universities Osteoarthritis Index/ WOMAC	Previous 48 hours
Hirsch-Western Ontario and McMaster Universities Osteoarthritis Index/ Hirsch-WOMAC	Previous 48 hours
Whitehouse- Western Ontario and McMaster Universities Osteoarthritis Index/ Whitehouse-WOMAC	Previous 48 hours
Tubach-Western Ontario and McMaster Universities Osteoarthritis Index/ Tubach -WOMAC	Previous 48 hours
WOMAC short form	Previous 48 hours

Appendix H. Key activities not covered by any PBT for hip or knee arthroplasty

Key activities
Washing lower body parts
Washing whole body
Drying oneself
Putting on clothes
Taking off clothes
Putting on footwear
Taking off footwear
Squatting
Bending over or to the side
Carrying in the arms
Putting down objects
Walking on different surfaces
Driving vehicles
Going shopping
Doing housework
Holding a sitting position
Holding a standing position
Lifting a heavy object

Appendix I. Non-key elements in PBTs after hip or knee arthroplasty

ICF Chapters/Categories	F8WT	FSST	mFSST	Kneeling Test	3MBWT	4MWT	8FTW	10MWT	20MWT	50FTW	STUp	Step Test	A-test	ILAS	mILAS	SPPB	TUG	L Test	2MWT	30-s CST	30MWT	40m FPWT	4 SCT	5xSST	6MWT	SCT	STS	SRT
Kneeling				X																								
Sitting													X	X	X	X	X	X		X				X			X	X
Rising from a chair													X	X	X	X	X	X		X				X			X	X
Walking around obstacles	X	X																						X				
Other specified walking					X								X															
Climbing												X																
Other specified moving around			X														X	X	X		X	X	X		X	X		
Toileting													X															
Sability of joint functions																X												
Support and relationships													X	X	X													

10mWT: 10-meter walk Test; **20mWT:** 20-meter walk Test; **2MWT:** 2-minute walk Test; **30mWT:** 30-minutes walk Test; **30-s CST:** 30-s chair stand Test; **3mBWT:** 3-m backward walk Test; **40m FPWT:** 40-m fast-paced walking Test; **4mWT:** 4-meter walk Test; **4 SCT:** Four-step stair climb Test; **50FTW:** 50-Foot Timed Walk Test; **5xSST:** Five Times Sit-to-Stand Test; **6MWT:** 6-minute walk Test; **8FTW:** 8-Foot Timed Walk Test; **A-test:** “A” like Activity or Assessment; **F8WT:** Figure of 8 Walk Test; **FSST:** Four Square Step Test; **ILAS:** Iowa Level of Assistance Scale; **mFSST:** Modified Four Step Square Test; **mILAS:** Modified ILAS; **SCT:** Stair Climb Test; **SPPB:** Short Physical Performance Battery; **SST:** Single-step Test; **STS:** Sit to stand Test; **STUp:** Stair Test Up [ascend]; **SRT:** Floor sitting-rising Test; **TUG:** Timed up and go.

CHAPTER 7: Patient Involvement Scoping Review (Manuscript 7)

Relationship of Manuscript 7 to the Dissertation

Patient involvement in PROM development is necessary to ensure that these measures reflect the patient's perspective. Despite its importance, there is limited understanding of how patients were involved in this process. Therefore, the manuscript presented in this chapter outlines a scoping review that aimed to explore the extent and nature of patient involvement in the development of 50 PROMs used to assess function after hip or knee arthroplasty. The findings revealed that patients were involved in 52% of PROMs used after hip or knee arthroplasty, but only 20% of these PROMs included input from patients who underwent these procedures. When patient involvement did occur, the methods for involving patients varied between PROMs, with limited use of interviews during item development and cognitive interviews for comprehensibility evaluation, and no involvement of patients as partners. Furthermore, the findings showed that patient involvement did not increase over time and some PROMs continue to be developed without patient input.

This manuscript has been prepared for submission. The numbering of tables and figures has been adjusted to fit the formatting of this dissertation.

Manuscript 7: Patient involvement in the development of patient-reported outcome measures used following hip or knee arthroplasty: A Scoping Review

Abstract

Background: To accurately capture the patient's perspective, involving patients in the development of patient-reported outcome measures (PROMs) is crucial. However, there is limited understanding of how and to what extent patients were involved in the development of PROMs used after hip or knee arthroplasty. This scoping review aimed to evaluate the level of patient involvement during the development of these PROMs and to compare the inclusion of key activities important to patients between PROMs developed with patient input and those developed without.

Methods: Patient involvement in the development of items and in testing their comprehensibility was documented by two independent reviewers for 50 PROMs used after hip or knee arthroplasty. Trends in patient involvement in the development of PROMs over time were also evaluated using binary logistic regression analysis.

Results: Patients were involved in 26 out of 50 PROMs (52%). They were involved in item development in 22 PROMs (44%), and in comprehensibility testing in 13 PROMs (26%). Patients who underwent hip or knee arthroplasty were involved in either one or both phases in ten PROMs (20%), and patients with other lower extremity conditions other than arthroplasty were involved in 16 PROMs (32%). Five PROMs involved patients who underwent hip or knee arthroplasty in both item development and comprehensibility evaluation (Oxford Knee Score-Activity and Participation Questionnaire, Patient's Knee Implant Performance Questionnaire, Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee,

Oxford Arthroplasty Early Recovery Score and Oxford Arthroplasty Early Change Score). In addition, our analysis revealed no significant change in patient involvement over time ($p=0.21$).

Conclusion: Since around half of PROMs used after hip or knee arthroplasty did not involve patients in their development, our findings highlight the need to improve patient involvement in the development of PROMs. There is also a need to analyze the content of existing PROMs to determine if they accurately reflect patients' perspectives.

Key Points:

- Our findings indicate that patients were not involved in approximately half of the PROMs used to assess function after hip or knee arthroplasty.
- Involving patients at various stages of recovery is essential, as their needs can change at different times following arthroplasty.
- Our results underscore the need for guidelines to address potential barriers and provide clear direction for incorporating patient involvement in the development of PROMs

Introduction

Hip and knee arthroplasty are effective surgical treatments for end-stage hip or knee osteoarthritis, aiming to relieve pain and restore joint function.^{1,2} Although there are many ways to evaluate outcomes following hip or knee arthroplasty, assessment of outcomes after arthroplasty have relied primarily on clinicians using criteria such as implant survival, complication rates, and objective measurements like range of motion or muscle strength.³ The increasing active involvement of patients in their care processes require a shift in the assessment of outcomes from the clinician's perspective to that of the patient.⁴ One method of capturing patient perspectives is through patient-reported outcome measures (PROMs). PROMs can play a major role across a range of settings, including routine patient care, clinical research, population surveys, resource allocation and assessing the quality of healthcare.⁵

To accurately capture the patient's perspective, it is crucial to involve patients in the development of PROMs,⁶ as only patients can accurately determine the relevance of outcomes and the comprehensibility of the questionnaire. Patient input is crucial at various stages of development to create a patient-centered PROM, such as identifying core concepts, contributing to item generation, and ensuring the comprehensibility of questionnaires.⁶ In addition, actively involving patients, which is commonly referred to as “patient partners” throughout all stages of research, from conception to analysis and dissemination of research findings, can enhance the quality and clinical relevance of PROMs.^{7,8} It has been considered an important step forward for enhancing the PROM development process.⁶

If PROMs fail to integrate patient perspectives, they may not effectively capture patient needs, thereby undermining patient-centered outcome assessment.⁹ In our previous research, we found that while some PROMs were developed for patients undergoing hip and knee

arthroplasty, they did not comprehensively address certain aspects of functional activities that were deemed important to patients.¹⁰ Consequently, clinicians may disregard essential aspects of care, potentially leading to inadequate outcome assessment. Moreover, including poorly targeted outcome measures can yield irrelevant or misleading information, wastages of resources and miss opportunities to highlight potential treatment effects. Ethical concerns may arise when patients are asked to complete measures that cannot effectively demonstrate treatment effects.^{11,12} Thus, given the potential consequences of using PROMs that do not adequately reflect the patient's perspective, prioritizing patient involvement is imperative.⁶

Despite the necessity of patient involvement to ensure that the operationalization of items reflects patient perspectives, there is little understanding in what ways and to what extent patients were involved in the development of PROMs used after hip or knee arthroplasty and whether their involvement led to the inclusion of more aspects that matter to them. This understanding can facilitate informed actions that promote the development and use of robust patient-centered outcome measures. Therefore, we conducted this scoping review aimed to assess the extent of patient involvement in the development of PROMs used after hip or knee arthroplasty and to compare the inclusion of key activities important to patients between PROMs developed with patient input and those developed without.

Methods

This study uses the scoping review methodology. This methodology is widely used to comprehensively map the literature on a specific topic or research area, determine key concepts, research gaps, and various types and sources of evidence to inform practice, policymaking, and future research.¹³ Thus, it was determined that this methodology was suitable for enhancing the understanding of patient involvement in the development of outcome measures and for

identifying gaps that could guide future research in developing new measures or modifying the existing ones. This review was guided by Arksey and O'Malley's methodological framework¹⁴, which involved five stages: formulating a research question, identifying relevant articles, selecting articles, extracting and charting data, and organizing, summarizing, and reporting the results. We reported our process according to the PRISMA Extension for Scoping Reviews¹⁵ and registered the protocol in Open Science Framework (osf.io/muspz).

Eligibility criteria

Inclusion criteria

We included the studies if they described the development of a PROM. A PROM is a questionnaire designed to capture person's perspective on their health, wellbeing or symptoms.¹⁶ PROMs were included if they met the following criteria: 1) Used to assess function after primary elective hip or knee arthroplasty, including total joint arthroplasty, uni-compartmental knee arthroplasty, and hip resurfacing or hemi-arthroplasty due to osteoarthritis (OA); 2) Contained at least two items to assess physical function, including participation in daily activities which are the primary goals of arthroplasty for patients undergoing hip or knee procedures;¹⁷⁻²⁰ 3) Were disease-specific (OA) or joint-specific (hip, knee, or lower limb); 4) Provided a numerical value; 5) Included patient-reported items for at least half of the items for PROMs containing both clinician-assessed and patient-reported items. In addition, we included shortened versions or modifications of existing PROMs. Many of the identified PROMs were initially developed for conditions other than hip or knee arthroplasty.¹⁰ However, we included studies on the development of these PROMs if their original target samples focused on lower extremity issues. We included studies on PROMs development using any research design (qualitative and quantitative) published in the peer-reviewed journals. We excluded the PROMs specifically

developed before surgery to predict outcomes. We also excluded PROMs that were not available in English.

Identification of related research

To identify PROMs used after hip or knee arthroplasty, we drew upon the findings of our previous systematic review, which identified 50 PROMs.¹⁰ To identify the studies for development of these PROMs, we conducted a manual search of the reference lists from the studies included in our previous systematic reviews, as these studies typically reference the original papers. If we did not find development studies through this initial search, we further traced back through the reference lists of the papers identified in the previous step.

Data extraction and charting

Two reviewers conducted data extraction independently using a comprehensive, standardized extraction form. The basic information that was collected from each PROM included the first author, the year of publication, the country, target population, and the level and type of patient involvement. Patient involvement was documented in two phases following the framework suggested by Wiering et al.⁶ : 1) developing PROM items through focus groups or interviews with patients, or other patient-involved methods; and 2) testing comprehensibility through cognitive interviews or other means. We also documented any active patient involvement beyond their role as research participants.⁷ In addition, we noted when items were developed using sources other than patients, such as expert opinions or literature reviews, or tested for comprehensibility without patient involvement.

Collating, summarizing and reporting results

After assessing the extent of patient involvement at each phase, we recorded the number of development phases where patients were involved. If patients were involved in any of the

abovementioned stages, we categorized that PROM as having patient involvement in its development. We described the extent of patient involvement in PROMs specifically developed for patients undergoing hip or knee arthroplasty and those developed for other lower extremity conditions but currently used after arthroplasty. We also described patient involvement between three categories of the PROMs: those used after knee arthroplasty; after hip arthroplasty; and after hip or knee arthroplasty. In addition, we reported the patient involvement in modified versions of the existing PROMs. Moreover, to assess whether patient involvement in the development of PROMs has changed over time, a binary logistic regression analysis was conducted using IBM SPSS (version 29). The dependent variable was patient involvement (coded as 1 for involvement and 0 for no involvement), and the independent variable was the year of publication. A p-value < 0.05 was considered statistically significant. We did not evaluate the quality of the included studies because our review aimed to determine the level of patient involvement rather than to appraise study development.

Using coverage of key activities important to the patients by each outcome measure identified in previous research, we compared coverage between PROMs developed with patient involvement and those without using the Mann-Whitney U test.

Results

PROMs characteristics

We included a total of 50 PROMs, with 19 used after knee arthroplasty, 13 after hip arthroplasty, and 18 after both procedures. These PROMs were developed between 1982 and 2023. Of these, 28 PROMs targeted patients undergoing hip or knee arthroplasty, while 32 were designed for individuals with lower extremity problems. The majority of PROMs were developed in the USA (n = 23), followed by the UK (n = 8) and Canada (n = 7).

Patient involvement

Tables 7.1 to 7.3 present the details for each PROM of patient involvement in two phases: item development and comprehensibility evaluation. Patients were involved in either or both phases in 26 out of 50 PROMs (52%) (Table 7.4). In 22 PROMs (44%), patients were involved in the item development, with interviews in nine PROMs (18%), surveys in eight PROMs (16%), focus groups in two PROMs (4%), both interview and focus group in one PROM (2%), both interview and survey in one PROM (2%) and unknown in one PROM (2%). Furthermore, patients were involved in comprehensibility testing in 13 PROMs (26%), with cognitive interview in five PROM (10%), and other methods (such as pilot testing or receiving feedback via survey) in eight PROM (16%) (Table 7.4). Patients were involved in both phases (item development and comprehensibility evaluation) in nine PROMs including the Oxford Knee Score (OKS), Oxford Knee Score-Activity and Participation Questionnaire (OKS-APQ), Patient's Knee Implant Performance Questionnaire (PKIP), Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee (PROMIS R-Plus-OAK), Hip and Groin Outcome Score (HAGOS), Oxford Hip Score (OHS), Marx Activity Rating Scale, Oxford Arthroplasty Early Recovery Score (OARS), and Oxford Arthroplasty Early Change Score (OACS). There was no documentation of active patient involvement as a partner in any of the PROM development processes.

Patients who underwent hip or knee arthroplasty were involved in either one or both phases in ten PROMs (20%), and patients with other lower extremity conditions other than arthroplasty were involved in 16 PROMs (32%) (Table 7.4). PROMs involving patients with hip or knee arthroplasty included 2011 Knee Society Score (2011 KSS, OKS-APQ, PKIP; PROMIS R-Plus-OAK, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)-

Total knee arthroplasty function short forms, WOMAC-Total hip arthroplasty function short forms, Forgotten Joint Score (FJS), Modified Forgotten Joint Score (MFJS), OARS, and OACS. Of these, five PROMs involved patients who underwent hip or knee arthroplasty in both item development and comprehensibility evaluation, including OKS-APQ, PKIP, PROMIS R-Plus-OAK, OARS and OACS.

Of the 50 PROMs included, 18 were modified versions. Among these, three modified PROMs (17%) involved patients who underwent knee or hip arthroplasty contrary to the original version, and five modified PROM (28%) involved patients with OA or scheduled to undergo hip or knee arthroplasty. The remaining modified PROMs did not involve patients.

When considering PROMs specific for each surgery, patients were involved in ten out of 19 PROMs (53%) for knee arthroplasty, with patients who underwent knee arthroplasty being involved in five PROMs (26%). For PROMs used after hip arthroplasty, patients were involved in six out of 13 PROMs (46%), with those who underwent hip arthroplasty being involved in one PROMs (8%). Moreover, in PROMs used after hip or knee arthroplasty, patients were involved in ten out of 18 PROMs (55.5%), with patients who underwent hip or knee arthroplasty being involved in four PROMs (22%) (Table 7.5).

In terms of the development of PROMs over time, the logistic regression analysis indicated that the year of publication was not significantly related to patient involvement in the development of PROMs used after hip or knee arthroplasty ($p = 0.21$, odds ratio= 1.04, 95% CI= [0.977, 1.108]). This suggests there was no significant change in patient involvement over time.

Tables 7.6, 7.7, 7.8 present the results of the comparisons of the coverage of key activities by each PROMs. Contrary to the expectation that PROMs developed with patient involvement in item development may show higher coverage, the analysis did not find a

significant association between the extent of coverage and the level of patient involvement in the development process of PROMs within two weeks, at six, 13 weeks and 26 weeks following hip or knee arthroplasty ($p>0.05$) (Tables 7.6, 7.7, 7.8).

Table 7.1. Patient involvement in the development of PROMs used after knee arthroplasty

PROM	Publication year/ Country	Patient recruited during development	Patient involvement in item development				Patient involvement in testing for comprehensibility			Phases with involving patient (n)	Patient involvement
			focus groups	interviews	other methods	other non-patient sources	Cognitive interviews	other methods	without patient input		
COMI-Knee ²⁵	2017/ Switzerland	No involvement	No	No	No	Yes	No	No	No	0	No
HSSP ²⁶	2006/ USA	No involvement	No	No	No	No	No	No	No	0	No
IKDC ^{27,28}	2001/ USA	With ligament injury, osteoarthritis, meniscal injury, patellofemoral pain, contusions, fractures, dislocations, tendinitis, synovitis, bursitis, loose bodies, and nonspecific joint pain	No	No	No	Yes	No	Yes	Yes	1	Yes
KOS-ADLS ²⁹	1998/ USA	No involvement	No	No	No	Yes	No	No	Yes	0	No
2011 KSS ³⁰	2011/ USA Canada	Underwent primary, unilateral TKA at least 12 months ago	No	No	Yes	Yes	No	No	Yes	1	Yes
2011 KSS-A ³¹ (2011 KSS modification)	2016/ The Netherlands	No involvement	No	No	No	Yes	No	No	No	0	No
KSS-S ³² (2011 KSS modification)	2016/ USA, Canada	No involvement	No	No	No	Yes	No	No	No	0	No
KOOS ³³	1998/ USA Sweden	With post- traumatic (meniscus surgery) osteoarthritis.	No	No	Yes	Yes	No	No	Yes	1	Yes
KOOS-12 ³⁴ (KOOS modification)	2019/ USA	Had OA	No	No	Yes	Yes	No	No	Yes	1	Yes
KOOS-PS ³⁵ (KOOS modification)	2008/ Sweden, Canada France, Estonia The Netherlands	No involvement	No	No	No	Yes	No	No	No	0	No
KOOS-JR ³⁶ (KOOS modification)	2016/ USA	Scheduled to undergo TKA	No	No	No	Yes	No	Yes	No	1	Yes
AKPS ³⁷	1993/ Finland	No involvement	No	No	No	Yes	No	No	No	0	No
Lille Score	1999/France	No involvement	No	No	No	No	No	No	No	0	No
OKS ³⁸	1998/ UK	Scheduled to undergo TKA	No	Yes	No	No	No	Yes	No	2	Yes
OKS-APQ ³⁹	2014/ UK	Scheduled to undergo TKA or UKA or underwent TKA or UKA between two and 24 months ago.	No	Yes	Yes	No	Yes	No	No	2	Yes
PAQ- Knee ⁴⁰	2012/ USA	No involvement	No	No	No	Yes	No	No	No	0	No

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PKIP ⁴¹	2014/ USA Northern Ireland Australia	Underwent TKA 10 to 18 months ago.	Yes	No	No	Yes	Yes	No	No	2	Yes
PROMIS R-Plus- OAK ⁴²	2018 USA	With knee osteoarthritis or underwent TJA within the previous 12 months	Yes	No	No	Yes	Yes	No	No	2	Yes
WOMAC- TKA function short forms ⁴³ (WOMAC modification)	2013/ Germany	Scheduled to undergo TKA or underwent TKA 3, 6, 12, or 24 months ago	No	No	Yes	Yes	No	No	No	1	Yes

COMI: Core Outcome Measures Index; **HSSP:** Hospital for Special Surgery Patellar score; **IKDC:** International Knee Documentation Committee; **KOS-ADLS:** Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS:** 2011 Knee Society Score; **2011 KSS-A:** Adjusted 2011 Knee Society Score; **KSS-S:** Short-form Knee Society Score; **KOOS:** Knee Injury and Osteoarthritis Outcome Score; **KOOS-12:** 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS:** Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR:** Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS:** Kujala Anterior Knee Pain Scale; **OKS:** Oxford knee score; **OKS-APQ:** Oxford knee score—activity and participation; **PAQ :** Patient Administered Questionnaire; **PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC:**

Table 7.2. Patient involvement in the development of PROMs used after hip arthroplasty

Instrument / Abbreviation/ Development year	Publication year/ Country	Patient recruited during development	Patient involvement in item development				Patient involvement in testing for comprehensibility			Phases with involving patient (n)	Patient involvement
			Focus groups	Interviews	Other methods	other non-patient sources	Cognitive interviews	Other methods	Without patient input		
COMI-Hip ⁴⁴	2013/ Switzerland	No involvement	No	No	No	Yes	No	No	Yes	0	No
Self-reported HHS ⁴⁵ (<i>HSS modification</i>)	2001/ USA Canada	No involvement	No	No	No	Yes	No	No	No	0	No
mHHS ⁴⁶ (<i>HHS modification</i>)	2005/ UK	No involvement	No	No	No	Yes	No	No	No	0	No
HOOS ⁴⁷	2003/ Sweden	With hip disability with or without hip OA.	No	Yes	No	Yes	No	No	No	1	Yes
HOOS-12/2019 (<i>HOOS modification</i>)	2019/ USA	With OA	No	No	Yes	Yes	No	No	Yes	1	Yes
HOOS-PS ⁴⁸ (<i>HOOS modification</i>)	2008/ Canada,UK, Sweden, USA France, Denmark	No involvement	No	No	No	Yes	No	No	No	0	No
HOOS-JR ⁴⁹ (<i>HOOS modification</i>)	2016/ USA	Scheduled to undergo THA	No	Yes	No	Yes	No	No	No	1	Yes
HOS ⁵⁰	2006/ USA	No involvement	No	No	No	Yes	No	No	No	0	No
HAGOS ⁵¹	2011/ Denmark	With hip and/or groin disability	No	Yes	No	Yes	No	Yes	No	2	Yes
Mayo Hip Score ⁵²	1985/ USA	No involvement	No	No	No	Yes	No	No	No	0	No
OHS ³⁸	1996/UK	Scheduled to undergo THA	No	Yes	No	No	No	Yes	No	2	Yes
PAQ-Hip ⁴⁰	2012/ USA	No involvement	No	No	No	Yes	No	No	No	0	No
WOMAC-THA function short forms ⁴³ (<i>WOMAC modification</i>)	2013/ Germany	Scheduled to undergo TKA, or underwent TKA 3, 6, 12, or 24 months ago	No	No	Yes	Yes	No	No	No	1	Yes

COMI: Core Outcome Measures Index; **HHS:** Harris Hip Score; **HOOS:** Hip dysfunction and Osteoarthritis Outcome Score; **HOS:** Hip Outcome Score; **HAGOS:** Hip and Groin Outcome Score; **OHS:** Oxford Hip score; **PAQ** : Patient Administered Questionnaire; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

Table 7.3 Patient involvement in the development of PROMs used after hip or knee arthroplasty

Instrument / Abbreviation / Development year	Publication year/ Country	Patient recruited during development	Patient involvement in item development				Patient involvement in testing for comprehensibility			Phases with involving patient (n)	Patient involvement
			Focus groups	Interviews	Other methods	other non-patient sources	Cognitive interviews	Other method	without patient input		
AAOS Hip and Knee Core Scale ⁵³	2004/ USA	No involvement	No	No	No	Yes	No	No	No	0	No
FJS ⁵⁴	2012/ Austria	Underwent THA and TKA on average 31.2 months ago	No	No	Yes	Yes	No	No	No	1	Yes
MFJS ⁵⁵ (<i>FJS modification</i>)	2018/ UK	Underwent THA and TKA (time after surgery not specified)	No	No	No	Yes	No	Yes	No	1	Yes
JAS ⁵⁶	2023/ USA	No involvement	No	No	No	Yes	No	No	No	0	No
LEFS ⁵⁷	1999/ USA	With any lower-extremity musculoskeletal condition	No	No	Yes	Yes	No	No	No	1	Yes
LLFI ⁵⁸	2012 Australia	With lower-limb conditions	No	No	No	Yes	No	Yes	No	1	Yes
LLFI-10 (<i>LLFI modification</i>)	2016	No involvement	No	No	No	Yes	No	No	No	0	No
LLTQ ⁵⁹	2007/ New Zealand	No involvement	No	No	No	Yes	No	No	Yes	0	No
Lysholm score ⁶⁰	1982/ Sweden	No involvement	No	No	No	Yes	No	No	No	0	No
Marx Activity Rating Scale ⁶¹	2001/ USA	With knee disorder	No	Yes	No	Yes	No	Yes	No	2	Yes
OAKHQOL ⁶²	2005/ France	With hip or knee OA	Yes	Yes	No	Yes	No	No	No	1	Yes
OARS ⁶³	2020/ UK	Underwent THA and TKA from the day of surgery to nine weeks postoperatively	No	Yes	No	Yes	Yes	No	No	2	Yes
OACS ⁶³	2020 UK	Underwent THA and TKA from the day of surgery to nine weeks postoperatively	No	Yes	No	Yes	Yes	No	No	2	Yes
WOMAC	1988	With hip or knee OA.	No	Yes	No	Yes	No	No	No	1	Yes
Hirsch-WOMAC ⁶⁴ (<i>WOMAC modification</i>)	2000 Canada	No involvement	No	No	No	Yes	No	No	Yes	0	No
Whitehouse-WOMAC ⁶⁵ (<i>WOMAC modification</i>)	2003 Australia UK USA	No involvement	No	No	No	Yes	No	No	Yes	0	No

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Instrument / Abbreviation / Development year	Publication year/ Country	Patient recruited during development	Patient involvement in item development				Patient involvement in testing for comprehensibility			Phases with involving patient (n)	Patient involvement
			Focus groups	Interviews	Other methods	other non-patient sources	Cognitive interviews	Other method	without patient input		
Tubach - WOMAC ⁶⁶ (WOMAC modification)	2005/ France	With hip or knee OA.	No	No	Yes	Yes	No	No	No	1	Yes
WOMAC short form(WOMAC modification)	2011/ Spain	No involvement	No	No	No	Yes	No	No	No	0	No

AAOS: American Academy of Orthopaedic Surgeons; **FJS:** Forgotten joint scale; **MFJS:** Modified Forgotten Joint Score; **JAS:** Joint Awareness Score; **LEFS:** Lower extremity functional scale; **LLFI:** Lower Limb Functional Index; **LLFI-10:** Lower Limb Functional Index-10; **LLTQ:** Lower Limb Task Questionnaire; **OAKHQOL:** Osteoarthritis Knee and Hip Quality of Life; **OARS:** Oxford Arthroplasty Early Recovery Score; **OACS:** Oxford Arthroplasty Early Change Score; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index.

