WHAT TRANSIENT EFFECTS DOES THE PERFORMANCE OF A HYPOPRESSIVE EXERCISE HAVE ON INTRA-ABDOMINAL PRESSURE AND ON PELVIC FLOOR MUSCLE ACTIVATION IN FEMALES?

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Abstract

The gold standard to treat mild to moderate urinary incontinence (UI) and pelvic organ prolapse (POP) in women is pelvic floor muscle training (PFMT). However, hypopressive exercises (HEs), a postural and respiratory exercise approach first described by Caufriez in 1997 (Caufriez, 1997) have gained popularity around the world as an alternative or adjunct to PFMT in the treatment of pelvic floor disorders (PFDs). The theoretical aim of HEs is to decrease intra-abdominal pressure (IAP), which supposedly leads to activation of the abdominal and pelvic floor muscles (PFMs) through reflex mechanisms. However, these proposed phenomena have not been studied empirically.

The objectives of this cross-sectional, observational study were (1) to investigate the acute, transient effect of HEs on IAP and abdominal and PFM activation in females, (2) to determine the relative importance of the postural maneuver and respiratory apnea components of HEs on the transient effects of these exercises on IAP and on abdominal and PFM activation, and (3) to determine whether any effects of the HEs on IAP or abdominal or PFM activation were more marked after six to eight weeks of training.

Thirty-six healthy participants with female-typical pelvic anatomy, who were naïve to HEs were recruited from the local community via flyers, advertisements, and word of mouth. Participants attended an initial training session, a follow-up session one week later to ensure the exercises were performed correctly, and the first data collection session two weeks after the initial training session. Twenty-four of these participants were invited and agreed to continue the HE training for an additional six to eight weeks prior to attending the second data collection session. The two data collection sessions were the same.

The primary outcome measures included the magnitude of change in IAP (measured by an intravaginal sensor), activation of the PFMs (measured using electromyography (EMG)), and changes in the levator plate length (LPL), the bladder neck height (BNH) and the levator plate angle (LPA) relative to horizontal observed through transperineal ultrasound video clips recorded during the HE maneuver performed with and without the HE posture.

The IAP did not decrease significantly during the HE in either visit [supine or standing; with or without hypopressive posture (HP)]. The PFMs and abdominal muscles were active during the first [levator ani muscles (LAMs): 44(35)%MVC (supine) to 50(44)%MVC (standing); external anal sphincter (EAS): 27(24)%MVC (supine) to 27(27)%MVC (standing); [external oblique

(EO): 21(13)%MVC (supine) to 36(31)%MVC (standing); internal oblique/transversus abdominis (IOTrA): 58(55)%MVC (supine) to 64(48)%MVC (standing)] and second [LAMS: 71(55)%MVC (supine) to 72(75)%MVC (standing); EAS: 45(52)%MVC (supine) to 35(34)%MVC (standing); EO; 34(41)%MVC (supine) to 52(75)%MVC (standing); IOTrA: 58(65)%MVC (supine) to 80(73)%MVC (standing)] data collection sessions. The pelvic floor morphology changed during the HE maneuver at both data collection sessions, suggesting the PFMs were active concentrically ([LPL (-2.2mm supine, η_p^2 = 0.08, p=0.18; -4.4mm in standing, η_p^2 = 0.12, p=0.10); BNH (0.2mm in supine, η_p^2 = 0.02, p=0.48; 0.3mm in standing, η_p^2 = 0.00, p=0.90), LPA (2.4° in supine, η_p^2 = 0.02, p=0.46; 1.0° in standing, η_p^2 = 0.11, p=0.12)]. There was no effect of body position or the HP on any outcomes at either visit. The training period of six to eight weeks did not result in any learning effect in terms of the exercise mechanism as theorized by Caufriez, and there was no increase in PFM voluntary contraction strength. Therefore, the theory proposed by Caufriez regarding the mechanism of action of the HEs is not supported by this cross-sectional study, nor does it corroborate the effectiveness of HEs in improving the contractile force or tone of the PFMs.

Key words: *hypopressive exercises, pelvic floor muscles, intra-abdominal pressure, electromyography, stress urinary incontinence, pelvic organ prolapse, pelvic floor disorders*

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List of Abbreviations

2D-USI	Two-dimensional transperineal ultrasound imaging
ANOVA	Analysis of variance
CI	Confidence interval
EMG	Electromyography
EO	External oblique
IAP	Intra-abdominal pressure
ICS	International Continence Society
ICIQ	International Consultation on Incontinence Questionnaire
IO	Internal oblique
IO/TrA	Internal oblique / Transversus abdominis
IVD	Intra-vaginal dynamometer
LPA	Levator plate angle
LPL	Levator plate length
MUI	Mixed urinary incontinence
MVC	Maximum voluntary contraction
PFD	Pelvic floor disorders
PFM	Pelvic floor muscle
PFMT	Pelvic floor muscle training
POP	Pelvic organ prolapse
RCT	Randomized clinical trial
RA	Rectus abdominis
EMG	Surface electromyography
SUI	Stress urinary incontinence
TP-USI	Transperineal ultrasound
UI	Urinary incontinence
UUI	Urgency urinary incontinence

Chapter 1: Introduction

Hypopressive exercises (HEs) are postural and respiratory exercises that were first described by Caufriez in 1997 as the “Abdominal Hypopressive Technique” (Caufriez, 1997). According to Caufriez (2007), these exercises improve core strength and posture and strengthen pelvic floor muscles (PFMs), making them effective in reducing symptoms of pelvic floor dysfunction (PFD) such as urinary incontinence (UI) and pelvic organ prolapse (POP) while also contributing to PFM rehabilitation in the postpartum period and decreasing lower back pain. These exercises have garnered popularity in Europe and South America and are now becoming well-known in North America as well (Dumoulin et al., 2014; Bellido-Fernández et al., 2018). They are prescribed by physiotherapists for the management of PFDs, yet there is limited empirical evidence that this exercise approach improves core or PFM strength (Katz & Barbosa, 2024) and there is limited and equivocal evidence that these exercises improve PFD (Bø & Herbert, 2013; Ruiz de Viñaspre Hernández, 2018; Bø et al., 2023; Katz & Barbosa, 2024).

1.1 Pelvic Floor Disorders (PFDs)

The International Continence Society (ICS) defines pelvic floor disorders (PFDs) as any abnormality in structure, function, or sensation at the level of the pelvic floor, of which the most common symptoms are UI and POP. UI is a complaint of involuntary loss of urine that can be related to: (1) stress (increased effort or physical exertion, or during sneezing or coughing; stress urinary incontinence – SUI), (2) urgency (a sudden and strong urge to void, which, when uncontrolled leads to urine leakage; urgency urinary incontinence – UUI), or (3) a combination of both (mixed urinary incontinence – MUI). POP is defined by the descent of one or more pelvic structures on straining, ultimately resulting in the urethra, bladder, cervix or rectum protruding through the vaginal wall (Doumouchtsis et al., 2023).

In Canada, one in four women reports urine leakage, with consequent negative effects on their quality of life (Shaw, 2020). Urinary incontinence costs the Canadian Health Care System $2.6 billion per year, creating a significant burden for our society (Canadian Continence Foundation, 2014). POP is also highly prevalent. It affects 50% of women over the age of 50 (Aytan et al., 2014). In the United States, it is estimated that the direct annual cost of POP repair exceeds $1billion USD, where 29% of the cost is associated with physician services and 71% accounts for hospitalizations (Subak et al., 2001).

Pelvic floor muscle training (PFMT), first described by Kegel in 1949 (Kegel, 1949), is prescribed by health care providers, particularly physiotherapists, to increase PFM strength. It is considered the first line of treatment when it comes to mild to moderate SUI (Jacomo et al., 2020; Dumoulin et al., 2014), resulting in a complete cure of symptoms in approximately half of women, and significant improvements in 80% of women (Dumoulin et al., 2020; Dumoulin et al., 2018). PFMT is also considered a first-line therapy for early-stage of POP (Bø et al., 2017).

1.2 Hypopressive Exercises (HEs)

Hypopressive exercises (Caufriez, 1997), Pilates (Pilates, 1998) and the Paula Method (Liebergall-Wischnitzer et al., 2005) have recently emerged as alternatives to traditional PFMT and are prescribed or instructed by physiotherapists as well as personal trainers and fitness instructors (Jacomo et al., 2020; Martín-Rodríguez & Bø, 2019). Barriers to pelvic health physiotherapy exist, including cost (Deslauriers et al., 2017; Bernard et al., 2020) and geographic access (Charette & McLean, 2024), contributing to the growing popularity of alternative approaches, including HEs.

In 2013, Bø and Herbert (2013) conducted the first systematic review that included seven randomized controlled trials (RCTs) evaluating the effectiveness of alternative approaches to PFMT for the management of SUI or MUI in women. The outcome measures of these studies were the presence or absence of UI, urine leakage on a standardized pad test, and PFD questionnaires. The comparisons found in the studies were among intervention vs control, intervention vs PFMT, intervention and PFMT vs PFMT alone. The quality of the retrieved studies was limited (mean of 5.7 out of 10 on the PEDro scale), and no convincing evidence was found to support a positive effect of any approach. A second systematic review was conducted by Jacomo et al. (2020) which included seven studies, and concluded that neither hypopressive exercises, Pilates nor the Paula Method, performed alone, strengthened the PFMs. In 2023, Bø et al. conducted a third review that aimed to investigate HEs and techniques other than PFMT in the treatment of POP. They concluded that PFMT is more effective than other exercise interventions for POP. The most recent systematic review of RCTs was conducted by Katz and Barbosa (2024) and aimed to specifically evaluate the effects of performing HEs for eight weeks or more on PFM and abdominal muscle in women over the age of 18, with or without the presence of PFDs. Despite HEs showing positive effects on PFM strength, tone and reduction of PFDs across the seven studies that were included, the evidence was deemed unreliable due to methodological divergence, such as lack of standardization. Therefore, the use of HEs for treating PFDs was discouraged.

