Physical Activity Maintenance in a Post-Cardiac Rehabilitation Population: A Mixed Methods Study

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A thesis submitted in partial fulfillment of the requirements for the
Doctorate in Philosophy degree in Population Health

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ABSTRACT

The purpose of this thesis was to better understand physical activity (PA) maintenance among patients who have completed cardiac rehabilitation (CR).

Study 1: This study was a systematic review and meta-analysis of 19 randomized controlled trials (RCTs) testing PA and exercise maintenance interventions for adults who have completed CR. Descriptive synthesis of the studies combined with meta-analysis results provided evidence of increased PA among intervention groups compared with control groups at follow-up. Results of the meta-analysis found a significant difference in PA in the intervention groups compared to the control groups, via multiple exercise outcomes including exercise sessions/week (SMD = 0.20; 95% CI, 0.04 - 0.35), kcal/week (SMD = 0.59; 95% CI, 0.19 - 0.98), and daily steps (SMD = 2.14; 95% CI, 0.90 - 3.38). There is evidence to support the effectiveness of interventions aimed at maintaining PA and exercise among adults who have completed CR.

Study 2: This study was a synthesis of qualitative studies examining factors affecting PA maintenance among individuals who have completed CR. Eight studies met the criteria for inclusion. Multiple factors were identified among participants, including self-efficacy and motivation, social support, support with the transition from supervised hospital or centre-based exercise to exercise in the community or home, perceived safety of the exercise program, and availability and accessibility of PA resources and opportunities. Examining qualitative literature suggests factors at the intrapersonal-, interpersonal-, organizational- and neighbourhood-level are important in supporting exercise maintenance after completion of CR. Results from this

synthesis identified key areas for tailored program design, grounded in a social ecological approach.

Study 3: This study was a secondary analysis of trial data examining predictors of participants' moderate to vigorous physical activity (MVPA) 26 weeks after enrollment in a RCT of a PA maintenance intervention. Participants completed baseline questionnaires assessing social ecological, demographic, clinical, fitness, and behavioural variables. MVPA was assessed by accelerometer at baseline and 26 weeks later. Univariate analyses revealed nine significant baseline predictors of MVPA at 26 weeks including beliefs about exercise benefits, beliefs about exercise barriers, baseline MVPA, peak oxygen consumption, diabetes, age, sex, marital status, and work status. Multivariate analysis indicated that baseline MVPA was the only independent predictor of MVPA at 26 weeks. Given the pre-eminence of baseline MVPA, the regression analyses were re-run without baseline MVPA in the model. In that case, peak oxygen consumption became the only independent predictor of MVPA at 26 weeks. Results have implications for targeting intervention for PA maintenance in the unsupervised phase.

Conclusion: The findings of this thesis provided insights into the influences on long-term PA among cardiac patients post-CR and the strategies which can support long-term PA. While there have been positive developments in understanding PA maintenance, there are important knowledge gaps that remain unaddressed. These knowledge gaps include the measurement, monitoring, and surveillance of PA behaviour and ways in which intervention research could be improved. Further research will be required to address these knowledge gaps and to build on the growing knowledge of effective PA interventions to support people with heart disease.

CO-AUTHORSHIP

This dissertation presents the research of Novella Martinello in collaboration with her supervisor, Dr. Robert Reid, and other manuscript authors. Novella Martinello was responsible for developing the program of research, including identifying the research questions, objectives, and methods to be used, completing the data analysis and interpretation, and drafting all three manuscripts.

Manuscript 1: *The effectiveness of interventions to maintain physical activity in post-cardiac rehabilitation populations: A systematic review and meta-analysis of randomized controlled trials*. N. Martinello conceived the study, carried out the design, bibliographic search, article screening, data abstraction, analysis, and synthesis, interpreted the results, and drafted and edited the paper. S. Saunders participated in paper screening and verified data abstraction and study quality and reviewed the paper. Dr. Reid participated in the design of the study, provided methodological input, and assisted in the editing of the paper. All authors gave final approval of the manuscript.

Manuscript 2: *A qualitative synthesis of factors affecting physical activity after cardiac rehabilitation*. N. Martinello conceived the study, carried out the design, bibliographic search, article screening, data extraction and synthesis and wrote and edited the manuscript. D. Buetti participated as second reviewer and assisted in the editing of the paper.

Manuscript 3: *Predictors of physical activity maintenance in a randomized controlled trial post-cardiac rehabilitation*. N. Martinello conceived the secondary analysis study, performed the analyses, and drafted and edited the manuscript. Sherry L. Grace, Evyanne Wooding, Chris M. Blanchard, Jennifer Harris, Guy-Anne Proulx, Stephanie Prince Ware, Kerri A. Mullen, Murray Krahn, Caroline Chessex, Andrew Pipe, Amy Mark, and Robert D. Reid participated in various aspects of trial design, implementation, analysis, and coordination.

The other components of this thesis (i.e. Introduction, Literature Review, Discussion, Conclusion, and Appendices) are all original work of N. Martinello.

ACKNOWLEDGEMENTS

I would like to thank my family, especially my parents Cindy and Glenn, and all of my friends for their continuous support and belief in me that I could pursue and accomplish this goal of mine. Their encouraging and motivating words were what kept me going.

To my cohort in the Population Health program - I appreciated the opportunity to get to know each of you and to learn alongside you. A big thank you to my cohort buddy David Buetti – I'm so glad we met and did this together!

I would like to thank my advisor, Bob Reid, for his guidance throughout my doctorate degree. My learnings while completing this research were tremendous and I owe it to him as well as my thesis committee: Dr. Kristi Adamo, Dr. Tim Ramsay, and Dr. Jennifer Reed. I'm grateful to many others at the Ottawa Heart Institute and while there are too many to name, a special shout out is needed for Evyanne Wooding who is an absolute rock star!

Finally, and most importantly, I would like to thank my husband Matt for his endless support, encouragement, and love. This PhD is as much yours as it is mine! If we can get through this six-year rollercoaster together, while becoming first-time parents, we can get through anything. I couldn't have done this without you, and I dedicate this dissertation to you.

Funding:

Support for this doctoral research was provided by the Ontario Ministry of Colleges and Universities – Ontario Graduate Scholarships and the University of Ottawa – Excellence Scholarships.

The "Ecologically optimizing exercise maintenance in men and women post-cardiac rehabilitation" (ECO-PCR) randomized controlled trial in Study 3 was funded by the Heart and Stroke Foundation of Canada.

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LIST OF ABBREVIATIONS

AMSTAR	A Measurement Tool to Assess Systematic Reviews
BMI	Body mass index
CAD	Coronary artery disease
CASP	Critical Appraisal Skills Programme
CHD	Coronary heart disease
CI	Confidence intervals
CR	Cardiac rehabilitation
ENTREQ	Enhancing Transparency in Reporting the Synthesis of Qualitative Research
ELMI	Extensive Lifestyle Management Intervention
GLTEQ	Godin Leisure-Time Exercise Questionnaire
HAPA	Health Action Process Approach
IPAQ	International Physical Activity Questionnaire
LTPA	Leisure-time physical activity
LPA	Light physical activity
MET	Metabolic equivalent
MVPA	Moderate-to-vigorous physical activity
PA	Physical activity
PAR	Physical activity recall
PASE	Physical Activity Scale in the Elderly
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QOL	Quality of life
RCT	Randomized controlled trial
SCT	Social cognitive theory
SD	Standard deviation
SET	Social ecological theory
SMD	Standardized mean differences
SMS	Short message service

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CHAPTER 1: INTRODUCTION

1.1 Purpose of the Thesis

The purpose of this thesis was to examine physical activity (PA) maintenance among patients who have completed cardiac rehabilitation (CR), using a perspective informed by social ecological theory (SET). Manuscript 1 was a systematic review and meta-analysis of randomized controlled trials (RCTs) to examine the effectiveness of interventions to maintain PA among post-CR populations. Manuscript 2 synthesized the qualitative literature to understand the factors that affect post-CR PA maintenance. Manuscript 3 examined predictors of PA outcomes among CR graduates enrolled in a RCT of an exercise maintenance intervention.

1.2 Rationale

Heart disease is the second leading cause of death in Canada.[1] An estimated 2.4 million Canadian adults age 20 and over live with diagnosed heart disease.[2] When compared to those without the condition, Canadian adults with diagnosed ischemic heart disease, who survived a heart attack, or with diagnosed heart failure were three, four, and six times more likely to die prematurely respectively.[2] CR supports patients with heart disease in becoming physically active,[3] thereby reducing risk factors for heart disease,[4] decreasing hospitalizations (RR: 0.82; 95% CI: 0.70 to 0.96) and cardiovascular mortality (RR: 0.74; 95% CI: 0.64 to 0.86) among this population.[5] Canadian guidelines recommend 30 to 60 minutes of moderate-to-vigorous physical activity (MVPA) on most, preferably, all days of the week for patients with heart disease.[6] Clinically,

these guidelines translate to the accumulation of 150 minutes of MVPA per week. Most CR participants achieve recommended levels for weekly MVPA while participating in CR programs.[7,8] However, only 38 to 56% of participants meet recommended PA levels one year after CR program completion,[9,10] losing many of the health benefits of CR.[11] Strategies to effectively support and maintain long-term PA behavior and provide an improved understanding of factors that impact long-term PA in this population are needed.

1.3 Theoretical Background

1.3.1 Population Health

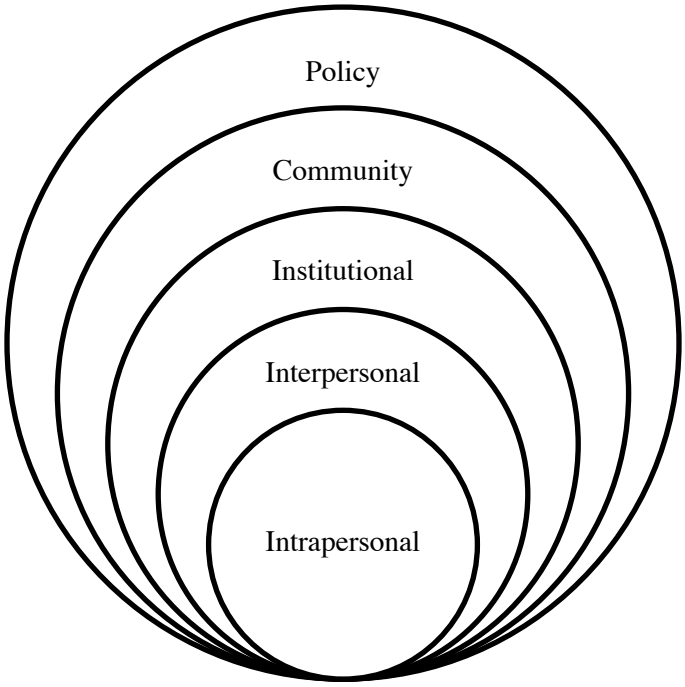
Population health is concerned with the health outcomes of a group of individuals, including the distribution of such outcomes within the group.[12] Applying a population health approach to research would look to identify the interrelated factors and conditions that increase the risk to the population over the life course and identify possible systematic variations.[12] Context and setting is important for population health research and a population health approach examines multiple levels of influence and their interactions.[13,14] A population health approach provides the basis from which health issues can be researched and for which appropriate interventions and policies can be developed.

1.3.2 Social Ecological Model

In this thesis, the program of research was guided by SET (Figure 1). Within SET, multiple factors operate and interact at multiple levels to influence health. SET examines health by

exploring interactions between people and their social, physical, and environmental settings.[15,16] Health research rooted in a social ecological framework incorporates multiple levels of analysis and methodologies.[16] SET is relevant for the aims of this research and consistent with a population health approach.

Figure 1. Levels of influence on health behaviours according to the Social Ecological Model.[15]



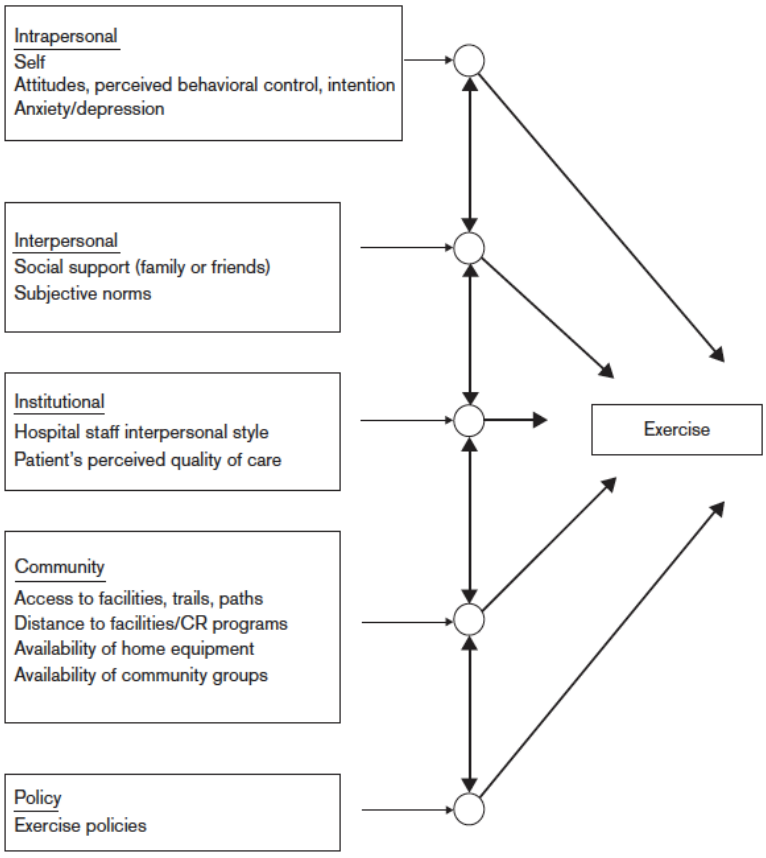
SET considers the various levels of influence on health, including individual/intrapersonal, interpersonal, organizational/institutional, community, and policy. Table 1 describes these multiple levels of influence in more detail.

Table 1. Social ecological levels of influence and descriptions.[15]

Level of Influence	Description
Intrapersonal	Individual characteristics that influence behavior, such as knowledge, attitudes, beliefs, and personality traits.
Interpersonal	Interpersonal processes and groups (family, friends, and peers) that provide social identity, support, and role definition.
Institutional	Rules, regulations, policies, and informal structures that may constrain or promote behaviors.
Community	Relationships, norms, and standards within defined boundaries; access, availability and quality of natural and built environment
Policy	Local, provincial, and/or federal policies and laws that regulate or support healthy actions and practices for disease prevention, early detection, control, and management.

These multiple levels of influence can either facilitate or impede health behaviours such as PA.[15] SET also recognizes the interactions between situational and personal factors in that the same environment might affect people differently, depending on a variety of personal attributes or histories.[14,15] Figure 2 portrays a proposed social ecological model of exercise among patients with heart disease, listing correlates of exercise at each level of influence and demonstrating their interaction and intersection with other levels of influencing factors to impact exercise.[17]

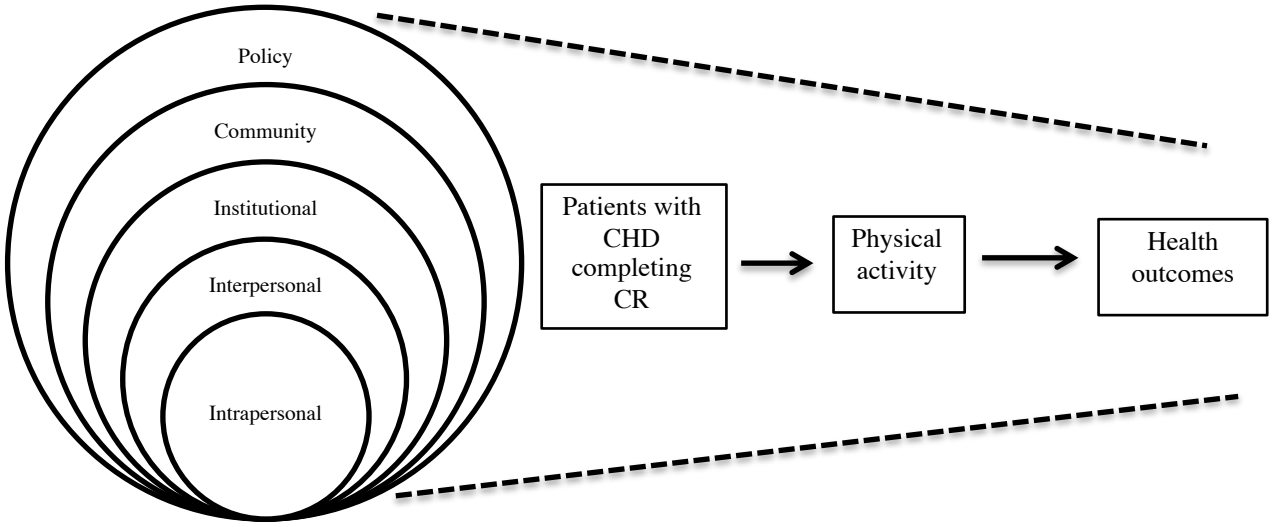
Figure 2. Social ecological model of exercise among coronary heart disease (CHD) patients (Petter et al., 2009).[17]



1.4 Conceptual Model

In the conceptual model for this research (Figure 3), factors at multiple levels influence PA both directly and indirectly through interactions with other factors, which consequently affect health outcome among CHD patients.

Figure 3. Conceptual model



This thesis used mixed methods to examine PA among CR graduates, guided by the theoretical frameworks of population health and SET. These theoretical frameworks guided the synthesis of evidence on this issue, supported the identification of factors at multiple levels which can impact long-term PA, and provided the theoretical underpinnings for the suggested implications for universal and targeted interventions and policies which could be developed to support PA among CR graduates.

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CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The literature review first provides a description of PA, then a description of heart disease, and the evidence linking the two. Then, CR is described and the link to PA is outlined. The following section reviews the literature on factors associated with maintaining PA among a post-CR population. Since manuscript 2 synthesizes qualitative research on this topic the present chapter only reviews quantitative studies on this topic. Then, research on PA interventions post-CR is reviewed, excluding RCTs which are systematically reviewed in Manuscript 1. The last section reviews the literature on sex and gender within the context of CR and PA and finally the chapter concludes with a summary of the research gaps overall and rationale for the current research.

2.2 Physical Activity and Heart Disease

Heart disease is the second leading cause of death in Canada,[1] and a leading cause of hospitalization.[2] Coronary artery disease (CAD) is the most common form of heart disease. It occurs when arteries in the heart become blocked, due to the build-up of a waxy substance called plaque inside the coronary arteries. These arteries supply oxygen-rich blood to heart muscle. When plaque builds up in the arteries, the condition is called atherosclerosis. The build-up of plaque occurs over many years, leading to complications including angina (chest pain) if the heart does not have enough oxygen; or heart attack if the heart does not get any oxygen at all.[3]

PA refers to "any bodily movement produced by the skeletal muscle that results in energy expenditure".[4] There is extensive evidence documenting the benefits of PA for patients with heart disease.[5-7] Regular PA not only has cardio-protective benefits but can reduce the incidence of cardiovascular events by impacting many risk factors for heart disease, including body composition, insulin sensitivity and glycemic control, blood pressure, dyslipidemia (i.e., elevated triglycerides, low high-density lipoprotein cholesterol, and other lipoprotein abnormalities), inflammation, fibrinolysis, and endothelial dysfunction.[5,8-10] PA is an independent and protective factor associated with reduced CV morbidity and mortality.[11] Canadian guidelines recommend 30-60 minutes of MVPA on most, preferably, all days of the week for patients with heart disease.[12,13] As a result, clinicians encourage patients to accumulate ≥150 minutes of MVPA each week.

2.3 Cardiac Rehabilitation

CR is a medically supervised program for people who have had a heart attack, heart failure, heart valve surgery, coronary artery bypass grafting, or percutaneous coronary intervention.[14] CR is a comprehensive program involving medical evaluation, prescribed exercise, cardiac risk factor modification, education, and counselling.[14] These programs are designed to limit the physiological and psychological effects of cardiac illness, reduce the risk for sudden death or re-infarction, control cardiac symptoms, stabilise or reverse the atherosclerotic process, and help patients develop healthy lifestyle changes.[14]

The CR team can include a range of health professionals, such as doctors, nurses, exercise specialists, physical and occupational therapists, dietitians, and mental health specialists.[15] International guidelines consistently recommend the provision of CR following a cardiovascular event.[16] Length, intensity, content, and participation rates considerably vary from country to country;[17] however, in Canada CR programs last an average of five months, usually consisting of two CR sessions per week.[18] CR programs are typically delivered in a supervised hospital or community-based setting.[16]

Exercise training is a core component of CR and a key secondary prevention strategy for heart disease.[13,19] Systematic reviews and meta-analyses demonstrate that among patients with coronary heart disease, exercise-based CR improves health outcomes, leading to reductions in morbidity, mortality and hospitalizations and improvements in health-related quality of life and risk factors.[16] Exercise-based CR is associated with a 13% and 26% lower all-cause and heart disease mortality, respectively, in addition to a 31% reduction in hospital admissions at 12 months in patients with heart disease.[20,21] Exercise-based CR is also associated with greater improvements in coronary heart disease risk factors, reduced angina symptoms and depression, improved exercise capacity and enhanced health-related quality of life.[16,22-24]

Canadian guidelines recommend adults aged 18-64 years achieve at least 150 minutes of MVPA per week.[25] Exercise-based CR supports heart disease patients in initiating regular exercise with approximately 70 to 85% of participants reporting that they achieve the recommended PA guidelines while in CR.[26,27] However, many individuals do not continue to exercise following completion of CR, with only 38 to 56% of participants meeting recommended PA levels one year

after CR program completion.[28-30] A systematic review of the short-term and long-term effects of CR on PA levels found little evidence of improved PA six months after completion of CR.[31] Unfortunately, the health benefits of PA are lost among individuals who discontinue regular PA after CR[30] and there is little support for those individuals to incorporate PA into their everyday lives at home. Evidence indicates that strategies to support long-term PA and exercise among CR graduates will not only reduce risk for adverse clinical events but also help to maintain the benefits from CR.[30]

2.4 Factors Affecting Physical Activity Maintenance Post-Cardiac Rehabilitation

There is a range of factors from all levels of a social ecological model that can either impede or promote PA. This section reviews the literature on factors that impact PA among CR graduates. Chapter 4 in this thesis reviews and synthesizes the qualitative literature on this topic; therefore, this section focuses on quantitative research.