Table 7.4 Summary of patient involvement in the development of PROMs used after hip or knee arthroplasty.

	N (%)
Patient involvement in any phase of the development in all PROMs (50 PROMs)	26 (52%)
Patient involvement in one phase	17 (34%)
Patient involvement in two phase	9 (18%)
1. Patient involvement in item development	18 (36%)
Use of interviews	9 (18%)
Survey	8 (16%)
Use of focus groups	2 (4%)
both interview and focus group	1 (2%)
Interview and survey	1 (2%)
Other method (unknown)	1 (2%)
2. Testing comprehensibility	13 (26%)
Cognitive interviews	5 (10%)
Other means than cognitive interviews	8 (16%)

Table 7.5 Comparison of patient involvement in the development of PROMs for knee arthroplasty, hip arthroplasty, and hip or knee arthroplasty.

		PROMs for knee arthroplasty (n=19)	PROMs for hip arthroplasty (n=13)	PROMs for hip or knee arthroplasty (n=18)
With patient involvement	Total patient involvement	10 (53%)	6 (46%)	10 (55.5%)
	Patient underwent arthroplasty involvement	8 (42%)	4 (31%)	4 (22.2%)
	Patient with other lower extremity condition involvement	2 (11%)	2 (15%)	6 (33.3%)
Without patient involvement		9 (47%)	7 (54%)	8 (44.5%)

Table 7.6 Comparing the coverage of PROMs for knee arthroplasty with involving patients in their development

	COMI-knee	HSSP	IKDC	KOS-ADLS	2011 KSS	2011 KSS-A	KSS-S	KOOS	KOOS-12	KOOS-PS	KOOS-JR	AKPS	Lille Score	OKS	OKS-APQ	PAQ-knee	PKIP	PROMIS-OAK	WOMAC-TKA short form	P-Value [†]	
																				Patient involvement vs. coverage	Arthroplasty patient involvement vs. coverage
Number of items	6	4	18	13	31	20	10	42	12	7	7	13	12	12	8	29	24	76	7		
Coverage of key activities covered adequately: within 2 weeks postop (n %)	0	20%	20%	33.3%	13.3%	13.3%	6.7%	53.3%	13.3%	20%	6.7%	6.7%	0	6.7%	0	6.7%	0	13.3%	26.7%	0.86	0.63
Patient involvement in item development					✓		✓	✓						✓	✓		✓	✓	✓		
Patient underwent arthroplasty involvement in item development					✓*										✓?		✓*	✓*	✓?		
Coverage of key activities covered adequately: at 6 weeks postop (n %)	0	19%	12.5%	25%	2.5%	19%	6.3%	44%	6.3%	12.5%	0	6.3%	0	12.5%	0	19%	0	25%	25%	0.55	0.96
Patient involvement in item development					✓		✓	✓						✓	✓		✓	✓	✓		
Patient underwent arthroplasty involvement in item development					✓*										✓*		✓*	✓*	✓?		
Coverage of key activities covered adequately: at 13 weeks postop (n %)	0	37.5%	25%	50%	37.5%	25%	25%	50%	12.5%	12.5%	0	12.5%	0	12.5%	12.5%	37.5%	0	37.5%	37.5%	0.35	0.66
Patient involvement in item development					✓		✓	✓						✓	✓		✓	✓	✓		
Patient underwent arthroplasty involvement in item development					✓*										✓*		✓*	✓*	✓?		
Coverage of key activities covered adequately: at 26 weeks postop (n %)	0	33.3%	33.3%	33.3%	33.3%	16.7%	33.3%	0	0	0	0	16.7%	0	16.7%	0	50%	0	33.3%	33.3%	0.75	0.69
Patient involvement in item development					✓		✓	✓						✓	✓		✓	✓	✓		
Patient underwent arthroplasty involvement in item development					✓*										✓*		✓*	✓*	✓?		

?=Involvement of patient underwent arthroplasty with another group of patients (such as patients with osteoarthritis or patients scheduled for arthroplasty); *= Involvement of patients beyond six months after arthroplasty only; †= P-value obtained from Mann-Whitney U test; A p-value < 0.05 was considered statistically significant

COMI: Core Outcome Measures Index; **HSSP**: Hospital for Special Surgery Patellar score; **IKDC**: International Knee Documentation Committee; **KOS-ADLS**: Knee Outcome Survey Activities of Daily Living Scale; **2011 KSS**: 2011 Knee Society Score; **2011 KSS-A**: Adjusted 2011 Knee Society Score; **KSS-S**: Short-form Knee Society Score; **KOOS**: Knee Injury and Osteoarthritis Outcome Score; **KOOS-12**: 12-item short forms Knee Injury and Osteoarthritis Outcome Score ; **KOOS-PS**: Knee injury and Osteoarthritis Outcome Score - Physical Function Short Form; **KOOS-JR**: Knee Injury and Osteoarthritis Outcome Score Joint Replacement ; **AKPS**: Kujala Anterior Knee Pain Scale; **OKS**: Oxford knee score; **OKS-APQ**: Oxford knee score—activity and participation; **PAQ** : Patient Administered Questionnaire; **PROMIS R-Plus-OAK**: Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **WOMAC**: Western Ontario and McMaster Universities Osteoarthritis Index

Table 7.7 Comparing the coverage of PROMs for hip arthroplasty with involving patients in their development

	COMI-hip	Self-report HHS	Modified HHS	HOOS	HOOS-12	HOOS-PS	HOOS-JR	HOS	HAGOS	Mayo Hip score	OHS	PAQ-Hip	WOMAC-THA short form	P-Value [†]	
														Patient involvement vs. coverage	Arthroplasty patient involvement vs. coverage
Number of items	6	5	8	40	12	6	6	37	37	7	12	26	8		
Coverage of key activities covered adequately: <i>within 2 weeks postop</i>	0	14.3%	14.3%	42.9%	7.1%	7.1%	0	42.9%	7.1%	0	7.1%	7.1%	21.4%	0.70	0.26
Patient involvement in item development				✓			✓		✓		✓		✓		
Patient underwent arthroplasty involvement in item development													✓?		
Coverage of key activities covered adequately: <i>at 6 weeks postop</i>	0	13.3%	13.3%	46.7%	13.3%	6.7%	0	20%	6.7%	0	13.3%	13.3%	26.7%	0.49	0.16
Patient involvement in item development				✓			✓		✓		✓		✓		
Patient underwent arthroplasty involvement in item development													✓?		
Coverage of key activities covered adequately: <i>at 13 weeks postop</i>	0	28.6%	28.6%	42.9%	28.6%	0	0	28.6%	14.3%	14.3%	14.3%	28.6%	28.6%	0.93	0.47
Patient involvement in item development				✓			✓		✓		✓		✓		
Patient underwent arthroplasty involvement in item development													✓?		
Coverage of key activities covered adequately: <i>at 26 weeks postop</i>	0	0	0	25%	25%	0	0	25%	25%	25%	0	25%	0	0.73	0.35
Patient involvement in item development				✓			✓		✓		✓		✓		
Patient underwent arthroplasty involvement in item development													✓?		

?=Involvement of patient underwent arthroplasty with another group of patients (such as patients with osteoarthritis or patients scheduled for arthroplasty);

†= P-value obtained from Mann-Whitney U test; A p-value < 0.05 was considered statistically significant.

COMI: Core Outcome Measures Index; **HHS:** Harris Hip Score; **HOOS:** Hip dysfunction and Osteoarthritis Outcome Score; **HOS:** Hip Outcome Score; **HAGOS:** Hip and Groin Outcome Score; **OHS:** Oxford Hip score; **PAQ:** Patient Administered Questionnaire; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index

Table 7.8 Comparing the coverage of PROMs for hip or knee arthroplasty with involving patients in their development

	AAOS scale	FJS	MFJS	JAS	LEFS	LLFI	LLFI-10	LLTQ	Lysholm score	Marx scale	OAKHQOL	OARS	OACS	WOMAC	Hirsch-WOMAC	Whitehouse-WOMAC	Tubach-WOMAC	WOMAC -Short form	P-Value [†]	
																			Patient involvement vs. coverage	Arthroplasty patient involvement vs. coverage
Number of items	7	12	10	6	20	25	10	20	8	4	43	14	14	24	8	12	8	11		
Coverage of key activities covered adequately: <i>within 2 weeks postop</i>	0	7.1%	0	0	21.4%	0	0	7.1%	0	0	14.3%	0	14.3%	35.7%	7.1%	14.3%	21.4%	21.4%	0.07	0.90
Patient involvement in item development		✓			✓					✓	✓	✓	✓	✓			✓			
Patient underwent arthroplasty involvement in item development		✓*										✓	✓							
Coverage of key activities covered adequately: <i>at 6 weeks postop</i>	0	0	0	0	26.7%	26.7%	13.3%	20%	0	0	13.3%	0	13.3%	46.7%	6.7%	13.3%	26.7%	26.7%	0.57	0.21
Patient involvement in item development		✓			✓					✓	✓	✓	✓	✓			✓			
Patient underwent arthroplasty involvement in item development		✓*										✓	✓							
Coverage of key activities covered adequately: <i>at 13 weeks postop</i>	0	0	0	0	57.1%	42.9%	14.3%	42.9%	0	0	0	0	0	28.6%	0	14.3%	14.3%	14.3%	0.76	0.11
Patient involvement in item development		✓			✓					✓	✓	✓	✓	✓			✓			
Patient underwent arthroplasty involvement in item development		✓*										✓	✓							
Coverage of key activities covered adequately: <i>at 26 weeks postop</i>	0	0	0	0	25%	25%	0	50%	0	0	0	0	0	0	0	0	0	0	0.63	0.41
Patient involvement in item development		✓			✓					✓	✓	✓	✓	✓			✓			
Patient underwent arthroplasty involvement in item development		✓*										✓	✓							

*= Involvement of patients beyond six months after arthroplasty only; †= P-value obtained from Mann-Whitney U test; A p-value < 0.05 was considered statistically significant

AAOS: American Academy of Orthopaedic Surgeons; **FJS:** Forgotten Joint Score; **MFJS:** Modified Forgotten Joint Score; **JAS:** Joint Awareness Score; **LEFS:** Lower extremity functional scale; **LLFI:** Lower Limb Functional Index; **LLFI-10:** Lower Limb Functional Index-10; **LLTQ:** Lower Limb Task Questionnaire; **OAKHQOL:** Osteoarthritis Knee and Hip Quality of Life; **OARS:** Oxford Arthroplasty Early Recovery Score; **OACS:** Oxford Arthroplasty Early Change Score; **WOMAC:** Western Ontario and McMaster Universities Osteoarthritis Index.

Discussion

This scoping review revealed that patients were involved in the development process of 52% of PROMs used after hip or knee arthroplasty, with 20% of these PROMs being developed with input from patients who underwent these procedures. The findings also showed that patients were involved using various methods at different stages of development. These results can guide clinicians and researchers in selecting PROMs that may be more patient-centered. In addition, our findings can help identify whether there is a need to develop new PROMs or modify existing ones and highlight the importance of establishing guidelines for effective patient involvement. Despite the need of a patient-centered approach to outcome measurement,^{67,68} 80% of PROMs used after hip or knee arthroplasty were not developed with input from patients who underwent hip or knee arthroplasty. Instead, these PROMs were developed by researchers, clinicians, individuals with other lower extremity problems, or through other methods. The limited involvement of patients in the development of PROMs does not ensure that they fully capture patients' perspective and concerns, which can undermine their content validity. When PROMs include questions that are not relevant to patients, it can create unnecessary burden, increase the likelihood of missing data, decrease response rate, and ultimately diminish the quality of patient-reported information.⁶⁹ This can impact the evaluation of treatment effectiveness, potentially leading to over or underestimation of treatment efficacy.⁷⁰ Due to limited patient involvement in developing PROMs, it is crucial to analyze the content of these measures to ensure that they accurately reflect patients' perspectives.

Qualitative research is recommended for achieving and assessing content validity, as it facilitates direct communication with patients. This approach allows developers to capture patient perspectives on the concept of interest and evaluate both the comprehension and acceptability of PROM items.⁶⁹ While interviews (either individual or focus group) are generally

preferred for elucidating patient experiences,^{71,72} our research found that these methods were used in only 24% of PROM development processes. In addition, although cognitive interviews, which explore patients' perspectives on item relevance, comprehensiveness, and potential ambiguities, are considered an important step in PROM development,⁷³ our results showed that they were used in developing only 10% of PROMs. These results may explain why we found no difference in the inclusion of key activities between PROMs developed with patient involvement and those without. This suggests that simply involving patients in the development process does not necessarily lead to better coverage of activities that are important to them. These findings could be due to potential barriers to use these methods, such as limited time, budget, and resources, challenges in recruiting a diverse patient sample and effectively engaging patients, the perception of laypeople as subordinate to clinicians, and a limited understanding among patients about the goals of their participation and the absence of clear guidelines.^{6,74} They also underscore the need for more robust methodological guidelines to address potential barriers and to facilitate patient involvement in PROM development.

Although, the value of active patient involvement in the design and delivery of healthcare services is increasingly recognized,⁷ our review found that PROMs were developed using patients merely as sources of information, rather than engaging them collaboratively throughout the research process. For example, while patients were interviewed, the decisions about including or excluding items were typically made by researchers, with limited collaborative input from patients. This could also help explain the lack of difference in the representation of key activities between PROMs developed with patient involvement and those developed without. PROMs were generally developed with research "about" or "to" patients rather than "with" or "by" them.⁷⁵ Given the documented discrepancies between patients' and healthcare providers'

assessments of important health outcomes, there is a clear need to improve actively patient involvement in PROM development and evaluation.⁷⁶ Engaging patient partners could offer a pathway for future PROMs development or evaluation, aiming to strengthen content validity through more collaborative processes. However, this approach may encounter challenges, such as the knowledge to actively participate and whether those who engage are truly representative of the broader patient group.⁶

Patients have different needs at various stages of recovery after arthroplasty,^{77,78} so it is important to consider involving patients at different stages when developing a PROM. This approach may lead to the development of different PROMs tailored to recovery phases. However, among the PROMs involving patients who underwent arthroplasty, only two⁶³ recruited patients at the early stages of recovery, the others recruiting patients much longer after surgery. The lack of information about the stages of recovery during patient recruitment for PROMs development can limit researchers and clinicians in selecting the appropriate tool for various recovery phases.

Regarding the modification of PROMs, patients who underwent arthroplasty were involved in only 17% of the modified versions. The goal of these modifications was to create shorter versions of the original PROMs to address issues related to nonresponse, missing responses, and patient burden.⁷⁹ However, research showed that the length of PROMs may not necessarily be associated with participant response burden, with shorter questionnaires with irrelevant items imposing a greater burden than longer PROMs with relevant items.⁶⁹ Thus, it is recommended to prioritize the relevance of content to the target population rather than focusing solely on reducing the length of PROMs. Shortening PROMs without patient input can lead to the exclusion of relevant items and the inclusion of irrelevant ones.⁶⁹ Thus, patient involvement

is important in the shortening process to maintain content validity. Moreover, computer adaptive testing (CAT), based on item response theory, provides a promising solution for mitigating respondent burden. CAT customizes PROM items to each patient by utilizing an item bank, improving efficiency and reducing the number of questions required, thus shortening completion time without sacrificing validity.⁸⁰ However, involving patients in selecting the item banks is crucial to ensure they encompass all relevant items for patients undergoing arthroplasty at different stages of recovery.⁸⁰

The development of PROMs over time was not statistically significant, and some PROMs continue to be developed without patient input. This is surprising given that many researchers have emphasized the importance of incorporating patient perspectives to ensure both face and content validity, especially in light of the discrepancies between clinician assessments and actual patient experiences.^{67,68,81} This limited progress may be attributed to unresolved barriers mentioned above. With the ongoing shift towards patient involvement in the development of PROMs, there is a clear need for frameworks to establish how best to involve patients in developing PROM tools and how to reconcile differences when patients and experts opinions diverge.

Limitation

One potential limitation of our study is that patient involvement in the PROMs development process was assessed using the information available in the articles. However, some did not provide detailed descriptions of the development process, which means patient involvement might have gone unnoticed.

Conclusion

Although PROMs are intended to gather information directly from patients, around half of PROMs used after hip or knee arthroplasty did not involve patients in their development. When patient involvement did occur, the methods used varied between PROMs with limited use of interviews during item development and cognitive interviews during comprehensibility evaluation, and no patient partner involvement. These findings highlight the need to analyze the content of existing PROMs to ensure they accurately reflect patients' perspectives. Furthermore, as patients may have different needs at various stages of recovery, it is crucial to involve them at various recovery phases during PROM development. Our findings also highlight the importance of establishing guidelines to address potential barriers and to enhance patient involvement, especially the role of patient partners, in the development of PROMs

Conflict of interest

The authors do not report a potential conflict of interest.

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Reference

1. Van Manen MD, Nace J, Mont MA. Management of primary knee osteoarthritis and indications for total knee arthroplasty for general practitioners. *Journal of Osteopathic Medicine*. 2012;112(11):709-715.
2. Neuprez A, Neuprez AH, Kaux JF, et al. Total joint replacement improves pain, functional quality of life, and health utilities in patients with late-stage knee and hip osteoarthritis for up to 5 years. *Clin Rheumatol*. 2020;39(3):861-871. doi:10.1007/s10067-019-04811-y
3. Eichler D, Beaulieu Y, Barry J, Massé V, Vendittoli PA. Perception of a Natural Joint After Total Knee Arthroplasty. *J Arthroplasty*. 2020;35(2):358-363. doi:10.1016/j.arth.2019.09.036
4. Hossain FS, Konan S, Patel S, Rodriguez-Merchan EC, Haddad FS. The assessment of outcome after total knee arthroplasty: are we there yet?. *Bone Joint J*. 2015;97-B(1):3-9. doi:10.1302/0301-620X.97B1.34434
5. Haywood KL. Patient-reported outcome II: selecting appropriate measures for musculoskeletal care. *Musculoskeletal Care*. 2007;5(2):72-90. doi:10.1002/msc.101
6. Wiering B, De Boer D, Delnoij D. Patient involvement in the development of patient-reported outcome measures: The developers' perspective. *BMC Health Serv Res*. 2017;17(1):635. doi:10.1186/s12913-017-2582-8
7. Davies S, Staley K. *Exploring Impact: Public Involvement in NHS, Public Health and Social Care Research*. Involve; 2009.
8. Weldring T, Smith SM. Patient-Reported Outcomes (PROs) and Patient-Reported Outcome Measures (PROMs). *Health Serv Insights*. 2013;6:61-68.doi:10.4137/HSI.S11093
9. Trujols J, Portella MJ, Iraurgi I, Campins MJ, Siñol N, Cobos JP de L. Patient-reported outcome measures: are they patient-generated, patient-centred or patient-valued? *J Ment Health*. 2013;22(6):555-562. doi:10.3109/09638237.2012.734653
10. Karimijashni M, Abtahi F, Abbasalipour S, et al. Functional patient-reported outcome measures after hip or knee arthroplasty: A systematic review and content analysis using the International Classification of Functioning, Disability and Health (ICF). *Arthritis Care Res*. n/a(n/a). doi:10.1002/acr.25413
11. Chang S, Newton PJ, Inglis S, et al. Are all outcomes in chronic heart failure rated equally? An argument for a patient-centred approach to outcome assessment. *Heart Fail Rev*. 2014;19(2):153-162. doi:10.1007/s10741-012-9369-0

12. McKenna SP. Measuring patient-reported outcomes: moving beyond misplaced common sense to hard science. *BMC Med*. 2011;9(1):86. doi:10.1186/1741-7015-9-86.
13. Daudt HM, Van Mossel C, Scott SJ. Enhancing the scoping study methodology: a large, inter-professional team's experience with Arksey and O'Malley's framework. *BMC Med Res Methodol*. 2013;13(1):48. doi:10.1186/1471-2288-13-48
14. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int. J. Soc. Res. Methodol*. 2005;8(1):19-32. doi:10.1080/1364557032000119616
15. Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med*. 2018;169(7):467-473. doi:10.7326/M18-0850
16. Meadows KA. Patient-reported outcome measures: an overview. *Br J Community Nurs*. 2011;16(3):146-151. doi:10.12968/bjcn.2011.16.3.146
17. Dreinhöfer K, Stucki G, Ewert T, et al. ICF Core Sets for osteoarthritis. *J Rehabil Med*. 2004;(44 Suppl):75-80. doi:10.1080/16501960410015498
18. Pisoni C, Giardini A, Majani G, Maini M. International Classification of Functioning, Disability and Health (ICF) core sets for osteoarthritis. A useful tool in the follow-up of patients after joint arthroplasty. *Eur J Phys Rehabil Med*. 2008;44(4):377-385.
19. Lange T, Schmitt J, Kopkow C, Rataj E, Günther KP, Lützner J. What Do Patients Expect From Total Knee Arthroplasty? A Delphi Consensus Study on Patient Treatment Goals. *J Arthroplasty*. 2017;32(7):2093-2099.e1. doi:10.1016/j.arth.2017.01.053
20. Lützner C, Postler AE, Druschke D, Riedel R, Günther KP, Lange T. Ask Patients What They Expect! A Survey Among Patients Awaiting Total Hip Arthroplasty in Germany. *J Arthroplasty*. 2022;37(8):1594-1601.e4. doi:10.1016/j.arth.2022.03.067
21. Research CI of H. Strategy for patient-oriented research capacity development framework. Published online 2015.
22. Riddle DL, Stratford PW, Singh JA, Strand CV. Variation in outcome measures in hip and knee arthroplasty clinical trials: a proposed approach to achieving consensus. *J Rheumatol*. 2009;36(9):2050-2056.
23. Tugwell P, Boers M, Brooks P, Simon L, Strand V, Idzerda L. OMERACT: An international initiative to improve outcome measurement in rheumatology. *Trials*. 2007;8(1):38. doi:10.1186/1745-6215-8-38