1.3 The proposed hypopressive mechanism

Caufriez (1997) theorized that through a combination of postural and breathing maneuvers, hypopressive exercises decrease intra-abdominal pressure (IAP) and lead to reflex activation of the type I muscle fibres in the abdominal wall and PFMs. Once a particular HE posture is assumed, the HE is described in three phases: diaphragm relaxation, "diaphragmatic aspiration" (or vacuum breath), and activation of the abdominal and PFMs (Caufriez, 1997) (Figure 1.1). However, Caufriez did not provide any empirical evidence to demonstrate the reduction in IAP nor reflex activation of the abdominal or PFMs. Further, no rationale for the series of postures was provided.

Little empirical evidence has emerged to confirm the mechanism of HEs despite the fact that they were originally described over 25 years ago. While published studies have provided evidence in support of HEs positive effect on PFM strength (Stüpp et al., 2011; Resende et al., 2012; Navarro-Brazalez et al., 2020a; Molina-Torres et al., 2023), their results must be interpreted cautiously due to the use of solely subjective outcome measures (e.g., the Modified Oxford Scale (MOS) for muscle strength) and patient reported outcome measures (e.g., the International Consultation of Incontinence Questionnaire (ICIQ) for

UI symptoms). Only four peer-reviewed studies have investigated the mechanism of action of HEs to date, both having reported EMG activation of the abdominal and PFMs during the HE maneuver.

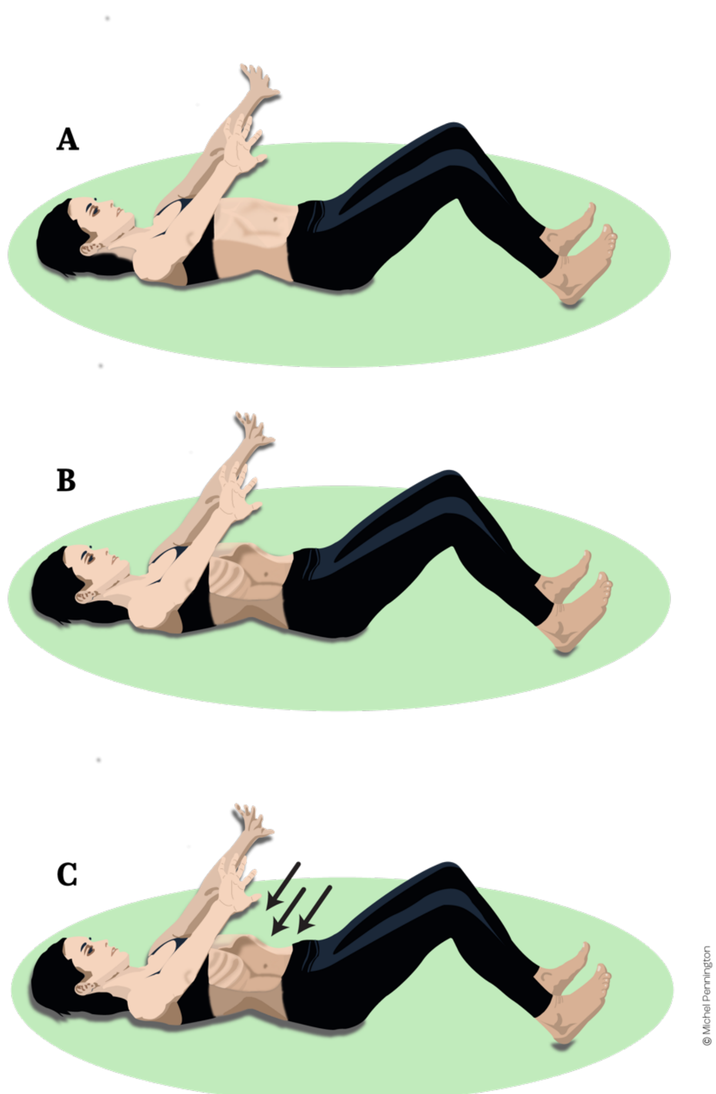

Figure 1.1 Hypopressive exercises in three phases. (A) diaphragm relaxation, (B) diaphragm aspiration, (C) activation of the abdominal muscles and PFMs.

In the first study, Navarro-Brazalez et al. (2017) examined the responses of PFMs and abdominal muscles during HEs using transabdominal US. The cross-sectional study involved thirty women who had completed an 8-week physiotherapy program focused on HEs. PFM strength was evaluated through manual palpation using a Spanish scale (TEA), akin to the MOS, and via intravaginal manometry. The transabdominal US, conducted in the supine position, revealed that the bladder base elevated cranially during HEs, even when participants were not instructed to actively contract their PFMs. Additionally, there was a noted increase in the thickness of deep abdominal muscles—internal oblique (IO), external oblique (EO), and transversus abdominis (TrA)—suggesting muscle contraction, while the morphology of the rectus abdominis (RA) did not alter. Although bladder base elevation is often used as an indicator of voluntary PFM contraction, the observed elevation, coupled with a reduction in IAP, might instead reflect passive tissue properties rather than active muscle contraction. Consequently, the study's findings were inconclusive, as changes in bladder morphology do not provide a direct measure of muscle activation, thus failing to confirm that the elevation of the bladder base during HEs was a result of PFM contraction as proposed by Caufriez.

In the second study, Ithamar et al. (2018), identified consistent PFM and abdominal EMG activation during HEs performed in various postures—supine, quadruped, and standing. They found that, among the postures tested, the PFMs (44% to 56% of maximum voluntary contraction - MVC) and internal oblique/transversus abdominis [IOTrA (52% to 77%MVC)] exhibited higher levels of activation compared to the rectus abdominus [RA (4% to 7%MVC)] and external obliques [EO (24%MVC)]. They concluded that the HEs resulted in synergistic activation of the PFMs and IOTrA muscles. Despite adhering to the SENIAM guidelines (Hermens et al., 2000) for EMG electrode placement, the authors encountered difficulties in normalizing the data for both quadruped and standing positions. Consequently, they used the data collected in the supine position as the normalization reference. This methodological choice may have led to misinterpretations of the data, such as crosstalk contamination (Keshwani & McLean, 2015), representing a significant limitation of the study.

In the third, Navarro-Brazalez and colleagues (2020b) confirmed that the PFMs and abdominal muscles are active during HEs. However, the magnitude of PFM activation, recorded using large, widely spaced surface electrodes located on either side of the anus, was moderate, at 35% of the MVC; the lateral abdominal muscles were activated by ~35% of the MVC of abdominal muscles (abdominal crunch); and the vaginal closure force recorded through dynamometry was 34.5% to 37.9% of PFM MVC force. They concluded that it is improbable that HEs would result in PFM hypertrophy due to its moderate contraction intensity. A major limitation of this study was the potential for crosstalk contamination (Keshwani & McLean, 2015) due to the size and configuration of the electrodes. The electrodes were positioned at a distance from the levator ani muscles, which likely compromised their ability to accurately reflect the EMG activation of these muscles.

In the fourth study, the same authors later investigated the effectiveness of performing HEs alone, PFMT alone, and a combination of both HEs and PFMT to treat a heterogeneous sample of females with PFDs. The outcomes were somewhat promising, since PFD symptoms and quality of life improved in the two groups who received the HE training intervention (both alone and in combination with PFMT) (Navarro-Brazalez et al., 2020a). However, there were limitations to this study. Participants from all three study groups received lifestyle advice about PFD risk factors and were instructed on how to perform the knack maneuver, a contraction of the PFMs, prior to and during physical efforts that increase intra-abdominal pressure (such as coughing, laughing, sneezing, or jumping). These educational components might have resulted in symptom improvements across the sample (Navarro-Brazalez et al., 2020). It thus remains unclear whether the HEs alone had any impact on symptoms of PFD.

1.4 Objectives and questions

A review of prior research suggested that there are several gaps in knowledge around the mechanism of action of HEs, including the role of the HP, the effect of HEs on PFM strength and tone, and the effectiveness of HEs for symptom reduction in different PFDs experienced by females.

The aim of this thesis was to better understand the physiological mechanism through which HEs may effectively be used to manage PFDs. More specifically, the objectives of this study were:

I. To investigate the acute, transient effect of HEs on IAP and on abdominal and PFM activation and morphology in women.

II. To determine the relative importance of the postural and respiratory maneuvers on the transient effects of HEs on IAP and on abdominal and PFM activation.

III. To determine whether the effects of the HEs are more marked after a period of training.

The specific questions to be answered by this study were:

1. Does a HE performed in a supine hypopressive posture or a standing hypopressive posture result in a reduction in IAP with concurrent activation of the abdominal and PFMs?
2. Does a HE performed in hypopressive posture result in a larger reduction in IAP or greater activation of the abdominal or PFMs than the HE performed in a regular supine or standing position?
3. Is the extent of PFM activation seen during a HE associated with the extent of reduction in IAP?
4. Does pelvic morphology reflect PFM shortening or lengthening change during a HE maneuver when observed on B-mode transperineal ultrasound imaging (USI)?
5. Is the extent of reduction in IAP observed during the HE maneuver associated with the extent of EMG activation of the PFMs?

6. Does eight to ten weeks of training using HEs result in changes in PFM strength and/or tone relative to two weeks of training among females who were previously naïve to HE training?
7. Do females who practice HEs for more than eight weeks demonstrate a learning effect on their HE performance, that is, do they achieve larger reductions in IAP, greater activation of their abdominal and PFMs or greater change in the length of their levator plate during an HE than they achieve after initially learning HEs and practicing for two weeks?

Chapter 2 of this thesis consists of an in-depth review of the literature around the history of HEs and the current state of knowledge around the HE mechanism and the effectiveness of HEs for improving PFM strength and tone and reducing symptoms of PFDs. The two data collections for this thesis have been split into two separate chapters (3 and 4) to facilitate detailed discussions for all the proposed research questions; both of these chapters are prepared in manuscript format to facilitate submission to a peer-reviewed journal. A cumulative discussion is presented in Chapter 5 to highlight key findings and the overall significance of this work.

Chapter 2: Literature review

This chapter describes HEs as they are used clinically, Caufriez's original theory regarding the mechanism through which HEs may enhance PFM function and improve PFDs, as well as the scientific evidence supporting the theory of HEs in terms of both mechanism of action and clinical outcomes.