One retrospective, cross-sectional study framed by a socio-ecological model examined the correlates of PA two to six years post-CR among a sample of 584 CR graduates.[32] Eligible CR graduates were mailed a questionnaire assessing self-report PA, using the Physical Activity Scale for the Elderly (PASE) scale, and information about 28 socioecological correlates. Univariate and multivariate analyses assessed associations between PA and correlates. Results showed that 75% of respondents were meeting Canadian PA guidelines at the time of the survey. The average time since CR graduation was 41.5 ± 11.5 months, with no significant association between the number of months since CR graduation and PASE scores ($r = 0.02$, $P = 0.66$). Univariate

analyses found statistically significant associations between higher PASE scores and younger age, male sex, cholesterol control, fewer comorbidities, higher VO_2 peak, higher perceived health, greater PA enjoyment, no fear of falling, higher household income, being married, full-time work status, living outside the city, having a personal form of transportation, higher social support, and higher level of perceived support from CR staff. Correlates that remained statistically significant in the multivariate regression model were age ($\beta = -1.60$; $P < 0.001$), PA enjoyment ($\beta = 13.90$; $P < 0.001$), work status ($\beta = -31.24$; $P < 0.001$), CR staff support ($\beta = 7.93$; $P = 0.005$), living outside of the city ($\beta = 19.46$; $P < 0.01$), and perceived health ($\beta = 7.93$; $P < 0.05$).[32]

A systematic review by Petter et al. identified the socio-ecological correlates of exercise of CHD patients across four contexts (i.e., during centre-based CR, home-based CR, after CR completion, and patients not attending CR).[33] Studies examining at least one documented correlate of exercise in a CHD population and either an objective (i.e., CR attendance/completion) or a subjective (i.e. self-report, activity check-list) measure of exercise were included. One hundred twenty-one studies and a total of 25,217 participants were included in the review. Of the included articles, 27 studies focused on participants after completion of CR. In the post-CR context, higher exercise levels were associated with better overall health status (i.e., fewer comorbidities, less severe cardiac illness), higher levels of self-regulatory self-efficacy (i.e., confidence in overcoming exercise barriers, scheduling and planning exercise), higher previous PA levels, higher intention to exercise, positive exercise beliefs and benefits (e.g., belief that exercise is beneficial to the individual), higher perceived behavioural control (i.e., perceived ease of participating in

exercise), increased social support, male sex, and receiving education or exercise consultation sessions.[33]

An observational study of 140 prospectively recruited cardiac, heart failure, and pulmonary rehabilitation patients examined factors affecting the transition to community-based PA maintenance programs after completion of rehabilitation.[34] Measures included a survey assessing factors such as intrinsic patient factors, exercise experience, health care team factors, and perceived barriers and examination of community program adherence data. This study found the most common barriers to be concerns about the community program staff or equipment and the ability of the community program to cater to patients with a chronic condition. The logistic regression analyses demonstrated that being retired (RR 2.1, 95% CI 1.1-2.5, p = 0.02) and exercising five days or more per week (RR 1.5, 95% CI 1.0-1.8, p = 0.03) were significant predictors of program participation, while transportation barriers (RR 0.2, 95% CI 0.0-0.4, p = 0.003) and safety concerns (RR 0.4, 95% CI 0.3-0.9, p = 0.01) significantly reduced the likelihood of continuing adherence.[34]

A longitudinal study prospectively examined the correlates of exercise maintenance among heart disease patients.[35] A total of 661 cardiac in-patients completed a questionnaire at discharge assessing sociodemographic characteristics, exercise behaviour, and psychosocial correlates. Exercise behaviour was assessed again at 9 and 18-months post-CR discharge using the exercise behaviour subscale of the Health Promoting Lifestyle Profile (HPLP). The subscale consists of eight items rated on a 4-point Likert scale (1 = never, 2 = sometimes, 3 = often 4 = routinely). A mean score was computed, with possible scores ranging from 1 to 4 and higher scores

indicating greater exercise participation. At 18-months post-discharge, 465 participants were retained in the study. The mean HPLP exercise subscale scores were 1.75 (standard deviation [SD] = 0.72; median = 1.90) in hospital, 2.36 (SD = 0.80; median = 2.38) at 9-months, and 2.25 (SD = 0.77; median = 2.25) at 18-months post-discharge. Participants were classified into one of three groups. Of 417 participants (mean age 63.1 ± 10.2) with complete data, 42.2% were classified as Exercise Maintainers, 21.3% as Irregular Exercisers, and 26.1% as Inactive. Compared to Inactive Participants and Irregular Exercisers, Exercise Maintainers were significantly more likely to be male, to have an exercise history, to be a cardiac rehabilitation enrollee, less likely to perceive exercise barriers, to attribute the cause of CAD to their own behavior, and to be current or past-smoker. The overall model was significant ($X^2 = 111.608$, $p < 0.0001$).[35] Patients more likely to maintain exercise have positive perceptions and utilize cardiac rehabilitation.

2.5 Neighbourhood Environment and Physical Activity

The term 'neighbourhood' has typically been used to refer to a person's immediate residential environment, which contains both physical and social characteristics potentially related to health.[36] These characteristics of neighbourhood environments can either promote or deter PA. Physical environmental characteristics such as access to PA facilities, adequate lighting, neighbourhood aesthetics and greenery, neighborhood safety, and the presence of sidewalks can promote PA whereas characteristics such as high amounts of traffic, high crime rates, and hilly terrain can discourage PA.[37,38] In addition, the home environment can influence PA through the possession or access of home exercise equipment and exercise opportunities.[27] The social

environmental features of a neighbourhood, including community support networks, social support, social capital, social cohesion, and culture, act as channels through which neighbourhoods impact our perception of health and ensuing health behaviours like PA.[39-42]

Relationships between a range of neighbourhood characteristics and diverse types of PA have been identified.[43] One systematic review found walkability and street connectivity (grid-like pattern of streets) to be correlates of transport-related activity (e.g. walking or cycling to school or work).[44] Leisure activity was consistently related to transportation environment (e.g. pavement and safety of crossings), to aesthetic variables (e.g., greenness and rated attractiveness), and to proximity to recreation facilities and locations.[44] Total PA was related to environmental variables in all five categories, most convincingly with recreation facilities and locations, transportation environment, and aesthetics.[44]

The effect of the neighbourhood environment on PA is highly context and behavior specific,[45] meaning that associations differ depending on the PA construct (e.g., active transport [such as walking or cycling for transport], leisure walking, moderate PA, vigorous PA, or overall PA) and the type of neighbourhood characteristic under investigation.[43,46] For example, some characteristics, such as street connectivity, proximity and access to transit, pedestrian and cycling infrastructure, and traffic-related characteristics, are more related to active transportation than recreational PA.[43]

Systematic reviews have found the strongest association of neighbourhood environment to walking than other forms of PA. A systematic review found objectively measured built

environment components such as provision of quality parks and playgrounds, active transportation infrastructure, street connectivity, paths and playgrounds, land use mix, and sidewalk safety to have positive effects on objectively measured walkability.[37] Within the Canadian context, a systematic review found objectively measured built environment characteristics, such as overall neighbourhood walkability, land use mix, and proximity to destinations, to be associated with walking among Canadian adults.[47]

Very little research has examined the effect of neighbourhood environment on PA among CR graduates. A longitudinal study performed by Perez et al. examined differences in weekly time spent in PA by level of perceived environmental resources, 6 months following graduation from CR.[48] There was a significant change over time in PA as measured by minutes per week, where PA increased between baseline and 3 months, and then dropped slightly at 6 months. This change over time differed by the level of perceived neighborhood resources, suggesting that home and neighborhood PA resources may positively influence PA maintenance following CR. The study was descriptive in nature, so did not attempt to evaluate the predictive utility of the environmental resource variables on PA level.[48]

The following subsections will review specific concepts of neighbourhood characteristics relevant to Study 3.

2.5.1 Neighbourhood Physical Activity Resources and Opportunities

Findings among the PA research examining proximity to PA opportunities and resources like parks, walking and cycling paths, and recreation centres have been mixed. A systematic review

of the association of proximity and density of parks and objectively measured PA in the United States found no consistent pattern between park exposure and objectively measured PA.[49] In summary, this systematic review found that five studies found a statistically significant positive association between access to parks and PA; nine studies found no association; and six studies had mixed findings.[49]

Van Cauwenberg et al.[50] found that perceived park proximity related to self-report PA among mid-to-older aged adults, and was moderated by reports of social cohesion/trust. These findings illustrate the importance of examining both physical and social neighborhood environmental factors as well as the interaction effects between park proximity and these neighborhood environmental factors. No significant relationships were observed between neighborhood physical environmental factors and recreational walking or other recreational MVPA.[50] The authors concluded that recreational MVPA other than walking may require specific skills or a certain level of fitness rendering these activities more susceptible to individual (e.g., self-efficacy, perceived competence, fitness level) rather than environmental factors.[50]

2.5.2 Neighbourhood Crime and Safety

Previous studies have found associations between neighbourhood crime and perceived safety and PA. One meta-analysis of 16 cross-sectional studies including 66,454 participants concluded that those who reported feeling safe from crime had a 27% greater odds of achieving higher levels of PA (OR = 1.27 [1.08, 1.49]), and those living in areas with a higher objectively-measured crime had a 28% reduced odds of achieving higher levels of PA (OR = 0.72 [0.61,0.83]) (PA data from

the included studies was dichotomized into low and high PA).[51] These findings suggest that lack of safety from crime, whether perceived or real, discourages PA participation.[51]

One longitudinal study looked at measures of fear of crime, neighbourhood perceptions and walking and identified that an increase in fear of crime was associated with a decrease in residents' walking inside the local neighbourhood.[52] For each increase in fear of crime (i.e., one level on a five-point Likert scale) total walking decreased by 22 minutes/week), recreational walking by 13 minutes/week and walking for transport by 7 minutes/week.[52] This study provided longitudinal evidence that changes in residents' fear of crime influence their walking behaviours. Another cross-sectional study found no association between subjective measures of PA and subjective measures of neighbourhood safety.[53] This study, however, found a borderline statistically significant relationship between objectively measured neighbourhood safety and subjectively measured PA, in that more residents were physically inactive who lived in areas characterized by high levels of criminal offences.[53]

2.5.3 Neighbourhood Aesthetics

The aesthetics of a neighbourhood relates to the presence of picturesque sights and landscape, cleanliness, and presence of natural elements, such as trees, water, natural light and fresh air.[54] Data from a meta-synthesis found environmental aesthetics to consistently have a positive influence on diverse types of walking, such as recreational walking and walking for transportation.[54] Natural elements were also found to mitigate the negative influence of some other factors on the walking experience. The presence of trees and natural light were emphasized walking for transportation and natural scenery was highlighted for recreational walking.[54]

The link between neighbourhood aesthetics and PA have been studied within the Canadian context. One cross-sectional study of 4,423 Canadian adults found walking for transport to be associated with tree density (B = 6.51; 2.29 to 10.72 minutes/week) and vigorous PA participation to be associated with proportion of neighbourhood green space (OR = 0.89; 0.82 to 0.98), as well as tree density (B = 7.28 minutes/week; 0.39 to 14.17).[55]

2.5.4 Neighbourhood Street Connectivity

Street connectivity refers to the directness of links and density of connections (i.e. intersections) in street networks.[56] A neighbourhood with a highly connected street network has streets with many short links, numerous intersections, and few dead-ends and cul-de-sacs.[56] Space syntax theory states that there will be higher movement density in the streets with higher connectivity, and much research to date has supported this theory.[57] One meta-synthesis found that the connectivity of walking spaces was important to participants when it came to both recreational walking and walking for transportation experiences.[54]

Unlike other reviews of street connectivity measures and PA in other countries,[43,58] a recent systematized literature review specific to the Canadian context found that out of four included studies, only one noted a positive association between objectively measured street connectivity and walking.[47] This supports the understanding that PA behaviours differ between countries, and that more research specific to the Canadian context is required.

2.6 Physical Activity Interventions Post-Cardiac Rehabilitation

Recognizing the gap between CR and long-term PA behavior, researchers have begun to test strategies that can assist CR graduates maintain PA. Chapter 3 of this thesis systematically reviews RCTs of PA interventions post-CR, and so this section of the literature review focuses on other high-quality, relevant studies.

One longitudinal study tested the effect of a peer support program on PA outcomes at 12 months among patients who had completed a 12-week CR program.[59] In peer support interventions, former patients act as mentors to support current patients. Patients were matched with and introduced to a lay mentor or 'peer' who were themselves former patients who had completed the CR program one to two years previously and were still participating in community-based PA. Seventy-nine patients with heart disease who had completed the CR program participated in the peer support program. Women were more likely to join the peer support program compared to men (85.3%, n = 29 versus 66.7%, n = 50, p = 0.044). At 12 months following the introduction of the peer support program, participants reported slightly more total PA (measured by pedometer) in comparison to those who did not join (1171.5 ± 220.1 versus 1070 ± 127.8 mins week^{-1} respectively; (p = 0.7)). Over the 12-month period, a significant decrease in total PA levels occurred in the non-peer support program group, decreasing by 211 minutes from 1382.5 ± 238.2 to 1171.5 ± 220.1 mins week^{-1} from baseline (p = 0.003). Conversely, those in the program group showed a slight increase in total PA levels, increasing by 48.9 from 1021.1 ± 141.9 to 1070 ± 127.8 mins week^{-1}. There may be potential for peer support programs to assist people with heart disease sustain PA after CR.[59]

One quasi-experimental study tested the effect of telephone-delivered "booster sessions" on long-term PA among CR graduates.[60] Booster sessions were conducted by trained university staff at six weeks and six months after CR discharge and focused on recall of positive exercise experience and action plan adherence, whereas participants in the control group completed questionnaires only at these timepoints. The boosters led to less decline in exercise, measured via Godin Leisure-Time Exercise Questionnaire, in the intervention group (n = 449) than in the control group (n = 435). The covariate-adjusted exercise means in minutes per week equaled 84.11 (SE = 5.01) for the control group, and 98.81 (SE = 4.92) for the intervention group at 18-month follow-up, demonstrating the value of booster sessions for supporting long-term PA among CR graduates.[60]

Another study investigating telephone-delivered booster sessions reported contrary findings.[61] Two hundred and seventeen patients were randomly assigned to one of two groups: the control group received the standard rehabilitation treatment, which included daily exercise training; the intervention group received the standard treatment plus an additional individualized self-efficacy and autonomy supportive intervention. The intervention group received two individual sessions delivered by trained health professional during the rehabilitation stay and two follow-up telephone calls at six and 24 months, focused on selecting personal goals. Exercise was assessed via a four-question exercise composite score at baseline, six-month and 24-month follow-up. No between-group difference in reported exercise measures was found in this RCT. The authors discussed that participants reported beneficial lifestyles and high motivation at baseline so it is possible an intervention aimed at improving motivation and lifestyle change would not demonstrate an effect. Findings may have also differed if PA had been measured via a PA scale

or by an objective measure, rather than the four-question composite score.[61] This study was not included in the systematic review because the included participants were still receiving rehabilitation treatment.

One RCT tested the effectiveness of telephone-monitored home-based CR versus traditional hospital CR on the long-term maintenance of PA among CR graduates.[62] The sample included 196 patients who had received coronary artery bypass graft surgery and were then enrolled in either traditional or home-based CR. Exercise sessions were approximately 30 to 50 minutes in length, three times per week over six months. Exercises for the hospital group included treadmill walking, stationary cycling, arm ergometry and stair climbing. Home-based exercise consisted primarily of walking but was tailored to include any exercise equipment possessed by the patient at the time of the study. PA scores, measured by PASE, were significantly higher among patients in the home group (n = 70) than in the hospital group (n = 74) at one year (mean difference 56.4 points, 95% CI 31.4 to 85.5; $p<0.0001$) and six year follow-up (mean difference 42.3 points, 95% CI 16.7 to 67.9; $p<0.001$).[62] Although this study did not test a post-CR intervention, and thus was not included in the systematic review, the findings have implications for the development of effective interventions, in terms of tailoring exercise programs and identifying required support post-CR based on patients' home environments and available PA resources.

2.7 Sex and Gender

It is important to integrate sex and gender into health research to comprehensively understand the biological, economic and social differences between women and men.[63] This integration is key to

strengthen the scientific knowledge base and inform the design and tailoring of health policy, planning, services and interventions.[63] The Canadian Institutes of Health Research defines sex and gender as the following:

"Sex refers to a set of biological attributes in humans and animals. It is primarily associated with physical and physiological features including chromosomes, gene expression, hormone levels and function, and reproductive/sexual anatomy. Sex is usually categorized as female or male but there is variation in the biological attributes that comprise sex and how those attributes are expressed."

"Gender refers to the socially constructed roles, behaviours, expressions and identities of girls, women, boys, men, and gender diverse people. It influences how people perceive themselves and each other, how they act and interact, and the distribution of power and resources in society. Gender is usually conceptualized as a binary (girl/woman and boy/man) yet there is considerable diversity in how individuals and groups understand, experience, and express it."

Differences in both sex (e.g., gene expression, protein patterns) and gender (e.g., patients' health seeking behaviour, physicians' disease management strategies) are factors in the manifestation, prevention, treatment and outcomes of heart disease.[64] Research shows that women are significantly less likely than men to be referred (39.6% vs 49.4%, respectively),[65] enroll (38.5% vs 45.0%),[66] and adhere (64.2% of prescribed sessions vs 68.6%)[67] to CR, and to maintain PA over the long-term,[35] which can have detrimental impacts on women's health outcomes.[68] These differences are due to distinct barriers to CR[69-71] and long-term PA among female cardiac

patients.[72,73] One systematic review examining sex differences in PA correlates among coronary heart disease patients found that PA in women with heart disease is more influenced by physical barriers (e.g., comorbidities), while PA in men with heart disease is more influenced by psychological issues (e.g., depression) and social support.[74]

Unfortunately, there is a lack of sex and gender-based analysis in research examining PA among heart disease patients, and most studies fail to include a representative number of women.[74,75] When combined with low sample sizes, the use of unequal groups by gender or sex limits the ability to conduct valid statistical comparisons and generalize findings to the female population.[74,75] Corroborating this, a recent study attempted to meta-analyze RCTs to understand mortality and morbidity outcomes among women after CR and was unable to proceed due to a dearth of women in CR trials and the lack of reporting of outcomes by sex.[75]

2.8 Research Gaps to be Addressed

Long-term maintenance of PA among cardiac patients who have completed CR remains a challenge. Although previous systematic reviews of the literature have demonstrated the effectiveness of community-based PA interventions on PA levels among the general population, to the author's knowledge none have reviewed the effectiveness of exercise interventions on levels of PA among graduates of CR. A better understanding of strategies to maintain PA among cardiac patients is needed. Furthermore, there is need for an in-depth examination of how factors at multiple levels, including those at the environmental level, can influence heart disease patients' ability to achieve recommended PA over the long-term, and examining differences by

sex and gender when possible. This lack of evidence provides support for the current proposed research, which investigated PA maintenance among post-CR patients, incorporating mixed methodologies and taking into account a social ecological theoretical perspective.

2.9 Research Questions

Research Question #1: Are PA interventions applied post-CR effective for maintaining PA levels compared to usual care among a post-CR population? By answering this question, I will know if effective interventions have already been reported in the literature and better understand the characteristics of effective interventions. By pooling data from other studies, I will be able to gain insight into the magnitude of effects that can be anticipated.

Research Question #2: From the perspective of patients and providers, what are the factors affecting PA maintenance among patients who have completed CR? By answering this question, I will be able to identify potential new intervention targets for PA maintenance interventions and gain insights into the experiences of the people most closely affected by the problem of post-CR recidivism.

Research Question #3: What are the factors which predict PA among CR graduates enrolled in a randomized controlled trial of a PA maintenance intervention? By exploring relationships between PA outcomes and predictors from different levels of SET, I will gain an understanding of the relative importance of these predictors.

2.10 Thesis Outline

This thesis is organized according to the Guide for Doctoral Thesis as stipulated by the Faculty of Graduate and Postdoctoral Studies at the University of Ottawa and the Population Health PhD Program. The remainder of this thesis is divided into four chapters. Three manuscripts are presented in Chapters 3 through 5. The manuscript in Chapter 3 is entitled "The effectiveness of interventions to maintain physical activity in post-cardiac rehabilitation populations: a systematic review and meta-analysis of randomized controlled trials". The manuscript in Chapter 4 is entitled "A qualitative synthesis of factors affecting physical activity after cardiac rehabilitation". The manuscript in Chapter 5 is entitled "Predictors of physical activity maintenance in a randomized controlled trial post-cardiac rehabilitation". Chapter 6 synthesizes the results from all studies and discusses overall conclusions.

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CHAPTER 3: MANUSCRIPT 1

This manuscript was written and published in accordance to the specifications for submission to the peer-reviewed *Journal of Cardiopulmonary Rehabilitation and Prevention*. It appears here in its published format.

The effectiveness of interventions to maintain exercise and physical activity in post-cardiac rehabilitation populations: A systematic review and meta-analysis of randomized controlled trials.

Journal of Cardiopulmonary Rehabilitation and Prevention 2019;39:161-167

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Abstract

Purpose: Cardiac rehabilitation is a medically supervised program addressing health behavior changes and promoting self-management among individuals with heart disease. This includes initiation of regular physical activity. However, long-term physical activity after cardiac rehabilitation among this population remains a challenge.

Methods: This study was a systematic review and meta-analysis according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Randomized controlled trials were identified by searching multiple databases and were selected if they evaluated an intervention with a physical activity or exercise component among individuals who completed cardiac rehabilitation. A descriptive synthesis was performed for all studies and means and standard deviations were used for meta-analysis when possible. Risk of bias, heterogeneity, and publication bias were assessed.

Results: Twenty-five studies met the inclusion criteria and 19 were included in the meta-analysis. The mean age of participants across studies was 60 yr and 80% were male. Descriptive

synthesis of the studies combined with meta-analysis results provided evidence of increased physical activity among intervention groups compared with control groups at follow-up. **Conclusion:** There is evidence to support the effectiveness of interventions aimed at maintaining physical activity and exercise among adults who have completed cardiac rehabilitation.

Key Words: cardiac rehabilitation, exercise, meta-analysis, physical activity, systematic review

Introduction

Heart disease is the leading cause of death in adults worldwide.[1] Physical activity (PA) is a key health behavior for preventing and improving the symptoms of heart disease.[2] Indeed, engaging in regular PA has cardioprotective benefits and can reduce the incidence of cardiovascular events.[3] Evidence indicates a volume of PA of just 75 min/wk can lead to health benefits.[4]

Cardiac rehabilitation (CR) is a medically supervised program addressing health behavior changes and promoting self-management among individuals with heart disease.[5] It includes a focus on PA counseling and training to help initiate regular PA.[6] Participation in CR has shown to decrease total and cardiac mortality by 20 to 26%[7] and approximately 70 to 85% of participants report that they achieve the recommended PA guidelines while participating in CR.[8,9] However, with only 38 to 56% of CR participants meeting PA guidelines 1 yr after CR program completion,[10,11] long-term maintenance of PA among this population remains a challenge. Few CR programs have addressed long-term maintenance of PA or incorporated strategies to assist patients in maintaining PA over the long-term. Recognizing this gap, researchers have begun to develop interventions that can assist with PA and/or exercise maintenance among post-CR populations. This manuscript reports on a systematic review of the literature for PA and exercise

interventions among post-CR populations and examines the effect on maintenance. This review includes both concepts of PA and exercise in order to include a broader range of interventions. While exercise is PA that is planned and structured, PA is any movement that requires an increase in energy expenditure that is greater than resting requirement.

Methods

A systematic review was performed to identify interventions that aim to maintain PA or exercise levels in adults after CR in any country. This review adheres to the reporting guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[12] and addresses the items outlined in "A Measurement Tool to Assess Systematic Reviews" (AMSTAR) checklist.[13,14] The systematic review methodology was prospectively registered in PROSPERO (Registration number CRD42016039426).

Inclusion/Exclusion Criteria

Eligible study designs included only randomized controlled trials (RCT). The inclusion criteria included participants who were graduates of a CR program and interventions aimed at maintaining and/or increasing PA or exercise post-CR, compared to usual care. Excluded were study designs other than RCT and interventions that did not include a PA component or exercise or were not post-CR. All intervention durations and duration of CR programs were considered. The primary outcome was change in PA or exercise. Both self-report and objective measures of PA and exercise were included.

Search Strategy

A search of electronic databases included: Ovid MEDLINE In-Process and Other Non-Indexed Citations (1946 to present); EMBASE Classic + (1947 to present); CINAHL (1981 to present); SPORTDiscus; and Dissertations and Theses (1980 to present) and were searched from inception to July 2016. The search strategy was developed with the assistance of a research librarian and was carried out by NM. The strategy is illustrated using the Medline search as an example (Appendix I) and was modified according to the indexing systems of the other databases. Gray literature, such as theses and dissertations, conference abstracts, and unpublished data and manuscripts (provided by original authors), that met the inclusion criteria was obtained. The bibliographies of key studies selected for the review and related systematic reviews were examined to identify further studies.

Study Selection

Papers were imported into EndNote (version X7.5.3, Thompson Reuters,) and duplicates were removed using the 'duplicate' function. Remaining duplicates were removed manually. Two reviewers (NM and SS) completed title and abstract screening, based on inclusion and exclusion criteria, to identify potentially relevant papers. The full texts of all studies that met the inclusion criteria were then obtained and reviewed independently by NM and SS. Reasons for exclusion were recorded using a standardized data extraction form, which was created prior to data extraction. Any disagreements that arose between the reviewers were resolved through discussion or with a third reviewer (RR) until consensus was reached.