24. de Wit M, Abma T, Koelewijn-van Loon M, Collins S, Kirwan J. Involving patient research partners has a significant impact on outcomes research: a responsive evaluation of the international OMERACT conferences. *BMJ open*. 2013;3(5):e002241.
25. Impellizzeri FM, Leunig M, Preiss S, Gugli T, Mannion AF. The use of the Core Outcome Measures Index (COMI) in patients undergoing total knee replacement. *The Knee*. 2017;24(2):372-379.
26. Baldini A, Anderson JA, Zampetti P, Pavlov H, Sculco TP. A new patellofemoral scoring system for total knee arthroplasty. *Clin Orthop Relat Res*. 2006;452:150-154. doi:10.1097/01.blo.0000238847.34047.90
27. Irrgang JJ, Anderson AF, Boland AL, et al. Development and Validation of the International Knee Documentation Committee Subjective Knee Form. *Am J Sports Med*. 2001;29(5):600-613. doi:10.1177/03635465010290051301
28. Irrgang JJ, Snyder-Mackler L, Wainner RS, Fu FH, HARNER CD. Development of a patient-reported measure of function of the knee. *JBJS*. 1998;80(8):1132-1145.
29. Noble PC, Scuderi GR, Brekke AC, et al. Development of a new Knee Society scoring system. *Clin Orthop Relat Res*. 2012;470(1):20-32. doi:10.1007/s11999-011-2152-z
30. Dinjens RN, Grimm B, Heyligers IC, Senden R. Adjustments in 2011 KSS increase the clinical suitability. *Acta Orthop Belg*. 2016;82(1):43-51.
31. Scuderi GR, Sikorskii A, Bourne RB, Lonner JH, Benjamin JB, Noble PC. The Knee Society Short Form Reduces Respondent Burden in the Assessment of Patient-reported Outcomes. *Clin Orthop Relat Res*. 2016;474(1):134-142. doi:10.1007/s11999-015-4370-2
32. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)—Development of a Self-Administered Outcome Measure. *J Orthop Sports Phys Ther*. 1998;28(2):88-96. doi:10.2519/jospt.1998.28.2.88
33. Gandek B, Roos EM, Franklin PD, Ware JE Jr. Item selection for 12-item short forms of the Knee injury and Osteoarthritis Outcome Score (KOOS-12) and Hip disability and Osteoarthritis Outcome Score (HOOS-12). *Osteoarthritis Cartilage*. 2019;27(5):746-753. doi:10.1016/j.joca.2018.11.011
34. Perruccio AV, Stefan Lohmander L, Canizares M, et al. The development of a short measure of physical function for knee OA KOOS-Physical Function Shortform (KOOS-PS) - an OARSI/OMERACT initiative. *Osteoarthritis Cartilage*. 2008;16(5):542-550. doi:10.1016/j.joca.2007.12.014

35. Lyman S, Lee YY, Franklin PD, Li W, Cross MB, Padgett DE. Validation of the KOOS, JR: A Short-form Knee Arthroplasty Outcomes Survey. *Clin Orthop Relat Res*. 2016;474(6):1461-1471. doi:10.1007/s11999-016-4719-1
36. Kujala UM, Jaakkola LH, Koskinen SK, Taimela S, Hurme M, Nelimarkka O. Scoring of patellofemoral disorders. *Arthroscopy*. 1993;9(2):159-163. doi:10.1016/s0749-8063(05)80366-4
37. Dawson J, Fitzpatrick R, Murray D, Carr A. Questionnaire on the perceptions of patients about total knee replacement. *J Bone Joint Surg Br*. 1998;80(1):63-69. doi:10.1302/0301-620x.80b1.7859
38. Dawson J, Beard DJ, McKibbin H, Harris K, Jenkinson C, Price AJ. Development of a patient-reported outcome measure of activity and participation (the OKS-APQ) to supplement the Oxford knee score. *Bone Joint J*. 2014;96-B(3):332-338. doi:10.1302/0301-620X.96B3.32845
39. Mancuso CA, Ranawat AS, Meftah M, Koob TW, Ranawat CS. Properties of the patient administered questionnaires: new scales measuring physical and psychological symptoms of hip and knee disorders. *J Arthroplasty*. 2012;27(4):575-582.e6. doi:10.1016/j.arth.2011.07.014
40. Lewis S, Price M, Dwyer KA, et al. Development of a scale to assess performance following primary total knee arthroplasty. *Value Health*. 2014;17(4):350-359. doi:10.1016/j.jval.2014.01.006
41. Schifferdecker KE, Yount SE, Kaiser K, et al. A method to create a standardized generic and condition-specific patient-reported outcome measure for patient care and healthcare improvement. *Qual Life Res*. 2018;27(2):367-378. doi:10.1007/s11136-017-1675-5
42. Liebs TR, Herzberg W, Gluth J, et al. Using the patient's perspective to develop function short forms specific to total hip and knee replacement based on WOMAC function items. *Bone Joint J*. 2013;95-B(2):239-243. doi:10.1302/0301-620X.95B2.28383
43. Impellizzeri FM, Mannion AF, Naal FD, Leunig M. A Core Outcome Measures Index (COMI) for patients undergoing hip arthroplasty. *J Arthroplasty*. 2013;28(9):1681-1686. doi:10.1016/j.arth.2013.01.014
44. Mahomed NN, Arndt DC, McGrory BJ, Harris WH. The Harris hip score: comparison of patient self-report with surgeon assessment. *J Arthroplasty*. 2001;16(5):575-580. doi:10.1054/arth.2001.23716

45. Sharma S, Shah R, Draviraj KP, Bhamra MS. Use of telephone interviews to follow up
z:10.1258/1357633054068883
46. Klässbo M, Larsson E, Mannevik E. Hip disability and osteoarthritis outcome score. An
extension of the Western Ontario and McMaster Universities Osteoarthritis Index. *Scand J
Rheumatol.* 2003;32(1):46-51. doi:10.1080/03009740310000409
47. Davis AM, Perruccio AV, Canizares M, et al. The development of a short measure of
physical function for hip OA HOOS-Physical Function Shortform (HOOS-PS): an
OARSI/OMERACT initiative. *Osteoarthritis Cartilage.* 2008;16(5):551-559.
doi:10.1016/j.joca.2007.12.016
48. Lyman S, Lee YY, Franklin PD, Li W, Mayman DJ, Padgett DE. Validation of the HOOS,
JR: A Short-form Hip Replacement Survey. *Clin Orthop Relat Res.* 2016;474(6):1472-1482.
doi:10.1007/s11999-016-4718-2
49. Martin RL, Kelly BT, Philippon MJ. Evidence of validity for the hip outcome score.
Arthroscopy. 2006;22(12):1304-1311. doi:10.1016/j.arthro.2006.07.027
50. Thorborg K, Hölmich P, Christensen R, Petersen J, Roos EM. The Copenhagen Hip and
Groin Outcome Score (HAGOS): development and validation according to the COSMIN
checklist. *British journal of sports medicine.* 2011;45(6):478-491.
51. Kavanagh BF, Fitzgerald RH Jr. Clinical and roentgenographic assessment of total hip
arthroplasty. A new hip score. *Clin Orthop Relat Res.* 1985;(193):133-140.
52. Johanson NA, Liang MH, Daltroy L, Rudicel S, Richmond J. American Academy of
Orthopaedic Surgeons lower limb outcomes assessment instruments. Reliability, validity,
and sensitivity to change. *J Bone Joint Surg Am.* 2004;86(5):902-909.
doi:10.2106/00004623-200405000-00003
53. Behrend H, Giesinger K, Giesinger JM, Kuster MS. The “forgotten joint” as the ultimate
goal in joint arthroplasty: validation of a new patient-reported outcome measure. *J
Arthroplasty.* 2012;27(3):430-436.e1. doi:10.1016/j.arth.2011.06.035
54. Robinson PG, Rankin CS, Lavery J, Anthony I, Blyth M, Jones B. The validity and
reliability of the modified forgotten joint score. *J Orthop.* 2018;15(2):480-485. Published
2018 Mar 27. doi:10.1016/j.jor.2018.03.029
55. Porter MA, Johnston MG, Kogan C, Gray CG, Eppich KE, Scott DF. The Joint Awareness
Score: A Shortened, Simplified, Improved Alternative to the Forgotten Joint Score.
Arthroplast Today. 2023;24:101239. Published 2023 Oct 27.
doi:10.1016/j.artd.2023.101239

56. Binkley JM, Stratford PW, Lott SA, Riddle DL. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. North American Orthopaedic Rehabilitation Research Network. *Phys Ther.* 1999;79(4):371-383.
57. Gabel CP, Melloh M, Burkett B, Michener LA. Lower limb functional index: development and clinimetric properties [published correction appears in *Phys Ther.* 2012 Jan;92(1):184]. *Phys Ther.* 2012;92(1):98-110. doi:10.2522/ptj.20100199
58. McNair PJ, Prapavessis H, Collier J, Bassett S, Bryant A, Larmer P. The lower-limb tasks questionnaire: an assessment of validity, reliability, responsiveness, and minimal important differences. *Arch Phys Med Rehabil.* 2007;88(8):993-1001. doi:10.1016/j.apmr.2007.05.008
59. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clinical Orthopaedics and Related Research (1976-2007).* 1985;198:42-49.
60. Marx RG, Stump TJ, Jones EC, Wickiewicz TL, Warren RF. Development and Evaluation of an Activity Rating Scale for Disorders of the Knee. *Am J Sports Med.* 2001;29(2):213-218. doi:10.1177/03635465010290021601
61. Rat AC, Coste J, Pouchot J, et al. OAKHQOL: a new instrument to measure quality of life in knee and hip osteoarthritis. *J Clin Epidemiol.* 2005;58(1):47-55. doi:10.1016/j.jclinepi.2004.04.011
62. Strickland LH, Murray DW, Pandit HG, Jenkinson C. Development of a patient-reported outcome measure (PROM) and change measure for use in early recovery following hip or knee replacement. *J Patient Rep Outcomes.* 2020;4(1):91. doi:10.1186/s41687-020-00262-1
63. Hirsch PB, Gollish JD, Hawker G, Kreder H, Mahomed N, Williams JI. Reduction of the WOMAC using Rasch methodology. In: Information strategy: urgency rating, waiting list management and patient out_comes monitoring for primary hip/knee joint replacement. Toronto: ICES Consensus Group; 2000. p. 68–73.
64. Whitehouse SL, Lingard EA, Katz JN, Learmonth ID. Development and testing of a reduced WOMAC function scale. *J Bone Joint Surg Br.* 2003;85(5):706-711. doi:10.1302/0301-620X.85B5.13681
65. Tubach F, Baron G, Falissard B, et al. Using patients' and rheumatologists' opinions to specify a short form of the WOMAC function subscale. *Ann Rheum Dis.* 2005;64(1):75-79. doi:10.1136/ard.2003.019539

66. Kirwan JR, Fries JF, Hewlett S, Osborne RH. Patient perspective: choosing or developing instruments. *J Rheumatol*. 2011;38(8):1716-1719. doi:10.3899/jrheum.110390
67. McKenna SP. Measuring patient-reported outcomes: moving beyond misplaced common sense to hard science. *BMC Med*. 2011;9(1):86. doi:10.1186/1741-7015-9-86
68. Rolstad S, Adler J, Rydén A. Response burden and questionnaire length: is shorter better? A review and meta-analysis. *Value Health*. 2011;14(8):1101-1108. doi:10.1016/j.jval.2011.06.003
69. Kluzek S, Dean B, Wartolowska KA. Patient-reported outcome measures (PROMs) as proof of treatment efficacy. *BMJ Evid Based Med*. 2022;27(3):153-155. doi:10.1136/bmjebm-2020-111573
70. Lasch KE, Marquis P, Vigneux M, et al. PRO development: rigorous qualitative research as the crucial foundation. *Qual Life Res*. 2010;19(8):1087-1096. doi:10.1007/s11136-010-9677-6
71. Magasi S, Ryan G, Revicki D, et al. Content validity of patient-reported outcome measures: perspectives from a PROMIS meeting. *Qual Life Res*. 2012;21(5):739-746. doi:10.1007/s11136-011-9990-8
72. Collins D. Pretesting survey instruments: an overview of cognitive methods. *Qual Life Res*. 2003;12(3):229-238. doi:10.1023/a:1023254226592
73. Ocloo J, Garfield S, Franklin BD, Dawson S. Exploring the theory, barriers and enablers for patient and public involvement across health, social care and patient safety: a systematic review of reviews. *Health Res Policy Sys*. 2021;19(1):8. doi:10.1186/s12961-020-00644-3
74. Manafo E, Petermann L, Mason-Lai P, Vandall-Walker V. Patient engagement in Canada: a scoping review of the ‘how’ and ‘what’ of patient engagement in health research. *Health Res Policy Sys*. 2018;16(1):5. doi:10.1186/s12961-018-0282-4
75. Hewlett SA. Patients and clinicians have different perspectives on outcomes in arthritis. *J Rheumatol*. 2003;30(4):877-879.
76. Rastogi R, Davis AM, Chesworth BM. A cross-sectional look at patient concerns in the first six weeks following primary total knee arthroplasty. *Health Qual Life Outcomes*. 2007;5(1):48. doi:10.1186/1477-7525-5-48
77. Kennedy DM, Stratford PW, Riddle DL, Hanna SE, Gollish JD. Assessing recovery and establishing prognosis following total knee arthroplasty. *Phys Ther*. 2008;88(1):22-32. doi:10.2522/ptj.20070051

78. Aiyegbusi OL, Cruz Rivera S, Roydhouse J, et al. Recommendations to address respondent burden associated with patient-reported outcome assessment. *Nat Med*. 2024;30(3):650-659. doi:10.1038/s41591-024-02827-9
79. Aiyegbusi OL, Roydhouse J, Rivera SC, et al. Key considerations to reduce or address respondent burden in patient-reported outcome (PRO) data collection. *Nat Commun*. 2022;13(1):6026. doi:10.1038/s41467-022-33826-4
80. Gossec L, Kirwan J, De Wit M. Patient perspective in outcome measures developed by OMERACT. *Indian J Rheumatol*. 2013;8(Suppl 2):S17-S22.

CHAPTER 8: Integrated Discussion

"The secret of the care of the patient is in caring for the patient"

-Francis W. Peabody

The overall purpose of my dissertation research is to explore the patient-centeredness of outcome measures used to assess function following hip or knee arthroplasty. To achieve this goal, I conducted seven studies: (1) a narrative review of key findings related to managing poorer outcomes after hip or knee arthroplasty; (2) a cognitive think-aloud interview with patients who underwent hip or knee arthroplasty, evaluating a developed self-report questionnaire on functional priorities; (3) a systematic review and content analysis of patient-reported outcome measures (PROMs) used to assess function after hip or knee arthroplasty; (4) a systematic review and content analysis of performance-based tests (PBTs) used after hip or knee arthroplasty; (5) a survey of functional activities with patients who underwent hip or knee arthroplasty; (6) a patient-centered content validity analysis of PROMs and PBTs used after hip or knee arthroplasty; and (7) a scoping review of patient involvement in PROMs development. This research may assist researchers and clinicians in selecting outcome measures that better reflect patients' perspectives and needs. Additionally, the findings could inform future efforts to develop new outcome measures or refine existing ones to more accurately capture patients' perspectives. In this final chapter, I first present a summary of the findings from each study associated with this dissertation in Table 8.1, followed by the details of these findings. I then integrate the information from these studies, highlighting common themes and their implications for clinical practice and research in assessing function after hip or knee arthroplasty. Finally, I outline the limitations of the research and conclude with a summary of the key points.

Table 8.1. Summary of Dissertation studies results

Overall aim of dissertation:			
To evaluate the patient-centeredness of outcome measures at different time points following hip or knee arthroplasty			
	Objectives	Methods	Results
Study 1: Narrative Review (<i>Chapter 1</i>)	To provide an overview of the key findings concerning the management of poorer outcomes after hip or knee arthroplasty	Narrative review	This review identified several unanswered questions to optimize outcomes after hip or knee arthroplasty. Future research could include the following: • Evaluating the patient-centeredness of outcome measures to assess recovery after hip or knee arthroplasty. • Determining how provider-assessed and patient-reported outcomes should be integrated or reconciled. • Determining the appropriate method to interpret the outcomes assessments. • Determining MCID, MIC, MDC, PASS and TF values within the first three months post-surgery when significant functional recovery typically occurs. • Determining the MCID, MDC, MIC, PASS, TF values after arthroplasty for patients with different characteristics such as baseline function. • Assessing psychometric properties at various time points after arthroplasty. • Determining whether subpar improvement or worsening of outcomes is more suitable for defining poor outcomes. • Identify which factors, focusing on postoperative factors, are most strongly associated with or predictive of poorer recovery. • Determining how and to what extent factors associated with poorer recovery can be modified, and the impact of these modifications on outcomes.
Study 2: Cognitive think-aloud interview study (<i>Chapter 2</i>)	To develop a self-report questionnaire evaluating functional priorities after hip or knee arthroplasty and evaluate patients' understanding of its items and conceptual relevance.	Qualitative cognitive think-aloud interview with 18 patient undergoing hip or knee arthroplasty	• All categories and corresponding activities of the ICF core set for OA were used to develop the questionnaire. • Several questionnaire issues were identified and addressed. • Most challenges were related to comprehension, followed by item ordering and visual elements. • Patients identified ambiguous wordings, which subsequently were simplified. • Ten activities of the core set were excluded due to lack of face validity, two activities were added, and four activities were modified.
Study 3: Systematic review and content analysis of PROMs (<i>Chapter 3</i>)	To identify the existing PROMs used in hip or knee arthroplasty and assess their content validity using the modified ICF core set for OA	Systematic review and content analysis 50 PROMs	• In this review, 50 PROMs were identified. 28 PROMs were specifically developed for arthroplasty procedures, and the remaining were designed for other lower extremity conditions. • The mobility chapter of activities and participation was the most common component, followed by sensory function and pain chapter of body function and structure. • The most frequent ICF activity and participation categories were d451:going up and down stairs, d4701:using private motorized transportation, d4104:standing, and d4154:maintaining a standing position. • Simple tasks such as changing basic body position covered by 40 PROMs. • Higher intensity activities such as running and doing sports were covered by 21 PROMs

			• 11 ICF categories of the modified OA coreset were not captured in any PROMs. • The HOOS and KOOS had the most coverage for activity and participation, addressing 18 categories (36.7%).
Study 4: Systematic review and content analysis of PBTs (Chapter 4)	To identify the existing PBTs used in hip or knee arthroplasty and assess their content validity using the modified ICF core set for OA	Systematic review and content analysis of 28 PBTs	• This review identified 28 PBTs. Seven were specifically developed for patients undergoing hip or knee arthroplasty and five for lower limb OA • The included PBTs covered 15 activity and participation categories of the OA core set. 34 activity and participation categories were not found in any PBTs • The categories of d4500:walking short distances, d4104:standing and d4103:sitting were the most frequently used, employed in 14, 10, and 10 PBTs, respectively. • A-test had the widest coverage covering 10 out of 49 core set categories. Four PBTs covered four activity and participation categories, one covered three categories, ten covered two categories and 12 covered one category. • The majority of PBTs were linked only to activity and participation components of the core set, with one PBT assessing an impairment (balance) and three PBTs evaluating environmental factors.
Study 5: Survey of functional activities (Chapter 5)	To explore key functional activities from patients' perspective at different timepoint during the first six months after hip or knee arthroplasty	Cross-sectional survey with 632 patients underwent hip or knee arthroplasty	• Patients highlighted different key activities across various stages:14, 15, 13 and 4 key activities were identified within 2 weeks, at 6, 13, and 26 weeks following hip or knee arthroplasty. • During the acute recovery phase, patients focused on simpler activities such as walking short distances and self-care, progressing to more advanced activities like squatting and walking long distances as recovery advanced. • The findings revealed slight differences in key activities between patients undergoing hip and knee arthroplasty. Rising from a chair within two weeks, socializing at six weeks, going up or down stairs at 13 and 26 weeks postoperative were key after knee arthroplasty, but not after hip arthroplasty.
Study 6: Patient-centered content analysis study (Chapter 6)	To evaluate the content of these outcome measures to identify the extent they are patient-centered	Content validity analysis of 78 outcome measures	• The outcome measures showed varying degrees of coverage of key functional activities at different time points following hip or knee arthroplasty. • PROMs failed to capture more than half of the key functional activities or covered them inadequately across various stages of recovery. • All PROMs included between three to 33 non-key elements across four postoperative time points. • PROMs had varying recall periods, with the previous week and previous four weeks being the most common. • For PBTs, 17 out of 28 tests covered less than half of the key activities at two and six weeks, and only one PBT covered a key activity at 13 and 26 weeks after arthroplasty. • Five key activities, including washing lower body parts, putting on clothes, taking off clothes, carrying objects, and placing objects on the floor were not covered by any outcome measures at any time points.
Study 7: Patient involvement scoping review (Chapter 7)	To assess the extent of patient involvement in the development of PROMs used after hip or knee arthroplasty	Scoping review of 50 studies.	• Patients were involved in the development of 26 out of 50 PROMs (52%). • Patients were involved in item development in 22 PROMs (44%), and in comprehensibility testing in 13 PROMs (26%). • Patients who underwent hip or knee arthroplasty were involved in either one or both phases in ten PROMs (20%), and patients with other

			lower extremity conditions other than arthroplasty were involved in 16 PROMs (32%). • Five PROMs involved patients who underwent hip or knee arthroplasty in both item development and comprehensibility evaluation: OKS-APQ, PKIP, PROMIS R-Plus-OAK, OARS, OACS. • Interviews (individual, focus group) were used in 24% and cognitive interviews were used in 10% of PROMs development process. • PROMs with patient involvement between 2008-2015 and after 2015 was higher compared to those developed before 2008, but their differences were not statistically significant ($p = 0.52$).
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A-test: “A” like Activity or Assessment; **HOOS:** Hip disability and Osteoarthritis Outcome Score; **ICF:** International Classification of Functioning, Disability and Health; **KOOS:** Knee injury and Osteoarthritis Outcome Score; **MCID:** Minimal Clinically Important Difference; **MDC:** Minimum Detectable Change; **MIC:** Minimum Important Change; **OA:** Osteoarthritis; **OACS:** Oxford Arthroplasty Early Change Score; **OARS:** Oxford Arthroplasty Early Recovery Score; **OKS-APQ:** Oxford Knee Score-Activity and Participation Questionnaire; **PASS:** patient acceptable symptom state; **PBT:** Performance-based test; **PKIP:** Patient’s Knee Implant Performance Questionnaire; **PROM:** Patient-reported outcome measures; **PROMIS R-Plus-OAK:** Patient-Reported Outcomes Measurement Information System R-Plus-Osteoarthritis of the Knee; **TF:** Treatment Failure.