Databases including Medline, Cochrane, PEdro, OVID, Elsevier Science Direct and CINAHL were searched from April 2021 and updated regularly until August 2024. The search terms included: "hypopressive exercises", "hypopressives", "HE", "abdominal hypopressive technique and "AHT". Sixty-eight relevant articles were retrieved: twelve were systematic reviews, sixteen were RCTs and the remainder were a combination of cross-sectional, pilot, exploratory and observational studies. Caufriez original description (Caufriez, 1997) of HEs and a book on HE techniques (Rebullido & Pinsach, 2015) were also retrieved and consulted.

2.1 How to perform Hypopressive Exercises

The core can be described as a cylinder formed by the diaphragm cranially, PFMs caudally, abdominal muscles anteriorly and the spine posteriorly. The modulation of pressure within this canister is thought to be important to spinal stability (Stokes, et al., 2011), to pelvic organ support (Ashton-Miller et al., 2001) and possibly to continence control (Ashton-Miller et al., 2001). The PFMs may also play a role in respiratory function (Hodges et al., 2007).

Hypopressive exercises (HEs) involve an organized sequential series of postural and respiratory patterns (Caufriez, 1997). The technique is performed using the principles of "pranayama Uddiyana banda" in yoga, whereby an individual holds their breath at the end of the expiration (expiratory apnea) then actively expands their rib cage. Next, during an abdominal vacuum breath (where abdominal muscles are suctioned inwards towards the spine), the participant's rib cage expands, their diaphragm moves cranially, and, consequently, their IAP is said to decrease, which results in cranial motion of the pelvic viscera and fascial connections (Caufriez, 1997; Rebullido & Pinsach, 2015).

HEs can be performed in several different positions, such as: supine lying, seated, quadruped, and standing. In each position, there is a variety of postures that are assumed during the HE. Common to most postures and positions is the following sequence: (1) axial lengthening of the spine, (2) isometric cervical muscle activation, (3) moving the centre of gravity anteriorly by leaning forward when standing, (4) isometric shoulder girdle muscle activation, (5) slight knee flexion, and (6) slight dorsi-flexion of ankles (Caufriez, 1997; Rebullido & Pinsach, 2015). Once the posture has been achieved, the HE involves: (1) full inspiration, (2) full expiration and (3) gradual abdominal suction and expansion of the chest wall through intercostal muscle contraction and a concurrent rise of the diaphragm, while maintaining apnea by keeping the glottis closed (Caufriez, 1997; Rebullido & Pinsach, 2015).

In his original manuscript, Caufriez describes 33 different exercises, where eight being intermediate, along with eight types of postures: supine, prone, orthostatic, kneeling, quadruped, genu pectoral, seated cross-legged and semi-seated (Fowler's position). The abdominal vacuum breath is common to all of them. The positions vary from standing to supine. The arms and legs can move in different angles. The poses can be static or dynamic. Some postures are considered beginner and others intermediate, based on the challenge of the exercise. Caufriez recommended that HEs be practiced daily, using three repetitions of each exercise, and in each, holding the apnea breath for 10-30 seconds (Caufriez, 1997). In Caufriez's (1997) original description of the HE, there is no rationale provided for the different positions and postures described.

2.2 Theory of Hypopressive Exercises

According to Caufriez, HEs promote pelvic floor and abdominal wall contraction via reflex activation in response to the "diaphragmatic aspiration" phase of the exercise. He claimed that when intra-abdominal pressure (IAP) decreases, it creates reflex activity in the type I muscle fibres of the PFMs and abdominal wall (Caufriez, 1997). Moreover, Caufriez states that these muscles may experience a latency period – characterized by reduced IAP – that lasts several seconds, and that results in long-term strength gains (Caufriez, 1997; Mateus-Vasconcelos et al., 2018). However, to date, there is limited scientific evidence evaluating the neuromuscular or mechanical effects of HEs. Five out of seven references belong to Caufriez, among books and specialization manuscripts; two belong to Roche, V. (1996) and Ladavid, A. (1993) that are specialization dissertations (Caufriez, 1997). None of the evidence cited by Caufriez in his manuscript published in 1997 (Caufriez, 1997) is based on scientific studies and/or peer reviewed articles.

Despite the popularity of HEs emerging as an alternative method to improve PFDs (Navarro-Brazalez et al., 2020a; Juez et al., 2019; Soriano et al., 2020; Resende et al., 2012; Bernardes et al., 2012), the theoretical mechanism described by Caufriez has, to the authors' knowledge, yet to be supported through empirical evidence. Indeed, the findings of a cross-sectional study by Stüpp et al. (2011) suggested that the activation of the transversus abdominal muscle (TrA) during HEs may increase the IAP, causing caudal, not cranial, displacement of the PFMs, contradicting Caufriez's theory. Therefore, Caufriez's theories around HE require confirmation using a systematic scientific approach.

2.3 Neuromechanical action of the Hypopressive Exercise approach

Only four studies were found that have reported on the acute neuromuscular or mechanical changes seen during the performance of an HE, and three of them were from the same research group.

In this first cross-sectional study that explored HE mechanism, Navarro-Brazalez et al. (2017) investigated the PFM and abdominal muscle responses associated with HEs using transabdominal US. Thirty women were recruited after attending an 8-week physiotherapy intervention based on HEs. PFM strength was assessed by manual palpation using a Spanish scale (TEA), which is similar to the MOS, and through pressure changes with an intravaginal manometry. Transabdominal ultrasound (US) was performed in supine to visualize the bladder base during the performance of HEs. They observed that the bladder base moved cranially during HEs performed when no instruction was provided to participants to voluntarily contract their PFMs. The authors also observed an increase in the thickness of the deep abdominal muscles [internal oblique (IO), external oblique (EO) and transversus abdominis (TrA)] suggestive of muscle contraction, while the morphology of the rectus abdominis (RA) muscle did not change. While bladder base elevation has been used to visualize voluntary PFM contraction, an elevation of the bladder base in the absence of voluntary activation and in conjunction with a reduction in IAP, may reflect muscle shortening due to passive tissue properties and not muscle activity. As such, the results were inconclusive because change in bladder morphology is not a direct measure of muscle activation. Therefore, using this method, the authors were unable to confirm that the elevation of the bladder base seen during HEs was a consequence of PFM contraction induced by the apnea as hypothesized by Caufriez (Navarro-Brazalez et al., 2017).

Ithamar et al. (2018) conducted an observational study involving 30 nulliparous women, who were recruited following one week of training in HEs. Surface electromyography (sEMG) was employed to assess PFM activity using an intra-vaginal probe (Miotec, Porto Alegre, Rio Grande do Sul, Brazil), while bipolar electrodes were used to measure the activity of the abdominal muscles, specifically the RA, EO, and internal oblique/transversus abdomins (IOTrA). Electromyography (EMG) signals were normalized based on an MVC for each respective muscle. For the PFMs, participants were instructed to perform a pulling action upwards and inwards around the probe. To assess RA, EO, and IOTrA activity, participants executed isometric trunk flexion, contralateral trunk rotation, and abdominal retraction, respectively. EMG data were collected during HEs performed in three distinct positions: supine, quadruped, and standing. Participants were required to hold their breath for 15 seconds and repeat the maneuver three times in each position. Ithmar et al. (2018) reported that the PFMs exhibited activation levels ranging from 44% to 56% of the maximal amplitude recorded during MVC, while the IOTrA muscles demonstrated activation levels between 52% and 77% MVC. These activation levels were notably higher than the RA, which ranged from 4% to 7% MVC, and the EO, which reached 24% MVC.

The authors concluded that the HEs resulted in synergistic activation of the PFMs and IOTrA muscles (Ithamar et al., 2018). Despite adhering to SENIAM guidelines (Hermens et al., 2000), Ithamar et al. (2018) were unable to normalize the EMG values in the standing position. Consequently, they opted to use the MVC of the abdominal and PFMs measured in the supine position for normalization purposes. Therefore, the findings from the study should be interpreted with caution.

Navarro-Brazalez and colleagues (2020b) conducted a second cross-sectional study where 66 women were recruited after participating in a 2-month physiotherapy program based on HEs to treat a variety of PFDs. They used an intravaginal dynamometer in a supine position to measure MVC force generated by the PFMs, then to measure the peak PFM force generated during HEs. While performing the HEs, the participants were not instructed to voluntary contract their PFMs nor to keep them relaxed. Surface electromyography (sEMG) paired with 10mm diameter adhesive electrodes was used to measure neuromuscular activation of the PFMs, abdominal, adductors and gluteal muscles but not concurrently with dynamometry. Maximal activation during MVCs was measured in both supine and orthostatic positions, followed by activation being measured during the HEs. The authors reported that the PFMs, abdominal, gluteal and adductor muscles were all activated during HEs, although, the level of muscle activation observed was unlikely to result in strength gains. For example, during the HE, the PFMs were activated to between 34.5 and 37.9% MVC, while the abdominal muscles were activated to 35.5% of their maximum. While these levels of contraction could improve endurance if the exercise was sustained or repeated, they are considered insufficient to result in any meaningful gains in strength (Quartly et al., 2010). Moreover, in Navarro-Brazalez et al. (2020b) there was no concurrent measure of IAP and thus the relationship between a reduction in IAP and muscle activation could not be established to confirm Caufriez's theory (Caufriez, 1997). Further, the EMG methods described by Navarro-Brazalez et al. (2020b) were not consistent with international standards, since PFM EMG activation was acquired through electrodes placed on the perineum (bilaterally). The size and spacing of the electrodes used carry a high risk of crosstalk contamination, particularly given that trunk and hip muscle activation is used in the HE approach (Keshwani & McLean, 2015; Hermens et al., 2000). Thus, the PFM activation levels reported by Navarro-Brazalez et al. (2020b) during the HEs may overestimate the true activation levels.