Data Extraction

Data were extracted independently by NM and verified by SS from studies using Review Manager (RevMan) 5.3 (The Cochrane Collaboration, 2012, The Nordic Cochrane Centre, Copenhagen, Denmark). Disagreements were resolved through discussion between NM and SS and consulting article full-texts until consensus was reached. Reviewers were not blinded to the authors or journals when extracting data. Extracted information consisted of participant characteristics (sample size, mean age, sex distribution, population), intervention description, outcomes (methods of measurement, units of measurement, follow-up length) and results (means and standard deviations at follow-up). The primary outcome measure was the mean change in PA or exercise following exposure to an intervention. Longest follow-up data available for each study were used, as outlined by the Cochrane handbook.[15] Unpublished data were acquired through email contact with authors of papers which described a PA or exercise outcome but did not report the data. When specific data were missing from a paper, 2 attempts were made to contact the correspondence author by email.

Statistical Analysis

Enough studies provided PA or exercise data with comparable outcomes to conduct a meta-analysis. When possible, continuous outcomes were transformed into uniform measurement scales. One study provided outcomes by month and this was transformed to week by assuming an average of 4.3 weeks in a calendar month. Metabolic equivalent (MET)-minutes per week (MET-min/wk) were transformed to calories per week (kcal/wk) by assuming the weight of the average person to be 150 lb.[16] Since not all studies could be included in the meta-analyses (units not comparable), a descriptive synthesis of the evidence for all studies was performed.

Forest plots and the meta-analyses were created using RevMan 5.3 to compare the mean differences and 95% confidence intervals (CI) in post-intervention PA between intervention and control groups. One study[17] included 2 different intervention arms and in this case both interventions were included in the appropriate meta-analysis and the control group sample size was divided to include half in each meta-analysis as per the Cochrane handbook.[15] A random-effects meta-analysis was used to provide an overall summary measure of effect (mean difference) and 95% CI for each PA outcome type. Standardized mean differences (SMD) were used due to the variability in the measurement methods for assessing physical activity across studies (eg, different objective and self-report measures). This allowed the results of the studies to be standardized on a uniform scale and represent the general effect size of the intervention.[15] *A priori* subgroup analyses were performed to test differences in the length of the intervention, length of CR, and objectively vs subjectively measured PA or exercise. Subgroup analyses were conducted within the outcome of exercise sessions/wk, which was the only exercise outcome with at least 10 studies included (as per the Cochrane handbook).[15] Only 1 study within exercise sessions/wk outcome used an objective measure; therefore, an examination of objective versus subjective measures could not be conducted. A sensitivity analysis was completed to assess whether differences existed between unpublished and published data.

Assessment of Risk of Bias and Quality of Evidence

Risk of bias in included studies was evaluated using methods outlined in the Cochrane Handbook for Systematic Reviews of Interventions to assess the risk of selection, detection, attrition, and reporting biases.[15] Risk of bias was assessed using RevMan 5.2 and was carried out by 2

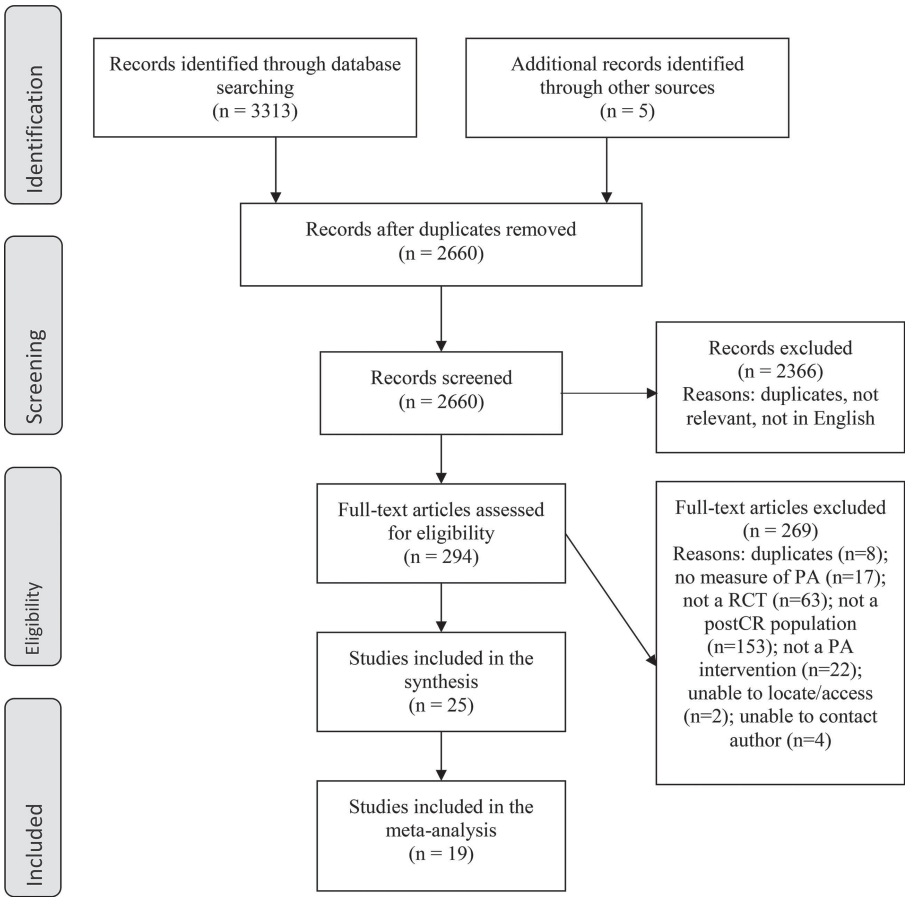
independent assessors (NM and SS). If disagreements between assessors occurred, consensus was achieved through discussion.

Results

Search Results

The electronic database search identified 3313 articles (Figure 1). Of these articles, 1010 were identified in MEDLINE, 1476 in EMBASE, 609 in CINAHL, and 218 in SPORTDiscus. After deleting duplicates, 2660 relevant papers remained. A preliminary title and abstract review resulted in the retrieval of 294 papers for full-text screening. Contact with authors and searching of bibliographies identified an additional 5 papers. Of these 299 papers, 25 studies met the criteria for inclusion in the synthesis and 19 were included in the meta-analysis. Reasons for excluding studies included: duplicates (n = 8), no measure of PA (n = 17), not a RCT (n = 63), not a post-CR population (n = 153), not a PA intervention (n = 22), unable to locate/access (n = 2), and unable to contact author (n = 4). Duplicate studies were retained based on most recent data.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram. CR indicates cardiac rehabilitation; PA, physical activity; RCT, randomized controlled trial.



Included Studies

A summary of the included studies is available in Table 1. These studies were published over a 20-yr period from 1995 to 2015. The included studies were conducted in 15 countries with 7 studies conducted in the United States,[18-24] 2 in Canada, [25,26] 2 in Belgium,[27,28] 2 in Italy,[29,30] and 2 in Norway.[31,32] The remainder were from Iran,[33] Switzerland,[34] Australia,[35] France,[36] Sweden,[37] Scotland,[38] Japan,[39] Netherlands,[40] Germany,[17] and Poland.[41] All studies used a RCT design. All studies were published in English.

Table 1. Summary of included studies.

Author (Year of Publication)	Sample size (baseline), n	Country	% Male	Mean Age, yr
Aliabad 2014	96	Iran	84.4	57.3
Antypas 2014	69	Norway	77.7	59.2
Arrigo 2008	261	Switzerland	85	61
Butler 2009	110	Australia	75.5	63.8
Duncan 2002	13	USA	84.6	66
Duncan 2003	14	USA	85.7	66.4
Frederix 2015a	80	Belgium	83	60.5
Frederix 2015b	140	Belgium	82.5	61
Giallauria 2009	52	Italy	84.6	57.8
Giannuzzi 2008	3241	Italy	86.3	57.9
Guiraud 2012	29	France	79.5	58.7
Hofman-Bang 1999	87	Sweden	83.9	53
Hopper 1995	80	USA	82.5	57.7
Hughes 2007	72	Scotland	80	60
Izawa 2005	45	Japan	84.4	64.2
Janssen 2014	199	Netherlands	81.4	57.7
Kaminsky 2013	28	USA	77.7	56.4
Lear 2003	302	Canada	82.5	64.1
Luszczynska 2006	114	Poland	64	54.3
Madssen 2014	49	Norway	77.6	61.5
Millen 2009	41	Canada	78	61.2
Moore 2006	250	USA	77.5	62.4
Pinto 2011	130	USA	75.4	63.6
Sniehotta 2005	240	Germany	81.5	57.7
Yates 2005	62	USA	69	66.7
Total	5804			
Mean	232.2		80.2	60.4

Participants

The number of participants in each study ranged from 13[18] to 3241.[30] The mean sample size at baseline was 232 with a total number of 5804 participants at baseline and 5457 total participants at follow-up. Overall, 80.2% of the participants were male at baseline and the mean age of all participants at baseline was 60.4 yr. Most of the studies did not report any sex-specific results. One study reported that women tended to perform more PA sessions at follow-up than men[41] and 3 studies reported no significant differences for the PA outcome between men and women.[22,23,34]

Interventions

Individual study characteristics of included studies are summarized in Appendix II. Intervention length ranged from 15 min[41] to 3 yr.[30] The modal intervention length was 12 wk. Three studies incorporated an online or mobile component,[27,28,31] 2 studies used telemonitoring[27,28] and 3 studies focused on the use of pedometers.[21,35,39] Ten studies incorporated strategies such as addressing barriers, problem solving, and counseling. Twelve studies implemented strategies such as self-monitoring, including exercise logs and diaries, goal setting, and feedback. Seven interventions took place in a clinical setting,[22,29,30,32,33,40,41] 1 intervention took place in both a clinical and home setting,[33] and the remainder took place at home.

Length of CR preceding the intervention varied, ranging from 2 wk[41] to 1 yr.[37] The content and setting of CR also differed depending on the country in which it was provided. Four studies did not clarify the length or provide a description of CR.

Outcomes

There was considerable variety in the measurement of PA and exercise behavior. Nine of the studies used objective measures of PA or exercise[21-23,27,28,36,38-40] and the remainder used subjective measures. The objective measures included triaxial and uniaxial accelerometers, pedometers, and a portable wristwatch heart rate monitor. The subjective measures included questionnaires, such as the Godin Leisure-Time and Minnesota Leisure-Time, and exercise diaries. Follow-up time ranged from 8 wk[21] to 2 yr.[29] A few studies reported on both a self-report and objective measure and in these cases the objective measures were used.

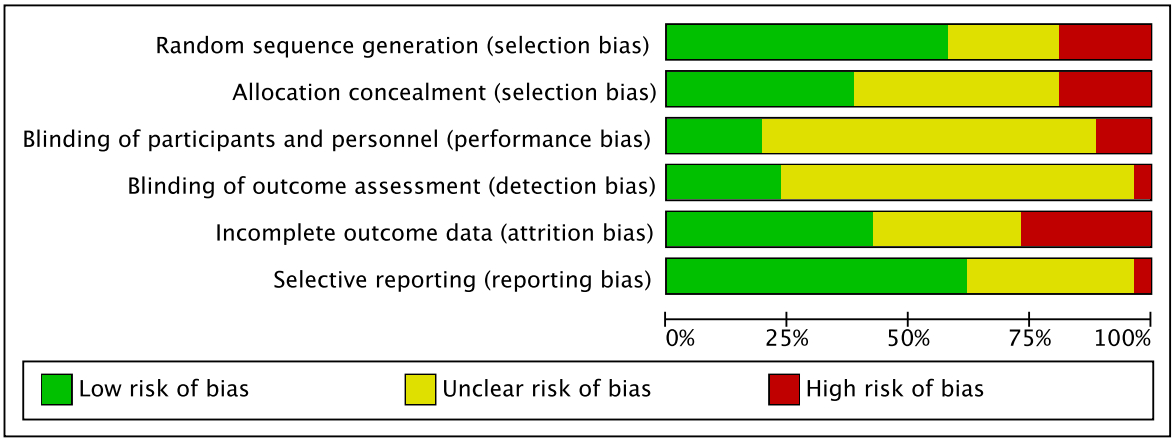
There was also considerable variety across outcomes. Nine studies used exercise sessions/wk[17-19,24,26, 32, 35,37,41] while 1 study used exercise sessions/mo.[22] Five studies used

steps/d.[21,27,28,39,40] Two studies used MET-min/wk[31,33] and 2 studies used kcal/wk.[25,36] One study used minutes of moderate to vigorous physical activity/wk[23] and 1 study used activity counts/wk.[38] One study used a dichotomous outcome of PA or no PA[34] and 1 study retrieved ordinal data related to level of exercise intensity.[29] The remainder used scores on questionnaires.

Risk of Bias in Included Studies

A summary of the risk of bias assessment can be seen in Figure 2. Overall, there were a high number of "unclear" verdicts, with many papers not reporting any information related to most biases. The majority of studies did report on randomization or blinding of participants or assessors. In PA studies, it is typically not possible to blind participants or treatment delivery personnel to allocation, creating a potential source of bias into the delivery.[42] Similarly, performance bias can be difficult to assess in PA interventions as participants and treatment delivery personnel could not be blinded to treatment allocation. The largest risk of bias came from selection bias (mainly issues with allocation concealment), and attrition bias (issues with participants lost to follow-up). Most articles reported on all outcomes at all time points, including nonsignificant effects.

Figure 2: Risk of bias summary presented as percentages across all included studies.

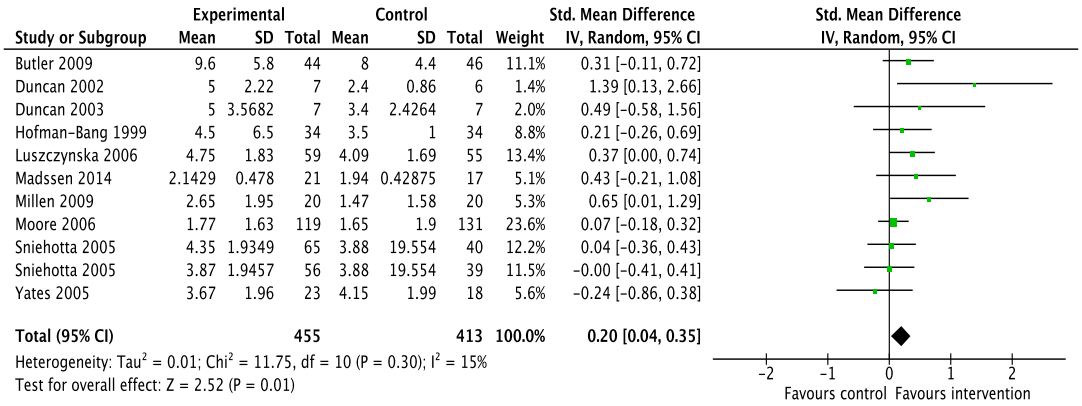


Effects of Interventions

Thirteen studies reported significant differences between the intervention group and control group for the PA outcome at the longest follow-up[21,23,33,31,34,35,18-20,27-30,36,37,39-41] and 7 studies reported no significant difference between the intervention and control groups at the longest follow-up.[22,38,25,26,32,17,24] Both interventions that encouraged family or spousal support[33,40] were effective. Interventions mainly delivered by telephone were not consistently effective.[24,25,38]

A total of 19 studies tracked similar outcome variables and were able to be included in the meta-analysis. Overall, results of the meta-analysis found a significant difference in PA in the intervention groups compared to the control groups, via multiple exercise outcomes including exercise sessions/wk (SMD = 0.20; 95% CI, 0.04 - 0.35) (Figure 3), kcal/wk (SMD = 0.59; 95% CI, 0.19 - 0.98) (Figure 4) and daily steps (SMD = 2.14; 95% CI, 0.90 - 3.38) (Figure 5).

Figure 3: Forest plot of standardized mean differences of number of exercise sessions per week from physical activity interventions. CI, confidence interval; df, degrees of freedom; SD, standard deviation; SMD, standardized mean differences.



*Same study with two different intervention arms, each presented separately.

Figure 4: Forest plot of standardized mean differences of calories per week from physical activity* interventions*. CI, confidence interval; df, degrees of freedom; SD, standard deviation; SMD, standardized mean differences.

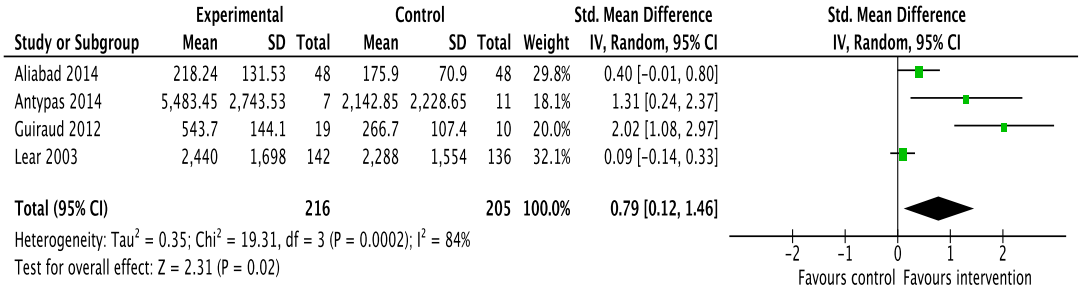
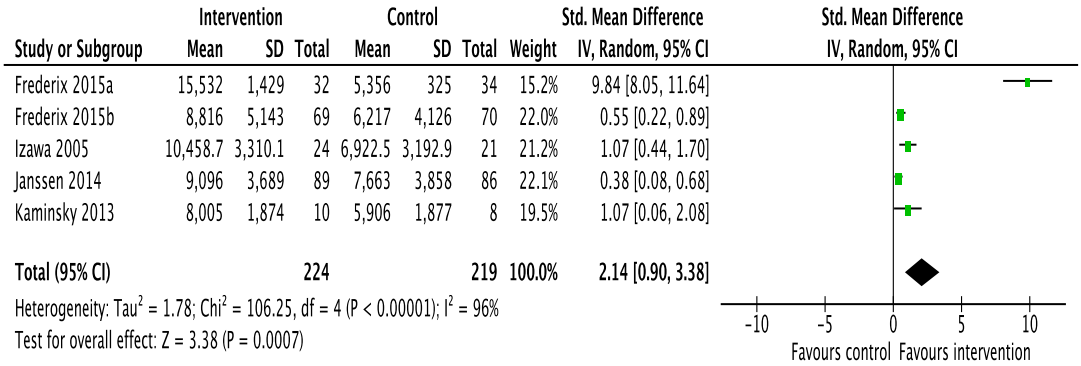


Figure 5: Forest plot of standardized mean differences of steps per day from physical activity interventions. CI, confidence interval; df, degrees of freedom; SD, standard deviation; SMD, standardized mean differences.



Studies using number of exercise sessions/wk as the outcome were mostly homogenous (I^2 = 15%, P = .30). Studies measuring kcal/wk and steps/d revealed high levels of statistical heterogeneity between studies and therefore require caution when interpreting the results (I^2 = 84%, P < .0002; I^2 = 96%, P < .00001).

Subgroup and Sensitivity Analyses

Results of the sensitivity analyses did not identify differences between the unpublished[27,28,32] and published data. Therefore, the unpublished data were retained in the meta-analysis. Subgroup analyses examined length of preceding CR program before the intervention and length of intervention. No significant difference was observed for length of CR program; however, only interventions lasting 12 wk or longer were effective (<12 wk SMD = 0.12; 95% CI, -0.16, 0.40; I^2 = 38%, P = .2 and ≥ 12 wk SMD = 0.25; 95% CI 0.05 - 0.45; I^2 = 10%, P = .35).

Discussion

This systematic review examined the effectiveness of interventions to maintain PA among adults who have completed CR. Results from the descriptive synthesis combined with the meta-analysis suggest that PA and exercise interventions post-CR can help individuals with heart disease maintain PA in the long-term compared to controls. Although length of the preceding CR did not demonstrate a significant difference when it came to intervention effectiveness, the duration of the intervention was significant, with effective interventions lasting 12 wk or longer.

The interventions in the included studies involved a range of strategies and delivery methods. Online/mobile interventions and pedometer-based interventions were consistently effective. Previous systematic reviews of internet- and/or mobile-based interventions and pedometer interventions for PA have reported consistent evidence that such programs are effective in increasing PA.[45-47] Although rehospitalization data was not collected in the present review, a study examining a telemonitoring intervention reported fewer cardiovascular events among the intervention group, resulting in a gross cost savings of $1418 USD/patient.[48] One study examining the effect of a pedometer intervention found the intervention to be associated with a 12% reduction in cardiac hospital admission rates.[40] Pedometer and internet or mobile-based interventions may be cost-effective alternatives to supervised exercise in the maintenance phase.

In a previous systematic review of PA interventions for individuals post-CR, Chase found that interventions consisting of behavioral strategies and combined behavioral and cognitive strategies were more successful in PA behavior change than cognitive strategies alone.[44] Chase also noted the variety in CR programs across different countries in terms of CR length, content and setting, which created difficulties with comparing the post-CR interventions. This review

addressed this issue by documenting CR characteristics and length for each included study and conducting a subgroup analysis. This analysis found that length of preceding CR did not demonstrate significant differences for intervention effectiveness.

Participants were predominantly male and under 65 yr of age, therefore generalizability to female and older adults is limited. Cultural and socioeconomic demographics were also not consistently addressed in the included studies. Sex-specific findings were mostly not reported in the studies. However, 3 studies reported much higher attrition rates among women than men,[22,23,31] confirming the need to address sex and gender differences in PA research among individuals with heart disease. PA maintenance is even more challenging among women with heart disease, who report PA levels that are significantly lower than men both during and after CR.[9,49-51] Given the importance of sex-based analysis and under-representation of women in these studies, this is an important area for further research.

The included studies used a range of both subjective and objective PA measures. Due to the range in PA outcomes tracked in the included studies, a subgroup analysis of subjective and objective measures was not possible. Both subjective and objective measures have limitations. Self-report measures may bring about an overestimation of PA and some questionnaires tend to ignore brief or low-intensity bursts of PA.[43] In addition, participants tend to recall purposeful PA better than incidental PA.[52]

Objective measures can create a reactive response and pedometers and accelerometers respond poorly to activities like cycling, skating, load-carrying, and other nonstandard activities.[43] There is also a lack of consistency in approaches to translating accelerometer signals into energy expenditure units.[53] One systematic review comparing direct and self-report measures for assessing PA in adults found low-to-moderate correlations between the 2 methods,

suggesting that measurement method can significantly impact on the observed levels of PA.[54] There is a need for consistent assessment of PA in research in order to accurately assess and compare the effectiveness of PA interventions and impacts on health. Additional limitations of this review include the use of exclusively English language publications, which may have introduced a potential for English bias, and the use of Bushman's[16] recommendation of transforming MET-min/wk to kcal/wk using an average body weight of 150 lb, which is likely an underestimation of body weight in a population with heart disease.

A qualitative synthesis exploring factors affecting physical activity maintenance among people who have completed CR found barriers to physical activity maintenance included physical limitations and illnesses such as obesity, arthritis and back pain, lack of social support, lack of support with the transition from hospital-based PA to community or home-based PA, cost and perceived safety of the exercise program, and availability and accessibility of physical activity opportunities and options.[55] Given the effectiveness of pedometer interventions, these interventions could promote walking as an accessible, safe and inexpensive form of physical activity for individuals to ensure the continuity of their PA after CR. We know that any PA is better than no PA at all and this standard is more attainable for people living with other chronic conditions.[4] As well, online/mobile interventions, which were consistently effective in this review, could be a cost-effective way of providing health professional support through the transition as well as connect users with others going through the same experience.

Conclusion

PA and exercise interventions after CR may help individuals with heart disease to maintain PA; however, measures and outcomes widely varied among the included studies and risk of bias

across studies was high. Research on PA maintenance among adults living with heart disease should examine separately the effects for men and women and high quality RCTs are needed.

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CHAPTER 4: MANUSCRIPT 2

This manuscript was written and prepared in accordance to the specifications for submission to the peer-reviewed *Health Education & Behavior*.