Summary of Key Findings

In this section, I summarize the key findings from each study included in this dissertation

Narrative review (Study 1)

Although hip or knee arthroplasty is generally a successful intervention, it is documented that up to one third of patients undergoing arthroplasty report suboptimal outcomes. To address this issue, I conducted a narrative review (Study 1) to highlight key areas where additional research is needed to optimize outcomes after arthroplasty. The review emphasized that a thorough exploration of appropriate assessment methods is essential as a first step for accurately identifying patients at risk of or experiencing poorer recovery and for optimizing outcomes. Several factors should be considered when selecting appropriate outcome measures, with further research needed in these areas. This includes understanding patients' priorities throughout the recovery process, evaluating the psychometric properties of these tools at different time points, reconciling provider-assessed and patient-reported outcomes, and determining the best methods for interpreting outcome measure scores. The review also suggested that future efforts to improve postoperative outcomes in patients experiencing or at risk of poorer recovery should focus on identifying key modifiable factors affecting recovery and developing interventions to address these factors. The findings of this review provided a foundation for guiding the subsequent studies in this dissertation.

Think-aloud cognitive interview (Study 2)

As identified in the first study, there is a need to explore postoperative patient priorities after hip or knee arthroplasty to determine the extent to which the outcome measures are patient centered. To address this gap, I first developed a self-reported questionnaire based on the ICF core set for OA for assessing functional priorities after hip and knee arthroplasty. I then evaluated the questionnaire's face and content validity through refinement by three

physiotherapists and cognitive think-aloud interviews with 18 patients who underwent hip or knee arthroplasty (Study 2). The results indicated that most third-level categories of the OA ICF core set are suitable for measuring function at various time points during the first six months after surgery. However, the findings revealed issues with the comprehensibility of ICF terminology, as some items were difficult for patients to understand, and several activities lacked face validity. These issues were subsequently addressed during the validation process. The developed questionnaire and modification of the ICF OA core set provided the basis for studies 3 to 6 in this dissertation.

Systematic review and content analysis of PROM (Study 3)

The most critical factor in selecting appropriate patient-centered PROMs is their content validity, which is often overlooked. There is a need to determine which aspects of function are covered by existing PROMs. Therefore, through a systematic review (Study 3), I aimed to evaluate the content of existing PROMs used to assess function after hip or knee arthroplasty using the modified ICF OA core set. This systematic review identified 50 PROMs and provided detailed information regarding their contents. This content analysis revealed significant variability in how PROMs cover activity and participation categories, though there are similarities among them. The analysis also indicated that some relevant categories were either inadequately covered or infrequently addressed. Moreover, the findings showed that some PROM items addressed multiple concepts or used complex wording, which could affect their interpretation from the patient's perspective and potentially lead to inaccurate results. This content analysis will assist clinicians and researchers in selecting the appropriate PROM by aligning the coverage results with key activities important to patients following hip or knee

arthroplasty. It also informs future research aimed at modifying existing PROMs or developing new ones for hip or knee arthroplasty.

Systematic review and content analysis of PBTs (Study 4)

Despite the availability of various PBTs to objectively assess function, it remains unclear to what extent these tests capture important aspects of functioning after hip or knee arthroplasty. To address this, I conducted a systematic review (Study 4) to identify existing PBTs used after these procedures and to map the activity components of each PBT to the modified ICF core set for OA. Our ICF-based content analysis revealed that the 28 PBTs covered only 15 out of the 49 activity and participation categories in the OA core set. This analysis can guide researchers and clinicians in selecting PBTs or a battery of tests that align with key activities important to patients following hip or knee arthroplasty. Additionally, it may facilitate the development of new PBTs to address concepts that are currently underrepresented.

Survey of functional activity (Study 5)

As mentioned, there remains limited understanding of which activities patients prioritize at various time points after hip or knee arthroplasty, despite a thorough exploration of patients' expectations and goals before surgery. To address this, I conducted a cross-sectional survey (Study 5) with patients who underwent hip or knee arthroplasty using the questionnaire validated in Study 2. It aimed to explore key functional activities from their perspectives at various stages during the first six months after surgery. The survey included 334 and 298 patients who underwent hip and knee arthroplasty respectively, who identified 26 key and 22 non-key functional activities within two weeks, at 6, 13, and 26 weeks after arthroplasty. Patients reported different key activities at each time point, with a decline in the number of key activities over time. These findings can assist clinicians and researchers in choosing outcome measures that

accurately reflect patients' perspectives and in tailoring interventions to better meet patients' needs, ultimately enhancing the recovery process.

Patient-centered content analysis (Study 6)

As demonstrated in previous studies, further research is needed to better understand how existing outcome measures used to assess function after hip or knee arthroplasty align with patients' perspectives, particularly with increasing focus on patient-centered approaches in outcome evaluation. Thus, I conducted a patient-centered content analysis (Study 6) of outcomes measures for hip or knee arthroplasty by mapping the results of Studies 3 and 4 with the results of Study 5. The results showed that the majority of current outcome measures used to assess function after hip or knee arthroplasty do not seem to be patient centered, which may result in inaccurate assessments of interventions following hip or knee arthroplasty. The results also showed that all included PROMs covered non-key elements across the four time periods, which can make the process of collecting outcome burdensome. Our content analysis highlights the need to address deficiencies in existing outcome measures.

Patient-involvement scoping review (Study 7)

Despite the importance of patient involvement in accurately capturing the patient's perspective in the development of PROMs for hip or knee arthroplasty, there is limited understanding of how and to what extent patients have been involved. To address this, I conducted a scoping review (Study 7) to evaluate the extent of patient involvement in the development of 50 PROMs used after hip or knee arthroplasty. The results revealed that approximately half of these PROMs did not involve patients in their development. When patient involvement did occur, it often took place more than six months after arthroplasty. This limited involvement, particularly during the first six months when most recovery occurs, may result in

PROMs that do not fully capture patients' perspectives and concerns. This review showed that various methods were employed to involve patients at different stages of development. In addition, patient involvement did not increase over time and some PROMs continue to be developed without patient input. These findings may explain why existing PROMs, as shown in Study 6, often fail to capture key activities relevant to patients during the first six months following arthroplasty. These findings highlight the need to enhance patient involvement in the development of PROMs, particularly emphasizing the role of patient partners.

Integrated Discussion

Overview of Integrated Discussion

Having summarized the main findings of each study, I now integrate the results from the various components of this dissertation research. In this section, I highlight several themes that could explain the level of patient-centeredness of outcome measures following hip or knee arthroplasty, as well as the unique contributions of each research study in my work. The first theme describes the impact of patient involvement on the coverage of key activities of the outcome measures. The second theme discusses the methods used for developing items in outcome measures. The third through fifth themes address the importance of the comprehensibility of PROMs, their response options and recall periods. The sixth theme compares the length and content of the outcome measures included in my dissertation. In the seventh theme, I discuss the importance of conducting both subjective assessments, using PROMs and objective assessments, using PBTs to create more comprehensive functional assessments. The remaining themes explore the practical implications of my work.

Patient-centered outcome measures following hip or knee arthroplasty: Why are we not there yet?

One central theme emerging from my research is that, despite the intent of PROMs to capture patients' assessments of their functioning and health, Study 6 demonstrated existing PROMs used after hip or knee arthroplasty offer limited coverage of patients' key functional activities. Consequently, many of these PROMs, though designed to be patient-reported, fail to address patient concerns effectively. These PROMs have been classified as "patient-irrelevant outcome measures" rather than "patient-centered outcome measures" (Trujols et al., 2013). Patient-irrelevant outcome measures often focus on aspects deemed important by clinicians or researchers rather than by patients themselves, as demonstrated in Study 7, which revealed that many PROMs were developed based on the judgments of researchers and clinicians. As a result, key functional activities considered important by patients are frequently excluded, while the included aspects are often considered non-key by them. This was highlighted in Study 6, which showed that the number of non-key elements was more than key activities across all included outcome measures. Furthermore, Studies 3 and 6 highlighted that many existing PROMs use ambiguous wording, which complicates interpretation for patients and leads to inadequate coverage of key activities. These issues suggest that the majority of current outcome measures used after hip or knee arthroplasty have suboptimal content validity for functional assessment which may decrease sensitivity and limit responsiveness to change. Such PROMs may lead to higher nonresponse rates, more missing data, and numerous clarifying queries from patients (Trujols et al., 2013). In the following sections, I will discuss the potential reasons why the existing outcome measure could not fully capture the key functional activities that are important to the patients.

Limited patient involvement during outcome measure development

One potential explanation for limited coverage of patients' key functional activities is insufficient involvement of patients during their developments, as highlighted in Study 7. Despite the emphasis over the past decade on the necessity of involving patients in outcome measure development to effectively assess outcomes relevant to patients and improve their clarity (Magasi et al., 2012; Patrick et al., 2007, Trujols et al., 2013), Study 7 revealed that only 20% of PROMs used after hip or knee arthroplasty incorporated input from patients underwent these procedures. Furthermore, Study 4 found that only 25% of PBTs were specifically designed for patients who underwent hip or knee arthroplasty. As previously noted, many outcome measures currently used after arthroplasty are based on the judgments of researchers and clinicians. However, what is considered a good outcome by clinicians or researchers may differ from what patients deem important, and only patients can determine if these measures effectively capture outcomes that matter to them (Connell et al., 2018).

The result of Study 7 showed that the lack of significant association between patient involvement and coverage of key activities suggests that simply involving patients in the development of PROMs does not guarantee improved coverage of relevant activities. In the following sections, I discuss the potential reasons for this lack of association.

Lack of representation of patients who underwent arthroplasty during the first 6 months after surgery

Ensuring that patient involvement is representative can significantly enhance the validity of outcome measures. This approach helps to minimize biases that might otherwise skew the results of outcome measures (Martin, 2008; Scholz et al., 2024). Representativeness is particularly important after hip or knee arthroplasty, given the changes in key activities over time shown in Study 5. Therefore, the representativeness of patients at all stages of recovery should

be a key consideration in the development or modification of existing outcome measures. One of the main reasons why patient involvement did not enhance the coverage of key activities during the first six months after arthroplasty may be due to the insufficient representation of patients who underwent these procedures during this period. This oversight led to a neglect of patients' needs during the first six months, as shown in Study 6. Previous research has noted that not all patient engagement should be considered equally valuable as involving patients may be unhelpful if the sample is not properly representative (Largent et al., 2018).

Findings from Study 7 revealed that, with the exception of four PROMs (Oxford Arthroplasty Early Recovery Score (OARS), Oxford Arthroplasty Early Change Score (OACS), Western Ontario and McMaster Universities Osteoarthritis Index-short form (WOMAC-total knee and hip arthroplasty (TKA/THA)-function short forms and Oxford knee score-activity and participation (OKS-APQ)), none were developed with input from patients who underwent hip or knee arthroplasty within the past six months. While OACS and OARS were specifically designed with input from patients during that period, they were intended to assess all aspects of acute postoperative recovery, including impairments such as nausea and appetite, rather than focusing only on functional recovery. As a result, their developments may not have emphasized functional aspects sufficiently, potentially missing some key activities. WOMAC-TKA/THA-function short forms and OKS-APQ involved patients during the first six months following arthroplasty, but it also included patients scheduled for arthroplasty and those who had undergone these procedures one to two years prior. This broader inclusion may have led to overlooking key activities specific to the three and six-month postoperative. Furthermore, a few PROMs included a mixed population. For instance, PROMIS-OAK included patients who

underwent hip or knee arthroplasty and patients with other health conditions, which may have diluted the focus on key activities relevant to the recovery following arthroplasty.

Lack of active collaboration with patients during the development process

Although the concept of "patient partners" has advanced significantly in various research domains (Brett et al., 2010; Mockford et al., 2012), it has not yet been widely integrated into the process of developing outcome measures. As demonstrated in Study 7, patient involvement has typically been limited to consultative role, where patient included as research subjects providing feedback about their experiences, rather than being actively involved in the design and conduct of the research as "patient partners".

To ensure that PROMs accurately reflect the patient's perspective, it is recommended to involve them more actively in all aspects of the research process from the development of research questions to the analysis of research findings. Evidence suggests that collaborative approaches, where patients are integral members of the research team, have greater potential impact on the development process compared to consultative approaches, where patients are only asked for their opinions (Staniszewska et al., 2012). The lack of patient partners in the development of outcome measures can be attributed to several factors, such as the scarcity of well-documented guideline illustrating how patients can effectively participate in the process and what their contributions should entail (De Wit et al., 2015).

Although it is recommended that patients be involved at all stages of the research process, Study 7 found that only nine PROMs involved patients as research participants in both item development and comprehensibility evaluation, with no PROMs incorporating patient partners throughout the development process. Consequently, researchers manage the organization, analysis, synthesis, and utilization of data in shaping the final outcome measures,

with limited input from patients in these processes. Considering the valuable insights patients can provide, researchers should enhance the PROM development process by integrating patient involvement more comprehensively. (Staniszewska et al., 2012).

Lack of consideration for the evolution of functional recovery following arthroplasty

Despite the demonstration of functional recovery patterns over time following arthroplasty, the methods used to assess patients throughout recovery have not significantly evolved in recent years. As mentioned previously, a shift in patient priorities over time following hip or knee arthroplasty was highlighted in Study 5. Not surprisingly, patients initially focus on simpler tasks, but as they progress, their priorities shift toward more complex activities. This shift in priorities has been documented in previous research (Liebs et al., 2013; Rastogi et al., 2007). These results suggest that the development of outcome measures should better account for changes in functional recovery and patients' key activities throughout their recovery journey.

The content analysis from Study 6 reveals that many PROMs tend to provide better coverage of key activities during the later stages of recovery, while PBTs cover more for early phase assessments. This observation aligns with previous research, which suggests that current PROMs often fail to capture changes in early recovery, compared to PBTs (Kennedy et al., 2006). This might be due to the use of PROMs that are not suitable for the early phase of recovery. Inappropriate PROMs for early recovery stages can limit the responsiveness of outcome measures, potentially leading to inaccurate assessments of patients' outcomes, either overestimating or underestimating their progress (Eckhard et al., 2021; Hossain et al., 2015). Also, most PBTs assess basic key activities relevant in earlier stages of recovery but fail to capture more advanced activities relevant in the later stages. Therefore, most current PBTs are less useful for detecting improvement in later stages (Alomar et al., 2020; Huber et al., 2016).

This finding is consistent with Study 6, which revealed that, apart from one exception, PBTs did not address key recovery priorities at later stages of recovery.

These results imply that outcome measures should be designed to better capture changes in functional recovery following arthroplasty. Currently, this aspect has been overlooked, resulting in a gap in the relevance of PROMs and PBTs for use during the first six months following arthroplasty which can increase the floor and ceiling effect at various time points following arthroplasty.

Application of inadequate methods for item development

Item development is a fundamental step in creating outcome measures. When done properly, it ensures that the items in an outcome measure accurately and comprehensively represent the intended construct (Sinclair et al., 2020). Developing robust outcome measures should involve both inductive and deductive processes. The process begins with creating an appropriate conceptual model, which is an inductive step involving the establishment of a theoretical foundation for the construct based on literature, expert opinion, and qualitative research with patients. Once this theoretical foundation is established inductively, it serves as the basis for item development through a deductive process, where the conceptual model guides the generation of an initial pool of items (Brod et al., 2009; Sinclair et al., 2020).

The most appropriate way to incorporate patient input during the inductive process is through qualitative research involving direct communication with patients to fully understand their perspectives. This input can be gathered via individual interviews and focus groups, which capture a range of unobservable experiences, including thoughts, feelings, intentions, and past behaviors (Rothrock et al., 2011). Despite the emphasis on the importance of a rigorous qualitative approach to ensure content validity in item development (Brod et al., 2009; Lasch et

al., 2010; Leidy & Vernon, 2008), this aspect often receives insufficient attention in the development of PROMs for hip or knee arthroplasty. Study 7 of this dissertation found that only 18% of PROMs were developed using individual interviews, and 6% used focus groups. Among these, just 6% of PROMs used individual interviews and 4% used focus groups with patients who underwent hip or knee arthroplasty. In addition, it has been suggested that both focus groups and individual interviews should be considered complementary rather than mutually exclusive. These methods can provide different types of information and help outcome measure developers obtain data saturation. Focus groups capture a broad range of experiences and perspectives, whereas individual interviews provide an opportunity for in-depth exploration (Brod et al., 2009). However, Study 7 indicated that only one PROM (Osteoarthritis Knee and Hip Quality of Life (OAKHQOL)) was developed using both interviews and focus groups, albeit with patients who had hip or knee OA.

When modifying existing outcome measures, the relevance of the content for patients should be evaluated, and any areas of interest that outcome measures may not currently address should be identified. However, Study 7 showed that in most outcome measure modifications patients were only asked whether the existing outcome measures' items were relevant to them, with less emphasis on evaluating if the existing PROMs are missing any relevant items.

Impact of item comprehensibility on patient-centeredness of outcome measures

PROMs should be designed to be easily readable and understandable for patients of all health literacy levels. This ensures that responses accurately reflect the patient's experience, which is essential for precise measurement and equitable patient-centered care (Issa et al., 2024). If questions are complex or difficult to understand, respondents may be reluctant to put in the effort required to provide meaningful answers and might instead choose neutral or non-

substantive responses, such as "don't know" (Lenzner, 2012). This can lead to less accurate answers and hinder clinicians' and researchers' ability to accurately assess patient improvement. If patients struggle to understand the questionnaires, it can impact their engagement in their care and undermine the patient-centeredness of PROMs (Issa et al., 2024). Poor comprehensibility can also result in lower completion rates, less accurate responses, and exclusion of individuals with low health literacy, thereby compromising the validity of PROMs (Tuinenburg et al., 2024). Clear and straightforward questions are essential to minimize response errors and maintain the quality of PROMs. Thus, the comprehensibility of PROMs is crucial for ensuring their content validity (Terwee et al., 2018). This issue was highlighted in Studies 3 and 6, where many categories were not covered due to comprehensibility problems. A common problem across all PROMs was the inclusion of multiple activities within a single item. For example, the 2011 Knee Society Score (2011 KSS) includes an item about "climbing up or down a flight of stairs". If a patient has difficulty going up stairs but not going down, it is unclear how to respond accurately. Such ambiguous items should be split into separate items during the development phase. This issue was identified in Study 2 through cognitive interviews with patients, which led to the splitting of some questions. This has also been noted in previous research (Comins et al., 2021).

It is recommended to use qualitative methods involving patients, such as cognitive interviews, to assess comprehensibility during the development of PROMs (Terwee et al., 2018). Results from cognitive interviews in Study 2 also revealed that the developed questionnaire required significant modifications that had been overlooked by researchers and clinicians. However, Study 7 found that only 26% of PROMs were evaluated for comprehensibility with patient involvement, and only 10% used cognitive interviews. Therefore, greater emphasis is needed on evaluating comprehensibility during the development and modification of PROMs.

The impact of response option on content validity

Choosing an appropriate response option to capture the patient experience is an important aspect in PROM development, as it can affect the validity of the PROMs (Haywood et al., 2017). It has been recommended that the choice of response format should be given the same amount of thought and examination as typically is put into the development of the PROM items themselves (Simms et al., 2019). However, Study 3 showed variability in the response option of the PROMs used after hip or knee arthroplasty. The optimal number of response options is debated, as it depends on balancing the simplicity of the scale with the need to maintain its validity and reliability (Haywood et al., 2017; Nadler et al., 2015). If options do not cover the range of perceptions, participants may have to select a response that is not an accurate reflection of their true perception. For example, the response options "yes, partly, no" used in Lower Limb Functional Index (LLFI) items that assess the functional activity difficulty are vague and do not capture varying degrees of difficulty. Someone might experience mild versus severe difficulty, but these nuances are not reflected. Moreover, respondents may interpret "partly" in different ways, which can lead to variability in responses. In contrast, if there are too many response options offered, participants may have trouble differentiating between similar response levels causing them to arbitrarily choose a response option (Nadler et al., 2015). It has been suggested that the appropriate number of response options should balance accuracy with practicality. The greater the number of options will enhance the ability of the patient to communicate their experience, thus enhancing precision and discriminant validity, whilst also increasing reliability and responsiveness. However, a smaller number of response options improve practicality (Streiner et al., 2024).

In addition, research has shown that questions with level of agreement response options, such as “strongly agree/tend to agree/neither agree nor disagree/tend to disagree/strongly disagree” in the OKS-APQ, generally lead to less nuanced responses compared to those with item-specific response options such as “no trouble/very little trouble/moderate trouble/extreme difficulty/impossible to do” in the OKS. The latter provided more detailed and accurate data, as respondents could more precisely indicate their perception with specific aspects of each item and may offer greater clarity and relevance in capturing respondents' true opinions and experiences (Saris et al., 2010).

Another aspect to consider is whether a PROM should use different response options for various functions or subscales. For instance, the OKS or 2011 KSS use varied response options for different questions, while WOMAC uses the same response options. While a uniform response set can streamline the process for respondents by avoiding the cognitive shifts required when switching between different scales, it may not always be ideal. Imposing a single response set for all items could lead to a mismatch, where alternative response options might better capture the nuances of different questions (Kroenke et al., 2015).

The impact recall period on content validity

The recall period in PROMs is important for ensuring the validity of outcome assessments and must be carefully considered during PROM development (Stull et al., 2009). However, Study 6 found that ten PROMs lacked a specified recall period, while others varied widely, ranging from the past two hours to the past year. This wide range highlights the challenge of selecting a one-size-fits-all recall period. Selecting the recall period should be a balancing act between recall accuracy (presumably favored by shorter time frames) and the

benefits of “time averaging” (so that one bad day or week does not overestimate the magnitude of the problem) (Kroenke et al., 2015).

The most important factor in choosing a recall period is the concept of being measured and how accurately patients can provide information over different time frames (Norquist et al., 2012). Following hip or knee arthroplasty, the selection of an appropriate recall period should consider the rate of postoperative functional recovery and frequency of key activities identified in Study 5. During the early phase following surgery, functional improvement is often rapid and characterized by considerable weekly variations. In addition, the key activities in the early phase of recovery occur frequently since they are basic daily activities, such as sitting on a chair, and personal care. Therefore, using a longer recall period (e.g. one month) could result in less accurate assessments of functional status. On the other hand, improvement becomes slower in the later stage of recovery, and the variations in function are less pronounced. Also, the key activities during this later stage are less frequent since they are more advanced, such as lifting heavy objects or walking on different surfaces. Thus, a shorter recall period (e.g. today or past week) might not allow sufficient time for the activity to occur, potentially failing to capture important functional changes. Therefore, a longer recall period might be less burdensome and offer a more comprehensive view of patient progress. The choice of recall period should balance the need for accurate, real-time data and minimize patient burden (Norquist et al., 2012). To enhance the validity of PROMs and reduce variability in outcome measures, further research is needed to determine and standardize the most appropriate recall periods appropriate for the recovery pattern following hip or knee arthroplasty.

Evaluating the trade-offs: long vs. short PROMs in terms of coverage and brevity

The relationship between the length and coverage of current PROMs is often inverse. Longer PROMs provide higher coverage of key activities, offering a more comprehensive view of a patient's condition compared to shorter PROMs. This can be particularly beneficial for capturing diverse and nuanced changes in functional recovery (Rolstad et al., 2011). Longer measures may be preferred if they include relevant items, even if they are lengthier. Research indicates that patients are more engaged with questionnaires that address their specific needs and concerns, suggesting that content relevance outweighs the consideration of length (Rolstad et al., 2011). However, Study 6 found that PROMs with more items and broader coverage also tend to include more irrelevant activities, which reduce their validity. It may also increase respondent burden and potentially lead to participant fatigue.

In contrast, shorter PROMs like the WOMAC Short Form-TKA are designed to be more concise by focusing on fewer aspects of function. While they offer less comprehensive coverage, they typically contain fewer irrelevant items, as shown in Study 6, which may enhance their validity. It can also reduce the burden on respondents and lead to potentially higher response rates (Rolstad et al., 2011). However, shorter PROMs may miss important key activities that longer PROMs can capture, often because they are developed through item reduction methods (e.g., factor analysis) rather than incorporating patient input. Study 7 revealed that only three out of 18 modified PROMs were adjusted based on input from patients who underwent hip or knee arthroplasty. Shorter PROMs developed without sufficient patient input might not cover all relevant aspects, potentially limiting their validity. Therefore, it is recommended to enhance the quality of shorter PROMs by incorporating patient input. This approach can offer additional benefits beyond those gained from having fewer items (Rolstad et al., 2011).