Navarro-Brazalez et al. (2020a) also conducted an RCT where 94 women were randomized into three groups: PFMT, HE training, and a combination of both PFMT and HE. All participants followed a home exercise program for 8 weeks, whereby they were advised to practice their assigned exercises twice per week for 45 minutes each session. Four follow-up visits were scheduled: (1) immediately after the exercise program had finished, (2) at 3 months, (3) at 6 months, and (4) at 12 months after completing the intervention. Differences in vaginal manometry values were observed across the visits. At the first follow-up visit the PFMT group showed highest strength gains, followed by HE group and the combined treatment group. At the 3 subsequent visits, both groups that performed PFMT (i.e.: PFMT alone or in combination with HE) showed greater strength gains than those who performed HE alone, with the PFMT-only group showing the highest PFM strength values across all visits. Changes in resting force were also observed. During the first two follow-up visits, the HE group showed higher resting forces, yet by visits 3 and 4, the groups that performed PFMT (alone or in combination PFMT with HE) demonstrated higher resting forces than the group that performed HE alone. Interestingly, PFMT alone, hypopressive exercises alone and a combination of both interventions significantly reduced PFD symptoms and enhanced quality of life, both in the short and longer term follow-up. However, for manometry and dynamometry, the Cohen's d effect sizes were very small (d=0.006) and moderate (d=0.50), respectively. While for basal tone, the effect size was small (d=0.35). Despite PFM strength gains being higher in group that performed PFMT alone, the differences between strength gains between the groups that performed HE alone and a combination of PFMT and HEs were not statistically significant.

2.4 Effectiveness of HEs in the management of PFD signs and symptoms among females

Twelve systematic reviews have been published on the effectiveness of HEs for the management of PFDs in females. Five different reviews [Jacomo et al. (2020); Martin-Rodriguez & Bø (2019); Bø & Herbert (2013); Bø et al., 2023; Katz & Barbosa, 2024] aimed to determine if training regimens other than PFMT improved PFM strength and PFD symptoms, and HEs were included among other exercise approaches including Pilates, the Paula Method, Tai Chi and Yoga. The reviews concluded that there was a lack of scientific evidence to support that any of these methods could effectively manage symptoms of PFDs or improve PFM strength, affirming that PFMT remains the gold standard for the conservative management of PFDs.

The review by Ruiz de Viñaspre Hernández (2018) compared the effectiveness of HE and PFMT in women, using outcome measures including pelvic floor muscle strength, the incidence of urinary incontinence or prolapse, and symptom remission. Four clinical trials (with quality scores between 5 and 6 out of 10 on PEDro scale) were retained, with findings that PFM activation, closure of the levator hiatus, PFM thickness, PFM strength and PFM tone improved more with PFMT when compared to HEs. Similar to PFMT, HEs appeared to improve PFM proprioception (Costa et al., 2011), although it was unclear how they measured it. Overall, the findings of the review did not support the use of HEs to improve PFM function nor to prevent or mitigate UI and/or POP in women. (Ruiz de Viñaspre Hernández, 2018).

Mateus-Vasconcelos et al. (2018) conducted a systematic review to investigate physiotherapy methods to facilitate PFM contraction. A total of six manuscripts (RCTs, quasi-experimental trials and systematic reviews) were included. Several interventions were examined, including instructions regarding the anatomy and function of the PFM, vaginal palpation, palpation of the central perineal tendon, interruption of urine flow during voiding, biofeedback using a perineometer, a proprioceptive technique using vaginal cones, PFM contraction associated with diaphragmatic breathing and visualization using a mirror, coactivation of the anterolateral abdominal muscles, and HEs. All studies reported improvements in PFM contraction ability after the intervention, with no method emerging as being superior to the others. Among these, Resende et al. (2012) found that a combination of HEs and PFMT increased the strength of the PFMs from 1.7 to 3.8 out of 5 on the MOS, but that the combined intervention was only slightly more effective than PFMT alone (2.4 to 3.6 out of 5 on the MOS). However, the grading of PFM strength during MVC efforts using palpation (MOS) is not sensitive to changes less than 2 grades thus this finding should be interpreted with caution (Morin et al., 2004). Also included in the review was Stüpp et al. (2011), who concluded that HE training alone was less effective than PFMT alone for activating PFMs (Stüpp et al., 2011).

The next review by Molina-Martinez et al. (2019) compared HEs, Pilates, Paula Method, and Tai Chi for the management of SUI and POP in women within the post-partum period. They found only two eligible studies and concluded that there was no scientific evidence to support HEs as a method to treat PFDs experienced in the post-partum period.

The most recent review by Martins Rodrigues et al. (2024) investigated the effects of HE training after one to eight weeks among healthy women without the presence of PFDs. The review aimed to identify various outcome measures for assessing the impact of HEs in this population. It included five studies, four conducted in Spain and one in Brazil. Among the variables investigated, waist circumference was reduced by 1.5 to 3.5 cm following the HE intervention. The review also highlighted an increase in height by 0.25 cm after a single HE session (Rebullido et al., 2014) and an improvement in lower back mobility by 2 cm as measured by Shober's test. PFM strength was assessed in two studies: Sáez et al. (2016) reported an increase in PFM contraction strength by 288 g/cm², as measured using a perineometer, while Alonso-Calvete et al. (2019) found no change in PFM strength. Additionally, peak expiratory flow improved by 40 L/min following the intervention, and the duration of tolerance to expiratory apnea increased by 4.9 seconds, although inspiratory apnea remained unchanged. Hemodynamic responses were also evaluated. Systolic and mean arterial blood pressures increased from 116.1 to 135 mmHg and from 85 to 98.6 mmHg, respectively. However, diastolic blood pressure and heart rate remained unchanged.

None of the included studies reported adverse reactions to the intervention. However, the studies were assessed as low quality due to methodological limitations, such as the absence of blinding and control groups. Martins Rodrigues et al. (2024) concluded that the literature on the effects of HEs in healthy women is limited and recommended that HEs should not be endorsed until further research clarifies their benefits and potential adverse effects.

2.5 Conclusion regarding the state of the scientific literature

In summary, despite it being over 25 years since Caufriez first published the HE technique, there is a dearth of empirical evidence to support his claim that the HE approach causes a reduction in IAP or generates reflex activation of the PFMs. One systematic review concluded that HEs may be as effective as other approaches for teaching women how to contract their PFMs, however the supporting studies were deemed to be low quality. Research on HEs has focused primarily on evaluating the effectiveness of HEs compared to standard PFMT for the management of PFDs, and there is limited evidence that the HE approach is effective for this purpose, with systematic reviews consistently concluding that PFMT is more effective than HE for the conservative management of PFDs. Yet HEs are still being prescribed by health care and allied health professionals for the management of PFDs.

The goal of this thesis research was to determine if empirical evidence supports the claims made by Caufriez around the mechanism of action of HEs and to determine if an HE training program results in changes in LAM strength and/or tone using multiple measurement modalities.

Chapter 3: Intra-abdominal pressure and pelvic floor muscle activation observed during hypopressive exercises performed in supine and standing: an observational cohort study

3.1 Abstract

Questions: Do hypopressive exercises (HEs) cause transient changes in intra-abdominal pressure (IAP), electromyographic (EMG) activation of the pelvic floor muscles (PFMs) and/or motion of urogenital structures, and are these effects different when the exercise is performed in supine or standing and with or without a hypopressive posture (HP)?

Design: Cross-sectional, observational

Participants: Thirty-six volunteers with female-typical pelvic anatomy, naïve to HEs.

Intervention: Two HE training sessions followed by one laboratory-based data collection session.

Outcome measures: Transient changes in IAP, EMG amplitude of the levator ani (LAMs) and external anal sphincter (EAS) muscles, and pelvic morphology [levator plate length (LPL), bladder neck height (BNH) and levator plate angle (LPA)] observed through ultrasound imaging throughout the HEs.

Results: IAP did not change during the HE in supine [95%CI: -1.82 to 1.25cmH_2O] or standing [95%CI: -5.80 to 0.27cmH_2O]. In supine, LAM activation was 44(35)% of that observed during maximum voluntary contraction (MVC) ($d=1.24$, $p<0.001$) and EAS activation was 27(24)%MVC ($d=1.15$, $p<0.001$), while in standing LAM activation was 50(44)%MVC ($d=1.12$, $p<0.001$) and EAS activation was 27(27)%MVC ($d=0.99$, $p<0.001$). Small transient changes in pelvic morphology were observed during the HE: the LPL shortened [supine 95%CI: -2.70 to -1.14mm; standing 95%CI: -2.96 to -0.72mm], the LPA increased [supine 95%CI: 3.05 to 6.70°; standing 95%CI: 1.37 to 4.74°] and BNH increased [supine: 95%CI 0.22 to 1.24mm; standing: 95%CI -0.48 to 0.99mm]. There was no effect of body position or the HP on any outcomes.

Conclusion: HE maneuvers performed with or without HPs do not reduce IAP, yet do cause PFM activation in women.

Key words*: pelvic floor muscles, stress urinary incontinence, pelvic organ prolapse, hypopressive exercises, physiotherapy*

Introduction

Hypopressive exercises (HEs) were first described by Caufriez (1997) as a means to improve core strength and posture and to strengthen the pelvic floor muscles (PFMs), with an ultimate goal of reducing symptom severity associated with pelvic floor disorders (PFDs) such as urinary incontinence (UI) and pelvic organ prolapse (POP). HEs have gained popularity across the globe (Dumoulin at al., 2014; Bellido-Fernández et al., 2018) and are prescribed by some physiotherapists for the management of PFDs (Bø & Herbert, 2009; Bø & Herbert, 2013). Yet there remains limited evidence that this exercise approach improves core or PFM strength (Bø & Herbert, 2013), and there is equivocal evidence that HEs improve symptoms of PFDs (Ruiz de Viñaspre Hernández, 2018). Indeed, we still lack empirical evidence to support the mechanism of action described by Caufriez (1997) when he first published the HE approach.

In the original description of HEs, Caufriez (1997) claimed that, through assuming specific "hypopressive postures" (HPs) and performing a "hypopressive maneuver" which involves exhaling to end expiratory volume, holding the breath, closing the glottis, then expanding the rib cage, an ensuing decrease in intra-abdominal pressure (IAP) would, among other things, cause a reflex contraction of the PFMs. Several HPs are described and cover a variety of body positions, including supine and standing.