A qualitative synthesis of factors affecting physical activity after cardiac rehabilitation

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Abstract

Introduction: Cardiac rehabilitation (CR) is a medically supervised program consisting of exercise, counselling, and education to support recovery and reduce future risk among people with heart disease. The initiation of physical activity (PA) is a key component of CR; however, long-term PA after CR among this population remains a challenge.

Methods: This study was a synthesis of qualitative literature on factors affecting PA maintenance among individuals who have completed CR, reported following the Enhancing Transparency in Reporting the Synthesis of Qualitative Research (ENTREQ) guidelines.

Results: Eight studies met the criteria for inclusion. Multiple factors were discussed among participants, such as self-efficacy and motivation, social support, support with the transition from supervised exercise to exercise in the home or community environment, safety and appropriateness of the exercise program, and local availability and accessibility of PA resources and opportunities.

Discussion: The synthesis of qualitative studies identified key areas for tailored program design. Patients with heart disease require additional support with the transition from CR completion to long-term PA at home. At CR discharge, it is necessary to identify potential co-morbidities and assess capacity and self-efficacy for unsupervised exercise and goals for long-term PA in order

to appropriately tailor health professional support and exercise strategies to meet the abilities and physical limitations of patients with heart disease and alleviate patient concerns surrounding safety and appropriateness of exercise programs.

Conclusions: A synthesis of qualitative studies suggests factors at the intrapersonal-, interpersonal-, organizational- and community-level are important in supporting exercise maintenance after CR; a social-ecological approach could ground intervention development.

Keywords

heart disease, qualitative synthesis, cardiac rehabilitation, physical activity, exercise

Introduction

Cardiac rehabilitation (CR) is a medically supervised program consisting of exercise, counselling, and education to support recovery and reduce future risk among people with heart disease. The initiation of regular physical activity (PA) is a key component of CR and there is extensive evidence documenting the benefits of PA for heart disease, including both improving and reversing some symptoms,[1,2] and reducing rates of coronary heart disease (CHD) related morbidity and mortality and hospital admissions.[3,4] However, maintaining optimal levels of PA after CR remains a challenge: only 38-56% of CR participants are adequately active one year after program completion.[5,6] An understanding of the factors affecting long-term PA among heart disease patients post-CR from the patient and provider perspective is needed. Identifying potential barriers and facilitators to PA maintenance among this population can help to design

and inform interventions and strategies to support heart disease patients maintain PA over the long-term.

To date, most studies[7-9] and systematic reviews[10] have taken a quantitative approach to examine the correlates of PA maintenance among patients with heart disease. While quantitative studies are important to establish different causal links between factors, qualitative studies go deeper into meaning and context using inductive methods, which could lead to a better understanding of the experience of PA maintenance after CR among patients. To date, there has not been a synthesis of qualitative research examining factors affecting post-CR PA maintenance among patients with heart disease patients. This research aims to address this gap by reviewing previous qualitative research on this topic, which will provide more insights into the factors affecting post-CR PA maintenance. Further, this systematic review of qualitative literature will be conducted using a perspective of social ecological theory (SET). According to SET, health is affected by multiple interdependent and interacting factors, including those at the intrapersonal, interpersonal, organizational, community, and policy-level, which either impede or facilitate PA.[11] As mentioned by Richard, Gauvin, and Raine, social ecological models are critical in improving population health as they: “offer an elegant conceptual contour of these levels of influence and guide the development of multilevel intervention models, which underscore the need for enacting various health education and promotion strategies to achieve population-level changes" (p. 309).[12] Therefore, this research aims to synthesize, for the first time, the qualitative literature concerning factors affecting PA maintenance among individuals post-CR, framed within a social ecological model. The findings can support the development and evaluation of multi-level interventions to increase PA maintenance after CR.

Reflexivity Statement

The authors of this qualitative synthesis take an ontological and epistemological critical realist stance,[13] meaning that our construction and understanding of the 'real world' is based on the perspectives and viewpoints of the participants and first authors, in addition to our own perspectives. Both authors are PhD candidates in Population Health and the frameworks and principles guiding this discipline can impact the construction of findings in this synthesis.

Methods

This synthesis of the qualitative literature was reported following the Enhancing Transparency in Reporting the Synthesis of Qualitative Research (ENTREQ) guidelines (Appendix III).[14]

Inclusion and Exclusion Criteria

This synthesis included all studies that use qualitative methods for data collection (including focus groups, interviews, observation, and document analysis) and that use qualitative methods for data analysis (including content analysis, narrative analysis, discourse analysis, framework analysis, and grounded theory). These criteria for inclusion of qualitative research are outlined in the Cochrane Qualitative and Implementation Methods Group supplementary guidance on qualitative evidence synthesis.[15] Studies were excluded if data were collected using qualitative methods, but not analyzed qualitatively. Mixed methods studies that used both qualitative and quantitative methods were included, provided that it was possible to extract data derived only from the qualitative methods. This review also included studies that focused on the experiences and perspectives about PA maintenance among people who have completed CR.

Search Strategy

Five electronic databases were searched: Ovid MEDLINE® In-Process and Other Non-Indexed Citations (1946 to present); EMBASE Classic + (1947 to present); CINAHL (1981 to present); PsycINFO; and Dissertations and Theses (1980 to present) (all searched on August 5, 2020). The search strategy had previously been developed with the assistance of a research librarian for the purposes of a systematic review of randomized controlled trials (RCT) of the same topic, and so this search strategy was used, removing RCT filters and applying a filter for qualitative studies. The search was limited to English language articles due to resource constraints. The strategy is illustrated using the Medline search as an example (Appendix IV) and was modified according to the indexing systems of the other databases. The bibliographies of key studies selected for the review were examined to identify further studies.

Selection of Studies

Study screening and selection was conducted using EndNote X7 software (Thomson Reuters). Duplicates were removed using the 'duplicate' function. Remaining duplicates were removed manually. The first author completed title and abstract screening based on inclusion and exclusion criteria to identify potentially relevant papers. The full-texts of all studies that met the inclusion criteria were obtained and reviewed.

Data Extraction

Qualitative data were extracted from papers included in the review and imported directly into NVivo-11 software (QSR International). The data extracted included bibliographic information,

study objectives and design, methodological background, sampling, participant description, data collection and analysis methods, themes and interpretations of results, and strengths and limitations.

Assessment of Methodological Quality

The qualitative papers were assessed using the standardised critical appraisal instrument CASP (Critical Appraisal Skills Programme) Qualitative Checklist. Criteria which were assessed included: i) the appropriateness of the methods and data analysis techniques to address the research questions and justification of the research design, ii) researchers' backgrounds, assumptions, and paradigms, iii) clarity and appropriateness of the sampling strategy, iv) rigor of the data analysis process, including verbatim quotes to support the findings, consideration of disconfirming data, and an in-depth description of the analysis process, v) discussion related to credibility and dependability of the findings including triangulation, an audit trail, and member checks, vi) consideration of ethical and equity issues, and vii) whether there was consideration of how the findings were situated within the broader context. The results of the quality assessment were not used to exclude studies from the review but were used to inform interpretation of the data.[15] Quality assessments were conducted by the first author (NM) and the second reviewer role (DB) in this study operated as a source of critical dialogue and feedback about the assessments.[16]

Data Analysis

The extracted data were analyzed using the principles of content analysis.[17] First, the extracted data were read through as a whole in order to gain a broad understanding of the data. Then, the

extracted data were read through a second time and coded inductively, line-by-line, looking for concepts, meanings, and related categories. SET informed the formulation of the coding scheme. Categories were compared and contrasted and organized into higher-level themes in order to produce an overall set of findings. Data coding and analysis were conducted by the first author (NM), and the second reviewer role (DB) in this study operated as a source of critical feedback and dialogue about codes and themes and encouraged reflexivity about interpretations and constructions of knowledge.[16]

Results

The electronic database search identified 11397 articles. Of these articles, 431 were identified in MEDLINE, 938 in EMBASE, 9945 in CINAHL, and 83 in PsycINFO. After de-duplication, 10997 papers remained. A preliminary title and abstract review resulted in the retrieval of 308 papers for full-text screening. Of these, eight studies met the criteria for inclusion in the synthesis. Studies were excluded because: 1) the participants were not CR graduates; 2) the study was not qualitative; and 3) the experience of the participants was not focused on PA. One study included both cardiac and pulmonary rehabilitation graduates and this study was included since rehabilitation models for these populations are similar[3,18] and research has shown that these two populations have been successfully integrated into a rehabilitation setting.[19,20] Study characteristics, along with their methodological approaches, can be found in Table 1.

Quality appraisals for the included studies based on the CASP tool can be found in Table 2. All eight studies had clear aims and rationale for the research, along with methodology and research designs to address the aims. Most of the studies described appropriate recruitment strategies

except two, where the recruitment strategy was not clearly described. Most studies provided adequate detail regarding data collection and analysis methods with the exception of two that did not discuss the concept of saturation. The most significant methodological issue with the included studies concerned a lack of clarity with respect to researcher role and ethical issues. Only one study considered the relationship between the researcher and participants, potential research bias, or potential ethical issues. Most studies provided clear descriptions of findings including supporting quotes and discussion of credibility. It was challenging to discern the use of disconfirming evidence in all studies. All included studies discussed the value of the research and situated the study within the broader body of research.

Multiple levels of factors affecting the maintenance of physical activity after cardiac rehabilitation were found and are discussed below. Table 3 lists the themes by level of the social ecological model, the number of total references per theme, and the number of studies which referenced the theme.

Intrapersonal Factors

Positive Exercise Beliefs

Positive exercise beliefs were a key theme, and within this theme, the ability to take control over one's health was consistently described. Many participants spoke about the ability to maintain health or fitness levels as an achievement and were aware of the link between their exercise participation and their current health state. According to these participants, maintaining PA provided one with the fitness to carry out everyday tasks, travel, spend time with family, and 'enjoy life'. Similarly, some participants spoke about the wish to maintain independence

throughout aging, avoiding ill health, or not wanting to be a burden on one's family as another motivator in this theme.

> 'it's also about preserving life and avoiding relapse into further heart episodes, avoiding death...fundamentally that is all about avoiding this, avoiding further relapse, further illness, further heart deterioration' (Hardcastle et al., 2015, participant quotation)

Exercise professionals shared similar sentiments and felt that if their patients believed that exercise adherence was associated with positive health benefits their patient would more likely adhere to exercise:

> 'If they see that there are positive changes coming from exercise and they believe that those changes are beneficial to them then they are going to stick with it. If they don't think that exercise has helped them and they don't see a benefit to it then they are much less likely to continue.' (Sweet et al., 2019, participant quotation).

Motivation

Many participants discussed concepts within the theme of motivation, e.g., an individual's degree of willingness to exert and maintain an effort towards personal or organizational goals.[21] For example, while some participants discussed the importance of mental attitude and enjoyment of exercise as important for sustaining exercise, other participants discussed a lack of motivation, interest, or acceptance of a sedentary lifestyle as a barrier to PA maintenance.

> "Exercising makes me feel better, I love doing it, and I feel better afterwards...I feel more energetic actually afterwards...I really do feel good when I leave here" (Hardcastle et al., 2015, participant quotation)

> "Being motivated to do it was my biggest problem. Just getting to it, it was alright once I started, you know, working on the treadmill or lifting some weights or whatever, but just getting the routine to do it on a regular basis was sort of my biggest problem." (Desveaux, 2016, participant quotation)

Self-efficacy

Within the theme of self-efficacy, that is an individuals' judgments of their capacities to perform specific actions,[22] participants discussed an overall lack of confidence in the ability to carry out independent exercise as well as a perceived lack of time or capacity to continue PA after CR. Regarding time constraints, the authors described their conversations with participants:

> 'Wide consensus across the groups existed in relation to the importance of personal confidence to successful rehabilitation and exercise continuation. During the hospital sessions, there was a widespread perception of being in a safe and secure "comfort zone" because the exercise environment was familiar and contained professionals with expertise in organizing and supervising exercise for people with heart diseases.' (Clark et al., 2011, author interpretation)

Participants discussed the importance of having a routine and structure in order to sustain exercise over the long-term.

Physical limitations / poor health

The final theme within individual-level factors surrounded physical limitations, disabilities, and illnesses. Some participants described co-morbid conditions such as arthritis or back pain, which had a detrimental effect on maintaining exercise.

Interpersonal Factors

Social support

A major theme referenced by participants in all included studies was the importance of social support and connectedness. Participants discussed the benefits of exercising in a group setting, with friends, family, or peers. Benefits included avoiding social isolation and promoting social inclusion and support, which were all motivators for exercise maintenance. Participants discussed meeting new friends and meeting other people with health conditions, which can offer a sense of relatedness and further encouragement and motivation to continue exercising.

> 'I feel more comfortable talking with people I know who are having the same problems and that so yeah that's reassuring and it makes me want to come' (Hardcastle et al., 2015, participant quotation)

Spousal support was the focus of one included study. Supportive communication and shared experience between the post-CR individual and their spouse are key components of spousal support and facilitators of PA adherence:

> 'If I ever get the feeling like I don't want to go (exercise), he will say 'you don't have your walk in for today', so I think that helps.' (Rowland et al., 2018, participant quotation)

Conversely, participants discussed a lack of social support as a barrier to PA maintenance. Authors summarized the responses of their participants:

> 'Responses indicating lack of social support as a barrier included "no one to participate with me," and "my wife is not interested in staying active."' (Fleury et al., 2004, author interpretation)

> 'The social aspect in the community is not as strong as the hospital program' (Adsett et al., 2013, author interpretation)

Work and family obligations

Some participants discussed constraints related to caregiving, family life such as cooking and cleaning, and work schedules and commitments as barriers to exercise maintenance. Dunn et al., (2014) described: 'people who worked long hours felt they were too tired or had no time to fit exercise in' (author interpretation).

Organizational Factors

Safety of the exercise program

A prominent theme at the organizational level included safety and appropriateness of the exercise program. Participants discussed the importance of the safety of the exercise facilities and knowledge and skills of fitness professionals related to exercise among people with heart disease. If participants felt the exercise was not safe or appropriate for people with heart disease or felt the fitness instructors had little knowledge about exercise prescription for special populations, this was viewed as a barrier to exercise maintenance.

> 'Hospital staff are more experienced. Fitness instructors do not have training or experience in this area' (Adsett et al., 2013, participant quotation)

> 'I think most of the gyms are not really effective in what they are doing or providing right now to people with heart conditions.' (Desveaux, 2016, participant quotation)

This led a few participants to discuss a perceived need for greater links between health care providers and fitness professionals. This need was echoed among exercise professionals, who viewed a need for stronger collaboration between hospitals and community.

> 'I think a greater coordination between, whether it is hospital or the cardiac rehabilitation program in the community is important … we send our patients to the community is one thing but having patients perhaps slowly enter the community while they are still in their

> cardiac rehabilitation program. Get them set up so that if they have questions in the community they can come back … We find that there is a gap.' (Sweet et al., 2019, participant quotation).

Support with transition

The second major theme at the organizational level was that of support with the transition from exercise in a CR setting to independent exercise at home or in the community. Participants discussed a lack of support with the transition as a challenge to maintaining prescribed exercise and citing a need for increased information on available programs and facilities and occasional contact with health care professionals to discuss the suitability of the exercise regimen.

> 'Well there should be a…not an interim period but a gradual decreasing of their being involved with you to develop that motivation and get used to it so that you are going to be able to continue on, which I thought would happen, but it didn't.' (Desveaux 2016, participant quotation)

Exercise professionals in one included study reiterated this barrier and felt that more effort is needed to help ensure a smooth transition from the end of CR to daily life and a formalized contact system post-CR may be needed to further support their patients:

> 'I think it is about supporting people both when they exit the program so that they do have a plan and in terms of that longer contact … I mean obviously they have our phone numbers if they have questions but it is not a formalized contact so I think that providing

> that aspect … would be really great in terms of supporting their change.' (Sweet et al., 2019, participant quotation).

Finally, costs or financial barriers were described by participants as limiting the ability to continue exercise.

> "Responses indicating financial costs of participating in physical activity included "cost of gym and other places." (Fleury et al., 2004, author interpretation)

Community Factors

Two neighbourhood / environmental themes emerged and included: 1) neighbourhood availability and accessibility of PA opportunities; and 2) weather. Participants described a lack of available or convenient places to do PA or transport constraints to gyms or programs as barriers to exercise maintenance.

> 'Lack of environmental resources was shown to be a barrier through responses such as "convenience of facilities," and "having to drive to take a short walk."' (Fleury et al., 2004, author interpretation)

Inclement weather was described as a barrier to PA maintenance as it impeded the ability to exercise outside.

Discussion

This study reviewed and synthesized the qualitative literature examining factors affecting PA maintenance among patients post-CR. Multiple factors were found to influence PA maintenance and were framed within a social ecological model. The central tenet of SET is that all levels of influence on health behaviours are important and thus researchers must integrate theories and models at each level in order to specify and describe the various processes and variables.[11]

At the intrapersonal level, self-efficacy, motivation, and positive exercise beliefs were found to be facilitating factors to PA post-CR. Self-efficacy refers to "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3).[22] Self-efficacy can relate to confidence in one's abilities to perform a task, perform the task under challenging conditions, and to scheduling relative to other responsibilities and duties. [22-24] Motivation is described as one's determination to act and the psychological energy that initiates and continuously directs behavior.[25] These findings are best explained by Social Cognitive Theory (SCT), which explains health behaviours as an interaction between personal cognitive factors, physical and social environments, and behavioural factors.[26] The three major constructs of this theory include self-efficacy, knowledge (an understanding of health risks and benefits), and outcome expectations (judgements about the likely outcomes or consequences of actions or behaviours); they form the basis of cognitive influences on health behaviours like PA.[26] The importance of these constructs is well supported in the literature on PA in CR populations.[23,25,27]

Findings from our study also showed physical illness or limitations to be a factor affecting PA maintenance. Sattar et al conducted a secondary analysis of data from a randomized controlled trial to examine the effects of multiple chronic conditions on exercise one year after completion of CR resulting in similar findings. Almost all participants had at least one other chronic condition and these conditions negatively impact levels of exercise. Thirty-one percent of participants had arthritis, 30% had diabetes, and 43% had obesity and hypertension, with obesity having the greatest impact, reducing amount of exercise by 3.5 hours per month.[28] These findings indicate that there is a large burden of chronic conditions present in this population and there is a need to identify those at high-risk of not continuing to exercise at discharge of CR.

Social support was found to be instrumental to maintaining PA after CR. Theories of social networks suggest that social networks can give way to improved health outcomes through different forms of social support, such as emotional support, instrumental support, informational support, and appraisal support, which can positively impact physical and mental health.[29] Similarly, a qualitative synthesis of factors influencing health behavior change among high-risk cardiovascular patients found social support to be a substantial theme.[30] Participants reported support through family, friends, or peers to be especially influential to remaining physically active.

The factors discussed at the organizational level are an important finding. Many CR programs lack strategies to meaningfully and efficiently support patients through the transition from exercise in a supervised setting to exercise in the home or community.[31] Researchers, recognizing this gap in care, are beginning to test the effectiveness of strategies to support this transition. For

example, Antypas and Wangberg tested an internet- and mobile-based intervention that provided participants with tailored self-management information about various topics, including PA, and an online discussion forum, and found that the intervention group had a significantly higher median level of overall PA than the control group.[32]

Many participants discussed the costs of gyms or exercise programs. Other qualitative research exploring the impact of financial barriers on the secondary prevention of heart disease discovered that participants experienced financial barriers to multiple aspects of care, including CR and exercise post-CR.[33] This financial barrier speaks to potential inequities in both the prevention and management of heart disease. There is a strong association between income and heart disease, in that those with heart disease are more likely to be living with low income.[34,35] This same relationship holds true for income and PA, in that those living with low income are less likely to be physically active due to costs of exercise, poor and unsafe neighbourhood quality, and lack of PA resources and opportunities in the neighbourhood.[36]

Strengths and Limitations

There were several strengths and limitations to this work. First, we were unable to report differences by sex or gender because there was a lack of analysis by sex in the included studies. Given that women are less likely than men to continue exercising after CR[9] and experience poorer heart health outcomes than men,[37] qualitative research exploring the unique factors affecting PA maintenance among women with heart disease is needed. The socioeconomic and cultural backgrounds of participants were also not well described in most studies. The total

participant sample may not have been truly representative of a culturally and economically diverse population.

A strength of this study was the completion of a quality appraisal of the included studies, not as a tool for exclusion but to provide a transparent assessment of study quality. Although most quality assessments of published studies tend to be an assessment of reporting rather than conduct, the assessments nevertheless provided value to the analysis and interpretation of findings.

Implications

This study identified several considerations to inform program and policy design. Patients with heart disease should be supported in developing appropriate assessments of their self-efficacy and goals for their long-term PA in order to promote better alignment to exercise strategies after completion of CR. Given the level of co-morbidity in a population with heart disease and concerns around the safety of exercise programs in the community, it is necessary to identify these conditions at discharge and appropriately tailor support and self-management advice to increase confidence and capacity for unsupervised exercise. Exercise mode, as well as intensity and pace, must be customized to meet the abilities and physical limitations of patients.

The expressed lack of transition support and the identified need for social support in maintaining PA pinpointed a key area for program design. Online programs have the capacity to connect CR graduates in the maintenance phase to build camaraderie and maintain motivation, as well as provide health professional advice if continued support is needed. Although this study did not

identify any factors at the policy-level, the findings of factors from other levels of the social ecological model (e.g., community level) can inform the development of policy. For example, recreational facilities and community centres could implement policy to remove financial barriers to PA opportunities or increase partnerships with local hospitals to ensure safety and appropriateness of their exercise programming for patients. This synthesis identified weather as a barrier to PA, and indeed, the climates of many countries pose unique challenges to year-round activity. However, many communities have begun opening arenas or schools in the off-hours to the public for indoor walking and other activity, and there is room to explore innovative solutions such as these further. In Ontario, Canada, Heart Wise Exercise Programs (HWE) are available in several locations. HWE locations meet standards regarding programs that are appropriate for people with chronic disease conditions and have in place emergency procedures to handle high-risk patients. Fitness leaders working in these facilities have completed additional training concerning ways to accommodate people with heart disease in exercise programs.

A number of areas for future research were identified. There is a need for future qualitative research to explore the factors affecting long-term maintenance of PA after CR unique to women, or to analyze data by sex and gender to gain an understanding of how these issues distinctively impact women. As well, qualitative research with policymakers and program administrators on strategies to maintain PA among cardiac patients could be an insightful area for future research.

Conclusion

This study synthesized relevant qualitative literature to explore factors affecting PA maintenance among post-CR patients. This systematic search and synthesis found a range of factors at multiple levels that impact long-term PA among individuals who have completed CR. Findings discovered areas for further research and highlighted implications to inform programming and policy to support patients with heart disease. Interventions that aim to create supportive physical and social environments for PA, removing barriers and increasing access to PA opportunities can meaningfully support patients with the transition from CR and assist with maintaining PA in their homes and communities. Future research should further explore factors at the organizational and community levels as they also appear to be important for PA maintenance among post-CR patients.

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Table 1. Characteristics of included studies.

Author, year (Country)	Study aim	Sampling	Participant description	Methods / methodological background
Clark et al., 2011[38] (Scotland)	To understand reasons for usage of these community-based services after cardiac rehabilitation, this study examined decisions to use community-based exercise services in CHD patients who had completed hospital-based cardiac rehabilitation.	Participants were eligible if they had completed a 12-week hospital-based cardiac rehabilitation program (following acute myocardial infarction, bypass graft surgery, angioplasty, or a diagnosis of acute coronary syndrome or angina).	27 individuals (71% of those invited) participated in 4 focus groups of 5 to 8 participants stratified by levels of maintenance program participation. 67% were men, 69% were of low-to-moderate socioeconomic status, and 55% were aged 65 years or older.	Focus groups. No preexisting coding framework or theory was used to categorize or code the data. Themes regarding the main factors influencing participation were developed from the transcripts by using the content analysis technique.
Fleury et al., 2004[39] (USA)	The purpose of this study was to examine perceived environmental and psychosocial factors that cardiac rehabilitation graduates have described as barriers to the maintenance of physical activity.	Participants had to be graduates from a formal, monitored cardiac rehabilitation program, have clinically diagnosed coronary heart disease, be able to speak English, be able to respond to questionnaires, be considered at low risk for participation in physical activity, and give informed consent to participate.	160 participants, 121 (76%) were men. Ages ranged from 36 to 86 years (mean of 64 years). Most of the participants (94%) were white. Among the remainder, 7 (4.3%) were African American and 3 (2%) reported their ethnicity as "other." Most of the participants were retired (53%), married (83%), and had an education level exceeding a high school level (80%).	Open-ended questionnaires. Guided by social ecological theory. The transcribed answers of the participants were assessed using content analysis.