Ultimately, the choice between longer and shorter PROMs should balance the need for comprehensive coverage with the practical considerations of respondent burden. Tailoring the length and content of PROMs to the specific needs of the study and patient population is important for obtaining valid data.

Evaluating function following arthroplasty: PROMs and PBTs

When deciding whether to use PROMs or PBTs following arthroplasty, it is essential to consider the advantages and limitations of each method. PROMs are valued for their ease of administration due to limited human and physical resource requirements and require no training. Also, PROMs do not necessitate clinic visits, which helps minimize patient dropout rates (Dayton et al., 2016; Mizner et al., 2011). These measures capture the patient's perception of their own functional ability, providing valuable insights into how patients feel about their recovery and overall function and quality of life (Mizner et al., 2011). However, PROMs have their drawbacks. They dependent upon patient's perception, which can sometimes lead to overestimation or underestimation of functional abilities, particularly influenced by pain (Dayton et al., 2016). Differentiating between pain and function can be challenging because they often impact each other, especially when their effects are not aligned. For instance, early postoperative pain might appear less severe compared to preoperative condition, leading to a more positive outlook and reported improvement in pain levels. This perception of pain reduction can result in patients reporting improvements in their condition, even though acute decline in functional activities might be present during the early recovery phase, as indicated by objective assessments (Dayton et al., 2016). In addition, it is influenced by socio-economic, cultural and psychological factors (Clement et al., 2011; Lavernia et al., 2012). Cultural differences may also affect their global applicability, requiring validation for use in different languages (Konan et al., 2014).

On the other hand, PBTs offer a more objective assessment of physical function. These tests are less susceptible to external influences like cognitive ability, cultural background, and language differences, providing a clearer picture of a patient's actual functional capacity (Latham et al., 2008). PBTs have been shown to be more responsive than PROMs in the acute stages following surgery. However, this pattern reverses when assessing long-term outcomes. Thus, there is poor concurrent validity between PROMs and PBTs following arthroplasty (Mizner et al., 2011). Study 6 supports this finding, showing that PBTs provide better coverage of key activities early in the recovery process, while most PROMs tend to offer better coverage during the later stages of recovery. Despite their benefits, PBTs are more resource-intensive, requiring equipment and trained personnel, more time-consuming to administer than PROMs which can make them less practical for routine clinical use (Konan et al., 2014). However, conducting virtual PBTs has recently been proposed as a way to provide valid and reliable remote measurements of real-life functional outcomes and overcome the limitations of in-person testing (Guidarelli et al., 2022). Also, self-assessed PBTs (i.e. patients perform activities independently and report their performances) has been proven as feasible and reliable in population with other health problems (Razmjou et al., 2023).

Considering these factors, a combined approach that integrates both PROMs and PBTs is often recommended (Bolink et al., 2015; Capin et al., 2022; Dayton et al., 2016; Mizner et al., 2011; Stevens-Lapsley et al., 2011). This dual approach provides a more accurate and holistic evaluation of recovery following arthroplasty by capturing both the subjective experiences of the patient and objective measures of functional performance.

Implications for future research

This dissertation identified several areas to enhance the patient-centeredness of outcome measures used after hip or knee arthroplasty. As noted, Study 6 highlighted that current measures often overlook activities important to patients, leading to reduced relevance and potential measurement issues. To address this concern, improvements in outcome measures are needed to better capture patient-relevant activities and needs. An important step forward is developing a guideline aimed at enhancing patient-centeredness by incorporating patient input throughout various stages of PROM development. This guideline should detail how patients should be involved from the initial development of a conceptual model through to the interpretation of results. It should be developed collaboratively with input from researchers, clinicians, relevant organizations, and patients. Such an inclusive approach will ensure that outcome measures are designed and refined to better reflect what is important to patients and to provide more comprehensive coverage of their needs.

The findings of this dissertation highlighted that existing PROMs and PBTs covered varying degrees of key activities. Thus, relying on a single existing outcome measure for assessing function may not be desirable due to the gaps in coverage of key activities across the outcome measures. Instead, a promising direction is the development of new tools that either combine existing PROMs or map scores from different PROMs onto a common scale. Recent efforts, such as the mapping of the OKS and the High Activity Arthroplasty Score (HAAS) using item response theory, have shown that creating a common scale can overcome limitations such as the ceiling effect of the OKS (Harrison et al., 2023). This approach provides a more precise measurement of function compared to using the OKS or HAAS individually. However, administering multiple outcome measures may increase the burden on patients, as this

dissertation also revealed that various PROMs cover many of the same key activities. To address this, future research should focus on integrating different PROMs into a unified tool rather than administering multiple measures and mapping their scores. This would optimize the assessment process by reducing the need for multiple tools while ensuring comprehensive coverage of relevant activities. In addition, future research should investigate the feasibility of combining PBTs that cover distinct key activities to develop a battery of tests to achieve a more comprehensive assessment at each time point following arthroplasty

Also, five key activities, including washing lower body parts, putting on clothes, taking off clothes, carrying objects, and placing objects on the floor were not covered by any PROMs. Future research should address these gaps when developing, modifying, or combining PROMs. Also, 18 key activities were not covered by any PBTs. Tests used in other populations such as the Barthel Index, Dressing Performance Scale (DPS) or Functional Independence Measure (FIM) assess activities like putting on and taking off clothing or bathing. This suggests addressing gaps in key activities assessment following hip or knee arthroplasty is feasible.

A more appealing solution that should be explored in future research is the development of a computerized adaptive test (CAT) for hip or knee arthroplasty outcomes. This advanced tool could dynamically select the most relevant items based on an individual's responses to previous questions. This tailored approach ensures that only the most pertinent questions are administered, enhancing the precision of the assessment while significantly reducing the number of items the patient needs to complete, making the evaluation experience more manageable and engaging (Hung et al., 2014). Future research should concentrate on developing and validating a CAT specifically for hip or knee arthroplasty, emphasizing the development of an item bank that covers all key activities.

In this dissertation, I analyzed the content of functional outcome measures based on all key activities identified in Study 5. Given that some activities may correlate with one another, future research could do further examine the results of this thesis, using factor analysis. By identifying which items cluster together, factor analysis can help determine the essential key activities to include, resulting in shorter, more efficient tools without compromising validity. This method effectively condenses large datasets into a smaller set of factors, revealing underlying concepts and facilitating interpretation. By prioritizing essential key activities over a multitude of trivial ones, this approach may allow for more meaningful data categorization, enhancing clarity and relevance in clinical practice (Floyd, 1995).

Implications for clinical practice

Patient-centered care is achieved when clinicians consider patients' needs and concerns. To facilitate this, data from patient-centered outcome measures should be collected and utilized by clinicians to ensure that patient perspectives are incorporated into care decisions (Wolff et al., 2021). This dissertation provided important insights into the coverage of key activities and the number of non-key elements across various outcome measures. Also, it provided information regarding the role of patient involvement in the development of PROMs. This information enables clinicians to select the most appropriate outcome measures based on their goals, ensuring these measures align closely with patients' needs and preferences in clinical practice.

As noted, this dissertation identified a wide range of outcome measures available for assessing function following hip or knee arthroplasty. This diversity of outcome measures potentially leads to problems when clinicians are attempting to integrate findings from multiple trials when different outcome measures are used. In addition, none of these outcomes could fully capture the activities mattering most to the patients. Given the time required for researchers and

clinicians to develop or modify outcome measures, there may be a need for consensus among stakeholders, including clinicians, patients, and decision-makers, on selecting the most appropriate current outcome measures to better align with patient priorities at various time points, emphasizing on higher coverage of key activities and lower number of non-key elements.

As described in the previous sections, this dissertation also identified the functional activities that patients prioritized at various stages of recovery following hip or knee arthroplasty. This knowledge allows clinicians to tailor care plans more effectively. By focusing on the activities that patients prioritize, clinicians can develop treatment strategies that resonate with patients' specific goals and needs. This patient-centered approach not only enhances the relevance of postoperative interventions but also promotes patient-provider communication, better adherence to treatment plans, leading to improved overall outcomes (Rathert et al., 2013; Tran, 2021). When patients feel that their individual concerns are being addressed, they are more likely to experience higher satisfaction with their care (Oates et al., 2000). This approach is particularly important for patients who are experiencing or are at risk of poorer outcomes. Identifying patient needs and concerns and engaging them in shared decision-making help recognize the areas that require more attention, thereby improving their recovery (Giovannetti et al., 2021). Moreover, understanding patients' priorities can help reduce the need for additional investigations or referrals. When patients are actively involved in setting their recovery goals and their concerns are adequately addressed, they are less likely to require further interventions. This not only optimizes the care process but also reduces the burden on healthcare resources (Oates et al., 2000).

Understanding patient priorities has implications for cost-effectiveness and resource allocation. By identifying what matters most to patients, decision-makers can assess the value of

postoperative interventions more accurately and prioritize resources accordingly. This knowledge enables the identification of patient groups who may benefit more from postoperative interventions, including rehabilitation. As a result, resources can be allocated more effectively, directing them toward those who stand to gain the most from these interventions. This approach is particularly important as healthcare systems transition from a volume-based to a value-based model. This shift aims to enhance the sustainability of the healthcare system and improve patient outcomes and experience (Obama, 2016; Spertus & Ghaferi, 2017). However, implementing interventions tailored to patient priorities presents challenges. It requires changes across all levels of healthcare delivery, including provider and patient expectations (Giovannetti et al., 2021).

Limitations

One limitation of my dissertation was that in addition to having clinicians such as orthopedic surgeons and physiotherapists as knowledge users in my research team, I was unable to include patient partners. This was largely due to the challenges imposed by the COVID-19 pandemic and the subsequent post-pandemic period. Despite these challenges, I made efforts to incorporate patient perspectives into the research by conducting interviews and surveys with patients. These methods provided valuable insights into their experiences and preferences, helping to address some of the gaps created by the absence of patient partners. Also, during the recruitment process, I had the opportunity to interact with a variety of patients, which allowed me to gather further valuable feedback and perspectives.

Another potential limitation is that the findings of this dissertation are limited to the first six months after arthroplasty, when most functional recovery typically occurs following arthroplasty. Since rehabilitation and recovery can extend beyond this period for specific patients

(Westby & Backman, 2010), further research is needed to determine if these results are applicable to longer timeframes. However, previous studies have indicated similar functional priorities one year following arthroplasty (Du et al., 2014; Harada et al., 2022; Weiss et al., 2002), suggesting that the results of this dissertation may be relevant for extended recovery periods.

Another limitation of this dissertation is that the patient recruitment was conducted at a single site in Canada. This geographic and site-specific limitation may affect the generalizability of the findings. The content analysis of outcome measures was based on the results from this survey, which might not fully represent the diverse range of patient experiences and outcomes in different contexts. While participants from different ethnic backgrounds were recruited in the survey, it is possible that patient priorities could vary across multiple sites with various healthcare systems and cultural contexts.

Another potential limitation is that participants were exclusively recruited from English and French-speaking populations due to the absence of translators in my research team. Also, I did not collect information on socioeconomic status of participants including education for the survey and cognitive think-aloud interviews. Consequently, some socioeconomic subgroups might be underrepresented. When developing questionnaires, it is important to ensure they are designed to be applicable to participants with varying levels of literacy. Despite this limitation, the use of convenience sampling to recruit participants and the high acceptance rates for both the survey and cognitive interview studies increase my confidence that participants from a range of socioeconomic statuses were included in these two studies.

Finally, in this dissertation, I focused on functional outcomes as one of the primary goals for patients following hip or knee arthroplasty. However, other aspects of care that patients may

prioritize at different stages after surgery should be identified in future research and incorporated into postoperative assessments. Also, future research is needed to determine whether function and other aspects should be assessed simultaneously or, if not, to establish the optimal timing for evaluating other symptoms.

Conclusion

The findings from the seven studies presented in this dissertation highlighted the importance of selecting appropriate outcome measures to accurately identify patients at risk of poorer recovery and to optimize outcomes following hip or knee arthroplasty. Central to this selection process is the extent to which outcome measures incorporate patients' perspectives. This dissertation identified 28 key activities within two weeks, at six weeks, 13 weeks, and 26 weeks following hip or knee arthroplasty. Understanding these activities enables clinicians to choose outcome measures that accurately reflect patients' perspectives and to tailor interventions to better align with patients' needs, thereby optimizing recovery. The content analysis of 50 PROMs and 28 PBTs used after hip or knee arthroplasty revealed that these measures do not fully capture all activities important to patients at various stages of recovery. Several reasons were explored for this limited coverage of key activities, including insufficient patient involvement in the development of these measures, and issues with comprehensibility, response options, and recall periods. This analysis provides valuable insights into selecting outcome measures for clinical practice by considering their coverage of relevant and less relevant activities and their overall length. The dissertation also emphasized the need to address deficiencies in existing outcome measures to more accurately capture patient-relevant activities throughout the recovery process. This can be achieved through the development of new outcome measures or by modifying or combining existing ones.

References (Chapter 1(part 3), Chapter 8)

- Algurén, B., Coenen, M., Malm, D., Fridlund, B., Mårtensson, J., Årestedt, K., & Collaboration and Exchange in Swedish cardiovascular caring Academic Research (CESAR) group (2020). A scoping review and mapping exercise comparing the content of patient-reported outcome measures (PROMs) across heart disease-specific scales. *Journal of patient-reported outcomes*, 4(1), 7. <https://doi.org/10.1186/s41687-019-0165-7>
- Alomar, J. A., Catelani, M. B. C., Smith, C. N., Patterson, C. G., Artman, T. M., & Piva, S. R. (2020). Validity and Responsiveness of Floor Sitting-Rising Test in Post-Total Knee Arthroplasty: A Cohort Study. *Archives of physical medicine and rehabilitation*, 101(8), 1338–1346. <https://doi.org/10.1016/j.apmr.2020.03.012>
- Alviar, M. J., Olver, J., Brand, C., Hale, T., & Khan, F. (2011). Do patient-reported outcome measures used in assessing outcomes in rehabilitation after hip and knee arthroplasty capture issues relevant to patients? Results of a systematic review and ICF linking process. *Journal of rehabilitation medicine*, 43(5), 374–381. <https://doi.org/10.2340/16501977-0801>
- Institute of Medicine (US) Committee on Quality of Health Care in America. (2001). *Crossing the Quality Chasm: A New Health System for the 21st Century*. National Academies Press (US).
- Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International journal of social research methodology*, 8(1), 19-32.
- Baethge, C., Goldbeck-Wood, S., & Mertens, S. (2019). SANRA-a scale for the quality assessment of narrative review articles. *Research integrity and peer review*, 4, 5. <https://doi.org/10.1186/s41073-019-0064-8>
- Bauernfeind, B., Aringer, M., Proding, B., Kirchberger, I., Machold, K., Smolen, J., & Stamm, T. (2009). Identification of relevant concepts of functioning in daily life in people with systemic lupus erythematosus: A patient Delphi exercise. *Arthritis and rheumatism*, 61(1), 21–28. <https://doi.org/10.1002/art.24165>
- Berta, W., Barnsley, J., Brown, A., & Murray, M. (2008). In the eyes of the beholder: Population perspectives on performance priorities for primary care in Canada. *Healthcare Policy*, 4(2), 86.
- Boldt, C., Brach, M., Grill, E., Berthou, A., Meister, K., Scheuringer, M., & Stucki, G. (2005). The ICF categories identified in nursing interventions administered to neurological patients with post-acute rehabilitation needs. *Disability and rehabilitation*, 27(7-8), 431–436. <https://doi.org/10.1080/09638280400014071>
- Bolink, S. A., Grimm, B., & Heyligers, I. C. (2015). Patient-reported outcome measures versus inertial performance-based outcome measures: A prospective study in patients

- undergoing primary total knee arthroplasty. *The Knee*, 22(6), 618–623.
<https://doi.org/10.1016/j.knee.2015.04.002>
- Brett, J. O., Staniszewska, S., Mockford, C., Seers, K., Herron-Marx, S., & Bayliss, H. (2010). The PIRICOM Study: A systematic review of the conceptualisation, measurement, impact and outcomes of patients and public involvement in health and social care research.
- Brockow, T., Cieza, A., Kuhlowl, H., Sigl, T., Franke, T., Harder, M., & Stucki, G. (2004). Identifying the concepts contained in outcome measures of clinical trials on musculoskeletal disorders and chronic widespread pain using the International Classification of Functioning, Disability and Health as a reference. *Journal of Rehabilitation Medicine*, 44 Suppl, 30–36. <https://doi.org/10.1080/16501960410015371>
- Brod, M., Tesler, L. E., & Christensen, T. L. (2009). Qualitative research and content validity: developing best practices based on science and experience. *Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation*, 18(9), 1263–1278. <https://doi.org/10.1007/s11136-009-9540-9>
- Capin, J. J., Bade, M. J., Jennings, J. M., Snyder-Mackler, L., & Stevens-Lapsley, J. E. (2022). Total Knee Arthroplasty Assessments Should Include Strength and Performance-Based Functional Tests to Complement Range-of-Motion and Patient-Reported Outcome Measures. *Physical therapy*, 102(6), pzac033. <https://doi.org/10.1093/ptj/pzac033>
- Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. J. H. W. (2019). Cochrane handbook for systematic reviews of interventions. *Hoboken: Wiley*.
- Cieza, A., Boldt, C., Ballert, C. S., Eriks-Hoogland, I., Bickenbach, J. E., & Stucki, G. (2011). Setting up a cohort study on functioning: deciding what to measure. *American journal of physical medicine & rehabilitation*, 90(11 Suppl 2), S17–S28.
<https://doi.org/10.1097/PHM.0b013e318230fddb>
- Cieza, A., Brockow, T., Ewert, T., Amman, E., Kollerits, B., Chatterji, S., Ustün, T. B., & Stucki, G. (2002). Linking health-status measurements to the international classification of functioning, disability and health. *Journal of rehabilitation medicine*, 34(5), 205–210.
<https://doi.org/10.1080/165019702760279189>
- Cieza, A., Ewert, T., Ustün, T. B., Chatterji, S., Kostanjsek, N., & Stucki, G. (2004). Development of ICF Core Sets for patients with chronic conditions. *Journal of rehabilitation medicine*, (44 Suppl), 9–11. <https://doi.org/10.1080/16501960410015353>
- Cieza, A., Fayed, N., Bickenbach, J., & Prodinger, B. (2019). Refinements of the ICF Linking Rules to strengthen their potential for establishing comparability of health information. *Disability and rehabilitation*, 41(5), 574–583.
<https://doi.org/10.3109/09638288.2016.1145258>

- Clement, N. D., Muzammil, A., Macdonald, D., Howie, C. R., & Biant, L. C. (2011). Socioeconomic status affects the early outcome of total hip replacement. *The Journal of bone and joint surgery. British volume*, 93(4), 464–469. <https://doi.org/10.1302/0301-620X.93B4.25717>
- Coenen, M., Cieza, A., Stamm, T. A., Amann, E., Kollerits, B., & Stucki, G. (2006). Validation of the International Classification of Functioning, Disability and Health (ICF) Core Set for rheumatoid arthritis from the patient perspective using focus groups. *Arthritis research & therapy*, 8(4), R84. <https://doi.org/10.1186/ar1956>
- Coenen, M., Stamm, T. A., Stucki, G., & Cieza, A. (2012). Individual interviews and focus groups in patients with rheumatoid arthritis: A comparison of two qualitative methods. *Quality of life research*, 21, 359-370.
- Comins, J. D., Brodersen, J., Siersma, V., Jensen, J., Hansen, C. F., & Krogsgaard, M. R. (2021). How to develop a condition-specific PROM. *Scandinavian journal of medicine & science in sports*, 31(6), 1216–1224. <https://doi.org/10.1111/sms.13868>
- Connell, J., Carlton, J., Grundy, A., Taylor Buck, E., Keetharuth, A. D., Ricketts, T., Barkham, M., Robotham, D., Rose, D., & Brazier, J. (2018). The importance of content and face validity in instrument development: lessons learnt from service users when developing the Recovering Quality of Life measure (ReQoL). *Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation*, 27(7), 1893–1902. <https://doi.org/10.1007/s11136-018-1847-y>
- Conrad, F., Blair, J., & Tracy, E. (1999, November). Verbal reports are data! A theoretical approach to cognitive interviews. In *Proceedings of the Federal Committee on statistical methodology research conference* (pp. 11-20). Tuesday B Sessions.
- Creswell, J. W. (2015). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. pearson.
- Daudt, H. M., Van Mossel, C., & Scott, S. J. (2013). Enhancing the scoping study methodology: A large, inter-professional team’s experience with Arksey and O’Malley’s framework. *BMC Medical Research Methodology*, 13(1), 48. <https://doi.org/10.1186/1471-2288-13-48>
- Dayton, M. R., Judd, D. L., Hogan, C. A., & Stevens-Lapsley, J. E. (2016). Performance-Based Versus Self-Reported Outcomes Using the Hip Disability and Osteoarthritis Outcome Score After Total Hip Arthroplasty. *American journal of physical medicine & rehabilitation*, 95(2), 132–138. <https://doi.org/10.1097/PHM.0000000000000357>
- de Wit, M. P., Kvien, T. K., & Gossec, L. (2015). Patient participation as an integral part of patient-reported outcomes development ensures the representation of the patient voice: a

- case study from the field of rheumatology. *RMD open*, 1(1), e000129.
<https://doi.org/10.1136/rmdopen-2015-000129>
- Donabedian A. (1966). Evaluating the quality of medical care. *The Milbank Memorial Fund quarterly*, 44(3), 166–206.
- Dreinhöfer, K., Stucki, G., Ewert, T., Huber, E., Ebenbichler, G., Gutenbrunner, C., Kostanjsek, N., & Cieza, A. (2004). ICF Core Sets for osteoarthritis. *Journal of rehabilitation medicine*, (44 Suppl), 75–80. <https://doi.org/10.1080/16501960410015498>
- Du, H., Tang, H., Gu, J. M., & Zhou, Y. X. (2014). Patient satisfaction after posterior-stabilized total knee arthroplasty: a functional specific analysis. *The Knee*, 21(4), 866–870.
<https://doi.org/10.1016/j.knee.2014.03.007>
- Dumenci, L., Perera, R. A., Keefe, F. J., Ang, D. C., Slover, J., Jensen, M. P., & Riddle, D. L. (2019). Model-based pain and function outcome trajectory types for patients undergoing knee arthroplasty: a secondary analysis from a randomized clinical trial. *Osteoarthritis and cartilage*, 27(6), 878–884. <https://doi.org/10.1016/j.joca.2019.01.004>
- Eckhard, L., Munir, S., Wood, D., Talbot, S., Brighton, R., Walter, B., & Baré, J. (2021). The ceiling effects of patient reported outcome measures for total knee arthroplasty. *Orthopaedics & traumatology, surgery & research : OTSR*, 107(3), 102758.
<https://doi.org/10.1016/j.otsr.2020.102758>
- Edwards, L., Monro, M., Butterfield, Y., Johl, R., Loftsgard, K. C., Pelletier, H., McGavin, C., & Lavergne, M. R. (2019). What matters most to patients about primary healthcare: mixed-methods patient priority setting exercises within the PREFeR (PRioritiEs For Research) project. *BMJ open*, 9(7), e025954. <https://doi.org/10.1136/bmjopen-2018-025954>
- Fayed, N., Cieza, A., & Bickenbach, J. E. (2011). Linking health and health-related information to the ICF: a systematic review of the literature from 2001 to 2008. *Disability and rehabilitation*, 33(21-22), 1941–1951. <https://doi.org/10.3109/09638288.2011.553704>
- Fayed, N., de Camargo, O. K., Kerr, E., Rosenbaum, P., Dubey, A., Bostan, C., Faulhaber, M., Raina, P., & Cieza, A. (2012). Generic patient-reported outcomes in child health research: a review of conceptual content using World Health Organization definitions. *Developmental medicine and child neurology*, 54(12), 1085–1095.
<https://doi.org/10.1111/j.1469-8749.2012.04393.x>
- Floyd, F. J., & Widaman, K. F. (1995). Factor analysis in the development and refinement of clinical assessment instruments. *Psychological assessment*, 7(3), 286.
- Geyh, S., Kurt, T., Brockow, T., Cieza, A., Ewert, T., Omar, Z., & Resch, K. L. (2004). Identifying the concepts contained in outcome measures of clinical trials on stroke using the International Classification of Functioning, Disability and Health as a