Only four peer-reviewed studies published on the mechanism of action of HEs to date. In the first study, Navarro-Brazalez et al. (2017) investigated PFM and abdominal muscle responses during HEs using transabdominal ultrasound. They assessed thirty women who had completed an 8-week physiotherapy intervention involving HEs. The results showed that the entire sample achieved a median elevation of the PFMs of 6.8 mm (interquartile range 3.7) in the transverse plane and 4.6 mm (4.7) in the sagittal plane during the exercises. Additionally, the TrA, IO, and EO muscles increased their thickness by 1.8 mm (1.2), 1.5 mm (1.9), and 0.5 mm (1.4), respectively ($p<.05$). In contrast, the rectus abdominis (RA) muscle showed a tendency towards a decrease in thickness, though this change was not statistically significant ($p=0.48$). The authors found that while the elevation of the bladder base and the thickness changes in the abdominal muscles suggested some level of muscle contraction, the observed bladder base elevation without explicit voluntary PFM contraction and the concurrent reduction in IAP might reflect passive tissue properties rather than direct muscle activity. Consequently, the study's findings were inconclusive regarding whether the bladder base elevation was due to PFM contraction as theorized by Caufriez, as changes in bladder morphology do not directly measure muscle activation.

In the second study, Ithamar et al. (2018) indicated that the PFMs and abdominal muscles became active across different postures: supine, quadruped and standing. PFMs were activated at 44% to 56% MVC, and the internal oblique/transversus abdominis (IOTrA) muscles at 52% to 77% MVC. In contrast, the rectus abdominis (RA) was activated at a lower range of 4% to 7% MVC, and the external obliques (EO) at 24% MVC. The authors concluded that the HEs led to synergistic activation of the PFMs and IOTrA muscles. Even though the authors followed the SENIAM guidelines (Hermens et al., 2000) for electrode placements, the study encountered challenges in normalizing the data for the quadruped and standing positions. Consequently, the authors used data from the supine position as the normalization reference. This methodological approach may have introduced potential misinterpretations, which represents a limitation of the study.

In the third study, Navarro-Brazalez et al. (2020a) conducted an RCT where 97 women were divided into three groups: pelvic floor muscle training (PFMT), hypopressive exercise (HE), or a combination of both. The intervention consisted of an 8-week home exercise program with bi-weekly 45-minute sessions. Four follow-up visits were conducted at the end of the program and at 3, 6, and 12 months post-intervention. At the first follow-up, the PFMT group showed the highest PFM strength gains, with manometry values improving from 8.61 to 9.32 cmH_2O and dynamometry values increasing from 106.2 to 247.7 g. The PFMT group also showed a rise in pelvic floor basal tone, with dynamometry values increasing from 1.8 to 22.9 grams. PFMT alone or combined with HE demonstrated greater strength improvements compared to HE alone at subsequent visits. By the third and fourth follow-ups, both PFMT groups exhibited higher resting forces compared to the HE group. All intervention groups significantly reduced pelvic floor dysfunction symptoms and improved quality of life. Effect sizes for manometry and dynamometry were very small (d=0.006) and moderate (d=0.50), respectively, and small for basal tone (d=0.35). Despite the PFMT-only group having greater strength gains, differences between the HE-only and combined PFMT and HE groups were not statistically significant.

In the fourth study, Navarro-Brazalez and colleagues (2020b) confirmed that the PFMs, along with the abdominal muscles, were active to ~35% of that observed during maximum voluntary contraction (35%MVC) (Navarro-Brazalez et al., 2020b). Navarro-Brazalez et al. (2020b) used large, perianal surface electrodes were used to record PFM activation using an electrode configuration that is susceptible to crosstalk contamination (Keshwani & McLean, 2015), and there was no concurrent confirmation that the posture or maneuver caused a reduction in IAP. It thus remains unclear whether the HE reduces IAP and to what extent it activates the PFMs. Further, it is not known whether the HP is necessary to induce a reduction in IAP or activation of the PFMs during the HE and whether findings are different in different body positions. The aim of this study was to describe the physiological mechanism observed during HEs. The research questions were:

1. What are the acute, transient effects of HEs on IAP, PFM and abdominal activation, and pelvic morphology [levator plate length (LPL) and bladder neck height (BNH)] among those with female-typical pelvic anatomy?
2. Does the HP affect transient changes in IAP, abdominal and PFM activation and pelvic morphology observed during the performance of HEs?
3. Is the extent of PFM and abdominal activation observed during an HE associated with the extent of reduction in IAP achieved?

3.2 Methods

3.2.1 Design

This was a cross-sectional, observational study. Approval was received from the local institutional research ethics board prior to any recruitment of participants (Appendix A). Data were collected between November 2021 and June 2022.

3.2.2 Participants

Volunteers with female-typical pelvic anatomy were recruited from the university community and physiotherapy clinics, and through social media and word of mouth. Screening was done through e-mail correspondence (Appendix B). Volunteers were included if they were older than 18 years, premenopausal, and had been fully vaccinated against COVID-19. Volunteers were excluded if they had previously learned HEs and had practiced HEs for more than 2 weeks, if they reported experiencing pain with tampon insertion, gynecological speculum exam or sexual activities, if they had any condition that prevented them from safely performing the HE technique (e.g., unregulated high or low blood pressure), if they had neuromuscular or metabolic conditions that might impact muscle activation or motor control, if they had known connective tissue disorders or endometriosis which might affect the composition or morphology of tissues within the pelvic or abdominal region, and/or if they had undergone previous pelvic surgery.

Eligible participants provided written informed consent (Appendix C), and demographic data (age, parity, delivery method, known PFDs, body mass index, and waist-hip ratio). Two validated questionnaires were administered using an online format: the International Consultation on Incontinence Questionnaire – Female Lower Urinary Tract Symptoms (ICIQ-FLUTS) (Abrams et al., 2006) (Appendix E) and Vaginal Symptoms (ICIQ-VS) modules (Price et al., 2006) (Appendix G) and the scores were used for descriptive purposes.

3.2.3 Sample size

The sample size was determined *a priori* based on pilot (n=7) IAP and EMG data acquired to address objective 1. IAP was lower (supine: 13.47±14.82 cmH20; standing 18.90±14.90 cmH20) and LAM EMG amplitude was higher (supine: 9.6±6.2 uV; standing 5.5 ±3.7 uV) during the HE compared to rest. To achieve power=0.80 (α=0.05), the required minimum sample size was deemed to be n=9 for a reduction in IAP and n=12 for activation of the LAMs. Because no pilot data were available for the second objective, a moderate effect size (d=0.50) was assumed for the relative effect of the HP, requiring a sample size of n=30 to achieve 80% power at α=0.05. We aimed to recruit a minimum of 30 and maximum of 40 participants.

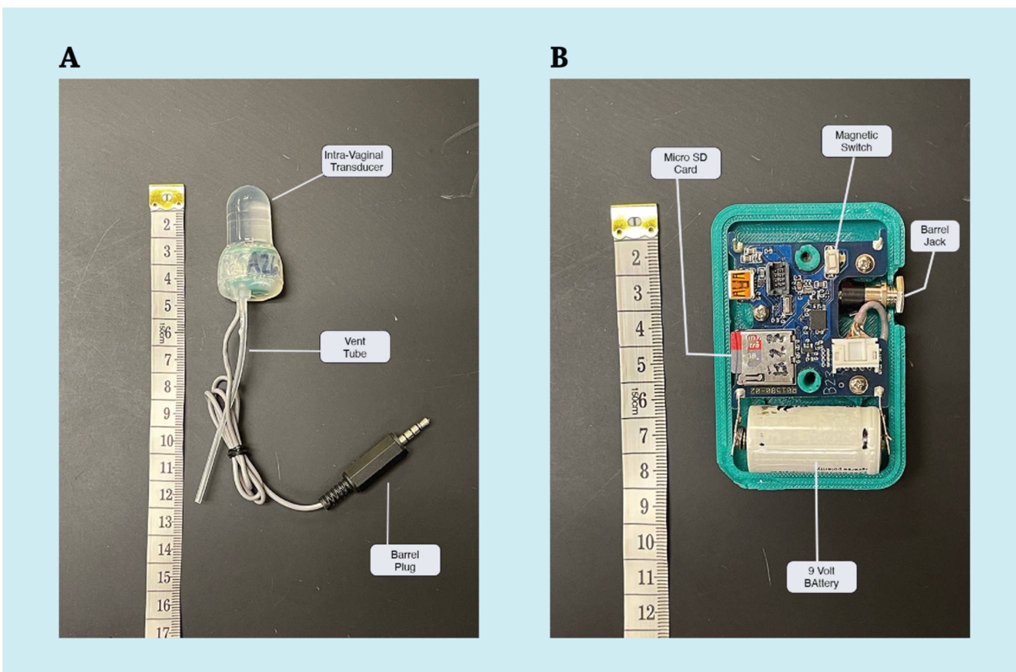

Figure 3.1 (A) Intravaginal intra-abdominal pressure (IAP) sensor; (B) Instrumentation Module (IM).

3.2.4 Outcome measures

The primary outcomes were change in IAP, normalized PFM EMG amplitude, and pelvic morphology observed during the HE. Secondary outcomes were changes in normalized abdominal (RA, EO, IOTA) EMG activation observed during the HE.

3.2.4.1 Intra-abdominal pressure (IAP)

The participant was instrumented with a single-use IAP sensor (Niederauer et al., 2017). The sensor was inserted by the participant, with instructions to insert it as deeply as possible into the vagina to reach the posterior fornix, with the positioning verified by the researcher through visual inspection and palpation. The IAP sensor was interfaced with an instrumentation module (Figure 3.1) which sampled pressure data at 200Hz using an on-board analog to digital converter interfaced with a SIM card (Niederauer et al., 2017; Rosenbluth et al., 2010).

3.2.4.2 Electromyography (EMG)

A differential suction electrode (DSE) (Keshwani & McLean, 2012; Keshwani & McLean, 2015) (Figure 3.2) was inserted intravaginally, and secured to the vaginal wall overlying the right puboviscerali (PV) muscle as described in Keshwani & McLean (2012). The wire ends of the DSE were interfaced with alligator clips coupled to a Delsys D.E. 2.1 differential amplifier. The DSE was chosen for its high within-session, between-trial reliability and its strong performance in terms of minimizing motion artifact and crosstalk contamination (Keshwani & McLean, 2012; Keshwani & McLean, 2015).