Hardcastle et al., 2015[40] (UK)	The aim was to explore the factors that influence motivation and commitment to continued exercise following participation in a cardiac rehabilitation program.	Participants were recruited on the basis that they had completed a cardiac rehabilitation community program at least 2 years previously and were willing to participate.	23 participants (5 females and 18 males, M age = 72.3 years, SD = 7.3) who had completed the four phases of cardiac rehabilitation were recruited from post phase four circuit based exercise classes at a leisure centre.	Semi-structured interviews with participant-led auto-photography. Interview transcripts were analyzed using thematic content analysis.
Adsett et al., 2013[20] (Australia)	To prospectively evaluate a community-based model of physical activity for patients who have completed formal cardiac, heart failure, or pulmonary rehabilitation.	Referred patients and rehabilitation staff were surveyed regarding perceived barriers to attendance.	The pre-attendance survey–response rate was 58% of referrals (140/241), including 98 attendees and 42 non-attendees. Most respondents were elderly, retired, and living with family. The response rate for surveys completed by staff was 89% (25/28).	Survey regarding perceived barriers and benefits and survey data were summarized into categories.
Desveaux, 2016[41] (Canada)	To explore the attitudes of individuals with CHF and COPD towards an integrated post rehabilitation community based maintenance program.	Participants were eligible if they had a diagnosis of chronic heart failure or COPD and had successfully completed formal, hospital-based rehabilitation. Purposive sample that recruited consecutive patients from two institutions immediately prior to discharge from their	11 participants (6 males). Mean age of 70, all but 2 participants living with co-morbidity.	An informal interview schedule consisting of open-ended questions. The schedule was then reviewed and revised according to feedback from clinicians and patients. A deductive thematic framework approach was used. Analysis consisted of six stages, as described by Braun and Clarke.

		respective programs.		
Dunn et al., 2014[42] (UK and NZ)	To analyze which influencing factors engender behavior change and maintenance in individuals post early phase CR.	All participants had previously been discharged from early phase CR programs phase I, II (NZ and UK), and III (UK) at least 6 months before and data were collected over a 3-month period.	22 participants (16 male and 6 female) were recruited in UK. 21 participants (16 male and 5 females) were recruited in NZ.	Focus groups consisting of 6-9 participants. Data was coded using thematic analysis.
Rowland et al., 2018[42] (USA)	To describe the couple-focused facilitators and barriers to healthy eating and PA behaviors in patients and spouses after CR.	A purposive subsample of couples (patient and spouse) was obtained from the sample of couples that participated in a larger clinical trial. A maximal variation strategy was used to achieve variation in gender, ethnicity, and socioeconomic status in relation to role.	A total of 11 couples participated in the study. Couples were either male patients and female spouses (n=9) or female patients and male spouses (n=2). The patients' mean age ± standard deviation was 64.3 ± 3.3 (range 60–70) years; the spouses' age was 62.5 ± 6.0 (range 51–71) years. All participants were married, well educated, and Caucasian except for 1 male Hispanic patient.	In-person, semi-structured interviews.
Sweet et al., 2019[43] (Canada)	To identify the factors related to exercise maintenance by obtaining the perspectives of post-CR exercise maintainers and	To be included in this study, participants must (1) have had a previous cardiac-related event or operation and have participated in a CR program;	A total of 15 exercise maintainers participated in this study (14 men and 1 woman). Five participants had one cardiac event and 10 had two events. The average number of	Semi-structured interviews analyzed using content analysis.

	exercise professionals.	(2) currently meeting or exceeding the Canadian Physical Activity Guidelines (i.e. 150 total minutes of moderate to vigorous aerobic and resistance training each week), and (3) hold a conversation in English.	years since completing a CR program was 4.3 years (range: 1.5–12 years). On average, exercise maintainers were 70 years old (range: 53–79 years) and exercised 306 minutes per week (range: 135–690 minutes).	

Table 2. Quality appraisal of included studies (CASP Qualitative Research Checklist)

	Clark et al., 2011	**Fleury et al., 2004**	**Hardcastle et al., 2015**	**Adsett et al., 2013**	**Desveaux, 2016**	**Dunn et al., 2014**	**Rowland et al., 2018**	**Sweet et al., 2019**
Was there a clear statement of the aims of the research?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is a qualitative methodology appropriate?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the research design appropriate to address the aims of the research?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the recruitment strategy appropriate to the aims of the research?	Can't tell	Yes	Yes	Can't tell	Yes	Yes	Yes	Yes

Was the data collected in a way that addressed the aims of the research?	Somewhat	Yes	Yes	Can't tell	Yes	Somewhat	Yes	Yes
Has the relationship between researcher and participants been adequately considered?	No	No	Yes	No	No	No	No	Yes
Have ethical issues been taken into consideration ?	No	No	Yes	No	No	Somewhat	No	Yes
Was the data analysis sufficiently rigorous?	Somewhat	Somewhat	Yes	No	Yes	Somewhat	Yes	Yes
Is there a clear statement of findings?	Somewhat	Somewhat	Somewhat	No	Somewhat	Somewhat	Yes	Yes
Has the researcher discussed the value of the research?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 3. Themes, number of references, and number of studies by theme.

Theme	**# of References**	**# of Studies**
Intrapersonal Factors		
Positive exercise beliefs	42	4
Motivation	30	5
Self-efficacy	24	5
Physical limitations / poor health	10	6
Interpersonal Factors		
Social and family obligations	8	3
Social support	56	8
Work responsibilities	6	2

Organizational Factors		
Variety in exercise	1	1
Safety and appropriateness of exercise	14	4
Lack of support with transition	28	5
Cost	11	4
Length of CR program	1	1
Lack of funding for CR	1	1
Stronger collaboration between hospital and community	2	1
Community Factors		
Neighbourhood availability of PA opportunities/resources	18	4
Weather	8	4

CHAPTER 5: MANUSCRIPT 3

This manuscript was written and prepared in accordance to the specifications for submission to the peer-reviewed *American Journal of Physical Medicine & Rehabilitation*.

Predictors of physical activity maintenance in a randomized controlled trial post-cardiac rehabilitation

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Abstract

Objective: Cardiac patients who engage in regular physical activity (PA) lower their risks for future cardiac events, yet PA levels declines following participation in supervised cardiac rehabilitation (CR). This study was a secondary analysis of trial data examining predictors of participants' PA 26 weeks after CR completion.

Design: 449 participants completed baseline questionnaires assessing social ecological, clinical, demographic, and fitness/behavioural variables. Moderate to vigorous PA (MVPA) was assessed by accelerometer 26 weeks later. Univariate and multivariate analyses tested the effect of variables on MVPA at 26-week follow-up.

Results: Univariate analyses revealed nine significant predictors of MVPA at 26 weeks including beliefs about exercise benefits ($r = 0.079$; $P = 0.149$), beliefs about exercise barriers –($r = 0.080$; $P = 0.109$), baseline MVPA ($r = 0.600$; $P < 0.001$), peak oxygen consumption ($r = 0.277$; $P < 0.001$), diabetes ($r = -0.104$; $P = 0.051$), age ($r = -0.225$; $P < 0.001$), sex ($r = -0.128$; $P = 0.017$), marital status ($r = -0.076$; $P = 0.150$), and work status ($r = -0.159$; $P = 0.004$). Younger, male, married, working, fitter, participants without diabetes, who perceived more benefits and

fewer barriers to exercise had higher levels of MVPA at 26 weeks. A multivariate analysis indicated that only baseline MVPA (B = 0.60; P = 0.001) independently predicted MVPA at follow-up.

Conclusion: Results have implications for designing and targeting interventions to improve PA maintenance among CR graduates.

Keywords: Cardiovascular disease, physical activity, predictor

Introduction

Heart disease is a leading cause of mortality and hospitalization in Canada.[1] Physical activity (PA) greatly reduces risk factors and improves health and quality of life for individuals with heart disease and is a core component of cardiac rehabilitation (CR) programs. Canadian CR guidelines recommend patients with heart disease achieve at least 150 minutes of moderate to vigorous PA (MVPA) per week.[2] Heart disease patients enrolled in CR consistently achieve recommended PA levels; however, this declines following completion of CR.[3-6]

Social ecological theory considers the multiple levels of influence that can either facilitate or impede health behaviours such as PA.[7] The social ecological model focuses on the interrelationships between individuals and the social, physical and policy environment.[8] The model helps to identify influences on PA at the intrapersonal level (e.g., individual characteristics that influence behavior, such as knowledge, attitudes, and beliefs), interpersonal level (e.g., social support and processes and norms which provide role definition and social identity), institutional level (e.g., institution regulations or policies which may constrain or

promote behaviours), community level (e.g., safety, quality, and accessibility of the natural and built environment and social networks in a defined area) and policy level (local, provincial, federal or international laws or policies which can regulate or support healthy living).[7]

Research has identified a range of factors at multiple levels that can either impede or promote long-term PA among CR graduates. Research has found PA post-CR to be positively associated with being male, younger age, health status perceived as better, higher VO_2 peak, better cholesterol control, higher income, rural location, being married, and full-time work status.[9] Results also identified a significant relationship between PA and PA enjoyment, number of comorbidities, fear of falling, mode of transportation to PA, and CR staff support.[9] A review of PA correlates among cardiac patients found that increased post-CR exercise levels were consistently associated with better overall health status, higher levels of self-regulatory self-efficacy (i.e. confidence in overcoming exercise barriers, scheduling and planning exercise), higher previous PA levels, greater intentions to exercise, positive beliefs about the benefits of exercise, and higher perceived behavioural control (i.e. perceived ease of participating in exercise).[10] Patients who perceived having increased social support, access to low-cost exercise facilities, and who received exercise consultation sessions also reported higher exercise levels post-CR.[10] Less research has evaluated the predictive utility of social ecological factors on PA levels post-CR.

Few studies have examined the influence of neighbourhood environments on long-term PA among CR graduates. Neighbourhood environments, including street connectivity, crime and safety, aesthetics and greenery, and access and availability of PA opportunities and resources,

can influence levels of PA.[11-13] One study examined differences in weekly time spent in PA by level of perceived environmental resources, six months following CR completion. This study used a descriptive, longitudinal design using standardized measures to evaluate perceived environmental resources and PA levels. There was a significant change over time in PA, which differed by the level of perceived neighborhood resources, suggesting that home and neighborhood PA resources may positively influence PA maintenance following cardiac rehabilitation.[14] However, the study was descriptive, so it did not evaluate the predictive utility of the environmental resource variables on PA level.

The present study aimed to identify critical social ecological predictors of PA maintenance among CR graduates, including measures of neighbourhood environment, by assessing predictors of MVPA at 26-weeks follow-up among patients who have completed CR and were enrolled in a randomized controlled trial (RCT) of a PA maintenance intervention.

Methods

Design and Procedure

Secondary analyses of data from the RCT named "ECologically Optimizing exercise maintenance in men and women Post-CR" (ECO-PCR) were undertaken (clinicaltrials.gov Identifier: NCT01658683). This study was a 2-arm parallel randomized controlled, single-blind superiority trial.[15] The Ottawa Health Science Network Research Ethics Board approved the secondary analysis of this dataset.

Study coordinators recruited participants from among patients that were completing CR programs. Sociodemographic characteristics, clinical, behavioural and fitness variables, and social ecological factors were collected at baseline. Participants were stratified by recruitment site and sex and randomized in a 1:1 ratio to either the PA maintenance intervention (PAMI) or a usual care (UC) control arm. The intervention was delivered over a 26-week period. Levels of PA were assessed by accelerometer at 26 weeks using the same procedures as baseline. Research assistants blinded to participant allocation performed follow-up assessments.

Intervention

The trial evaluated the comparative effect of an activity facilitator-led intervention versus usual care on weekly levels of MVPA among patients who had completed CR. The intervention in the ECO-PCR trial aimed to optimize transition of patients from structured, supervised exercise to self-managed home- or approved community-based exercise programs to increase maintenance of PA behaviour post-CR. It was hypothesized that compared to UC, those receiving the intervention would be engaging in more MVPA. The intervention was delivered by trained activity facilitators (physiotherapists or exercise specialists) and used small group counseling teleconferences (five sessions), personal telephone contacts (three sessions), and community program demonstrations that facilitated linkages between patients and approved community programs. The intervention began immediately after structured CR. Usual care consisted of the provision of an updated exercise prescription and a home-based exercise program before program completion.

Participants

CR graduates from supervised CR programs in Ontario, Canada who had completed at least 75% of their prescribed exercise sessions in CR were approached to participate. Participants were recruited from two programs in Toronto and one program in Ottawa. Patients were included in the study if they participated in an on-site CR program of at least 8-weeks duration, graduated from CR, had a documented diagnosis of coronary artery disease (CAD), were at least 18 years old, and were able to walk unaided at 2 mph. Patients who had New York Heart Association class III or IV heart failure, were pregnant, lactating or planning to become pregnant during the study period, were planning to leave the region in the next 12 months, or were unable to read and understand English or French were excluded. All participants provided written informed consent before participating.

Measures

Participants completed baseline self-report questionnaires assessing a range of variables. All scales were validated psychometrically, pilot-tested in CR samples, and have demonstrated adequate validity and reliability.[16]

Outcome Measure

The primary outcome was MVPA measured 26 weeks after study enrollment. MVPA was measured directly by having participants wear the Actigraph GT3X+ accelerometer (Actigraph, Pensacola, Florida) over the right hip using a waist belt for nine consecutive days, excluding periods when they were sleeping, swimming, or bathing. The accelerometer provides PA measurements including activity counts, energy expenditure, and step counts, in addition to

activity intensity levels. The Actigraph GT3X+ has been shown to be valid and reliable using treadmill walking at known speed and a laboratory shaker.[17] MVPA was also measured at baseline.

The total minutes each of moderate and vigorous PA per week were calculated and summed as a measure of MVPA. A 15-second sampling epoch was used and converted into 60-second epochs (counts min-1 (cpm)). A valid day was defined as 10 or more hours of wear time, and participants were required to have a minimum of four valid days to be retained in the analyses. Wear time was calculated by subtracting non-wear time from 24 hours. For participants with >7 valid days, the first day was removed (to minimize reactivity), and the subsequent 7 days used for the average. MVPA was defined using a previously-validated cut-point of ≥ 2690 cpm using the vector magnitude output.[18] Weekly average MVPA was calculated by multiplying the daily average (minutes per day) above this threshold by 7.

Predictors

Demographic data were collected by self-report and consisted of age, sex, racial background, marital status (dichotomized to married versus other), education (dichotomized to university education versus other), and employment status (dichotomized as working versus retired) as per the Canadian Cardiovascular Society's Data Dictionary.[19] Medical data were collected from medical records and consisted of: use of beta-blockers, nitrates and/or anti-depressants; history of type 1 or 2 diabetes mellitus, peripheral vascular disease, myocardial infarction, and/or heart failure; revascularization procedures (PCI and/or CABG); and smoking status. Psychosocial variables were assessed prior to randomization in all participants and consisted of Exercise

Barriers and Benefits (Appendix V),[20] Task Self-Efficacy (Appendix VI),[21] Barrier Self-Efficacy (Appendix VII),[22] Subjective Norm (Appendix VIII),[23] and Physical Activity Self-Regulation (Appendix IX).[24] Physical fitness variables were measured at baseline and included peak oxygen consumption (VO_{2peak}), and body weight and height to calculate body mass index (BMI). Patient-rated outcomes consisted of quality of life measured using the EuroQoL visual analogue scale (EQ-5D; Appendix X),[25] and depressive symptoms assessed by the 2-item depression screener The Patient Health Questionnaire-2 (PHQ-2; Appendix XI).[26] Institutional (program) – related variables included: program site (Toronto or Ottawa) and exposure to the maintenance intervention (yes or no). Environmental variables included neighbourhood environment (aesthetics, crime, and street connectivity) and exercise opportunities in the community as measured by the Physical Activity Neighbourhood Environment Scale (PANES) and availability of home exercise equipment in Appendices XII, XIII, and XIV.[27-29] Table 1 provides descriptions and score ranges for each scale.

Statistical Analysis

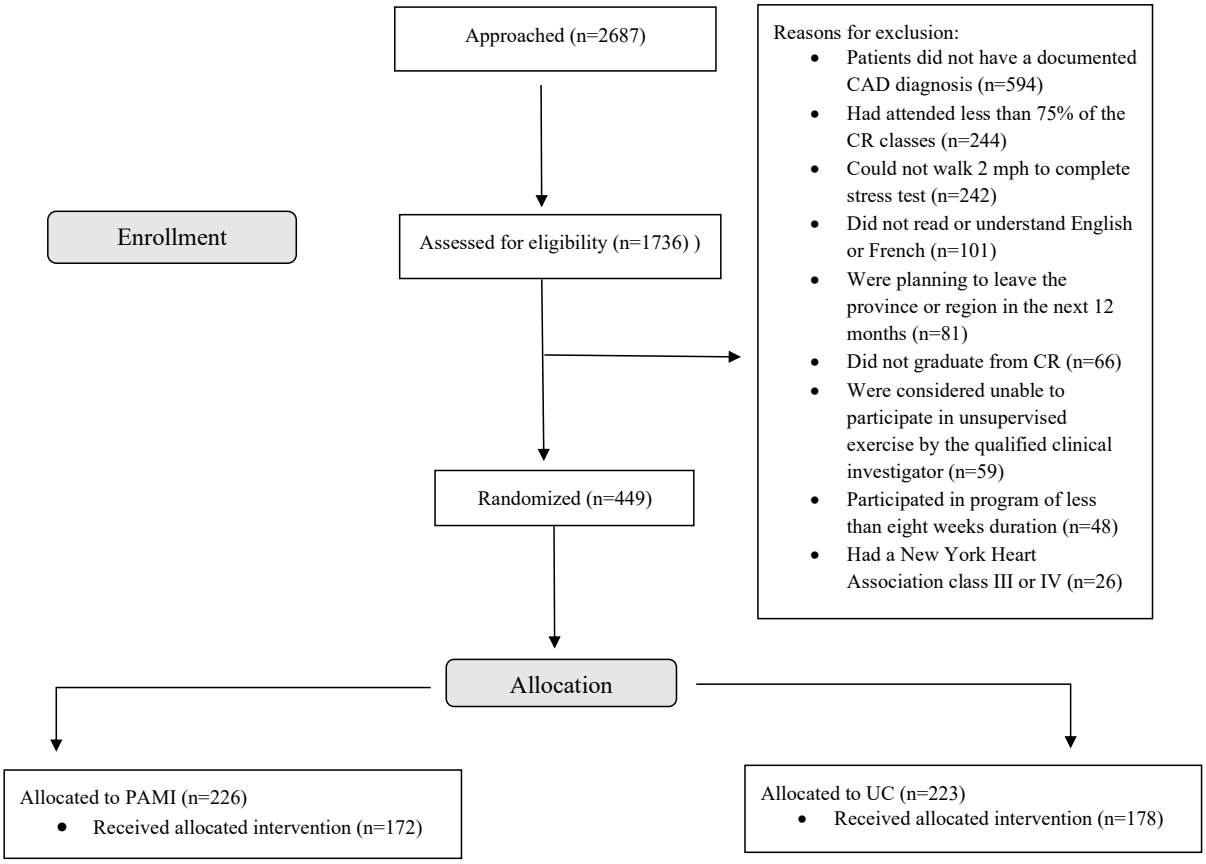
All analyses were conducted using the Statistical Package for the Social Sciences (SPSS v.26). We first computed two-tailed Pearson correlations for each of the potential predictors of MVPA at 26 weeks. Although the study was underpowered to test for statistically significant differences between men and women, univariate analyses were stratified by sex to explore potential differences. Variables that had statistically significant or borderline significant ($P < 0.15$) univariate associations with MVPA at 26 weeks in the total group were retained for a hierarchical multiple regression analysis. The regression analysis was conducted using prespecified blocks of variables as follows: a) demographic and medical, b) program

(institutional), c) fitness and body composition, d) patient-rated outcomes, e) environmental, and f) psychosocial. The blocks were ordered from the most proximal determinants of behavior (which are the most amenable to change) to the most distal determinants of behavior (which are the least amenable to change). The order of the blocks was as follows: 1) social ecological variables, including interpersonal-level variables, intrapersonal-level variables, and environment-level variables, 2) QOL variables, 3) behavioral/fitness variables, 5) medical variables, and 6) demographic variables. For the multivariate analysis a p-value of <0.05 was considered statistically significant.

Results

Participant accrual and allocation is depicted in Figure 1.

Figure 1. Flow diagram of participant accrual and allocation.



Primary outcomes of the trial are reported elsewhere,[15] but in brief, MVPA levels declined between baseline and 26-week follow-up and there were no significant effects of the PA maintenance intervention among men or women. Participants with complete data at follow-up were significantly older and engaged in more MVPA at baseline, and retained UC participants were significantly more educated than those lost to follow-up; no other differences observed.[15] Multiple imputation was used for missing data, using five imputed datasets (refer to Appendix

XV for supplemental information on missing data). Baseline variables overall and by group are presented in Table 2.

At the 26-week follow-up, 71.4% of participants were meeting MVPA guidelines ≥ 150 minutes per week (mean MVPA=365.89, SD=43.91) and 28.6% of participants were not meeting MVPA guidelines (mean MVPA=60.63, SD=177.89). Univariate predictors of MVPA at 26 weeks are presented in Tables 3 (social ecological), 4 (QOL), 5 (behavioural/fitness), 6 (medical) and 7 (demographic). Variable categories were created based on clinically important cut-points or natural cut-points devised from descriptives of the data. Sex-stratified univariate analyses are presented in Table 8.

In the total group, we found significant (P<.15) univariate relationships between MVPA at 26 weeks and beliefs about exercise benefits ($r = 0.079$; $P = 0.149$), beliefs about exercise barriers ($r = 0.080$; $P = 0.109$), peak oxygen consumption ($r = 0.277$; $P < 0.001$), baseline MVPA ($r = 0.600$; $P < 0.001$), diagnosed Type 1 or Type 2 diabetes ($r = -0.104$; $P = 0.051$), age ($r = -0.225$; $P < 0.001$), sex ($r = -0.128$; $P = 0.017$), marital status ($r = -0.076$; $P = 0.150$), and whether they were working or retired ($r = -0.159$; $P = 0.004$). Younger, male, married, working, fitter, participants without diabetes, who perceived more benefits and fewer barriers to exercise had higher levels of MVPA at 26 weeks.

The nine significant predictors were examined in a multiple regression analysis entered in the following blocks: 1) exercise benefits and exercise barriers; 2) MVPA at baseline and peak oxygen consumption; 3) diabetes; and 4) age, sex, marital status, and working status.

Independent predictors of MVPA at 26 weeks in the model were MVPA at baseline (B = 0.60 ; P = 0.001) with an adjusted R^2 of 0.36. Exercise benefits (B = -0.39; P = 0.68), exercise barriers (B = -0.98; P = 0.605), peak oxygen consumption (B = 0.92; P = 0.513), diabetes (B = -9.82; P = 0.688), age (B = -0.57; P = 0.656), sex (B = 11.31; P = 0.601), working vs. retired (B = -9.16; P = 0.706), and married vs. other (B = -26.32; P = 0.228) became nonsignificant. With MVPA at baseline removed from the model, peak oxygen consumption independently predicted MVPA at 26 weeks (B = 4.77; P = 0.002) with an adjusted R^2 of 0.10 and exercise benefits (B = 0.096; P = 0.926), exercise barriers (B = -2.69; P = 0.178), diabetes (B = -34.05; P = 0.199), age (B = -3.02; P = 0.05), sex (B = -9.65; P = 0.692), married vs. other (B = -20.11; P = 0.417), and working vs. retired (B = -10.44; P = 0.713) became nonsignificant.