- reference. *Journal of rehabilitation medicine*, (44 Suppl), 56–62.
<https://doi.org/10.1080/16501960410015399>
- Giovannetti, E. R., Clair, C. A., Jennings, L. A., Sandberg, S. F., Bowman, A., Reuben, D. B., & Scholle, S. H. (2021). Standardised approach to measuring goal-based outcomes among older disabled adults: results from a multisite pilot. *BMJ quality & safety*, 30(2), 157–166. <https://doi.org/10.1136/bmjqs-2019-010742>
- Goldberg, R. J., McManus, D. D., & Allison, J. (2013). Greater knowledge and appreciation of commonly-used research study designs. *The American journal of medicine*, 126(2), 169.e1–169.e1698. <https://doi.org/10.1016/j.amjmed.2012.09.011>
- Government of Canada, I. A. P. on R. E. (2023, January 11). *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans – TCPS 2 (2022)*.
https://ethics.gc.ca/eng/policy-politique_tcps2-eptc2_2022.html
- Guidarelli, C., Lipps, C., Stoyles, S., Dieckmann, N. F., & Winters-Stone, K. M. (2022). Remote administration of physical performance tests among persons with and without a cancer history: Establishing reliability and agreement with in-person assessment. *Journal of geriatric oncology*, 13(5), 691–697. <https://doi.org/10.1016/j.jgo.2022.02.002>
- Harada, S., Hamai, S., Gondo, H., Higaki, H., Ikebe, S., & Nakashima, Y. (2022). Squatting After Total Hip Arthroplasty: Patient-Reported Outcomes and In Vivo Three-Dimensional Kinematic Study. *The Journal of arthroplasty*, 37(4), 734–741.
<https://doi.org/10.1016/j.arth.2021.12.028>
- Harrison, C. J., Plessen, C. Y., Liegl, G., Rodrigues, J. N., Sabah, S. A., Beard, D. J., & Fischer, F. (2023). Overcoming floor and ceiling effects in knee arthroplasty outcome measurement. *Bone & joint research*, 12(10), 624–635. <https://doi.org/10.1302/2046-3758.1210.BJR-2022-0457.R1>
- Haywood, K. L., De Wit, M., Staniszewska, S., Morel, T., & Salek, S. (2017). Developing Patient-Reported and Relevant Outcome Measures. In K. M. Facey, H. Ploug Hansen, & A. N. V. Single (Eds.), *Patient Involvement in Health Technology Assessment* (pp. 103–120). Springer Singapore. https://doi.org/10.1007/978-981-10-4068-9_9
- Hickmann, E., Richter, P., & Schlieter, H. (2022). All together now – patient engagement, patient empowerment, and associated terms in personal healthcare. *BMC Health Services Research*, 22(1), 1116. <https://doi.org/10.1186/s12913-022-08501-5>
- Hossain, F. S., Konan, S., Patel, S., Rodriguez-Merchan, E. C., & Haddad, F. S. (2015). The assessment of outcome after total knee arthroplasty: Are we there yet? *The Bone & Joint Journal*, 97-B(1), 3–9. <https://doi.org/10.1302/0301-620X.97B1.34434>

- Huber, E. O., Meichtry, A., de Bie, R. A., & Bastiaenen, C. H. (2016). Construct validity of change scores of the Chair Stand Test versus Timed Up and Go Test, KOOS questionnaire and the isometric muscle strength test in patients with severe knee osteoarthritis undergoing total knee replacement. *Manual therapy*, 21, 262–267. <https://doi.org/10.1016/j.math.2015.09.012>
- Hung, M., Franklin, J. D., Hon, S. D., Cheng, C., Conrad, J., & Saltzman, C. L. (2014). Time for a Paradigm Shift With Computerized Adaptive Testing of General Physical Function Outcomes Measurements. *Foot & Ankle International*, 35(1), 1–7. <https://doi.org/10.1177/1071100713507905>
- Hylkema, T. H., Brouwer, S., Stewart, R. E., van Beveren, J., Rijk, P. C., Brouwer, R. W., Bulstra, S. K., Kuijer, P. P. F. M., & Stevens, M. (2022). Two-year recovery courses of physical and mental impairments, activity limitations, and participation restrictions after total knee arthroplasty among working-age patients. *Disability and rehabilitation*, 44(2), 291–300. <https://doi.org/10.1080/09638288.2020.1766583>
- Issa, T. Z., Lee, Y., Mazmudar, A. S., Lambrechts, M. J., Sellig, M., Hilibrand, A. S., Vaccaro, A. R., Schroeder, G. D., & Kepler, C. K. (2024). Readability of Patient-Reported Outcomes in Spine Surgery and Implications for Health Literacy. *Spine*, 49(11), 811–817. <https://doi.org/10.1097/BRS.0000000000004761>
- Judd, D. L., Dennis, D. A., Thomas, A. C., Wolfe, P., Dayton, M. R., & Stevens-Lapsley, J. E. (2014). Muscle strength and functional recovery during the first year after THA. *Clinical orthopaedics and related research*, 472(2), 654–664. <https://doi.org/10.1007/s11999-013-3136-y>
- Kagan, R., Anderson, M. B., Christensen, J. C., Peters, C. L., Gililland, J. M., & Pelt, C. E. (2018). The Recovery Curve for the Patient-Reported Outcomes Measurement Information System Patient-Reported Physical Function and Pain Interference Computerized Adaptive Tests After Primary Total Knee Arthroplasty. *The Journal of arthroplasty*, 33(8), 2471–2474. <https://doi.org/10.1016/j.arth.2018.03.020>
- Kennedy, D. M., Hanna, S. E., Stratford, P. W., Wessel, J., & Gollish, J. D. (2006). Preoperative function and gender predict pattern of functional recovery after hip and knee arthroplasty. *The Journal of arthroplasty*, 21(4), 559–566. <https://doi.org/10.1016/j.arth.2005.07.010>
- Kennedy, D. M., Stratford, P. W., Hanna, S. E., Wessel, J., & Gollish, J. D. (2006). Modeling early recovery of physical function following hip and knee arthroplasty. *BMC musculoskeletal disorders*, 7, 100. <https://doi.org/10.1186/1471-2474-7-100>

- Kennedy, D. M., Stratford, P. W., Riddle, D. L., Hanna, S. E., & Gollish, J. D. (2008). Assessing recovery and establishing prognosis following total knee arthroplasty. *Physical therapy*, 88(1), 22–32. <https://doi.org/10.2522/ptj.20070051>
- Kennedy, D. M., Stratford, P. W., Robarts, S., & Gollish, J. D. (2011). Using outcome measure results to facilitate clinical decisions the first year after total hip arthroplasty. *The Journal of orthopaedic and sports physical therapy*, 41(4), 232–239. <https://doi.org/10.2519/jospt.2011.3516>
- Konan, S., Hossain, F., Patel, S., & Haddad, F. S. (2014). Measuring function after hip and knee surgery: the evidence to support performance-based functional outcome tasks. *The bone & joint journal*, 96-B(11), 1431–1435. <https://doi.org/10.1302/0301-620X.96B11.33773>
- Kowalczyk, N., & Truluck, C. (2013). Literature reviews and systematic reviews: what is the difference?. *Radiologic technology*, 85(2), 219–222.
- Kroenke, K., Monahan, P. O., & Kean, J. (2015). Pragmatic characteristics of patient-reported outcome measures are important for use in clinical practice. *Journal of clinical epidemiology*, 68(9), 1085–1092. <https://doi.org/10.1016/j.jclinepi.2015.03.023>
- Largent, E. A., Lynch, H. F., & McCoy, M. S. (2018). Patient-Engaged Research: Choosing the “Right” Patients to Avoid Pitfalls. *Hastings Center Report*, 48(5), 26–34. <https://doi.org/10.1002/hast.898>
- Lasch, K. E., Marquis, P., Vigneux, M., Abetz, L., Arnould, B., Bayliss, M., Crawford, B., & Rosa, K. (2010). PRO development: Rigorous qualitative research as the crucial foundation. *Quality of Life Research*, 19(8), 1087–1096. <https://doi.org/10.1007/s11136-010-9677-6>
- Latham, N. K., Mehta, V., Nguyen, A. M., Jette, A. M., Olarsch, S., Papanicolaou, D., & Chandler, J. (2008). Performance-based or self-report measures of physical function: which should be used in clinical trials of hip fracture patients?. *Archives of physical medicine and rehabilitation*, 89(11), 2146–2155. <https://doi.org/10.1016/j.apmr.2008.04.016>
- Lavernia, C. J., Alcerro, J. C., Brooks, L. G., & Rossi, M. D. (2012). Mental health and outcomes in primary total joint arthroplasty. *The Journal of arthroplasty*, 27(7), 1276–1282. <https://doi.org/10.1016/j.arth.2011.11.015>
- Leidy, N. K., & Vernon, M. (2008). Perspectives on patient-reported outcomes : content validity and qualitative research in a changing clinical trial environment. *Pharmacoeconomics*, 26(5), 363–370. <https://doi.org/10.2165/00019053-200826050-00002>

- Lenguerrand, E., Wylde, V., Gooberman-Hill, R., Sayers, A., Brunton, L., Beswick, A. D., Dieppe, P., & Blom, A. W. (2016). Trajectories of Pain and Function after Primary Hip and Knee Arthroplasty: The ADAPT Cohort Study. *PloS one*, 11(2), e0149306. <https://doi.org/10.1371/journal.pone.0149306>
- Lenzner, T. (2012). Effects of Survey Question Comprehensibility on Response Quality. *Field Methods*, 24(4), 409–428. <https://doi.org/10.1177/1525822X12448166>
- Liberati, A. (2009). The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *Annals of Internal Medicine*, 151(4), W. <https://doi.org/10.7326/0003-4819-151-4-200908180-00136>
- Liebs, T. R., Herzberg, W., Gluth, J., R  ther, W., Haasters, J., Russlies, M., & Hassenpflug, J. (2013). Using the patient’s perspective to develop function short forms specific to total hip and knee replacement based on WOMAC function items. *The Bone & Joint Journal*, 95-B(2), 239–243. <https://doi.org/10.1302/0301-620X.95B2.28383>
- Martin, G. P. (2008). ‘Ordinary people only’: Knowledge, representativeness, and the publics of public participation in healthcare. *Sociology of Health & Illness*, 30(1), 35–54. <https://doi.org/10.1111/j.1467-9566.2007.01027.x>
- Mizner, R. L., Petterson, S. C., Clements, K. E., Zeni, J. A., Jr, Irrgang, J. J., & Snyder-Mackler, L. (2011). Measuring functional improvement after total knee arthroplasty requires both performance-based and patient-report assessments: a longitudinal analysis of outcomes. *The Journal of arthroplasty*, 26(5), 728–737. <https://doi.org/10.1016/j.arth.2010.06.004>
- Mizner, R. L., Petterson, S. C., & Snyder-Mackler, L. (2005). Quadriceps strength and the time course of functional recovery after total knee arthroplasty. *The Journal of orthopaedic and sports physical therapy*, 35(7), 424–436. <https://doi.org/10.2519/jospt.2005.35.7.424>
- Mockford, C., Staniszewska, S., Griffiths, F., & Herron-Marx, S. (2012). The impact of patient and public involvement on UK NHS health care: a systematic review. *International journal for quality in health care : journal of the International Society for Quality in Health Care*, 24(1), 28–38. <https://doi.org/10.1093/intqhc/mzr066>
- Morel, T., & Cano, S. J. (2017). Measuring what matters to rare disease patients – reflections on the work by the IRDiRC taskforce on patient-centered outcome measures. *Orphanet Journal of Rare Diseases*, 12(1), 171. <https://doi.org/10.1186/s13023-017-0718-x>
- Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, 18(1), 143. <https://doi.org/10.1186/s12874-018-0611-x>

- Nadler, J. T., Weston, R., & Voyles, E. C. (2015). Stuck in the Middle: The Use and Interpretation of Mid-Points in Items on Questionnaires. *The Journal of General Psychology*, 142(2), 71–89. <https://doi.org/10.1080/00221309.2014.994590>
- Naik, A. D., & Catic, A. (2021). Achieving patient priorities: an alternative to patient-reported outcome measures (PROMs) for promoting patient-centred care. *BMJ quality & safety*, 30(2), 92–95. <https://doi.org/10.1136/bmjqs-2020-012244>
- Naylor, J. M., Harmer, A. R., Heard, R. C., & Harris, I. A. (2009). Patterns of recovery following knee and hip replacement in an Australian cohort. *Australian health review : a publication of the Australian Hospital Association*, 33(1), 124–135. <https://doi.org/10.1071/ah090124>
- Norquist, J. M., Girman, C., Fehnel, S., DeMuro-Mercon, C., & Santanello, N. (2012). Choice of recall period for patient-reported outcome (PRO) measures: criteria for consideration. *Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation*, 21(6), 1013–1020. <https://doi.org/10.1007/s11136-011-0003-8>
- Obama B. (2016). United States Health Care Reform: Progress to Date and Next Steps. *JAMA*, 316(5), 525–532. <https://doi.org/10.1001/jama.2016.9797>
- Organization, W. H. (2001). World Health Organization international classification of functioning, disability and health. *Geneva: World Health Organization*.
- Paulhus, D. L. (2017). Socially desirable responding on self-reports. *Encyclopedia of Personality and Individual Differences*, 1(5).
- Post, M. W., Brinkhof, M. W., von Elm, E., Boldt, C., Brach, M., Fekete, C., Eriks-Hoogland, I., Curt, A., Stucki, G., & SwiSCI study group (2011). Design of the Swiss Spinal Cord Injury Cohort Study. *American journal of physical medicine & rehabilitation*, 90(11 Suppl 2), S5–S16. <https://doi.org/10.1097/PHM.0b013e318230fd41>
- Prinsen, C. A. C., Mokkink, L. B., Bouter, L. M., Alonso, J., Patrick, D. L., De Vet, H. C. W., & Terwee, C. B. (2018). COSMIN guideline for systematic reviews of patient-reported outcome measures. *Quality of Life Research*, 27(5), 1147–1157. <https://doi.org/10.1007/s11136-018-1798-3>
- Proding, B., Cieza, A., Williams, D. A., Mease, P., Boonen, A., Kersch-Schindl, K., Fialka-Moser, V., Smolen, J., Stucki, G., Machold, K., & Stamm, T. (2008). Measuring health in patients with fibromyalgia: content comparison of questionnaires based on the International Classification of Functioning, Disability and Health. *Arthritis and rheumatism*, 59(5), 650–658. <https://doi.org/10.1002/art.23559>

- Pua, Y. H., Seah, F. J., Poon, C. L., Tan, J. W., Alan Clark, R., Liaw, J. S., & Chong, H. C. (2018). Age- and sex-based recovery curves to track functional outcomes in older adults with total knee arthroplasty. *Age and ageing*, 47(1), 144–148. <https://doi.org/10.1093/ageing/afx148>
- Rastogi, R., Davis, A. M., & Chesworth, B. M. (2007). A cross-sectional look at patient concerns in the first six weeks following primary total knee arthroplasty. *Health and Quality of Life Outcomes*, 5(1), 48. <https://doi.org/10.1186/1477-7525-5-48>
- Rathert, C., Wyrwich, M. D., & Boren, S. A. (2013). Patient-Centered Care and Outcomes: A Systematic Review of the Literature. *Medical Care Research and Review*, 70(4), 351–379. <https://doi.org/10.1177/1077558712465774>
- Rauch, A., Cieza, A., & Stucki, G. (2008). How to apply the International Classification of Functioning, Disability and Health (ICF) for rehabilitation management in clinical practice. *European journal of physical and rehabilitation medicine*, 44(3), 329–342.
- Razmjou, H., Denis, S., Robarts, S., Falconer, J., Anunciacion, M., Nunn, A., Wainwright, A., Dickson, P., Najafi, R., & Murnaghan, J. (2023). Virtual performance measure in osteoarthritis: An innovative transformation of patient care. *Osteoarthritis and cartilage open*, 5(4), 100410. <https://doi.org/10.1016/j.ocarto.2023.100410>
- Rolstad, S., Adler, J., & Rydén, A. (2011). Response burden and questionnaire length: is shorter better? A review and meta-analysis. *Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research*, 14(8), 1101–1108. <https://doi.org/10.1016/j.jval.2011.06.003>
- Rothrock, N. E., Kaiser, K. A., & Cella, D. (2011). Developing a valid patient-reported outcome measure. *Clinical pharmacology and therapeutics*, 90(5), 737–742. <https://doi.org/10.1038/clpt.2011.195>
- Sacristan, J. A., Aguaron, A., Avendaño, C., Garrido, P., Carrion, J., Gutierrez, A., Kroes, R., & Flores, A. (2016). Patient involvement in clinical research: Why, when, and how. *Patient Preference and Adherence*, 631. <https://doi.org/10.2147/PPA.S104259>
- Saris, W. E., Revilla, M., Krosnick, J. A., & Shaeffer, E. M. (2010). Comparing questions with agree/disagree response options to questions with construct-specific response options. *Survey Research Methods*. 2010; 4 (1): 61-79. <https://repositori.upf.edu/handle/10230/43541>
- Schattner, A., Bronstein, A., & Jellin, N. (2006). Information and shared decision-making are top patients' priorities. *BMC Health Services Research*, 6(1), 21. <https://doi.org/10.1186/1472-6963-6-21>

- Scholz, B., Kirk, L., Warner, T., O'Brien, L., Kecskes, Z., & Mitchell, I. (2024). From a Single Voice to Diversity: Reframing 'Representation' in Patient Engagement. *Qualitative Health Research*, 10497323231221674. <https://doi.org/10.1177/10497323231221674>
- Setia M. S. (2016). Methodology Series Module 3: Cross-sectional Studies. *Indian journal of dermatology*, 61(3), 261–264. <https://doi.org/10.4103/0019-5154.182410>
- Simms, L. J., Zelazny, K., Williams, T. F., & Bernstein, L. (2019). Does the number of response options matter? Psychometric perspectives using personality questionnaire data. *Psychological Assessment*, 31(4), 557. <https://psycnet.apa.org/fulltext/2019-12091-001.html>
- Simon, H. A., & Ericsson, K. A. (1984). Protocol analysis: Verbal reports as data. (*No Title*). <https://cir.nii.ac.jp/crid/1130000795825118336>
- Sinclair, S., Jaggi, P., Hack, T. F., McClement, S. E., & Cuthbertson, L. (2020). A Practical Guide for Item Generation in Measure Development: Insights From the Development of a Patient-Reported Experience Measure of Compassion. *Journal of nursing measurement*, JNM-D-19-00020. Advance online publication. <https://doi.org/10.1891/JNM-D-19-00020>
- Spertus, J. A., & Ghaferi, A. A. (2017). Transforming the National Surgical Quality Improvement Program to the Delivery of Precision Medicine to Improve the Value of Surgical Care: Summary of the John R. Clarke Keynote Address for the Surgical Outcomes Club 2016 Annual Meeting. *JAMA surgery*, 152(9), 815–816. <https://doi.org/10.1001/jamasurg.2017.1610>
- Staniszewska, S., Haywood, K. L., Brett, J., & Tutton, L. (2012). Patient and public involvement in patient-reported outcome measures: evolution not revolution. *The patient*, 5(2), 79–87. <https://doi.org/10.2165/11597150-000000000-00000>
- Stevens-Lapsley, J. E., Schenkman, M. L., & Dayton, M. R. (2011). Comparison of self-reported knee injury and osteoarthritis outcome score to performance measures in patients after total knee arthroplasty. *PM & R : the journal of injury, function, and rehabilitation*, 3(6), 541–549. <https://doi.org/10.1016/j.pmrj.2011.03.002>
- Stewart, M., Brown, J. B., Donner, A., McWhinney, I. R., Oates, J., Weston, W. W., & Jordan, J. (2000). The impact of patient-centered care on outcomes. *The Journal of family practice*, 49(9), 796–804.
- Streiner, D. L., Norman, G. R., & Cairney, J. (2024). *Health measurement scales: A practical guide to their development and use*. Oxford university press.
- Stucki, G. (2005). ICF linking rules: An update based on lessons learned. *J Rehabil Med*, 37(4), 212–218.

- Stucki, G., Ewert, T., & Cieza, A. (2002). Value and application of the ICF in rehabilitation medicine. *Disability and rehabilitation*, 24(17), 932–938.
<https://doi.org/10.1080/09638280210148594>
- Stull, D. E., Leidy, N. K., Parasuraman, B., & Chassany, O. (2009). Optimal recall periods for patient-reported outcomes: Challenges and potential solutions. *Current Medical Research and Opinion*, 25(4), 929–942. <https://doi.org/10.1185/03007990902774765>
- Terwee, C. B., Prinsen, C. A. C., Chiarotto, A., Westerman, M. J., Patrick, D. L., Alonso, J., Bouter, L. M., De Vet, H. C. W., & Mokkink, L. B. (2018). COSMIN methodology for evaluating the content validity of patient-reported outcome measures: A Delphi study. *Quality of Life Research*, 27(5), 1159–1170. <https://doi.org/10.1007/s11136-018-1829-0>
- Terwee, C. B., Prinsen, C., Chiarotto, A., De Vet, H., Bouter, L. M., Alonso, J., ... & Mokkink, L. B. (2018). COSMIN methodology for assessing the content validity of PROMs–user manual. *Amsterdam: VU University Medical Center*, 1159-70.
- Thompson, C. B., & Panacek, E. A. (2007). Research study designs: non-experimental. *Air medical journal*, 26(1), 18–22. <https://doi.org/10.1016/j.amj.2006.10.003>
- Tran, B. Q. (2021). Strategies for effective patient care: Integrating quality communication with the patient-centered approach. *Social and Personality Psychology Compass*, 15(1), e12574. <https://doi.org/10.1111/spc3.12574>
- Trujols, J., Portella, M. J., Iraurgi, I., Campins, M. J., Siñol, N., & de Los Cobos, J. P. (2013). Patient-reported outcome measures: are they patient-generated, patient-centred or patient-valued?. *Journal of mental health (Abingdon, England)*, 22(6), 555–562.
<https://doi.org/10.3109/09638237.2012.734653>
- Tuinenburg, A., Determann, D., Quik, E. H., Van Der Willik, E. M., Hofstra, G., Hallegraeff, J. M., Vriend, I., Warmerdam, L., Van Bommel, H. E., Boland, G., & Oude Voshaar, M. A. H. (2024). Evaluating Comprehensibility of 157 Patient-Reported Outcome Measures (PROMs) in the Nationwide Dutch Outcome-Based Healthcare Program: More Attention for Comprehensibility of PROMs is Needed. *The Patient - Patient-Centered Outcomes Research*. <https://doi.org/10.1007/s40271-024-00710-w>
- Weigl, M., Cieza, A., Andersen, C., Kollerits, B., Amann, E., & Stucki, G. (2004). Identification of relevant ICF categories in patients with chronic health conditions: a Delphi exercise. *Journal of rehabilitation medicine*, (44 Suppl), 12–21.
<https://doi.org/10.1080/16501960410015443>
- Weiss, J. M., Noble, P. C., Conditt, M. A., Kohl, H. W., Roberts, S., Cook, K. F., Gordon, M. J., & Mathis, K. B. (2002). What functional activities are important to patients with knee replacements?. *Clinical orthopaedics and related research*, (404), 172–188.
<https://doi.org/10.1097/00003086-200211000-00030>

- Wensing, M., Jung, H. P., Mainz, J., Olesen, F., & Grol, R. (1998). A systematic review of the literature on patient priorities for general practice care. Part 1: Description of the research domain. *Social science & medicine* (1982), 47(10), 1573–1588.
[https://doi.org/10.1016/s0277-9536\(98\)00222-6](https://doi.org/10.1016/s0277-9536(98)00222-6)
- Westby, M. D., & Backman, C. L. (2010). Patient and health professional views on rehabilitation practices and outcomes following total hip and knee arthroplasty for osteoarthritis: a focus group study. *BMC Health Services Research*, 10(1), 119. <https://doi.org/10.1186/1472-6963-10-119>
- Wieczorek, M., Rotonda, C., Guillemin, F., & Rat, A. C. (2020). What Have We Learned About the Course of Clinical Outcomes After Total Knee or Hip Arthroplasty?. *Arthritis care & research*, 72(11), 1519–1529. <https://doi.org/10.1002/acr.24045>
- Willis, G. B. (2004). *Cognitive interviewing: A tool for improving questionnaire design*. sage publications.
- Wolff, A. C., Dresselhuis, A., Hejazi, S., Dixon, D., Gibson, D., Howard, A. F., Liva, S., Astle, B., Reimer-Kirkham, S., Noonan, V. K., & Edwards, L. (2021). Healthcare provider characteristics that influence the implementation of individual-level patient-centered outcome measure (PROM) and patient-reported experience measure (PREM) data across practice settings: a protocol for a mixed methods systematic review with a narrative synthesis. *Systematic reviews*, 10(1), 169. <https://doi.org/10.1186/s13643-021-01725-2>
- Yen, T. H., Liou, T. H., Chang, K. H., Wu, N. N., Chou, L. C., & Chen, H. C. (2014). Systematic review of ICF core set from 2001 to 2012. *Disability and rehabilitation*, 36(3), 177–184. <https://doi.org/10.3109/09638288.2013.782359>
- Zumbo, B. D., & Hubley, A. M. (Eds.). (2017). *Understanding and Investigating Response Processes in Validation Research* (Vol. 69). Springer International Publishing.
<https://doi.org/10.1007/978-3-319-56129-5>

APPENDICES

Appendix A: Ethics Approval Letters

- OHSN-REB Approval Letter initial submission: Cognitive think-aloud interview and survey of functional activities studies (Studies 2&5)
- OHSN-REB Institutional Approval Letter: Cognitive think-aloud interview and survey of functional activities studies (Studies 2&5)
- University of Ottawa Research Ethics Board approval: Cognitive think-aloud interview and survey of functional activities studies (Studies 2&5)

Appendix B: Consent Forms

- Informed consent form: Cognitive think-aloud interview (Study 2)
- Verbal consent form: Cognitive think-aloud interview (Study 2)
- Information sheet: Cognitive think-aloud interview (Study 2)
- Implied consent form: Survey of functional activities (Study 5)

Appendix C: Interview guide: Cognitive think-aloud interview (Study 2)

Appendix D: Permission from journal to use published article in PhD thesis (Study 2)

Appendix E: Contribution of Collaborators

Appendix A: Ethical Approval letters

OHSN-REB Approval Letter initial submission for cognitive think-aloud interview and survey of functional activities studies (Studies 2 & 5)



Ottawa Health Science Network Research Ethics Board (OHSN-REB) / Conseil d'éthique de la recherche du réseau de science de la santé d'Ottawa (CÉR-RSSO)

Date: May 29, 2023
Principal Investigator: Dr. Paul Beaulé, TOH/OHRI
Protocol ID: 20230252-01H
Study Title: Determination of the functional priorities and abilities within 1 week, and at 6, 12, and 26 weeks after knee and hip arthroplasty.
Submission Type: Initial Application
Review Type: Delegated
Date of Approval: May 29, 2023
Study Approval Expiry Date: May 29, 2024

Dear Dr. Beaulé,

An **Institutional approval (OHRI) letter is required prior to the conduct of the study** at this site. The institutional approval letter is an indication that you have satisfied ethics, contracts, departmental notifications, as applicable.