Figure 3.2 Intravaginal differential suction electrode (DSE).

Two surface electrodes (Kendall H49P; Cardinal Health) were adhered to the skin overlying the EAS on the right side with inter-electrode spacing of 20 mm. Four D.E. 2.1 (Delsys, Boston) surface electrodes were adhered over the rectus abdominis (RA), external oblique (EO), internal oblique / transversus abdominis (IOTrA) muscles on the right side following SENIAM guidelines (Hermens et al., 2000). A common reference electrode was adhered to the skin overlying the right anterior superior iliac spine (ASIS). All instrumentation met current standards for EMG acquisition (Besomi et al., 2019; Besomi et al., 2020, Dick et al., 2024).

Hypo14 Sup N trial1 rest

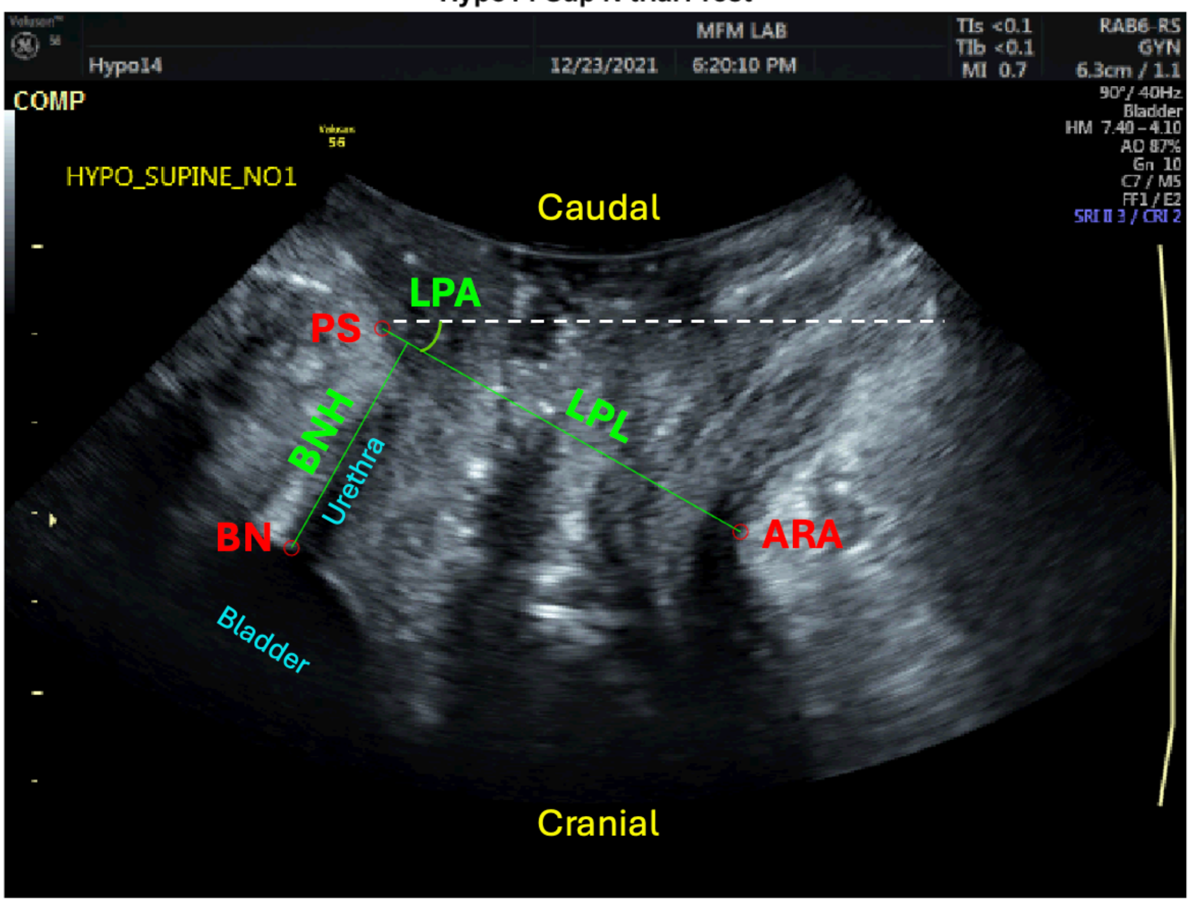

Figure 3.3 Sample 2D B-mode transperineal ultrasound image of the pelvis. PS: pubis symphysis; BN: bladder neck; ARA: anorectal angle; BNH: bladder neck height – distance between PS and BN that shows cranial-caudal displacement characterizing PFM contraction; LPL: levator plate length – distance between PS and ARA that shows shortening or lengthening of the PFMs; LPA: levator plate angle.

3.2.4.3 Pelvic morphology measured using transperineal ultrasound imaging

Two-dimensional transperineal ultrasound imaging (2D-TPUS) was performed using a GE Voluson S6 system (GE Canada, Toronto, Canada) coupled with a RAB6-D 4D convex curvilinear probe throughout each HE task, keeping the pubic symphysis, the bladder neck, and the anorectal angle visible within the imaging frame (Figure 3.3). Changes in levator plate length (LPL), levator plate angle (LPA) and bladder neck height (BNH) were measured as the difference between the rest condition and the largest displacement observed during each HE maneuver, as described elsewhere (Dietz, 2004; McLean et al., 2016; Berube & McLean, 2023).

3.2.5 Protocol

Data were collected by the first author, who is a registered physiotherapist trained in the assessment and management of female PFDs with over 10 years of clinical experience in this area of practice, and who received certification as a Hypopressive Exercise instructor (Hypopressive Training System – Level 1; Hypopressives Canada 2021) prior to initiating the study. The first author was trained by the senior author (>60 hours) on the safe and effective use of all laboratory instrumentation and was deemed proficient prior to proceeding with participant recruitment.

Participation in the study involved 3 sessions: (1) an initial training session (45 min), (2) a follow-up session to ensure that the exercises were being performed correctly (15 min), and (3) a data collection session (2 hours).

At the initial training session, height, weight, and waist and hip circumference were measured using standard techniques. Participants were instructed how to perform four tasks involving HEs in two beginner-level HPs: "Demeter" in supine and "Athenas" in standing. Once deemed proficient, they were asked to perform the following tasks three times daily over a two-week period: (1) HE in supine without adopting the HP [Figure 3.4 (A)], (2) HE in supine with the HP [Figure 3.4 (B)], (3) HE in standing without the HP [Figure 3.5 (A)] and (4) HE in standing with the HP [Figure 3.5 (B)]. Adherence was monitored via self-report at the follow-up visit (in person or virtual) one week after the initial training session and again at the data collection session. If a participant was not able to perform the HEs correctly at the follow-up session, they were removed from the study. If a participant developed COVID-19 or associated symptoms, they were given additional time to practice prior to the data collection session, which occurred only once they were symptom-free and testing negative on a nasobuccal COVID-19 antigen test.

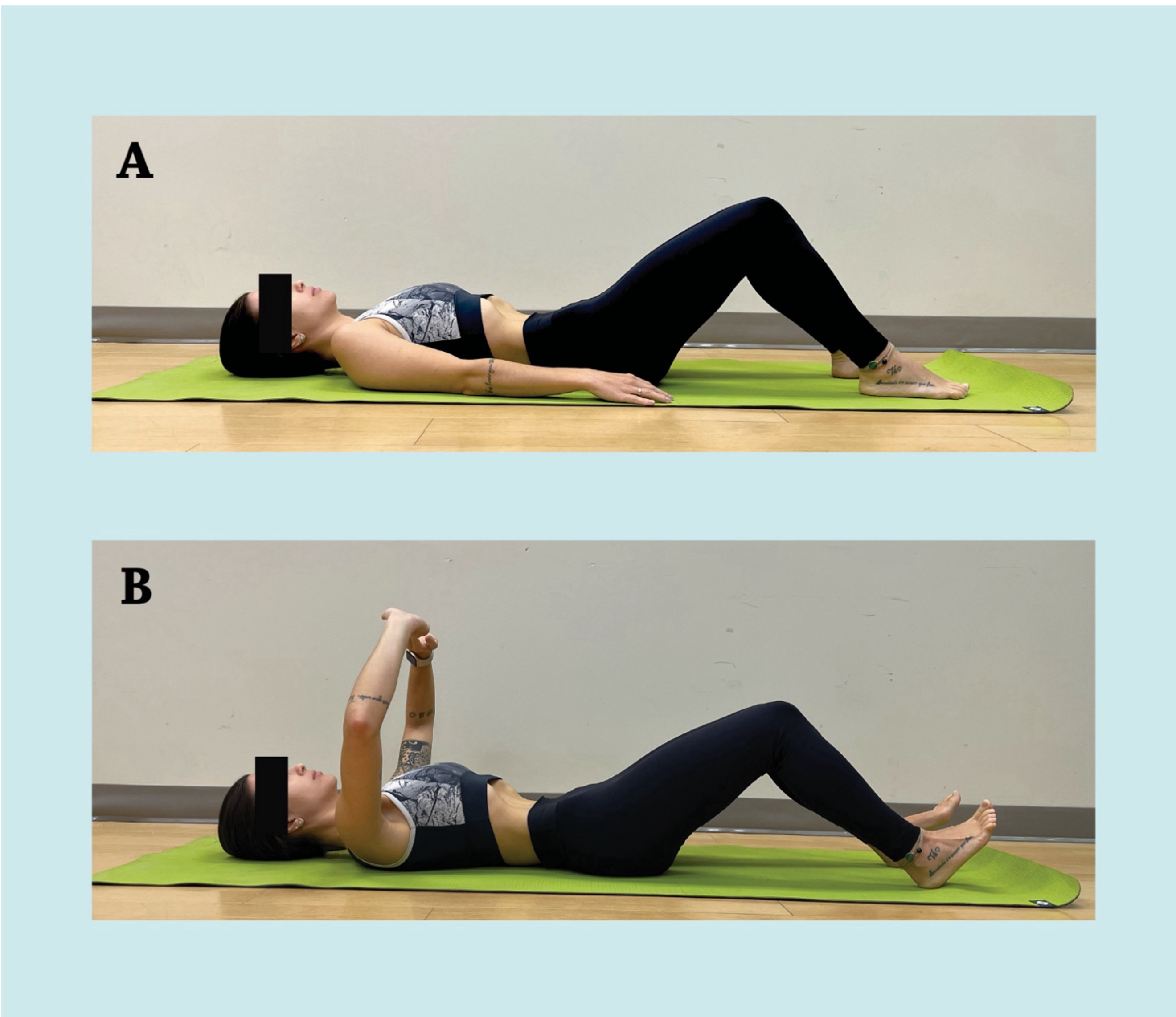

Figure 3.4 Hypopressive exercise performed in the supine position (A) without the hypopressive posture and (B) with the hypopressive posture (Demeter).