Discussion

PA levels decline among cardiac patients following completion of CR. Results of the univariate analyses identified multiple factors associated with MVPA 26 weeks after CR completion. In the multi-variate analysis, only MVPA at baseline was an independent predictor of MVPA at 26 weeks, accounting for 36% of the variance. When the multi-variate analysis was re-run without baseline MVPA in the model, peak oxygen consumption was the only independent predictor of MVPA at 26 weeks. The findings have practical implications for variables that can be measured and monitored to adapt and improve support for long-term PA among CR graduates.

Factors from multiple levels of a social ecological model were assessed in this study; however, intrapersonal-level factors showed the highest degree of association with MVPA at 26-week

follow-up. The independent predictors MVPA and peak oxygen consumption at baseline (if MVPA at baseline was left out of the analysis) are highly correlated with other univariate predictors (i.e., age, sex, diabetes, working full-time, and beliefs about exercise barriers and benefits).

Ecological models can incorporate and integrate other models and theories that focus on psychological, social, and organizational levels of influence to provide a comprehensive framework for examining health behaviours like PA.[7] The mechanisms underlying the influence of the intrapersonal-level predictors is best understood by Social Cognitive Theory (SCT), which emphasizes the dynamic interaction between personal cognitive factors, physical and social environments, and behaviour.[30] The three major constructs of this theory include self-efficacy (a person's confidence in his or her ability to perform a behaviour that leads to an outcome), knowledge (an understanding of health risks and benefits), and outcome expectations (judgements about the likely outcomes or consequences of actions or behaviours). These three constructs form the basis of cognitive influences on health behaviours like PA and align with the intrapersonal-levels findings, which include beliefs about exercise benefits and barriers and, the strongest predictor, past PA behavior.[30] SCT stresses the importance of recognizing barriers to health-promoting behavior change and identifying ways in which those barriers can be removed or overcome. Overall, it can be inferred that a cardiac patient who has mastered PA behavior by the end of CR - understanding how to overcome barriers to consistent PA with positive beliefs about exercise - is more likely to continue PA over the long-term. These constructs indicate which modifiable variables can be assessed and observed throughout CR to identify patients who

may require additional support. Additional interventions could be targeted at individuals not meeting MVPA guidelines at the end of CR.

The role of these intrapersonal-level factors on exercise are well-supported in research on CR populations.[31-35] For example, one cross-sectional study examining perceived exercise benefits and barriers among participants of a community-based CR maintenance program found that, compared to non-attenders, high attenders (≥60% attendance) perceived greater psychological (an improved sense of accomplishment), physiological (body functioning), functional (ability to perform activities of daily living), and social benefits (social standing and ease with people) from participating in the maintenance community-based CR programs.[36] Non-attenders perceived more barriers including personal preferences (already undertaking own exercise, managing their health, not liking group situations, and perceiving no need for CR). Another observational study assessed the effects of different types of self-efficacy on PA during and after CR and found that scheduling self-efficacy (one's confidence for managing time demands of exercising regularly) to be most strongly related to self-reported exercise one month post-CR.[37] Addressing modifiable barriers, promoting the benefits of PA, and providing opportunities to increase self-efficacy should be targeted for supporting long-term PA after CR completion.[36,37] CR participants who fail to meet guidelines by end of CR or who are less fit will likely need more intervention after CR to maintain/increase their PA. These individuals could be targeted with interventions known to work if there are resource constraints.

While not statistically conclusive due to study power, the sex-stratified results provide an indication of potential differences between men and women. Working status appeared to have

stronger influence among women and beliefs about exercise barriers appeared to have a stronger influence among men. These differences are likely due to gendered factors (e.g., socially constructed roles, behaviours, expressions and identities) as opposed to differences due to sex (e.g., biological attributes).[38] Research on sex and gender differences in PA among cardiac patients is lacking. In view of the fact that women are less likely to maintain PA after CR,[39] this represents an important area for future research.

Considering the evidence supporting the association between neighbourhood characteristics and PA, it is interesting that none of the measured neighbourhood characteristics reached significance in this study. However, all participants in the sample resided in large urban cities (Toronto and Ottawa), and this could account for the lack of effect. Urban areas have greater access and availability of PA resources and opportunities than do rural areas.[40,41] Future research could explore potential rural / urban differences in the effects of neighbourhood characteristics on PA among CR graduates.

There are several strengths and limitations with respect to this study. The sample in the trial was a large sample relative to other similar trials, which is a strength. Only one included study[42] in the systematic review in the first manuscript had a larger sample size with 3,241 participants. The trial in the present study was sufficiently powered to examine a range of predictor variables. Additional strengths include the prospective study design, the objective measurement of the main outcome variable, and the use of validated instruments to assess predictor variables.

The principle limitation of this study lies in the potential threats to validity in the use of existing datasets for secondary analyses. In secondary analyses, the datasets are often re-analyzed for answering different research questions other than those for which the original data collection was intended. There is not necessarily a good fit between the secondary research questions and the dataset, which creates the potential for errors and decreased validity.[43] Analyses are limited to the variables that are available in the original dataset, and there may be important predictors/confounders that were not measured in the original study. There is also variability in the quality of the measurement of different constructs. In the case of our study, some constructs are measured with multi-item scales (e.g., physical activity self-regulation) and others are measured with single-item scales (e.g., diabetes). The secondary analyses also rely on the data collection instruments used in the primary data collection process.[43,44] For example, neighbourhood environment attributes were measured by self-report in the trial and objective measures of the neighbourhood environment would have been ideal if postal code data had been available. Research has found some mismatch between perceived and objectively-assessed neighbourhood characteristics and that perceived neighborhood environment and objectively measured neighborhood environments are related but distinct constructs that account for unique variance in PA.[45] Some people may accumulate their MVPA away from their home community (e.g. because they work in another community) and their neighbourhood environment is a less important influence. Future research could examine the effect of neighbourhood environment attributes on PA maintenance among CR graduates using objective measures of the neighbourhood environment.

There are also some limitations related to the objective measure used for MVPA. Accelerometers can create a reactive response and do not adequately capture activities like cycling, skating, load-carrying, and other nonstandard activities.[46] Another limitation may be related to the accelerometer cut-points used. The cut-points were based on absolute rather than relative intensity. Research has demonstrated variability in activity counts/minute based on fitness level.[47] The accelerometer cut-points used for the exercise intensities were not based on CR samples and therefore may have misclassified some PA. There are no validated cut-points to use in the CR population.[48,49] Previous work has shown that PA results vary among individuals with heart disease based on cut-points chosen.[50] Sasaki's cut-points were applied in this research because they are the most widely used, and so can be compared with other studies.

Finally, it is important to note that the generalizability of this study is limited. We included people with CAD who were highly adherent to/successful completers of their prescribed CR program who were living in the two largest urban areas in Ontario. There are differences between patients who complete CR and those who do not complete or enroll in CR. CR graduates likely engage in more MVPA than the average cardiac patient.[48] Those who gain access to CR and complete the program represents approximately 20% of cardiac outpatients.[5] Research shows that certain populations are less likely to access or complete CR,[51] including patients with low socioeconomic status,[52] women,[53,54] and patients who live in rural areas.[55] Moreover, there were differences between participants included in this sample and CR graduates who did not consent to participate. Included participants were historically more physically active than those not included.[48] This discrepancy suggests that those who access CR, and potentially

post-CR maintenance interventions, are the patients who are self-selected healthier populations and have better outcomes.[56,57]

Conclusion

PA declines in the unsupervised period following CR. Intrapersonal-level factors, including past exercise behaviour, predicted PA maintenance among CR graduates. Findings of this research have implications for program design and delivery to support long-term PA for cardiac patients. Future research could examine rural / urban differences in the effects of the neighbourhood environment on PA among post-CR patients, include objective measurements of neighbourhood environment attributes, as well as further explore sex and gender differences.

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Table 1. Description of scales.

Scale	Score Range	Description
Physical Activity Neighbourhood Environment	Aesthetics: 4 – 16 Street connectivity: 3 – 12 Crime: 3 – 12 Exercise opportunities in community: 0 – 26 Home exercise equipment: 0 – 22	Questions 1 through 4 were mean scored to create a measure of "neighbourhood aesthetics", with a higher score denoting better neighbourhood aesthetics. Questions 5 through 7 were mean scored to create a measure of "neighbourhood crime", with a lower score denoting lower neighbourhood crime. Questions 8 through 10 were mean scored to create a measure of "neighbourhood street connectivity", with a higher score denoting better street connectivity. Exercise opportunities in community and at home scales were scored no=0 and yes=1 for both "is it available" and "would you use it" for a total score.
Beliefs about exercise benefits and barriers	Total scale: 43 – 172 Benefits subscale: 29 – 116 Barriers subscale: 15 – 56	43 item scale total or two subscales. If used in its entirety, the higher the overall score, the more positively the individual perceives the benefits of exercise in relation to barriers to exercise.
Task self-efficacy	0 – 100	7-item scale. Participants rated their confidence to engage in physical activity for more than 20 min during their free time for at least 1, 2, 3, and up to 7 days per week. Answers were rated on a scale from 0% (not at all confident) to 100% (completely confident) and a mean percentage was calculated.
Barrier self-efficacy	0 – 100	13-item scale consisting of eight core items from an existing validated measure along with five additional items developed through focus groups and interviews for this specific population to enhance the construct's content validity. Ours was modified and an additional item was added. Participants rate their confidence on a scale from 0% (not at all confidence) to 100% (extremely confident) and a mean percentage was calculated.
Physical activity self-regulation - 12	12 – 60	Measures the use of self-regulation strategies to support PA adoption and adherence. Participants were asked to rate how often they used each self-regulation strategy in the past week on a scale from 1 to 5 (never, rarely, sometimes, often, very often).
EuroQol visual analogue	0 - 100	Mean general population scores in Canada range from 80 to 72 for individuals 50 to 79 years old,

		decreasing with age and slightly higher among men.
The Patient Health Questionnaire – 2	0 – 6	2-item scale which asks about the frequency of depressed mood and anhedonia over the past 2 weeks, scoring each as 0 ("not at all") to 3 ("nearly every day"). A cut-point of 3 has been suggested as a screener for depression and was used to dichotomize this variable in the analyses.
Subjective norm	3 – 15	3-item scale rated on 7-point scales that ranged from 1 (strongly disagree) to 7 (strongly agree). This was modified to a 5-point scale in our baseline survey.

Table 2. Baseline variables overall and by group assignment.

Variable	Overall (n=449) Mean (SD)	PAMI (n=226) Mean (SD)	UC (n=223) Mean (SD)
Age (years)	63.89 (9.87)	63.73 (9.97)	64.05 (9.80)
BMI (kg/m2)	28.45 (4.99)	28.42 (4.94)	28.47 (5.05)
Peak oxygen consumption (ml/kg/min)	24.86 (6.77)	24.76 (6.47)	24.97 (7.04)
MVPA (minutes/week)	298.76 (192.51)	294.92 (185.20)	278.35 (203.97)
Exercise benefits	94.59 (11.90)	93.61 (12.76)	95.60 (10.89)
Exercise barriers	24.68 (5.38)	25.29 (5.52)	24.05 (5.17)
Neighbourhood aesthetics	3.46 (0.68)	3.49 (0.76)	3.43 (0.58)
Neighbourhood safety	1.22 (0.39)	1.20 (0.36)	1.23 (0.41)
Neighbourhood street connectivity	3.04 (0.81)	3.06 (0.81)	3.02 (0.80)
Task self-efficacy	51.35 (14.90)	51.38 (15.1)	51.31 (14.7)
Barrier self-efficacy	7.28 (6.00)	6.99 (2.36)	7.67 (8.16)
Subjective norm	12.73 (2.15)	12.58 (2.28)	12.89 (1.99)
Physical activity self-regulation	20.67 (4.37)	20.37 (4.25)	20.97 (4.48)
Exercise opportunities in community	9.53 (2.99)	9.36 (2.8)	9.69 (3.13)
Home exercise equipment available	4.26 (1.84)	4.11 (1.86)	4.4 (1.82)

PAMI = physical activity maintenance intervention; UC = usual care; BMI = body mass index; MVPA = moderate to vigorous physical activity

Table 3. Associations between baseline social ecological variables and MVPA at 26 weeks.

Variable	Mean (SD)	R	P
Neighbourhood aesthetics			
0-1.0 (n=2)	168.63 (47.80)	0.004	0.952
1.1-2.0 (n=17)	373.85 (279.64)		
2.1-3.0 (n=91)	226.04 (169.78)		
3.1≥ (n=338)	287.84 (203.90)		
Neighbourhood safety			
0-1.0 (n=279)	288.11 (198.64)	-0.004	0.962
1.1-2.0 (n=145)	254.60 (213.23)		
2.1-3.0 (n=18)	326.16 (193.31)		
3.1≥ (n=1)	359.00		
Neighbourhood street connectivity			
0-1.0 (n=16)	242.09 (166.38)	0.051	0.369
1.1-2.0 (n=55)	275.93 (189.24)		
2.1-3.0 (n=167)	267.19 (194.82)		
3.1≥ (n=210)	291.58 (203.14)		
Task self-efficacy			
<55 (n=227)	265.44 (194.57)	0.016	0.778
≥55 (n=222)	292.30 (204.38)		
Barrier self-efficacy			
<5 (n=81)	277.66 (247.82)	-0.024	0.667
5-8 (n=197)	265.28 (187.39)		
8> (n=165)	296.32 (203.43)		
Subjective norm			
<13 (n=157)	292.00 (218.39)	-0.062	0.269
≥13 (n=292)	271.41 (188.90)		
Exercise benefits			
<50 (n=2)	197.15 (197.86)	0.079	0.149*
50-100 (n=307)	269.84 (194.40)		
100> (n=139)	299.21 (209.36)		
Exercise barriers			
<25 (n=221)	285.40 (194.04)	-0.080	0.109*
≥25 (n=228)	272.17 (205.93)		
Physical activity self-regulation		0.032	0.536
≤21 (n=229)	267.59 (209.03)		
>21 (n=220)	290.03 (189.39)		

Exercise opportunities in community ≤3 (n=17) 3.1-7.0 (n=101) 7.1-10 (n=123) >10 (n=207)	 191.76 (161.29) 269.98 (208.03) 293.22 (214.48) 281.79 (195.09)	0.065	0.399
Home exercise equipment available <5 (263) ≥5 (n=185)	 272.28 (206.29) 278.46 (199.53)	0.061	0.261

*. Correlation is significant at the 0.15 level (2-tailed)

Table 4. Associations between baseline quality of life variables and MVPA at 26 weeks.

Variable	Mean (SD)	R	P
QOL <80 (n=210) ≥80 (n=239)	 273.79 (230.76) 278.64 (179.09)	0.030	0.688
Depressive symptoms No = (n = 406) Yes (n = 43)	 295.29 (197.02) 203.80 (244.21)	-0.100	0.175

QOL = quality of life

Table 5. Associations between baseline behavioural and fitness variables and MVPA at 26 weeks.

Variable	Mean (SD)	R	P
BMI <25 (n=109) 25-29.9 (n=196) ≥30 (n=142)	 297.10 (191.38) 276.78 (208.36) 268.49 (207.20)	-0.060	0.260
Peak oxygen consumption <15 (n=37) 15-19.9 (n=75) 20-24.9 (n=121) 25-29.9 (n=100) 30-34.9 (n=69) 35≥ (n=44)	 174.66 (160.18) 213.86 (191.73) 255.33 (183.75) 318.41 (199.51) 332.38 (208.44) 369.97 (227.00)	0.277**	0.000

Baseline MVPA			
<150 (n=105)	129.35 (136.37)	0.600**	0.000
≥150 (n=341)	326.63 (197.41)		
Smoking status			
No (n=407)	281.40 (203.84)	-0.044	0.573
Yes (n=42)	278.64 (192.9)		

BMI = body mass index

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6. Associations between baseline medical variables and MVPA at 26 weeks.

Variable	Mean (SD)	R	P
Comorbidities			
No (n=440)	279.81 (203.47)	-0.040	0.422
Yes (n=9)	221.28 (192.32)		
Beta-blockers			
No (n=104)	298.25 (211.03)	-0.053	0.328
Yes (n=345)	272.73 (200.67)		
Nitrates			
No (n=274)	281.74 (205.05)	-0.019	0.713
Yes (n=175)	273.79 (200.74)		
Anti-depressants			
No (n=388)	281.68 (206.20)	-0.038	0.457
Yes (n=61)	259.27 (183.35)		
Diabetes			
No (n=363)	288.87 (200.77)	-0.104***	0.051
Yes (n=86)	235.64 (208.80)		

***. Correlation is significant at the 0.10 level (2-tailed).

Table 7. Associations between baseline demographic variables and MVPA at 26 weeks.

Variable	Mean (SD)	R	P
Age			
<40 (n=6)	293.95 (123.76)		
40-49 (n=29)	330.77 (184.75)	-0.225**	0.000
50-59 (n=115)	334.75 (231.86)		
≥60 (n=299)	251.69 (188.89)		

Sex Male (n=314) Female (n=135)	 295.73 (204.23) 238.90 (195.77)	 -0.128*	 0.017
Ethnic background Caucasian (n=374) Other (n=75)	 278.64 (202.26) 281.80 (208.95)	 -0.006	 0.905
Working status Working (n=211) Retired (n=238)	 312.87 (203.81) 248.20 (198.13)	 -0.159**	 0.004
Education University (n=217) Other (n=232)	 278.64 (196.20) 278.79 (209.95)	 -0.001	 0.990
Marital status Married (n=319) Other (n=130)	 288.45 (197.24) 254.44 (216.07)	 -0.076	 0.150****
Program Intervention (n=226) Control (n=223)	 283.49 (200.18) 273.73 (206.51)	 -0.024	 0.662
Program site Toronto (n=143) Ottawa (n=306)	 298.98 (220.66) 269.14 (194.08)	 -0.0688	 0.216

****. Correlation is significant at the 0.01 level (2-tailed).

Table 8. Associations between variables and MVPA at 26 weeks by women and men.

	Women (n=135)		**Men (n=314)**	
Variable	**R**	**P**	**R**	**P**
Age	-0.316	0.006	-0.168	0.010
Ethnic background	0.048	0.649	-0.015	0.811
Working status	-0.251	0.006	-0.098	0.155
Education	-0.023	0.815	0.005	0.938
Marital status	-0.045	0.688	-0.043	0.452
Program site	-0.069	0.503	-0.081	0.169
Comorbidities	-0.059	0.553	-0.022	0.695
Nitrates	-0.158	0.094	0.044	0.493
Beta-blockers	-0.023	0.797	-0.068	0.288
Anti-depressants	0.010	0.917	-0.033	0.591
Diabetes	-0.009	0.937	-0.142	0.005
BMI	-0.051	0.625	-0.078	0.210
Peak oxygen consumption	0.253	0.018	0.248	0.000
Baseline MVPA	0.631	0.000	0.581	0.000

Smoking status	-0.005	0.966	-0.057	0.457
QOL	-0.004	0.976	0.045	0.543
Depressive symptoms	-0.101	0.527	-0.102	0.228
Neighbourhood aesthetics	0.043	0.666	0.009	0.914
Neighbourhood safety	0.023	0.852	0.011	0.899
Neighbourhood street connectivity	0.097	0.441	0.039	0.516
Task self-efficacy	0.152	0.206	-0.029	0.659
Barrier self-efficacy	-0.038	0.664	0.016	0.865
Subjective norm	-0.091	0.336	-0.053	0.461
Exercise benefits	0.064	0.500	0.077	0.263
Exercise barriers	0.055	0.563	-0.128*	0.054
Physical activity self-regulation	0.081	0.427	0.027	0.665
Exercise opportunities in community	0.050	0.690	0.061	0.404
Home exercise equipment available	0.073	0.497	0.038	0.559

BMI = body mass index; MVPA = moderate to vigorous physical activity; QOL = quality of life

CHAPTER 6: DISCUSSION AND CONCLUSION

6.1 Physical activity maintenance after cardiac rehabilitation: Where are we and where are we going?

This thesis paints an important picture of the state of interventions for PA maintenance following CR, based on quantitative and qualitative reviews of existing literature, and an analysis of predictors of successful PA maintenance from a clinical trial of 440 patients. This final chapter will offer a discussion, based on data, of lights and shadows of post-CR PA maintenance interventions and speculation about where we are going with these interventions under the pressures of healthcare funding, technology development, and current and future pandemics.

6.2 The Lights

Decades of research have informed guidelines for MVPA in patients with heart disease. It is clear that patients who accumulate ≥ 150 minutes of MVPA each week improve critical patient-relevant outcomes like cardiorespiratory fitness (CRF), symptoms of anxiety and depression, quality of life, re-hospitalization and mortality.[1-3] Participation in CR is the standard of care following acute cardiac events and interventions to increase MVPA (e.g. exercise testing, exercise prescription, supervised exercise classes, activity counseling) are core components of CR.[4] Men engage in 182 weekly minutes of accelerometer-measured MVPA (in bouts of 10 minutes or more) by the end of CR, while women engage in 131 minutes.[5] However, without intervention, mean MVPA levels drop to 152 minutes per week (-16.5%) in men and 109 minutes per week (-16.8%) in women by six months post-CR.[5]

PA maintenance interventions have been developed to address the problem of declining MVPA after CR. The systematic review and meta-analysis of RCT of interventions to maintain MVPA following CR showed there was overall evidence of effectiveness. The number of self-reported exercise sessions per week were higher (about one additional exercise session every two weeks) at follow-up among those receiving maintenance interventions compared to those receiving no intervention. Self-reported weekly calories expended in PA (+ 958 kcals, equivalent to an additional 96 minutes per week) were also higher among those receiving maintenance interventions. Only a few studies included objective measures of MVPA (i.e., accelerometers or pedometers). These data indicated that those engaged in maintenance interventions take an extra 1433 to 3536 steps per day compared to controls. Between group differences in steps per day of this magnitude are equivalent to an additional 1.2 to 2.8 km of walking per day. One RCT demonstrated that steps per day translated to peak oxygen consumption scores that were 2.2 $mLO_2/kg/min$ higher in those receiving intervention.[6] This is clinically meaningful since, among people with heart disease, every 1 $mLO_2/kg/min$ increase in peak VO_2 is associated with an approximate 15% decrease in risk of death.[7]

Interventions that produced the greatest improvements in *objectively* measured MVPA included the following elements: on-going contact for 8 or more weeks; personalized goal-setting; continuous self-monitoring of PA (using accelerometers or pedometers); performance-related feedback; and periodic tele-coaching from health and fitness experts (delivered via phone, text message, or secure website). These elements should be foundational for institutions planning their approach to PA maintenance.

Our qualitative review showed that patients and providers share similar views on the challenges of MVPA maintenance after CR graduation. In addition to motivational and clinical issues, they describe social and physical environment influences on MVPA that can inhibit or facilitate greater levels of activity. Consistent with interventions that have been tried to date, patients and providers say they need: on-going contact with CR professionals; personalized guidance and goal setting; and coaching to overcome barriers and challenges. The review identified additional expressed needs: structure and accountability; reassurance about exercising safely; peer support from others with heart disease; and assistance identifying and navigating community programs and supports. These wants and needs point to ways MVPA maintenance programs can be improved.

At this point, it appears that variation in exercise maintenance can be predicted from a relatively small number of variables. MVPA and CRF at the end of CR are powerful predictors of MVPA maintenance several months after CR completion, accounting for 36% and 10% of variation, respectively. Those who are more fit and more active at the end of CR, have a higher probability of achieving the 150 weekly minute threshold at follow-up. These factors could be useful in helping health care providers tailor interventions to individual patients.