Thank you for submitting the above referenced study. The Ottawa Health Science Network Research Ethics Board (OHSN-REB) has reviewed the application and granted approval for your study. This approval is granted until the expiration date noted above. This research study is to be conducted by the investigator noted above.

The **OHSN-REB ethics approval** is applicable only for The Ottawa Hospital.

The **OHSN-REB ethics approval** is applicable only for The Ottawa Hospital.

Documents Approved:

Document Name	Document Version Date
English Implied Consent form - survey	May 3, 2023
English Information Sheet - think-aloud interview	May 3, 2023
English Informed Consent Form - think-aloud interview	May 3, 2023
English recruitment poster	May 3, 2023
English survey phone script	March 27, 2023
English survey questionnaire	March 27, 2023
English think-aloud interview demographic questionnaire	March 27, 2023
English think-aloud interview guide	March 27, 2023
English Verbal Consent Script - think-aloud interview	May 3, 2023
French recruitment poster	May 3, 2023
French Survey Phone Script	May 3, 2023
French survey Questionnaire	May 3, 2023
French think aloud interview demographic questionnaire	May 3, 2023
French think aloud interview guide	May 3, 2023
Protocol	May 29, 2023

Document Version Date

Appendices

No deviations from, or changes to, the protocol should be initiated without prior written approval of an appropriate amendment from the OHSN-REB, except when necessary to eliminate immediate hazard(s) to study participants.

REB members involved in the research project do not participate in the review, discussion or decision.

If the study is to continue beyond the expiry date noted above, a Continuing Review Form must be received by the OHSN-REB on or prior to the full board submission deadline date of the meeting scheduled to occur a minimum of 30 days prior to the study expiry date. If the study has been completed by the expiry noted above, a Study Closure Report must be received by the OHSN-REB.

The OHSN-REB operates in compliance with, and is constituted in accordance with, the requirements of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2); International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use; Integrated Addendum to ICH E6 (R1): Guideline for Good Clinical Practice E6 (R2); Part C, Division 5 of the Food and Drug Regulations; or with the definition in the Interim Order Respecting Clinical Trials for Medical Devices and Drugs Relating to COVID-19; Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations; and the provisions of the Ontario Personal Health Information Protection Act (PHIPA 2004) and its applicable regulations. OHSN-REB is qualified through the CTO REB Qualification Program and is registered with the U.S. Department of Health and Human Services (DHHS) Office for Human Research Protection (OHRP).

Please do not hesitate to contact us if you have any questions.

Civic Campus, Box 675, 725 Parkdale Avenue, Ottawa, Ontario, K1Y 4E9
613-798-5555 extension 16719 Fax: 613-761-4311 <http://www.ohri.ca/ohsn-reb>
Page 1 of 2

OHSN-REB Institutional Approval Letter for cognitive think-aloud interview and survey of functional activities studies (Studies 2 & 5)



July 14, 2023

Dr. Paul Beaulé

The Ottawa Hospital - General Campus
Division of Orthopaedic Surgery
501 Smyth Road,
Box 502, CCW 1646
Ottawa, Ontario K1H 8L6

Re: OHRI Institutional Approval for Ottawa Health Science Network Research Ethics Board (OHSN-REB) Submission

Protocol ID#: 20230252-01H;

Determination of the functional priorities and abilities within 1 week, and at 6, 12, and 26 weeks after knee and hip arthroplasty.

Dear Dr. Paul Beaulé,

This letter serves as **Ottawa Hospital Research Institute (OHRI)** Institutional Approval for the above-referenced study. Please maintain this documentation in your investigator study file.

Based on the information you provided about this study through the Clinical Research Registration Form, you have satisfied the requirements for institutional (OHRI) approval. This includes initial research ethics approval by OHSN-REB, appropriate departmental/service area notifications and execution (fully signed versions) of all agreement(s) required to begin the study locally. Please note there may be additional agreement(s) pending execution that are required to send funds, samples, or data to external sites, but are not required for you to begin your study locally.

Changes and/or additions to your study that may require additional agreement(s) or revisions to existing agreement(s) must be communicated to the OHRI Contracts Office. This should be undertaken simultaneously with any related OHSN-REB amendment submission.

Changes and/or additions to your study that affect various hospital/institution departments (e.g., pharmacy, Department of Medical Imaging, EORLA, EEG, etc.) must be communicated to the relevant departments.

As mentioned in the 'Response' tab of the Ethics application, you have 3 months from the date of initial OHSN-REB approval to submit French documents including the translation certificate to OHSN-REB through the Translated Documents section of the ethics application (if applicable).

Should you have any questions, please contact REBadministration@ohri.ca or 613-798-5555 extension 16719.

University of Ottawa Research Ethics Board approval for cognitive think-aloud interview and survey of functional activities studies (Studies 2 & 5)

04/07/2023

Université d'Ottawa

Bureau d'éthique et d'intégrité de la recherche

University of Ottawa

Office of Research Ethics and Integrity

Lettre d'approbation administrative | Letter of administrative approval

Numéro de dossier / Ethics File Number

H-06-23-9425

Titre du projet / Project Title

Determination of the functional priorities and abilities within 1 week, and at 6, 12, and 26 weeks after knee and hip arthroplasty.

Type de projet / Project Type

Thèse de doctorat / Doctoral thesis

CÉR primaire / Primary REB

Réseau de science de la santé d'Ottawa (RSSO) / Ottawa Health Science Network (OHSN)

Statut du projet / Project Status

Approuvé / Approved

Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)

04/07/2023

Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)

29/05/2024

Équipe de recherche / Research Team

**Chercheur /
Researcher**

Affiliation

Role

Motahareh
KARIMJASHNI

École des sciences de la réadaptation / School of
Rehabilitation Sciences

Chercheur Principal / Principal Investigator

Stéphane
POITRAS

École des sciences de la réadaptation / School of
Rehabilitation Sciences

Superviseur / Supervisor

Simon GARCEAU The Ottawa Hospital

Co-chercheur principal / Co-principal
investigator

Paul BEAULE

Chercheur principal - site d'examen
primaire / Primary review site PI

Timothy RAMSAY

Département d'épidémiologie et santé publique / Department
of Epidemiology and Public Health

Collaborateur / Collaborator

Conditions spéciales ou commentaires / Special conditions or comments:

OHSN REB Protocol ID: 20230252-01H

Appendix B: Consent Forms

Informed consent form: Cognitive think-aloud interview (Study 2)

Study Title: Determination of the functional priorities and abilities within 1 week, and at 6, 12, and 26 weeks after knee and hip replacement.

Principle Investigator: Dr. Paul Beaulé, MD, FRCSC

The Ottawa Hospital

Division of Orthopedic Surgery

501 Smyth Road, CCW 1646, Ottawa, ON, K1H 8L6

pbeaule@toh.ca

(613) 737-8899 ext 78920

OHSN-REB Number: 20230252-01H

INTRODUCTION

You are being invited to participate in one interview. You are invited to participate in this study because you underwent a knee or hip replacement 6 or 12 or 26 weeks ago. The results of this study will inform the best outcome assessment tools after knee and hip replacement which will occur in a next phase in this project.

This consent form provides you with information to help you make an informed choice. Please read this document carefully and ask any questions you may have. All your questions should be answered to your satisfaction before you decide whether to participate in this research study.

Please take your time in making your decision. You may find it helpful to discuss it with your friends and family.

Taking part in this study is voluntary. You have the option to not participate at all or you may choose to leave the study at any time. Whatever you choose, it will not affect the usual medical care that you receive outside the study.

IS THERE A CONFLICT OF INTEREST?

There are no conflicts of interest to declare related to this study.

WHY IS THIS STUDY BEING DONE?

The research study aims to validate a questionnaire to determine the activities that are important to patients and their ability to do them, which will help determine the most appropriate patient assessment tools after knee and hip replacement.

Currently, there is limited information about the most appropriate assessments after knee and hip replacement. The purpose of this study is to validate a questionnaire which helps determine the activities that are important to patients and their ability to do them, which will inform the best outcome assessment tools after knee and hip replacement which will occur in a next phase in this project.

HOW MANY PEOPLE WILL TAKE PART IN THIS STUDY?

It is anticipated that 5 to 7 patients who underwent knee and hip replacement at The Ottawa Hospital will participate in this study.

The component of this study (validation of the questionnaire) should take about two months to complete. However, you will only need to participate in one interview. The study in its entirety (selection of appropriate outcome measures after knee and hip replacement) should take approximately two years to complete.

WHAT WILL HAPPEN DURING THIS STUDY?

If you agree to participate in this study, you would be asked to participate in a think-aloud interview. The questions are on the importance of functional activities to you right now and your ability to do these activities with respect to your recovery from joint replacement surgery. Your participation in this study will require participating in one interview. During the interview, you will meet with a member of the research team. The interview will last about 45 minutes in length and will take place virtually over the Microsoft Teams platform or in person at a convenient time and location, depending on your preferences. In this interview, you will be asked to say out loud whatever comes to your mind from the first time you read while answering the survey questions. The researcher remains silent so long as you continue to think aloud. You will be reminded to “keep thinking aloud” if you stop talking for more than ten seconds. You are not asked to explain or justify what you are saying.

The information you provide is for research purposes only. Some of the questions are personal. You can choose not to answer questions if you wish.

The interview will be audio-video recorded through the Microsoft Teams platform record function or it will be audio recorded using an encrypted digital audio recorder.

HOW LONG WILL PARTICIPANTS BE IN THE STUDY?

You will be involved in this study for one think-aloud interview. Your participation in this study will last approximately 45 minutes.

CAN PARTICIPANTS CHOOSE TO LEAVE THE STUDY?

You can choose to end your participation in this research (called withdrawal) at any time without having to provide a reason. If you choose to withdraw from the study, you are encouraged to contact the research team.

You may withdraw your permission to use information that was collected about you for this study at any time by letting the study doctor know. However, this would also mean that you withdraw from the study.

If you decide to leave the study, you can ask that the information that was collected about you not be used for the study. Let the research team know if you choose this.

WHAT ARE THE RISKS OR HARMS OF PARTICIPATING IN THIS STUDY?

There are no known risks for you in taking part in this study. Some of the questions may, however, make you feel uncomfortable, or you may become uncomfortable while thinking aloud. You may choose not to answer questions or leave the think-aloud interview at any time if you experience any discomfort.

WHAT ARE THE BENEFITS OF PARTICIPATING IN THIS STUDY?

You may not receive direct benefit from participating in this study. The aim is to validate the questionnaire to determine key functional priorities and abilities after joint replacement from the perspectives of the patients. We hope the information learned from this study will help identify the most appropriate assessment tools after knee and hip replacement, which will in turn help outcomes of other people with joint replacement in the future.

HOW WILL PARTICIPANT INFORMATION BE KEPT CONFIDENTIAL?

If you decide to participate in this study, the research team will only collect the information they need for this study.

Records identifying you at this center will be kept confidential and, to the extent permitted by the applicable laws, will not be disclosed or made publicly available, except as described in this consent document.

Authorized representatives of the following organizations may look at your original (identifiable) research records at the site where these records are held, to check that the information collected for the study is correct and follows proper laws and guidelines.

- The Ottawa Health Science Network Research Ethics Board who oversees the ethical conduct of this study.
- Ottawa Hospital Research Institute, to oversee the conduct of research at this location.

Information that is collected about you for the study (called study data) may also be sent to the organizations listed above. Your name, address, email, or other information that may directly identify you will not be used. The records received by these organizations may contain your participant code, partial date of birth (month and year), sex, and pseudo-initials.

The following organization may also receive study data:

- The University of Ottawa.

Communication via e-mail is not absolutely secure. We do not recommend that you communicate sensitive personal information via e-mail.

During the discussions, participants will be encouraged to refrain from using names. If names or other identifying information is shared during the discussion, it will not be included in the written records.

The video/audio recordings will be stored in a secure location and viewed only by members of the research team. The recordings will be kept until they have been transcribed (turned into written records), and then they will be destroyed.

If the results of this study are published shared, or presented at scientific meetings, your identity will remain confidential. It is expected that the information collected during this study will be used in analyses and will be published/presented to the scientific community at meetings and in journals.

Your de-identified data from this study may be used for other research purposes. If your study data is shared with other researchers, scientific journals, or deposited in an online repository, information that links your study data directly to you will not be shared.

Even though the risk of identifying you from the study data is very small, it can never be completely eliminated.

WHAT IS THE COST TO PARTICIPANTS?

Participation in this study will not involve any additional costs to you or your private health care insurance.

ARE STUDY PARTICIPANTS PAID TO BE IN THIS STUDY?

If you decide to participate in this study, you will receive a \$20 coffee shop gift card.

WHAT ARE THE RIGHTS OF PARTICIPANTS IN A RESEARCH STUDY?

You have the right to be informed of the results of this study once the entire study is complete. If you would like to be informed of the results of this study, please contact the research team.

Your rights to privacy are legally protected by federal and provincial laws that require safeguards to ensure that your privacy is respected.

By signing this form, you do not give up any of your legal rights against the researcher or involved institutions for compensation, nor does this form relieve the researcher or their agents of their legal and professional responsibilities.

You will be given a copy of this signed and dated consent form prior to participating in this study.

WHOM DO PARTICIPANTS CONTACT FOR QUESTIONS?

If you have questions about taking part in this study, you may contact Dr. Paul Beaulé, (613) 737-8899 extension 78920.

If you have questions about your rights as a participant or about ethical issues related to this study, you can talk to someone who is not involved in the study at all. Please contact The Ottawa Health Science Network Research Ethics Board, Chairperson at 613-798-5555 extension 16719.

Study Title: Determination of the functional priorities and abilities within 1 week, and at 6, 12, and 26 weeks after knee and hip arthroplasty.

SIGNATURES

- All my questions have been answered,
- I understand the information within this informed consent form,
- I allow access to medical records and related personal health information as explained in this consent form,
- I do not give up any of my legal rights by signing this consent form,
- I agree, to take part in this study.

_____ Signature of Participant /	_____ Printed Name	_____ Date
_____ Signature of Person Conducting the Consent Discussion	_____ Printed Name and Role	_____ Date

Verbal consent form: Cognitive think-aloud interview (Study 2)

Verbal Consent Script

Study Title: Determination of the functional priorities and abilities within 1 week, and at 6, 12, and 26 weeks after knee and hip arthroplasty.

Principle Investigator: Dr. Paul Beaulé, MD, FRCSC

The Ottawa Hospital

Division of Orthopedic Surgery

501 Smyth Road, CCW 1646, Ottawa, ON, K1H 8L6

pbeaule@toh.ca

(613) 737-8899 ext 78920

OHSN-REB Number: 20230252-01H

Participant name:	Person calling:
Date Called:	Time Called:

Hello, may I please speak with [\[name of the potential participant\]](#).

***If respondent asks who the caller is:**

My name is [name of caller] and I am a [\[Clinical Research Assistant/Clinical Research Coordinator\]](#) and I am calling on behalf of Dr. Paul Beaulé, orthopaedic surgeon at The Ottawa Hospital about a research study.

***If potential participant is unavailable:**

Is there a better time to call back? Date/time:

***If potential participant indicates they are not interested:**

Thank you for your time. Goodbye.

***If potential participant is respondent:**

Continue with script below

My name is [name of caller] and I am calling on behalf of Dr. Paul Beaulé, orthopaedic surgeon at The Ottawa Hospital about a research study.

Is this an ok time to talk?

- ☐ No ***If no** → Is there a better time? **Date/time:**
- ☐ Yes ***If yes** → *Continue with script below*

I'm calling because your medical record indicates that you have agreed to be contacted about research and we have a research study that you might be interested in.

The study is being conducted by Dr. Paul Beaulé, orthopaedic surgeon at The Ottawa Hospital.

You are a candidate for this research because you underwent knee (or hip) replacement 6, or 12, or 26) weeks ago.

The research study aims to validate a questionnaire to determine the activities that are important to patients and their ability to do them, which will inform the best outcome assessment tools after knee and hip replacement which will occur in a next phase in this project.

Are you willing to hear more about the study?

- ☐ No ***If no** → Thank you for your time. Goodbye
- ☐ Yes ***If yes** → *Continue with script below*

I am going to read you the consent form and ask for your verbal consent once I have finished.

Conflicts of Interest:

There are no conflicts of interest to declare related to this study.

Research Activities:

Your participation in this study would involve completion of one interview. During the interview, you will meet with a member of the research team. The interview will last about 45 minutes in length and will take place virtually over the Microsoft Teams platform or in person at a convenient time and location, depending on your preferences.

In this interview, you will be asked to say out loud whatever comes to your mind from the first time you read while answering the survey questions. The researcher remains silent so long as you continue to think aloud. You will be reminded to “keep thinking aloud” if you stop talking for more than ten seconds. You are not asked to explain or justify what you are saying.

The questions are about the importance of functional activities to you right now and your ability to do these activities with respect to your recovery from joint replacement surgery.

It is anticipated that 5 to 7 patients who underwent knee and hip replacement at The Ottawa Hospital will participate in this study. The component of this study (validation of the questionnaire) should take about two months to complete. However, you will only need to participate in one interview.

The information you provide is for research purposes only. Some of the questions are personal. You can choose not to answer questions if you wish.

The interview will be audio recorded through the Microsoft Teams platform record function or it will be audio recorded using an encrypted digital audio recorder.

Do you have questions about the activities this study involves?

- ☐ No **If no → Continue with script below*
- ☐ Yes **If yes → Answer questions and document all questions and answers before continuing with script below*

Questions: _____

Answers: _____

Other Comments: _____

Voluntary Participation and Withdrawal:

Taking part in this study is voluntary.

You have the option to not participate at all, or you may choose to leave the study at any time (called withdrawal) at any time without having to provide a reason. Your decision will not affect any healthcare services you are entitled to at The Ottawa Hospital.

If you decide to leave the study, you can ask that the information that was collected about you not be used for the study.

Do you have questions about the voluntary nature and ability to withdraw from of this study?

- ☐ No ***If no** → *Continue with script below*
- ☐ Yes ***If yes** → *Answer questions and document all questions and answers before continuing with script below*

Questions: _____

Answers: _____

Other Comments: _____

Potential Risks, Harms, Discomforts:

There are no known risks for you in taking part in this study. Some of the questions may however make you feel uncomfortable, or you may become uncomfortable while thinking aloud. You may choose not to answer questions or leave the think-aloud interview at any time if you experience any discomfort.

Do you have questions about the potential risks this study involves?

- ☐ No ***If no** → *Continue with script below*
- ☐ Yes ***If yes** → *Answer questions and document all questions and answers before continuing with script below*

Questions: _____

Answers: _____

Other Comments: _____

Potential Benefits:

You may not receive direct benefit from participating in this study. The aim is to validate the questionnaire to determine key functional priorities and abilities after joint replacement from the perspectives of the patients. We hope the information learned from this study will help identify the most appropriate assessment tools after knee and hip replacement, which will in turn help outcomes of other people with joint replacement in the future.

Do you have questions about the potential benefits this study involves?

- ☐ No **If no → Continue with script below*
- ☐ Yes **If yes → Answer questions and document all questions and answers before continuing with script below*

Questions: _____

Answers: _____

Other Comments: _____

Privacy/Confidentiality:

If you decide to participate in this study, the research team will only collect the information they need for this study.

Records identifying you at this center will be kept confidential and, to the extent permitted by the applicable laws, will not be disclosed or made publicly available, except as described in this consent document.

Authorized representatives of the following organizations may look at your original (identifiable) research records at the site where these records are held, to check that the information collected for the study is correct and follows proper laws and guidelines.

- The Ottawa Health Science Network Research Ethics Board who oversees the ethical conduct of this study.
- Ottawa Hospital Research Institute, to oversee the conduct of research at this location.

Information that is collected about you for the study (called study data) may also be sent to the organizations listed above. Your name, address, email, or other information that may directly identify you will not be used. The records received by these organizations may contain your participant code, partial date of birth (month and year), sex, and pseudo-initials.

The following organization may also receive study data:

- The University of Ottawa.

Communication via e-mail is not absolutely secure. We do not recommend that you communicate sensitive personal information via e-mail.

During the discussions, you will be encouraged to refrain from using names. If names or other identifying information is shared during the discussion, it will not be included in the written records.

The audio-video recordings will be stored in a secure location and viewed only by members of the research team. The recordings will be kept until they have been transcribed (turned into written records), and then they will be destroyed.

If the results of this study are published, your identity will remain confidential. It is expected that the information collected during this study will be used in analyses and will be published/presented to the scientific community at meetings and in journals.

Your de-identified data from this study may be used for other research purposes. If your study data is shared with other researchers, information that links your study data directly to you will not be shared.