At the start of the data collection session, a custom intravaginal dynamometer was used to evaluate PFM strength (diameter 35mm) and stiffness (opening the arms to a diameter of 40mm at a rate of 15mm/s) using the standardized protocol described in previous literature (Bérubé et al., 2018; Czyrnyj et al., 2021). Three repetitions of each task were performed.

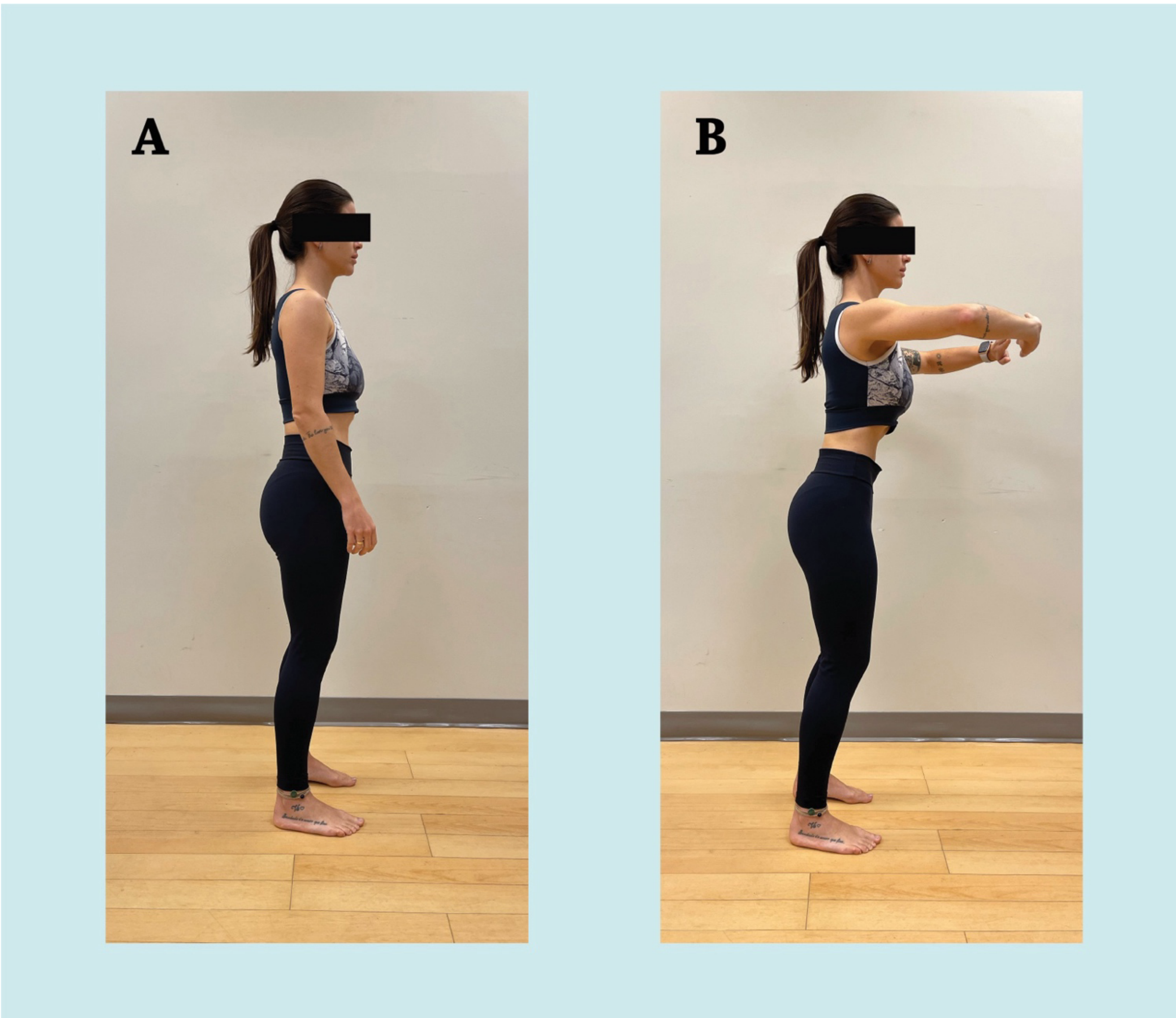

Figure 3.5 Hypopressive exercise performed in the standing position (A) without the hypopressive posture and (B) with the hypopressive posture (Athenas).

Participants were then instrumented with EMG electrodes and the IAP sensor. They were first asked to rest for 45 seconds while baseline EMG data were recorded, then to perform three maximum voluntary contractions (MVCs) of their PFMs and three MVCs of their abdominal muscles (abdominal crunch against resistance to failure); these data were used for normalization of the EMG data acquired during the HE tasks. To minimize data loss due to sensor disruption, the HEs were first performed in supine, then repeated in standing. In each position, participants performed HEs with and without assuming the HP, with the order randomized as determined by a coin toss. Concurrently with IAP and EMG data, transperineal USI was acquired throughout the performance of each HE.

For each HE trial, the start and end were marked by asking participants to perform a single cough, which allowed us to align the IAP data recorded on an SD card with the EMG and ultrasound imaging data. Participants were instructed to cough, then to assume the correct posture (HP or no HP) and to inhale and exhale over two cycles. At the end of the second exhalation, the participant paused their breathing and executed the vacuum breath of the HE. They maintained the vacuum breath for as long as possible, then released it, took a deep breath and then coughed to mark the end of the trial before returning to the resting position. After each trial, participants performed quiet breathing for 2 minutes. Each task was repeated three times [Figures 3.4 (A) and (B); Figure: 3.5 (A) and (B)].

3.2.6 Data processing

IAP data were extracted from the SD card and processed using custom MATLAB (v. R2022a, MathWorks, Inc., USA) programs. IAP data were aligned in time with the PFM and abdominal EMG data based on the timing of the peak amplitudes observed during the coughs (Figure 3.6). All EMG data (abdominal and PFM MVCs, HEs) were bias corrected, full wave rectified, then low-pass filtered using a 4^{th} order, dual-pass low-pass Butterworth filter with the cut-off of 6Hz. The highest smoothed EMG amplitude recorded from each muscle during each HE trial was normalized (%MVC) to the highest EMG amplitude recorded among the three MVC trials for the appropriate muscle group (PFMs, abdominals).

Ultrasound data were processed using Image J Version 1.53s (U.S. National Institutes of Health, Bethesda, Maryland, USA) software. Bladder neck height (BNH) (McLean et al., 2016) and levator plate length (LPL) (Dietz, 2004) were measured in each position and posture by selecting a stable frame before the HE began (baseline) and a frame that reflected the maximal displacement of the bladder neck and anorectal angle during the HE. The change between baseline and maximal excursion was retained as the outcome for each trial.

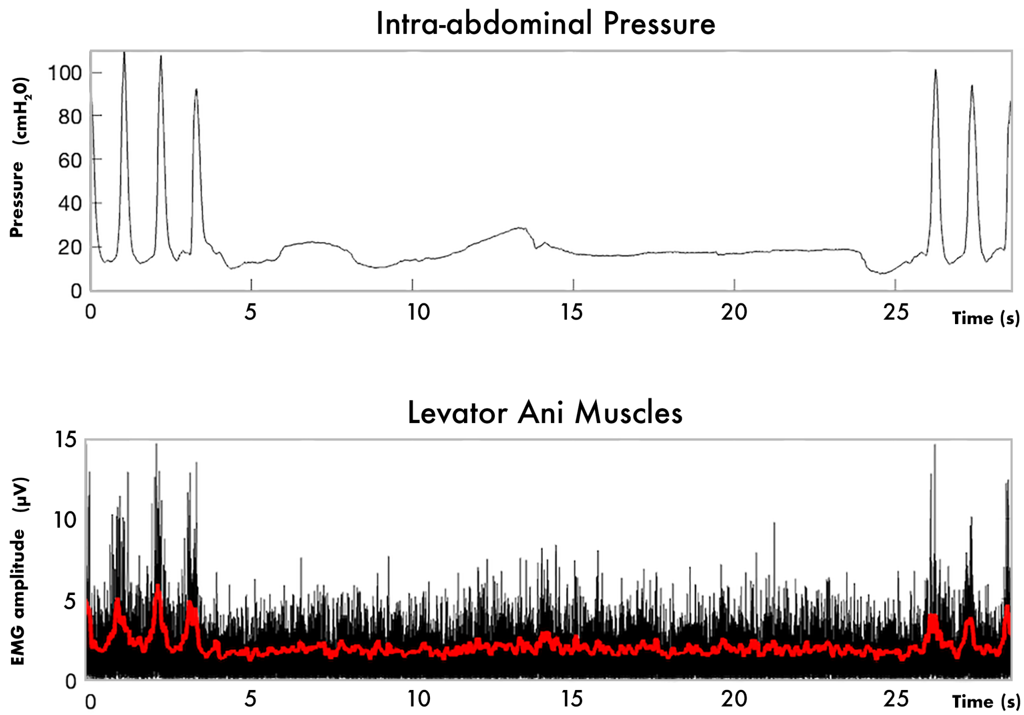

Figure 3.6 Sample of intra-abdominal pressure data (top) aligned with the electromyographic (EMG) signal data recorded from the levator ani muscle (bottom) during a hypopressive maneuver. Distinct peaks are observed at the beginning and at the end of the time series, corresponding to coughing events that mark the start and end of the task. The black line represents raw rectified EMG amplitude and the red trace represents the low-pass filtered EMG amplitude.