Advances in communication and information technology offer new opportunities to democratize maintenance interventions (i.e., to make something available to all people). A high percentage of patients (> 80%) have and use smartphones with internet connectivity (personal communication, Jennifer Harris, University of Ottawa Heart Institute). Wearable technologies (to monitor the volume and intensity of PA) such as Fitbits, Apple watches, and Garmin monitors allow patients

to generate their own PA data with their own devices.[8,9] Wearable sensors extend to other physiologic metrics (such as blood pressure, blood glucose, and ECG tracings).[8] Bluetooth technology allows data generated by smart devices to be easily downloaded and stored to help patients self-track data over time and to share these data with healthcare professionals coordinating their care. Patients can download apps to guide and track their daily workouts and to identify community resources to support their PA.[9] The recent pandemic has sparked rapid adoption and acceptance of 'virtual' interactions between people with heart disease and their care providers.

6.3 The Shadows

Multiple operational definitions of maintenance have been used to frame research. In the systematic review and meta-analysis, we defined maintenance as a significant difference in PA between intervention and control groups, as this was the definition used by most of the included studies. Few trials have defined maintenance in terms of achieving clinically relevant thresholds over time.

Mode of delivery, duration and content of interventions are heterogenous. While there is some suggestion that internet-based interventions lasting 8-12 weeks or more are most effective, there is no gold standard. There is no 'one size fits all' when it comes to intervention. The effective components of interventions need to be unpacked. Understanding relapse curves for different kinds of patients can help to define times when contacts are most likely to useful. The intervention that was tested in the clinical trial from which data were derived for Study 3 did not

demonstrate an effect among men, while demonstrating an effect only in women who were adherent to the intervention.[5]

Self-reported outcomes dominate the published literature due to their practicality and cost-effectiveness.[10] There are, however, wide discrepancies between self-reported and objectively measured levels of MVPA.[11] Self-report measures of PA are subject to response bias and high social desirability bias.[12] There is a lack of consistency across studies in PA measures and there can be poor agreement between subjective and objective measures for the same PA constructs.[11,13] Subjective measures of PA can also generally overestimate PA, relying on participant recall.[14]

Objective measures indicate that people engage in moderate activities more so than vigorous activities,[15] however, vigorous activities may be the most useful in developing CRF. CRF, measured as peak oxygen consumption, improves effectively with training intensities at or above 35-50% of heart rate reserve.[16] Population-wide surveys show Canadian adults accumulate an average of 182 minutes of MVPA each week.[15] Less than half of the MVPA accumulated is performed in bouts of at least 10 minutes (84 minutes weekly, on average). Average daily vigorous PA is less than five minutes, which indicates that the majority of MVPA accumulated is at a moderate intensity.[15]

Participation in CR is suboptimal.[17] Those who gain access to CR and complete the program represents only approximately 20%-30% of cardiac outpatients.[18] Research shows that certain populations are less likely to access or complete CR,[19] including patients with low

socioeconomic status,[20] women,[21,22] and patients who live in rural areas.[23] People attending centre-based programs are also likely more motivated than average.[24] MVPA levels among those attending and completing CR likely over-estimate MVPA levels among all patients with heart disease[25] and little is known about MVPA patterns in people with heart disease who do not attend CR. People that do not attend CR receive little intervention (beyond general guidance in a booklet) regarding MVPA targets and strategies to initiate, let alone maintain, PA following hospitalization for an acute cardiac event and/or revascularization procedure.

The effects of social and physical environmental variables are hard to discern. They were described as important in the qualitative review, but they did not appear in predictor analyses. This discrepancy may relate to the varying neighbourhood definitions, measurements, and outcomes used in the literature.[26] In Study 3, the analyses were limited to the variables selected and the subjective measures used in the original trial. Studies have discovered discrepancies between perceived and objectively-assessed neighbourhood characteristics.[27] As well, research confirms that perceived neighborhood characteristics and objectively measured neighborhood characteristics are related but distinct constructs that account for different effects on physical activity.[28-31] A range of factors including individual attitudes, beliefs, self-efficacy, preferences, past experiences, health status, sex and gender, socioeconomic status, and cultural values and individual experiences relative to PA can influence perceptions of the neighbourhood environment.[32-34 35] There is also the issue of residential self-selection, which is the non-random process of individuals choosing to reside in neighbourhoods that align with their PA preferences.[36]

There are dramatic sex differences in MVPA. We know that women experience distinct barriers to CR[37-39] and long-term PA.[40,41] Men are much more active than women at the end of CR and engage in an additional 51 minutes of MVPA each week (182 vs. 131 minutes).[5] Men have higher average levels for cardiorespiratory fitness. There are also differences in age at disease presentation and levels of body fatness.[5]

The landscape for CR is changing. Current and future pandemics are likely to feature waves of infection necessitating frequent, prolonged periods of physical distancing, isolation and healthcare disruption, particularly for vulnerable populations, such as those with heart disease. CR programs across Canada largely suspended in-person services as a result of large-scale physical distancing recommendations designed to flatten the COVID-19 pandemic curve.[42] This places additional burdens on an already strained health care system. Prolonged closure of or reduced access to CR is likely to result in a significant waitlist expansion for this service, as well as increase rates of cardiac-related ED visits and hospital admissions and exposure of this vulnerable cardiac population to infection.[42] Even when current restrictions ease, patients may be unwilling to risk crowded conditions in community- and hospital-based exercise facilities. This has compelled a re-examination of the provision of post-acute care for cardiac patients, particularly how CR is delivered.

6.4 Where are we going?

A summary of recommendations for program administrators is provided in Table 1.

Research and program development need to be better framed with a clear definition of MVPA maintenance. Pragmatically, patients, program administrators and funders would like to know if people are still achieving a threshold of activity associated with improved health and well-being over time. We need to examine data in new ways. In future research, we will operationally define exercise maintenance as 'continued behaviour over a period of time consistent with a threshold believed to improve well-being or health' (e.g., at least 150 minutes of MVPA per week). Using this approach, patients could be classified as maintainers (meet threshold at baseline and follow-up), adopters (do not meet threshold at baseline but meet threshold at follow-up), relapsers (meet threshold at baseline but not at follow-up), or continuously inactive (do not meet threshold at baseline or follow-up).

It will be important to continue to measure MVPA levels objectively, rather than relying on self-reports of PA (which overestimate actual levels). Currently, objective data generated by accelerometers is converted to time spent at various intensities by applying accepted cut-points; however, accelerometers are expensive and additional time and expertise is required to manipulate the data to derive endpoints.[43] As a result, MVPA data is gathered only over predetermined periods of time (e.g., we assessed 7-day volume of activity only twice over a six-month period). Increasingly, wearable trackers will replace accelerometers in MVPA interventions and research. Fitbit, Apple, Garmin and other health trackers can monitor heart rate, activity levels, sleep levels, and some have even launched ECG tracings as a new feature. Wearable health trackers are relatively inexpensive, easy to use, and data are displayed in real-time.[9,44] Further, wearables allow MVPA and steps per day to be measured continuously over time, accounting for week-to-week volatility in PA. Maintenance curves could then be developed

to guide the timing of interventions. Wearables can provide feedback on performance and facilitate the sharing of behavioural and physiological information between health professionals and patients (via Bluetooth connection), and even among peers to capitalize on peer support networks.[9]

Emerging evidence suggests there is less need to emphasize MVPA in bouts of 10 or more minutes.[45,46] Rather, more emphasis can be placed on total weekly minutes of MVPA. There also needs to be greater emphasis on vigorous PA. CRF, measured as peak oxygen consumption, improves significantly (≥ 3.5 mlO_2/kg/min) with training intensities at or above 35-50% of heart rate reserve.[16] Time-based MVPA guidelines should be mapped on to steps per day guidance to align with outputs from wearable fitness trackers. People need to do an additional 3000-4000 steps per day, over and above basal levels to meet MVPA targets.[43] For patients with heart disease, this translates into 8000-9000 total steps per day.[47,48]

Continuous development and assessment of new program components needs to continue. Advances in technology afford new opportunities to communicate and interact with patients in home and community settings.[44,49,50] For example, few smartphone apps are designed to meet the unique needs of people with heart disease. The right kind of home exercise equipment combined with 'live' and on-demand, direct-to-home exercise instruction (e.g. Peleton, Mirror) could optimize intensity (the main driver of CRF improvement) and reduce geographic and time barriers to participation. Training intensities required to improve CRF are more likely when patients are using equipment and receiving exercise instruction. Adaptive designs and multi-site studies will be needed to complete this work efficiently. CR programs in Canada are connected

through the Canadian Association of Cardiovascular Disease Prevention and Rehabilitation and a program of research concerning MVPA research could be developed to leverage these connections.

Programmatically, there should be a greater emphasis on precision medicine. A principle tenet of precision medicine is that subpopulations may be reasonably identified who differ in their risk, prognosis and response to treatment due to differences in underlying biology and other characteristics.[51] Research is needed to combine data from clinical databases, behavioural data captured through wearables, and administrative data from provincial authorities (e.g. ICES) into multidimensional datasets that capture critical between-patient variation. These datasets can then be 'trained' using artificial learning algorithms to find the cryptic combinations of factors that predict risk, treatment response, prognosis and other outcomes in individual patients based on their own characteristics. If maintenance of PA can be accurately forecast, appropriately timed interventions could be directed at those most in need and/or most likely to benefit, rather than the 'one size fits all' approach currently in use. This would also allow the development of clinical tools to aid providers in decision making. The risk assessment could include variables such as: MVPA and CRF at CR graduation; proximity to community programs and access to appropriate home exercise equipment; presence of depression, diabetes, or mobility issues; and social support for MVPA participation.

CR programs have limited resources to address post-program maintenance.[52] Despite the documented reduction in MVPA following active engagement in CR, and despite evidence of the effectiveness of maintenance interventions, these interventions are not routinely provided as part

of funded CR. Healthcare costs are increasing faster than the rate of inflation. The business case for MVPA maintenance programs needs to be made. If the healthcare system is going to pay, the impact of maintenance interventions on downstream healthcare utilization and costs needs to be evaluated. If patients will be the payers, the value proposition they are willing to buy into needs to be carefully developed. With patient-pay scenarios, equity will be a concern. To further expand resources, community capacity will need to increase. Hub and spoke models can be developed where large, specialized centres support community-based and self-managed CR efforts. There is a need for pragmatic research to understand the costs and effects of interventions using real-life data and information from administrative databases and data linkage to examine downstream impacts on healthcare outcomes and utilization. This is how the business case can be made for funders.

Heart disease is a chronic illness characterized by long periods of stability punctuated by occasional, potentially life-threatening, periods of disease instability.[4] Regular participation in MVPA is a central tenet of disease management in these patients and exercise behaviours need to be maintained throughout the lifespan.[4] Mechanisms for long-term engagement of patients are required, with periodic re-assessments of MVPA and adjustments to account for changes in disease state, co-morbidities, and personal circumstances that may occur over time. The identification and registration of patients in such disease management systems should start at the time of index hospitalization, rather than waiting for patients to appear at CR programs.

Since MVPA levels are lower in women than men[53] and interventions show differential effects on men and women,[5] sex-and gender-specific interventions are likely required. There is also a

need for sex and gender-based analyses and reporting would provide necessary evidence on the differential experience of long-term PA maintenance among men and women with CHD.[54] Overall, a sex and gender-based approach to the study of PA maintenance among cardiac patients is warranted.

Finally, we need to move further upstream to consider social and economic determinants. Many of the determinants of health and health inequities in populations have social, environmental, and economic origins that extend beyond the direct influence of the health sector.[55] Policy approaches to health promotion and disease prevention which aim to influence the social determinants of health (e.g. universal basic income) will reach the broader population and create the conditions and environments necessary to support PA.[56,57]

6.5 Conclusion

While there have been positive developments in understanding PA maintenance, there are important knowledge gaps that remain unaddressed. There are opportunities for improvement in the measurement, monitoring, and surveillance of PA behaviour and ways in which intervention research could be improved. Advances in technology must be maximized so that continued support for people with heart disease can be adapted to meet needs, resources, and current context. Support to maintain PA among cardiac patients must be situated within the broader social context of creating supportive environments and policy for PA in the general population. Further research will be required to address these knowledge gaps and to build on the growing knowledge of effective PA interventions to support people with heart disease.

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Table 1. Summary of recommendations for program administrators.

Issue	Recommendations
Operational definition of physical activity maintenance	• Frame research and program evaluation regarding physical activity maintenance using the following operational definition: 'continued behaviour over a period of time consistent with a threshold believed to improve well-being or health' (i.e. ≥ 150 minutes of MVPA per week or 8000-9000 steps per day)
Monitoring of physical activity	• Encourage use of wearable activity monitors to gather objective, continuous data concerning PA levels • Encourage patients to share personal PA data with health coaches to enable progress tracking and expert feedback on performance
Program elements	• Incorporate fitness trackers • In addition to time-based goals (i.e. minutes of MVPA per week), provide step count goals (i.e. 8000-9000 steps per day) • Provide individualized guidance based on MVPA and/or CRF the end of formal CR • Have health and fitness experts monitor patient activity levels and provide feedback on performance via text message or email

	• Provide tele-coaching on multiple occasions for at least 8-12 weeks after CR graduation
Precision medicine	• Explore data linkage • Utilize machine learning, using algorithm driven recommendations that learn from input
Sex and gender	• Conduct and encourage sex-and gender-specific interventions • Incorporate and advocate for sex-and gender-based analysis and reporting
Program funding	• Explore user pay models (subscriptions) • Gather cost and impact data to facilitate business case development
Additional research	• Explore impact of specific home exercise equipment • Explore live streaming of exercise classes to patient homes

Appendix I. Systematic review Medline search strategy.

1. exp Rehabilitation/
2. exp Exercise Therapy/
3. therap*.ti,ab.
4. rehab*.ti,ab.
5. exp Heart Diseases/
6. exp Coronary Disease/
7. cardiac.ti,ab.
8. heart?.ti,ab.
9. coronar*.ti,ab.
10. exp Physical Fitness/
11. exp Exercise/
12. exercis*.ti,ab.
13. physical activit*.ti,ab.
14. physical fitness.ti,ab.
15. resistance training.ti,ab.
16. physical conditioning.ti,ab.
17. run*.ti,ab.
18. swim*.ti,ab.
19. walk*.ti,ab.
20. jog*.ti,ab.
21. myocardial.ti,ab.
22. pericardial.ti,ab.
23. ventricular.ti,ab.
24. maintain*.ti,ab.
25. sustain*.ti,ab.
26. comply.ti,ab.
27. compliance.ti,ab.
28. complies.ti,ab.
29. compliant.ti,ab.
30. adher*.ti,ab.
31. maintenance.ti,ab.
32. 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31
33. 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20

34. 1 or 2 or 3 or 4
35. 5 or 6 or 7 or 8 or 9 or 21 or 22 or 23
36. 32 and 33 and 34 and 35
37. randomized controlled trial.pt.
38. controlled clinical trial.pt.
39. randomized.ab.
40. placebo.ab.
41. clinical trials as topic.sh.
42. randomly.ab.
43. trial.ti.
44. 37 or 38 or 39 or 40 or 41 or 42 or 43
45. exp animals/ not humans.sh.
46. 44 not 45
47. 36 and 46

Appendix II. Individual study characteristics of included studies.

Study	Length	Follow-up	Measure	Units	Intervention description	Results
Aliabad (2014)[33]	3 sessions	4 months after end of CR	Godin Leisure-Time Exercise Questionnaire (GLTEQ)	METs/ week	HAPA (Health Action Process Approach)-based training in 3 sessions, booklet designed based on HAPA, with family support. HAPA is a health behavior change model which distinguishes between pre-intentional motivational processes leading to behavioural intention and post-intentional volitional processes leading to actual health behaviour.	PA in the intervention group was significantly higher than the control group after the intervention.
Antypas (2014)[31]	12 weeks	12 weeks	International Physical Activity Questionnaire (IPAQ)	METs/ week	Tailored Internet- and mobile-based intervention which contained general information about CHD and self-management, including information about diet, PA, smoking, and medication, as well as access to an online discussion forum and tailored content. The participants in the tailored group were required to answer more online questions than the control group, usually every 2 weeks, and they were reminded to log in through email and short message service (SMS) text messages and answer the questionnaires.	Intervention group had a significantly higher median level of overall PA than the control group.
Arrigo (2008)[34]	1 year	1 year after end of CR	Exercise diary	Physically active (Y/N)	Diary in which PA had to be described and quantified in minutes, physician-supervised exercise session once every 3 months where diary was discussed. Not well described.	Intervention showed a significant impact on regular PA at follow-up.
Butler (2009)[35]	18 weeks	6 months	Active Australia Survey	Sessions /week	The intervention group was given a pedometer, a step calendar, and a walking safety sheet after the baseline questionnaire was completed. Participants were trained in the use of the pedometer and were instructed to record daily steps for 6 weeks. Telephone calls to participants were made 1 week after receiving the pedometer and step calendar and at weeks 3, 12, and 18. Key features of the intervention included use of verbal reinforcement, individualized goal setting, and objective feedback from the pedometer to support the adoption and maintenance of a physically	PA sessions and minutes were significantly greater in the intervention group than the control group at follow-up.

					active lifestyle. Outcome expectancies, goal setting, and barrier identification were also addressed.	
Duncan (2002)[18]	12 weeks	12 weeks	Exercise diary	Sessions /week	Unsupervised home-based program + adherence facilitation intervention including goal-setting, graphic feedback and problem-solving guidance delivered to each patients at 3-week intervals provided by a nurse researcher.	Exercise frequency and duration was significantly higher in the intervention group at follow-up.
Duncan (2003)[19]	12 weeks	24 weeks	Exercise diary	Sessions /week	Adherence facilitation intervention including goal-setting, graphic feedback and problem-solving guidance delivered to each patients at 3-week intervals during unsupervised home-based phase provided by a nurse researcher.	Exercise adherence significantly higher in the intervention group at follow-up.
Frederix (2015a)[28]	12 weeks	18 weeks	Triaxial accelerometer	Steps/day	Motion sensor, online patient account, and weekly personalized automated feedback by SMS text messaging or email. Program was designed to encourage the patient to increase their daily step count to reach the recommended daily step count of 6500-8000 steps per day.	VO2 peak increased significantly in the intervention group, and was significantly correlated with daily steps.
Frederix (2015b)[27]	24 weeks	24 weeks	Triaxial accelerometer	Steps/day	The telerehabilitation included an online program and tailored exercise prescription. Participants were instructed to wear accelerometer continuously and to regularly transmit their registered activity data to the telerehabilitation center's local server. These data enabled a semiautomatic telecoaching system to provide the patients with feedback via email and SMS text messaging (once weekly), encouraging them to gradually achieve predefined exercise training goals. The content of the feedback messages changed over time based on how well the patient changed his prior lifestyle behavior.	Daily steps increased in the intervention group from baseline to follow-up; however, was not significant. Self-reported PA significantly increased in the intervention group.
Giallauria (2009)[29]	2 years	2 years	Questionnaire	Exercise intensity	Multifactorial continued education and behavioural program. Patients were seen in hospital once a month throughout the 24-month follow-up. Each patient received a booklet for exercise,	At follow-up, only 27% of the control group compared

				categories	diet, and smoking cessation to help patients assume a greater role in their healthcare, summarizing ideal lifestyle and risk factor targets, aiming to empower patients to manage each risk factor and lifestyle behavior. In addition, patients received, at each monthly visit, dietary advice, reinforcement on maintaining a correct lifestyle, a session of exercise training. Intervention team was made up of a psychologist, dietitian, cardiac specialist nurse, and a physiotherapist supported by a lead cardiologist.	with 58% of the intervention group reported moderate or high level of leisure-time physical activity (P<0.001).
Giannuzzi (2008)[30]	3 years	3 years	Questionnaire	Leisure-time physical activity (LTPA) score	The multifactorial, continued educational, and behavioral program was performed by a CR team composed of a specialist cardiac nurse, a physiotherapist, and a cardiologist (who was the supervisor). Comprehensive sessions with one-to- one support were held monthly from month 1 to month 6, then every 6 months for 3 years. Each session consisted of 30 minutes of supervised aerobic exercise, plus lifestyle and risk factor counseling lasting at least 1 hour and reinforcement of preventive interventions lasting approximately 30 minutes. Booklets explaining how to deal with exercise, diet, smoking cessation, and stress management was distributed.	The improvement in PA scores was significantly larger in the intervention group.
Guiraud (2012)[34]	8 weeks	8 weeks	Single-axis accelerometer	Kcal/week	The kinesiologist insisted on the importance of wearing the accelerometer from first thing in the morning to last thing at night. To motivate the patients, the kinesiologist called them every 15 days. During the telephone interview, the kinesiologist gave standard feedback on the amount of PA performed and counseled patients to identify potential barriers encountered to achieve PA recommendations, and to implement strategies to increase the daily amount of moderate-intensity PA.	The intervention group had a significantly higher total active EE compared to the control group.
Hofman-Bang (1999)[37]	11 months	24 months	Questionnaire	Sessions /week	Regular follow-up contacts were established between the patient and the nurse. These contacts were based on the agreed individual goal, and consisted of continued self-observation and recording of important aspects on everyday life in a diary, monitoring of behavioural changes, and, when needed, problem-solving and replanning discussions. At discharge from the rehabilitation centre	Exercise improved significantly in the intervention group compared to the control group.

					a referral note was sent to the family physician with information on achieved lifestyle changes. This maintenance program was successively stepped down over the 11-month period, leaving the patients on their own during the second year of follow up.	
Hopper (1995)[20]	12 months	15 months	13 item questionnaire	Score for "current exercise habit"	The intervention group received monthly telephone calls from rehabilitation staff (i.e., health care professionals) to provide social support and encourage their adherence to the exercise regime established during rehabilitation. A cardiac nurse or exercise physiologist contacted each participant of the intervention group and, during a structured telephone interview, addressed the following areas: (a) consistent exercise, (b) maintenance of a healthy diet, (c) consistency with medication, (d) knowledge of current blood pressure and cholesterol levels, and (e) symptoms that required medical attention and/or physician awareness.	The intervention group demonstrated significantly greater exercise adherence at follow-up than the control group.
Hughes (2007)[38]	9 months	12 months	Uniaxial accelerometer	Activity counts/ week	Participants received an exercise consultation after baseline and 6 month assessments and a support phone call three months after each consultation. Control participants received a phone call on topics unrelated to exercise three and nine months after the baseline assessment. Exercise consultations involved a 30 minute one-to-one discussion with a trained researcher. Strategies included: assessing current physical activity status, exploring pros and cons of being active, problem-solving barriers, social support, exploring activity options, setting realistic activity goals (for 1, 3 and 6 months) and preventing relapse. Support phone calls given 3 months after each consultation lasted approximately 10 minutes and involved a discussion on barriers to activity, achieving activity goals and remaining active.	Activity counts did not significantly change in intervention group (however were exceeding PA guidelines at baseline therefore maintained). Activity decreased in the control group but was not significant.
Izawa (2005)[39]	6 months	6 months after end of CR	Pedometer	Steps/day	Patients were asked to continue self-monitoring after CR by recording body weight, objective physical activity derived from the pedometer, blood pressure, and heart rate. The goal in the self-monitoring approach group was to promote self-efficacy for physical activity in relation to exercise maintenance and leisure-time physical activity. The self-monitoring approach used in this	Mean objective PA was significantly higher in the intervention group than control group at follow-up.

					study was based on Bandura's self-efficacy theory and was designed to enhance confidence for exercise maintenance. Performance accomplishments were addressed by written feedback on exercise, muscle strength test results, body composition test results (percentage of fat), and discussion of the self-monitoring log.	
Janssen (2014)[40]	19 weeks	15 months post-CR	Pedometer	Steps/day	The intervention was a self-regulation program focused on maintenance of lifestyle change. The program started with an individual 1-h motivational counseling session with a health psychologist (week 1). During the interview important (life) goals for the patients were explored, on the basis of which a personal health goal was set. Potential barriers to goal achievement, and costs and benefits of change were examined. Patients then attended five 2-h group sessions (weeks 3, 5, 7, 9 and 11) and two 2-h follow-up sessions (weeks 15 and 19) at the cardiac rehabilitation center led by the same health psychologist. Group sessions were structured around the self-regulatory phases of goal pursuit, in particular the maintenance phase, and focused on enhancing the relevant self-regulation skills. Patients were also encouraged to bring their partner (or a significant other) to one of the sessions in order to increase social support.	Steps significantly increased from baseline to follow-up in the intervention group compared to control.
Kaminsky (2013)[21]	8 weeks	8 weeks	Pedometer	Steps/day	Participants wore a pedometer daily for the entire study period, whereas the control group only wore the pedometer during initial assessment week and during week 8. With each week of pedometer use, participants completed a PA log form to report pedometer wear-time on a given day. All participants, regardless of group, were given the same recommendation to obtain a minimum of 30-40 min/d MVPA, on days they did not attend CR. Following baseline assessment, intervention participants received individualized daily step count goals to increase by 10% of baseline steps/d for weeks 2-8.	Intervention participants significantly increased steps/day from baseline to follow-up. There was no difference in control participants.
Lear (2003)[25]	9 months	1 year	4-week modified	Kcal/week	The Extensive Lifestyle Management Intervention (ELMI) was designed so that each participant was contacted at least once per	There were no significant

			Minnesota Leisure Time Physical Activity (LTPA) questionnaire		month using a case management model based on principles of behavioural change. During these sessions participants were counselled to establish a home-based exercise program. Each participant received a logbook for exercise, diet and medications at the study's onset to aid in lifestyle adherence. Telephone follow-up calls were conducted by the case manager to identify any new or change in symptoms, follow-up on goal progress, and assess and counsel on lifestyle behaviours and risk factors. ELMI lifestyle and risk factor counselling sessions were held at months 6 and 9. Participants received a ELMI Lifestyle and Risk Factor Report upon entry.	differences between two groups.
Luszczynska (2006)[41]	10-15 minutes	8 months after MI	Questionnaire	Exercise sessions /week	Patients received instructions about what implementation intentions should include, completed the intervention form, screened the intervention form together with an interviewer and received supportive feedback from an interviewer regarding their implementation intentions, and were complimented by an interviewer regarding successful implementation of their intentions. The intervention was given on an individual basis and lasted 10–15 min. Patients were instructed that they would be asked to form a plan regarding their physical activity and that their plans should always include the information about when, where, and how to exercise.	Patients in the intervention group exercised more frequently than the control group at follow-up.
Madssen (2014)[32]	12 months	12 months	Questionnaire	Exercise sessions /week	Patients in the maintenance program group received a written exercise program with the aim of three sessions of high intensity interval training (HIIT) per week, and were invited to attend a monthly supervised exercise session at the hospital. The HIIT program consisted of 8–10 minutes of warmup, followed by four times four minutes intervals, with an active pause of three minutes in-between intervals and at the end. Physiotherapists or exercise physiologist motivated the patients on how to perform HIIT and asked about their home training.	There was no difference in physical activity levels between groups after 12 months.