Even though the risk of identifying you from the study data is very small, it can never be completely eliminated.

Do you have questions about the how your privacy will be protected?

- ☐ No **If no → Continue with script below*
- ☐ Yes **If yes → Answer questions and document all questions and answers before continuing with script below*

Questions: _____

Answers: _____

Other Comments: _____

Cost to participation:

Participation in this study will not involve any additional costs to you.

Payment or Reimbursement:

As a token of our appreciation, you will be given a \$20 coffee shop gift card for your participation in this study. The gift card will be sent to you by mail after completion of the questionnaire.

Do you have questions about the costs of participation or payment/reimbursement?

- ☐ No **If no → Continue with script below*
- ☐ Yes **If yes → Answer questions and document all questions and answers before continuing with script below*

Questions: _____

Answers: _____

Other Comments: _____

Participant Rights:

You have the right to be informed of the results of this study once the entire study is complete. If you would like to be informed of the results of this study, please let the research team know.

Your rights to privacy are legally protected by federal and provincial laws that require safeguards to ensure that your privacy is respected.

Questions:

In case you have any questions, here are some contact numbers that are good to have. Do you have a pen and paper ready?

If you have any questions about taking part in this study, you may contact Motahareh Karimijashni at 613-737-8899 ext 74711.

If you have questions about your rights as a participant or about ethical issues related to this study, you can talk to someone who is not involved in the study at all. Please contact The Ottawa Health Science Network Research Ethics Board, Chairperson at 613-798-5555 extension 16719.

Have all of your questions been answered?

☐ No **If no → Answer questions and document all questions and answers before continuing with script below*

Questions: _____

Answers: _____

Other Comments: _____

☐ Yes **If yes → Continue with script below*

Consent:

Based on the description of the study, would you like to participate? Or would you like some time to think about it?

☐ No

☐ Yes

☐ More time to think about it

**If they do not want to participate: Thank you for your time. Goodbye.*

**If they do want to participate: Continue with script below*

**If they would like more time: Continue with script below*

For your records and to help in making your decision, I can send you the Information Sheet by email.

☐ Email (as a Microsoft 365 SharePoint link or password protected attachment)

Before I can initiate email contact with you, I'm required to inform you of the risks associated with use of email. I'm going to read a series of statements to you. Please stop me at any time if you have questions.

Read the 'Research Participant Consent to Communicate by Email'

Discussed on: ____/____/____ Time: ____ hours

Consenting Process completed by: _____ Date:
____/____/____

Record and confirm email address: _____

***If they wanted more time:** When would be a good time for me to call you back to answer any further questions you may have and obtain your decision? Date/time:

Wrap up with a reminder of the next steps and end the call.

Documentation of Verbal Consent

Study Title: Determination of the functional priorities and abilities within 1 week, and at 6, 12, and 26 weeks after knee and hip arthroplasty.

OHSN-REB Number: 20230252-01H

Name of Participant: _____

Date of Discussion: _____

Duration of Discussion: _____

SIGNATURES

- The participant's questions have been answered,
- The participant understands the information within this Verbal Consent Script,
- Each page of the Verbal Consent Script has been read to the participant.
- The participant agrees to take part in this study.

Investigator or Delegate Statement

I have carefully explained the study to the study participant. To the best of my knowledge, the participant understands the nature, demands, risks and benefits involved in taking part in this study.

Signature of Person
Conducting Consent Discussion

Printed Name and Role

Date

Information sheet: Cognitive think-aloud interview (Study 2)

Study Title: Determination of the functional priorities and abilities within 1 week, and at 6, 12, and 26 weeks after knee and hip replacement.

Principle Investigator: Dr. Paul Beaulé, MD, FRCSC

The Ottawa Hospital

Division of Orthopedic Surgery

501 Smyth Road, CCW 1646, Ottawa, ON, K1H 8L6

pbeaule@toh.ca

(613) 737-8899 ext 78920

OHSN-REB Number: 20230252-01H

IS THERE A CONFLICT OF INTEREST?

There are no conflicts of interest to declare related to this study.

WHY IS THIS STUDY BEING DONE?

Currently, there is limited information about the most appropriate assessments after knee and hip replacement. The purpose of this study is to validate a questionnaire which helps determine the activities that are important to patients and their ability to do them, which will inform the best outcome assessment tools after knee and hip replacement which will occur in a next phase in this project.

WHAT WILL HAPPEN DURING THIS STUDY?

Your participation in this study would involve completion of one interview. During the interview, you will meet with a member of the research team. The interview will last about 45 minutes in length and will take place virtually over the Microsoft Teams platform or in person at a convenient time and location, depending on your preferences.

In this interview, you will be asked to say out loud whatever comes to your mind from the first time you read while answering the survey questions. The researcher remains silent so long as you continue to think aloud. You will be reminded to “keep thinking aloud” if you stop talking for more than ten seconds. You are not asked to explain or justify what you are saying.

The questions are about the importance of functional activities to you right now and your ability to do these activities with respect to your recovery from joint replacement surgery.

It is anticipated that 5 to 7 patients who underwent knee and hip replacement at The Ottawa Hospital will participate in this study. The component of this study (validation of the questionnaire) should take about two months to complete. However, you will only need to participate in one interview.

The information you provide is for research purposes only. Some of the questions are personal. You can choose not to answer questions if you wish.

The interview will be audio- recorded through the Microsoft Teams platform record function or it will be audio recorded using an encrypted digital audio recorder.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

Taking part in this study is voluntary.

You have the option to not participate at all, or you may choose to leave the study (called withdrawal) at any time without having to provide a reason. Your decision will not affect any healthcare services you are entitled to at The Ottawa Hospital.

If you decide to leave the study, you can ask that the information that was collected about you not be used for the study.

HOW LONG WILL PARTICIPANTS BE IN THE STUDY?

You will be involved in this study for one think-aloud interview. Your participation in this study will take approximately 45 minutes.

CAN PARTICIPANTS CHOOSE TO LEAVE THE STUDY?

You can choose to end your participation in this research (called withdrawal) at any time without having to provide a reason. If you choose to withdraw from the study, you are encouraged to contact the study staff.

If you decide to leave the study, you can ask that the information that was collected about you not be used for the study.

WHAT ARE THE RISKS OR HARMS OF PARTICIPATING IN THIS STUDY?

There are no known risks for you in taking part in this study. Some of the questions may, however, make you feel uncomfortable, or you may become uncomfortable while thinking aloud. You may choose not to answer questions or leave the think-aloud interview at any time if you experience any discomfort.

WHAT ARE THE BENEFITS OF PARTICIPATING IN THIS STUDY?

You may not receive direct benefit from participating in this study. The aim is to validate the questionnaire to determine key functional priorities and abilities after joint replacement from the perspectives of the patients. We hope the information learned from this study will help identify the most appropriate assessment tools after knee and hip replacement, which will in turn help outcomes of other people with joint replacement in the future.

HOW WILL PARTICIPANT INFORMATION BE KEPT CONFIDENTIAL?

If you decide to participate in this study, the research team will only collect the information they need for this study.

Records identifying you at this center will be kept confidential and, to the extent permitted by the applicable laws, will not be disclosed or made publicly available, except as described in this consent document.

Authorized representatives of the following organizations may look at your original (identifiable) research records at the site where these records are held, to check that the information collected for the study is correct and follows proper laws and guidelines.

- The Ottawa Health Science Network Research Ethics Board who oversees the ethical conduct of this study.
- Ottawa Hospital Research Institute, to oversee the conduct of research at this location.

Information that is collected about you for the study (called study data) may also be sent to the organizations listed above. Your name, address, email, or other information that may directly identify you will not be used. The records received by these organizations may contain your participant code, partial date of birth (month and year), sex, and pseudo-initials.

Communication via e-mail is not absolutely secure. We do not recommend that you communicate sensitive personal information via e-mail.

During the discussions, you will be encouraged to refrain from using names. If names or other identifying information is shared during the discussion, it will not be included in the written records.

The audio-video recordings will be stored in a secure location and viewed only by members of the research team. The recordings will be kept until they have been transcribed (turned into written records), and then they will be destroyed.

If the results of this study are published, your identity will remain confidential. It is expected that the information collected during this study will be used in analyses and will be published/presented to the scientific community at meetings and in journals.

Your de-identified data from this study may be used for other research purposes. If your study data is shared with other researchers, information that links your study data directly to you will not be shared.

Even though the risk of identifying you from the study data is very small, it can never be completely eliminated.

WHAT IS THE COST TO PARTICIPANTS?

Participation in this study will not involve any additional costs to you.

ARE STUDY PARTICIPANTS PAID TO BE IN THIS STUDY?

As a token of our appreciation, you will be given a \$20 coffee shop gift card for your participation in this study. The gift card will be sent to you by mail after completion of the questionnaire.

WHAT ARE THE RIGHTS OF PARTICIPANTS IN A RESEARCH STUDY?

You have the right to be informed of the results of this study once the entire study is complete.

Your rights to privacy are legally protected by federal and provincial laws that require safeguards to ensure that your privacy is respected.

WHOM DO PARTICIPANTS CONTACT FOR QUESTIONS?

If you have any questions about taking part in this study, you may contact Dr. Paul Beaulé, (613) 737-8899 ext 78920.

If you have questions about your rights as a participant or about ethical issues related to this study, you can talk to someone who is not involved in the study at all. Please contact The Ottawa Health Science Network Research Ethics Board, Chairperson at 613-798-5555 extension 16719.

Implied consent form: Survey Study (Study 5)

Study Title: Determination of the functional priorities and abilities within 1 week, and at 6, 12, and 26 weeks after knee and hip arthroplasty.

Principle Investigator: Dr. Paul Beaulé, MD, FRCSC

The Ottawa Hospital

Division of Orthopedic Surgery

501 Smyth Road, CCW 1646, Ottawa, ON, K1H 8L6

pbeaule@toh.ca

(613) 737-8899 ext 78920

OHSN-REB Number: 20230252-01H

INTRODUCTION

You are being invited to participate in a survey. You are invited to participate in this study because you underwent knee or hip replacement. This research study aims to find out which activities of daily living are important to you right now and your ability to do them. The results of this survey will inform identification of the most appropriate patients assessment tools after knee and hip replacement.

IS THERE A CONFLICT OF INTEREST?

There are no conflicts of interest to declare related to this study.

WHAT WILL HAPPEN DURING THIS STUDY?

Your participation in this study will require the completion of a survey. The survey asks questions about functional activities that are important to you right now and the activities that you are able to do with respect to your recovery from your surgery. The survey should take approximately 20 minutes of your time.

If you would like to participate, you will be given 15 days to complete the survey. The research team will call you for a reminder if you do not respond the questionnaire at day 5 and day 10 after initial distribution of the survey.

The information you provide is for research purposes only. Some of the questions are personal. You can choose not to answer questions if you wish.

Review of your health record at The Ottawa Hospital will occur. Information about your function before surgery, other health problems, and surgical approach will be collected from your health record. This will be collected.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

Participation in this study is voluntary. You do not have to be in this study if you do not want to be. You can choose to end your participation in this research (called withdrawal) at any time without having to provide a reason. The decision will not affect any healthcare services you are entitled to at The Ottawa Hospital.

If you decide to leave the study, you can ask that the information that was collected about you not be used for the study. Let the research team know if you choose this.

RISKS AND/OR BENEFITS

There are no known risks to you for participating in this study. However, some questions may make you feel uncomfortable. If you prefer not to answer a question, you can skip it.

You may not receive direct benefit from participating in this study. The aim is to determine key functional priorities and abilities after joint replacement from the perspectives of the patients. We hope the information learned from this study will help identify the most appropriate assessment tools after knee and hip replacement, which will in turn help outcomes of other people with joint replacement in the future.

PRIVACY/CONFIDENTIALITY

Records identifying you at this center will be kept confidential and, to the extent permitted by the applicable laws, will not be disclosed or made publicly available, except as described in this consent document.

Authorized representatives of the following organizations may look at your original (identifiable) research records at the site where these records are held, to check that the information collected for the study is correct and follows proper laws and guidelines.

- The Ottawa Health Science Network Research Ethics Board who oversees the ethical conduct of this study.
- Ottawa Hospital Research Institute, to oversee the conduct of research at this location. Information that is collected about you for the study (called study data) may also be sent to the organizations listed above. Your name, address, email, or other information that may directly identify you will not be used. The records received by these organizations may contain your participant code, partial date of birth (month and year), sex, and pseudo-initials.

The following organization may also receive study data:

- The University of Ottawa.

This research study is collecting information on ethnicity as well as other characteristics of individuals because they may influence functional priorities. Providing information on your ethnic origin is voluntary.

Communication via e-mail is not absolutely secure. We do not recommend that you communicate sensitive personal information via e-mail.

If the results of this study are published, your identity will remain confidential. It is expected that the information collected during this study will be used in analyses and will be published/presented to the scientific community at meetings and in journals.

Your de-identified data from this study may be used for other research purposes. If your study data is shared with other researchers, information that links your study data directly to you will not be shared.

Even though the risk of identifying you from the study data is very small, it can never be completely eliminated.

COST AND/OR PAYMENT

Participation in this study will not involve any additional costs to you or your private health care insurance.

You will not be paid for taking part in this study.

RIGHTS OF PARTICIPANTS

You have the right to be informed of the results of this study once the entire study is complete. If you would like to be informed of the results of this study, please let the research team know.

Your rights to privacy are legally protected by federal and provincial laws that require safeguards to ensure that your privacy is respected.

QUESTIONS:

If you have any questions about taking part in this study, you may contact you can contact Motahareh Karimijashni at 613-737-8899 extension 74711.

If you have questions about your rights as a participant or about ethical issues related to this study, you can talk to someone who is not involved in the study at all. Please contact The Ottawa Health Science Network Research Ethics Board, Chairperson at 613-798-5555 extension 16719.

CONSENT

By completing this survey your consent to participate are implied.

Thank you!

Appendix C: Think-aloud Interview guide (Study 2)

Think-Aloud Protocol instruction.

- In this interview, I want you to answer the online survey questions I sent you. The aim of these questions is to determine activity priorities and abilities after knee and hip replacement.
- I am interested in what you say to yourself as you read and answer the survey questions.
- In order to do this, I will ask you to think and say aloud your thoughts that would normally remain silent as you answer this survey.
- What I mean is that I want you to say out loud whatever comes to your mind from the first time you read while answering the survey questions.
- I do not want you to try to justify or explain to me what you are saying. I want to know everything that crosses your mind as you answer the questions, even if you think that it is insignificant or irrelevant.
- Please speak naturally. Just act as if you are alone in the room talking to yourself.
- You will read each question to yourself, and when you are finished, select your answer. You may refer back to the questions as you answer.
- It is important that you keep talking.
- If you stop or forget talking for more than 10 seconds, I will remind you to keep talking aloud.
- Do you understand what I would like you to do? [*wait for a positive response before proceeding*].
- Do you have any questions? [*answer question(s) if asked*].
- If at any point you need to take a break or stop the session, please let me know, as that is not a problem. If you experience any inconvenience due to thinking aloud, you are encouraged to stop and let me know.

***For virtual meeting**

At this point, I am starting the audio and video recording and asking you to begin to answer the questions while thinking aloud. Are you ready? [*wait for a positive response before proceeding*]. Please keep your microphone on for the remainder of the session. Now you can begin to fill out the questions.

***For the in-person meeting**

At this point, I am starting the audio recording and asking you to begin to answer the questions while thinking aloud. Are you ready? [*wait for a positive response before proceeding*]. Now you can begin to fill out the questions.

Appendix D: Permission from journal to use published article in PhD thesis (Study 2)

Appendices



apc@tandf.co.uk

To: Motahareh Karimijashni

Dear Motahareh,

I hope you are well.

I have heard back from the relevant department, which advised that Authors are welcome to use their article as part of their thesis or dissertation, regardless of its open access status.

If you have any further questions, please do not hesitate to contact me.

Kind regards,
Amy McDonald

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Appendix E: Contribution of Collaborators

Role of Primary Researcher and Funding

I, Motahareh Karimijashni, was primarily responsible for this dissertation, which is submitted as part of the requirements for the Doctorate in Philosophy degree in Rehabilitation Sciences (Table E.1). Throughout my doctoral journey, I received financial support from various sources, including the admission scholarship (2020-2024), international doctoral scholarship (2020-2024), Special Merit Scholarship (2022-2024) from the University of Ottawa, Hans K. Uhthoff, MD FRCSC Graduate fellowship from The Ottawa Hospital (2022, 2023), BMO financial Group Graduate scholarship (2022), and Ontario Physiotherapy Scholarship (2023, 2024). Additionally, my PhD supervisor (Dr. Stéphane Poitras) and the GSEAD provided me with a conference grant to present preliminary research findings at academic conferences. The University of Ottawa provided me with a publication grant to cover the open-access publication fee for a manuscript not included in this dissertation. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscripts or the dissertation. During my doctoral studies, I was a teaching and research assistant at the University of Ottawa, a clinical research assistant in the Division of Orthopedic Surgery, Rehabilitation Center and the Ottawa Method Center at the Ottawa Hospital.

Supervisor

My research studies were supervised by Professor Stéphane Poitras, a full professor in the School of Rehabilitation Sciences at the University of Ottawa and the director of the Physiotherapy Program. With a strong professional background in physiotherapy and orthopedic surgeries, Professor Poitras provided crucial support throughout my research. He assisted in conceptualizing and designing the research studies, preparing the research proposal, and offered guidance during data collection. Additionally, he was involved in data analysis of all research

studies and made significant contributions to reviewing and editing the manuscripts and dissertation sections. He has served as my Ph.D. supervisor since my enrollment into the program in 2020.

Thesis committee members

Dr. Paul Beaulé, Dr. Tim Ramsay, and Dr. Marie Westby served as members of my dissertation committee, offering invaluable feedback and guidance throughout my research.

Dr. Beaulé is an orthopedic surgeon at The Ottawa Hospital, a professor at the University of Ottawa, and Chief of Staff at Hawkesbury and District General Hospital. With a strong background in orthopedic surgery, he has been a member of my thesis advisory committee since I began the program in 2020. He also acted as the principal investigator for the ethics applications related to cognitive think-aloud study (Study 2) and the cross-sectional survey (Study 5) at The Ottawa Hospital.

Dr. Ramsay is a senior scientist at the Ottawa Hospital Research Institute, an associate professor at the University of Ottawa, and the Scientific Director of the Ottawa Methods Centre. His expertise in methods and biostatistics has been instrumental, and he has been a member of my thesis advisory committee since 2020.

Dr. Westby, a physiotherapist with a strong background in total joint arthroplasty, works at the Mary Pack Arthritis Centre in Vancouver and serves as a clinician-scientist at the Vancouver Coastal Health Research Institute. She acted as the external examiner for my thesis proposal and has continued to support my research projects since the defense of my proposal.

Other Research Collaborators

In addition to my supervisors and committee members, several individuals made important contributions to my work. Marie-Cécile Domecq, a librarian at the University of Ottawa Health Sciences Library, assisted in developing the literature search strategy for the

systematic reviews. Kaitlyn Chambers, Clinical Research Manager for the Orthopedic Division at The Ottawa Hospital, reviewed the ethics application for The Ottawa Hospital and offered valuable feedback. She also provided valuable support during the participant recruitment for the cognitive think-aloud interviews (Study 2) and the survey of functional activities (Study 5).

Forough Abtahi, with a background in physiotherapy and a PhD candidate at Virginia Commonwealth University, assisted with abstract screening, full-text review, data extraction from included studies, coding the included outcome measures in two systematic reviews (Studies 3 and 4), and coding qualitative data in the study of functional activities (Study 5). Shokoofeh Abbasalipour, with a background in physiotherapy and a PhD candidate at the University of Western Ontario, contributed to abstract screening, full-text review, and data extraction in two systematic reviews (Studies 3 and 4), and coded the included outcome measures in one systematic reviews (Study 3). Parisa Ranjbar, with a background in physiotherapy and a PhD candidate at the University of New Brunswick, assisted with abstract screening, full-text review, and data extraction in the two systematic reviews (Studies 3 and 4). Dr. Armaghan Dabbagh, with a background in physiotherapy and a postdoctoral research fellow at the University of Toronto, supported abstract screening and full-text review for two systematic reviews (Studies 3 and 4). Dr. Simon Garceau, an orthopedic surgeon at The Ottawa Hospital, and a professor at the University of Ottawa acted as a co-principal investigator for the ethics applications related to cognitive think-aloud study (Study 2) and the survey of functional activity (Study 5) at The Ottawa Hospital. Keely Barnes, with a background in kinesiology and a PhD candidate in Rehabilitation Sciences at the University of Ottawa, provided valuable feedback on my proposal and the questionnaires developed in Study 2. Christina Charles, a PhD candidate in Rehabilitation Sciences at the University of Ottawa, offered important insights on the

questionnaire developed in Study 2. Margaret Norenberg, a language professor at the University of Ottawa, contributed valuable feedback on the questionnaire developed in Study 2. Dr. Simon Garceau, an orthopedic surgeon at The Ottawa Hospital, and a professor at the University of Ottawa acted as a co-principal investigator for the ethics applications related to cognitive think-aloud study (Study 2) and the survey of functional activity (Study 5) at The Ottawa Hospital

Manuscript Authorship

Authorship criteria for the manuscripts were based on the guidelines established by the International Committee of Medical Journal Editors (ICMJE). According to these guidelines, authors must make substantial contributions to the research conception and design, data acquisition, or data analysis and interpretation; draft or critically revise the manuscript for important intellectual content; and approve the final version. Collaborators who met these criteria for authorship are listed in Table E.1.

Table E.1 Research Collaborators

	Chapter 1: Introduction /Narrative review	Chapter 3: Think-aloud interview	Chapter 4: Systematic review	Chapter 5: Systematic review	Chapter 6: Survey	Chapter 7: Scoping review	Chapter8: Integrated Discussion
Design and conceptualization	MK, SP,TR, PB	MK, SP, MW,TR, PB	MK, SP, MW,TR, PB	MK, SP, MW,TR, PB	MK, SP, MW,TR, PB	MK, SP, TR, PB	MK
Data collection	MK	MK, PB, KC	MK, FA, SA, PR, AD, SP	MK, FA, SA, PR, AD, SP	MK, FA, PB, KC, SG	MK,SA	MK
Data analysis and interpretation	MK, SP	MK, SP, MW	MK, SP, FA, SA	MK, SP, FA	MK, SP	MK, SP	MK
Initial draft preparation	MK	MK	MK	MK	MK	MK	MK
Review and revision	MK, SP, PB, TR	MK, SP, MW, PB, TR, CC, KB, MN	MK, SP, AD, FA, MW,PR, PB,SA,TR	MK, SP, AD, FA, MW,PR, PB,SA,TR	MK, SP, MW, PB, TR, FA, SG	MK, SA, SP, PB, TR	MK, SP, PB, TR
Approval of final version	MK, SP, PB, TR	MK, SP, MW, PB, TR	MK, SP, AD, FA, MW,PR, PB,SA,TR	MK, SP, AD, FA, MW,PR, PB,SA,TR	MK, SP, MW, PB, TR, FA, SG	MK, SA, SP, MW, PB, TR	MK, SP, PB, TR
Manuscript authorship (in order of authorship)	MK, PB, TR, PB, SP	MK, MW, TR, PB, SP	MK, FA, SA, PR, AD, MW, TR, PB, SP	MK, FA, SA, AD, PR, MW, TR, PB, SP	MK, MW, PB, TR, FA, SG, SP	MK, SA, TR, PB, SP	NA

AD: Armaghan Dabbagh; **CC:** Christina Charles **FA:** Forough Abtahi; **KB:** Keely Barnes, **KC:** Kaitlyn Chambers **MN:** Margaret Norenberg. **MW:** Marie Westby; **MCD:** Marie-Cécile Domecq; **MK:** Motahareh Karimijashni; **PR:** Parisa Ranjbar; **PB:** Paul Beaulé; **SG:** Simon Garceau; **SP:** Stéphane Poitras; **SA:** Shokoofeh Abbasalipour; **TR:** Tim Ramsay.