Millen (2009)[26]	3 months	3 months	Modified Physical Activity Scale for the Elderly (PASE)	Exercise sessions /week	Social Cognitive Theory Based Resistance Training Manual. A 30-page instructional resistance-training manual was designed for the cardiac patients in the intervention group. The content of the manual was based on fundamental strength training principles for cardiac patients and social cognitive theory constructs targeting self-efficacy and outcome expectancies. Were also provided Thera-Band Resistive Bands and a logbook. All participants were given an orientation to exercises.	There was no difference between groups at follow-up.
Moore (2006)[48]	2 months	12 months	Portable wristwatch heart rate monitor	Exercise sessions /mont	"Change Habits by Applying New Goals and Experiences" (CHANGE), the intervention consists of five small-group (6–8 people) counseling and behavior modification sessions for participants attending a CRP in which they are taught self-efficacy enhancement, problem-solving skills, and relapse prevention strategies to address their identified exercise maintenance problems. The CHANGE intervention is based on several cognitive–behavioral theoretical frameworks. The intervention is provided in three 1½-hr sessions once a week during the last 3 weeks of the CRP and two sessions held at 1 and 2 months following completion of the CRP.	No significant differences between groups at follow-up.
Pinto (2011)[23]	6 months	12 months	7-day Physical Activity Recall (PAR) validated by Triaxial accelerometer	Minutes of MVPA/ week	The participant was given home logs to monitor exercise participation and a pedometer to wear during exercise activities that involved walking. Each participant received calls over 6 months (weekly over the first 2 months, biweekly for the next 2 months, and monthly for the last 2 months, a total of 14 calls) from the Intervention Coordinator to promote adherence to prescribed aerobic exercise, incorporating components of social cognitive theory, motivational interviewing, and transtheoretical theory. Participants were mailed an information sheet for each call and received feedback letters throughout.	The intervention group reported significantly higher exercise participation at 12 months than the control.
Sniehotta (2005)[17]	4 months	4 months after end of CR	Modified Kaiser Physical	Exercise sessions /week	Planning intervention: Participants received a planning booklet with two sheets for action plans and for coping plans.	The planning plus diary group reported the highest levels of PA at

			Activity Survey		Personalized Weekly Diary Intervention: Participants in the planning plus diary group received the planning booklet and they received by mail six weekly diaries after discharge, tailored to individual requirements. In each diary participants received copies of their own personal plans previously formulated in the planning intervention.	follow-up; however, did not reach statistical significance.
Yates (2005)[24]	9 weeks	6 months	Questionnaire	Exercise sessions /week	The intervention was by telephone and was guided by Bandura's (1997) self-efficacy theory. During booster sessions, the subject's individualized goals, negotiated in CR, were used as a basis for intervening. Subjects who reported progress toward goal achievement received praise and were encouraged to attribute accomplishments to their own abilities. Factors inhibiting achievement of target goals were also discussed to deal with areas of relapse. Four BSN-prepared RNs with expertise in CR provided the booster intervention. Participants met with a RN at 3 and 9 weeks after CR.	Intervention group had greater exercise at follow-up compared to baseline, however, there were no significant differences between groups.

Appendix III. Enhancing Transparency in Reporting the Synthesis of Qualitative Research (ENTREQ) (Tong et al. 2012) checklist with relevant manuscript page number *(submitted version)*.

No.	Item	Description	Page #
1	Aim	State the research question the synthesis addresses.	3
2	Synthesis methodology	Identify the synthesis methodology or theoretical framework which underpins the synthesis, and describe the rationale for choice of methodology.	3-4
3	Approach to screening	Indicate whether the search was pre-planned or iterative.	4
4	Inclusion criteria	Specify the inclusion/exclusion criteria.	4
5	Data sources	Describe the information sources used and when the searches conducted; provide the rationale for using the data sources.	5
6	Electronic search strategy	Describe the literature search.	Appendix I
7	Study screening methods	Describe the process of study screening and sifting	5-6
8	Study characteristics	Present the characteristics of the included studies.	8
9	Study selection results	Identify the number of studies screened and provide reasons for study exclusion.	7
10	Rationale for appraisal	Describe the rationale and approach used to appraise the included studies or selected findings	6
11	Appraisal items	State the tools, frameworks and criteria used to appraise the studies or selected findings.	6
12	Appraisal process	Indicate whether the appraisal was conducted independently by more than one reviewer and if consensus was required.	6
13	Appraisal results	Present results of the quality assessment and indicate which articles, if any, were weighted/excluded based on the assessment and give the rationale.	10-11
14	Data extraction	Indicate which sections of the primary studies were analysed and how were the data extracted from the primary studies?	6
15	Software	State the computer software used, if any.	6

16	Number of reviewers	Identify who was involved in coding and analysis.	7
17	Coding	Describe the process for coding of data.	7
18	Study comparison	Describe how were comparisons made within and across studies.	7
19	Derivation of themes	Explain whether the process of deriving the themes or constructs was inductive or deductive.	7
20	Quotations	Provide quotations from the primary studies to illustrate themes/constructs, and identify whether the quotations were participant quotations of the author's interpretation.	13-19
21	Synthesis output	Present rich, compelling and useful results that go beyond a summary of the primary studies	19-25

Appendix IV. Qualitative synthesis search strategy

1. exp Rehabilitation/
2. exp Exercise Therapy/
3. therap*.ti,ab.
4. rehab*.ti,ab.
5. exp Heart Diseases/
6. exp Coronary Disease/
7. cardiac.ti,ab.
8. heart?.ti,ab.
9. coronar*.ti,ab.
10. exp Physical Fitness/
11. exp Exercise/
12. exercis*.ti,ab.
13. physical activit*.ti,ab.
14. physical fitness.ti,ab.
15. resistance training.ti,ab.
16. physical conditioning.ti,ab.
17. run*.ti,ab.
18. swim*.ti,ab.
19. walk*.ti,ab.
20. jog*.ti,ab.
21. myocardial.ti,ab.
22. pericardial.ti,ab.
23. ventricular.ti,ab.
24. maintain*.ti,ab.
25. sustain*.ti,ab.
26. comply.ti,ab.
27. compliance.ti,ab.
28. complies.ti,ab.
29. compliant.ti,ab.
30. adher*.ti,ab.
31. maintenance.ti,ab.
32. 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31
33. 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20

34. 1 or 2 or 3 or 4
35. 5 or 6 or 7 or 8 or 9 or 21 or 22 or 23
36. 32 and 33 and 34 and 35

37. interview:.mp.

38. experience:.mp.

39. qualitative.tw.

40. 37 or 38 or 39

41. 36 and 40

Appendix V. Exercise benefits and barriers scale.

SECTION Q: BENEFITS AND BARRIERS

Instructions: Below are statements that relate to ideas about physical activity. Please indicate the degree to which you agree or disagree with the statements by circling SA for strongly agree, A for agree, D for disagree, or SD for strongly disagree.[15]

	Strongly Agree	Agree	Disagree	Strongly Disagree
1. I enjoy physical activity	**SA**	**A**	**D**	**SD**
2. **Physical activity** decreases feelings of stress and tension for me	SA	A	D	SD
3. Physical activity improves my mental health.	**SA**	**A**	**D**	**SD**
4. **Physical activity** takes too much of my time	SA	A	D	SD
5. I will prevent heart attacks by engaging in physical activity	**SA**	**A**	**D**	**SD**
6. **Physical activity** tires me	SA	A	D	SD
7. Physical activity increases my muscle strength	**SA**	**A**	**D**	**SD**
8. **Physical activity** gives me a sense of personal accomplishment	SA	A	D	SD
9. Places for me to engage in physical activity are too far away	**SA**	**A**	**D**	**SD**
10. **Physical activity** makes me feel relaxed	SA	A	D	SD
11. Physical activity lets me have contact with friends and persons I enjoy	**SA**	**A**	**D**	**SD**
12. I am too embarrassed to **engage in physical activity**	SA	A	D	SD
13. Physical activity will keep me from having high blood pressure	**SA**	**A**	**D**	**SD**
14. It costs too much to **engage in physical activity**	SA	A	D	SD
15. Physical activity increases my level of physical fitness	**SA**	**A**	**D**	**SD**
16. **Physical activity** facilities do not have convenient schedules for me	SA	A	D	SD
17. My muscle tone is improved with physical activity	**SA**	**A**	**D**	**SD**
18. **Physical activity** improves functioning of my cardiovascular system	SA	A	D	SD
19. I am fatigued by physical activity	**SA**	**A**	**D**	**SD**
20. I have improved feelings of well being from **physical activity**	SA	A	D	SD
21. My spouse (or significant other) does not encourage physical activity	**SA**	**A**	**D**	**SD**
22. **Physical activity** increases my stamina	SA	A	D	SD
23. Physical activity improves my flexibility	**SA**	**A**	**D**	**SD**
24. **Physical activity** takes too much time from family relationships	SA	A	D	SD
25. My disposition is improved with physical activity	**SA**	**A**	**D**	**SD**
26. **Physical activity** helps me sleep better at night	SA	A	D	SD
27. I will live longer if I engage in physical activity	**SA**	**A**	**D**	**SD**

	Strongly Agree	Agree	Disagree	Strongly Disagree
28. I think people in **physical activity** clothes look funny	SA	A	D	SD
29. Physical activity helps me decrease fatigue	**SA**	**A**	**D**	**SD**
30. Physical activity is a good way for me to meet people	SA	A	D	SD
31. My physical endurance is improved by physical activity	**SA**	**A**	**D**	**SD**
32. Physical activity improves my self-concept	SA	A	D	SD
33. My family members do not encourage me to engage in physical activity	**SA**	**A**	**D**	**SD**
34. Physical activity increases my mental alertness	SA	A	D	SD
35. Physical activity allows me to carry out normal activities without becoming tired	**SA**	**A**	**D**	**SD**
36. Physical activity improves the quality of my work	SA	A	D	SD
37. Physical activity takes too much time from my family responsibilities	**SA**	**A**	**D**	**SD**
38. Physical activity is good entertainment for me	SA	A	D	SD
39. Physical activity increases my acceptance by others	**SA**	**A**	**D**	**SD**
40. Physical activity is hard work for me	SA	A	D	SD
41. Physical activity improves overall body functioning for me	**SA**	**A**	**D**	**SD**
42.There are too few places for me to engage in physical activity	SA	A	D	SD
43. Physical activity improves the way my body looks[12]	**SA**	**A**	**D**	**SD**

Appendix VI. Task self-efficacy scale.

SECTION O: YOUR CONFIDENCE

Instructions: All of the items listed below are designed to **assess your confidence** to continue participating in at least 30 minutes of moderate-to-vigorous regular physical activity. Please circle the percentage (%) that best represents your response for EACH question using the scale provided. **Please answer each question on lines 1-7.** [13]

During a typical week over the next 6 months, how confident are you that you will definitely accumulate at lease 30 minutes of moderate-to-vigorous physical activity	**Not at all Confident (%)**				**Moderately Confident (%)**					**Completely Confident (%)**
1. **1 day out of the next 7** →	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
2. **2 days out of the next 7** →	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
3. **3 days out of the next 7** →	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
4. **4 days out of the next 7** →	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
5. **5 days out of the next 7** →	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
6. **6 days out of the next 7** →	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
7. **7 days out of the next 7** →	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Appendix VII. Barrier self-efficacy scale.

SECTION F: YOUR CONFIDENCE TO DO PHYSICAL ACTIVITY

Using the 0% to 100% scale below, please circle how confident you are that you will accumulate 30 or more minutes of moderate to vigorous physical activity per day on at least 5 days[6], EVEN IF…

	Not at all Confident					Moderately Confident					Extremely Confident	Not Applicable (N/A)
1. you fear you will have another cardiac event	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
2. you are experiencing back pain	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
3. you are experiencing medication side effects	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
4. the weather is bad	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
5. you feel you have too much work to do	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
6. you feel you do not have time	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
7. you had angina / chest pain earlier in the day	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
8. you have other health problems	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
9. it is too expensive	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
10. you have to do physical activity alone	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
11. you do not enjoy it	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
12. you feel tired	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
13. you feel anxious or stressed	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A
14. you feel depressed	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	N/A

Appendix VIII. Subjective norm.

SECTION N: IMPORTANT OTHERS

Instructions: These questions ask you about **what you think** important people in your life would think about you engaging in physical activity after completing cardiac rehabilitation on a weekly basis during the next six (6) months. Please circle a number for EACH question using the scale provided.

After my Cardiac Rehabilitation Program, in a typical week during the next 6 months …	***Strongly disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly agree***
(1) most people important to me will definitely think I should be participating in regular physical activity.	***1***	***2***	***3***	***4***	***5***
(2) most people important to me will definitely want me to engage in regular physical activity.	***1***	***2***	***3***	***4***	***5***
(3) most people important to me will definitely themselves engage in regular physical activity.	***1***	***2***	***3***	***4***	***5***

Appendix IX. Physical activity self-regulation scale.

SECTION L: SELF-REGULATION

Instructions: Please indicate how often you used each self-regulation strategy in the past week. [1112]

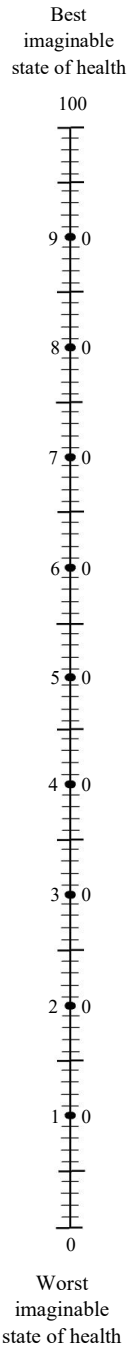
	Never	Rarely	Sometimes	Often	Very Often
1. I mentally kept track of my physical activity	1	2	3	4	5
2. I mentally noted specific things that helped me be active	**1**	**2**	**3**	**4**	**5**
3. I set short term goals for how often I am active	1	2	3	4	5
4. I set physical activity goals that focused on my health	**1**	**2**	**3**	**4**	**5**
5. I asked someone for physical activity advice or demo	1	2	3	4	5
6. I asked a physical activity expert or health professional for physical activity advice or demo	**1**	**2**	**3**	**4**	**5**
7. After physical activity I focused on how good it felt	1	2	3	4	5
8. I reminded myself of physical activity health benefits	**1**	**2**	**3**	**4**	**5**
9. I mentally scheduled specific times for physical activity	1	2	3	4	5
10. I rearranged my schedule to ensure I had time for physical activity	**1**	**2**	**3**	**4**	**5**
11. I purposefully planned ways to do physical activity when on trips away from home	1	2	3	4	5
12. I purposefully planned ways to do physical activity in bad weather	**1**	**2**	**3**	**4**	**5**

Appendix X. EuroQol visual analogue scale.

To help people say how good or bad their state of health is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0.

We would like you to indicate on this scale how good or bad your own health is today, in your opinion. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your state of health is today.

YOUR HEALTH TODAY =



Appendix XI. The Patient Health Questionnaire – 2 (PHQ-2).

Please circle one number in each row below:

Over the past 2 weeks, how often have you been bothered by any of the following problems?	Not At All	Several Days	More Than Half the Days	Nearly Every Day
a. Little interest or pleasure in doing things	0	1	2	3
b. Feeling down, depressed or hopeless	0	1	2	3

Appendix XII. Neighbourhood characteristics.

SECTION G: NEIGHBOURHOOD CHARACTERISTICS

Instructions: For the next series of questions, we would like to know about what you think about your current neighbourhood (that is, where your room, apartment, or house is located- the area in which you currently reside/live).

Please circle the number for each question (i.e. from 1= strongly disagree to 4 = strongly agree) that best applies to your neighbourhood during the next week.[7]

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1. There are trees along the streets in my neighborhood.	1	2	3	4
2. There are many interesting things to look at while walking in my neighborhood.	**1**	**2**	**3**	**4**
3. There are many attractive natural sights in my neighborhood (such as landscaping, views).	1	2	3	4
4. There are attractive buildings / homes in my neighborhood.	**1**	**2**	**3**	**4**
5. There is a high crime rate in my neighborhood.	1	2	3	4
6. The crime rate in my neighborhood makes it unsafe to do physical activity outside DURING THE DAY.	**1**	**2**	**3**	**4**
7. The crime rate in my neighborhood makes it unsafe to do physical activity outside **AT NIGHT.**	1	2	3	4
8. The distance between intersections in my neighborhood is usually short (100 yards or less; the length of a football field)	**1**	**2**	**3**	**4**
9. There are many alternative routes for getting from place to place in my neighborhood (I don't have to go the same way every time).	1	2	3	4

10. Is your neighborhood (Please check one ☑):

☐1. Residential ☐ 2. Mixed commercial and residential ☐ 3. Mainly commercial

Appendix XIII. Places to do physical activity.

SECTION H: PLACES TO DO PHYSICAL ACTIVITY

Instructions: Please indicate if each place is present in your community. If **you live** in an **urban community**, please consider places that are **within a 15 minute walk** of your house. If **you live** in a **rural community**, please consider places that are **within a 15 minute drive** of your house. Please check a box beside each place that is present in your community and whether or not you will use it within the next week.[8]

Places to do physical activity	Is it available?		Will/would you use it?	
	Yes	No	Yes	No
1. Fitness clubs	☐	☐	☐	☐
2. Schools offering recreation programs	☐	☐	☐	☐
3. Community recreation centres	☐	☐	☐	☐
4. Arenas (skating, hockey)	☐	☐	☐	☐
5. Jogging / walking paths	☐	☐	☐	☐
6. Bicycle lanes / paths	☐	☐	☐	☐
7. Swimming pools	☐	☐	☐	☐
8. Racquet clubs / courts (tennis)	☐	☐	☐	☐
9.Indoor shopping malls	☐	☐	☐	☐
10. Golf courses	☐	☐	☐	☐
11. Beaches, lake, river, or creek	☐	☐	☐	☐
12. Public parks	☐	☐	☐	☐
13.Playing fields (soccer, football, etc.)	☐	☐	☐	☐

Appendix XIV. Home physical activity equipment.

SECTION I: HOME PHYSICAL ACTIVITY EQUIPMENT

Instructions: What **physical activity equipment**, if any, do you (or will you) own **during the next week?** (Please consider only equipment that is in working condition and safe for you to use, and answer the "will/would you use it?" column even if you have answered that you do NOT have the equipment.)[9]

Home Environment	Do / will you own it?		Will/would you use it?	
	Yes	No	Yes	No
Treadmill	☐	☐	☐	☐
Stationary bicycle	☐	☐	☐	☐
Outdoor bicycle	☐	☐	☐	☐
Skis (downhill, cross country, water)	☐	☐	☐	☐
Skates (ice, roller)	☐	☐	☐	☐
Weight training equipment	☐	☐	☐	☐
Running, walking shoes	☐	☐	☐	☐
Swimming pool	☐	☐	☐	☐
Toning devices (exercise balls, dynabands)	☐	☐	☐	☐
Aerobic work-out video or audiotapes	☐	☐	☐	☐
Dog	☐	☐	☐	☐

Appendix XV. Missing data.

Variable	N	Missing Count	Missing %
Age	449	0	0.0
BMI	443	6	1.3
Peak oxygen consumption	242	207	46.1
QOL	405	44	9.8
Baseline MVPA	403	46	10.2
MVPA at 26 weeks	350	99	22.0
Exercise benefits	407	42	9.4
Exercise barriers	407	42	9.4
Neighbourhood aesthetics	406	43	9.6
Neighbourhood crime	405	44	9.8
Neighbourhood street connectivity	406	43	9.6
Task self-efficacy	398	51	11.4
Barrier self-efficacy	400	49	10.9
Subjective norm	403	46	10.2
Depressive symptoms	405	44	9.8
Physical activity self-regulation	404	45	10.0
Exercise opportunities in community	352	97	21.6
Home exercise equipment available	368	81	18.0
Sex	449	0	0.0
Co-morbidities	449	0	0.0
Beta-blockers	449	0	0.0
Nitrates	448	1	0.2
Anti-depressants	448	1	0.2
Ethnicity	407	42	9.4
Diabetes	440	9	2.0
Program site	449	0	0.0

Working status	399	50	11.1
Education	424	25	5.6
Smoking	388	61	13.6
Marital status	406	43	9.6

Appendix XVI. Secondary data analysis ethics approval.

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UNIVERSITY OF OTTAWA HEART INSTITUTE
INSTITUT DE CARDIOLOGIE DE L'UNIVERSITÉ D'OTTAWA

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:	September 20, 2018
To:	Dr. Robert Reid, UOHI/OHIRC
Protocol ID:	20180605-01H
Study Title:	Physical Activity Maintenance in a Post-Cardiac Rehab Population: a mixed methods study
Submission Type:	Initial Application
Review Type:	Delegated Review Secondary Use of Information (i.e., no participant contact, chart/patient record review, use of existing database, and/or previously collected biological samples)
Date of Approval:	September 18, 2018
Approval Expiry Date:	September 18, 2019

Dear Dr. Robert Reid,

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 University of Ottawa Heart Institute.

An **Institutional approval UOHI 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.

Documents Approved:

Document Name	**Document Version Date**
Proposal Aug 1, 2018	August 1, 2018

Documents Acknowledged:

Document Name