3.2.7 Data analysis

All data were analyzed using SPSS v. 22 (IBM Statistics). All outcomes were tested for normality using the Shapiro-Wilk test, inspection of the Q-Q plots and histograms. An adjusted α (0.05/10) was set for all hypothesis testing to account for multiple outcomes. To adjust for multiple statistical tests (ten different outcome measures), the p-values were multiplied by 10. Since p-values cannot exceed one, any adjusted p-values greater than one were capped at $p = 1.0$ (Wright, 1992; Vickerstaff et al., 2019). First, independent t-tests were used to determine whether there were changes in IAP, EMG amplitude or pelvic morphology during the HEs performed in supine or standing in conjunction with the corresponding HP as described by Caufriez (1997). Next, separate two-way repeated-measures analysis of variance (RM-ANOVA) models were used to determine if there were significant position (supine vs standing) or posture (HP vs no HP) interactions or main effects. Because some data sets were non-normal (LAMs, EAS, EO), Friedman's ANOVAs were also performed, with hypothesis testing outcomes compared to the results of parametric testing. The outcomes of hypothesis testing of non-normal outcomes were consistent between parametric and non-parametric testing, and therefore all statistical outcomes are described using parametric ANOVAs for consistency. Cohen's d effect sizes were computed for objective 1 and partial eta squared (η_p^2) effect sizes were computed for objective 2. Pearson correlation coefficients were computed between transient changes in IAP and %MVC of the LAMs to fulfill objective 3.

3.3 Results

Thirty-seven participants completed the training and attended the data collection session (Figure 3.7); instrumentation issues resulted in the loss of one data set. Participants reported practicing the HEs an average of three times per week. All the demographic outcomes are described in Table 3.1.

All primary outcomes are presented in Table 3.2. There was no significant change in IAP during the HE performed with the HP in supine [d=0.07, p=1.0] or in standing [d=0.34, p=0.7]. The effect sizes were very small. The post hoc power was 0.96% and a sample size of n=1084 would have been needed to achieve a power of 80%. Concurrently, in supine, LAM activation was 44(35)%MVC (d=1.24, p<0.01) while in standing it was 50(44)%MVC (d=1.12, p<0.01). In supine EAS activation was 27(24)%MVC (d =1.15, p<0.01) while in standing it was 27(27)%MVC (d=0.99, p<0.01). Small transient changes in pelvic morphology were observed: the LPL shortened in supine [mean -1.9 (2.3)mm, 95% CI -2.7 to -1.1mm, d=0.84] and in standing [mean -1.8 (3.3)mm, 95% CI -3.0 to -0.7mm, d=0.56], the LPA increased in supine [mean 4.9 (5.4)°, 95% CI 3.1 to 6.7°, d=0.90] and in standing [mean 3.1 (5.0)°, 95% CI 1.4 to 4.7°, d=0.61], and BNH increased in supine [mean 0.7 (1.5)mm, 95% CI 0.2 to 1.2mm, d=0.49] and in standing [mean 0.5 (1.5)mm, 95% CI -0.5 to 1.0mm, d=0.10] during the HE.

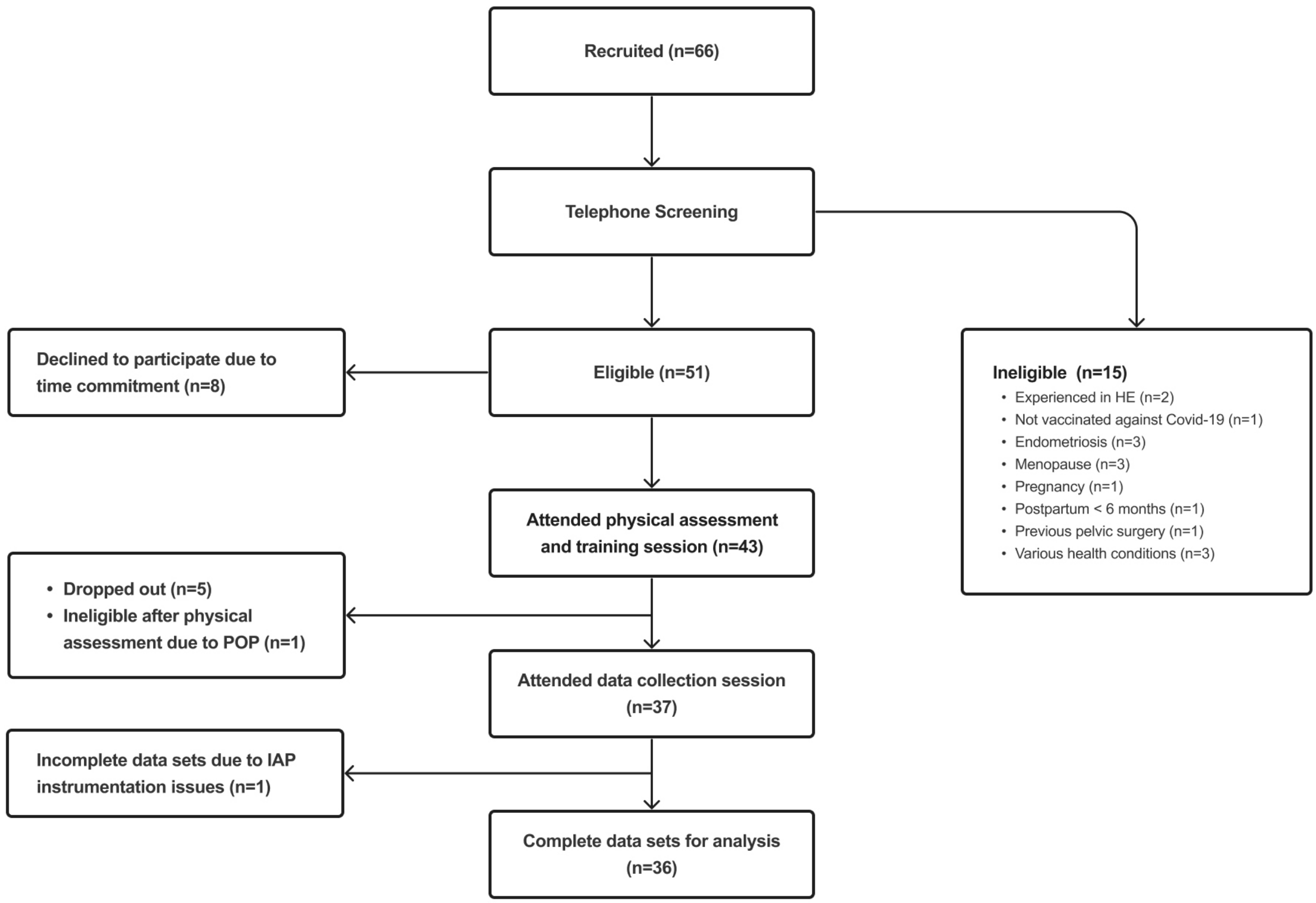

Figure 3.7 STROBE Flowchart

There was no interaction between body position (supine vs standing) and the use of the HP (with vs without) [$F_{LAM}(1,31)=0.851$, $p=0.363$; $F_{EAS}(1,31)=3.337$, $p=0.77$] and no main effect of body position [$F_{LAM}(1,31)=0.255$, $p=0.617$; $F_{EAS}(1,31)=0.952$, $p=1.0$ or the HP [$F_{LAM}(1,31)=0.75$, $p=1.0$; $F_{EAS}(1,31)=1.303$; $p=1.0$] on PFM EMG activation. The effect sizes were also very small. The post hoc test indicated that the study power was 25%. In order to achieve a power of 80%, a sample size of n=82 would have been needed.

In supine, RA activation was 5(4)%MVC (d=1.33, p<0.01), EO activation was 20(13)%MVC (d=1.60, p<0.01) and IOTrA activation was 61(53)%MVC (d=1.15, p<0.01; in standing RA activation was 8(6)%MVC (d=1.30, p<0.01), EO activation was 34(27)%MVC (d=1.23, p<0.01), IOTrA activation was 55(43)% (d=1.29, $p<0.01$). As with the PFMs, there was no interaction between body position and HP [$F_{RA}(1,29)=3.840$, $p=1.0$; $F_{EO}(1,31)=0.510$, $p=1.0$; $F_{IOTrA}(1,31)=0.21$, $p=1.0$] and no body position or

Table 3.1 *Demographic information*

Measure		Mean / n	SD / %
Demographics	***Age (years)***	*34*	*6*
	Birthing History		
	Parous (n, %)	*21*	*58%*
	Primipara (n, %)	*6*	*29%*
	Multipara (n, %)	*15*	*42%*
	Vaginal delivery (n, %)	*15*	*42%*
	C-section delivery (n, %)	*6*	*29%*
	UI (n, %)	*14*	*39%*
	POP (n, %)	*7*	*19%*
	BMI (kg/m²)	*25*	*5*
	Waist-hip ratio	*0.8*	*0.2*
International Consultations on Incontinence Questionnaires	***ICIQ-FLUTS total score (/48)***	*8.3*	*5.4*
	ICIQ-vaginal symptoms (/53)	*6.1*	*5.7*
	ICIQ-sexual matters (/58)	*10.6*	*13.5*
	ICIQ-quality of life (/10)	*1.3*	*1.6*
IVD	***Relative peak force during LAMs MVC (N)***	*3.8*	*2.7*
	Stiffness during LAMs passive elongation (N/s)	*6.0*	*2.2*

BMI (body mass index), ICIQ-FLUTS (International Consultation on Incontinence – Female Lower Urinary Tract), IVD (Intravaginal Dynamometry), LAM (levator ani muscle), MVC (maximal voluntary contraction), POP (pelvic organ prolapse, UI (urinary incontinence) posture main effects for the abdominal muscles, with the exception of EO which was active to a larger extent in standing compared to supine [($F_{EO}(1,31)=17{,}242$, $p<0.01$; $\eta_p^2=0.375$]; all other effect sizes were small (Table 3.2).

Pearson correlation coefficients revealed no significant associations between change in IAP and extent of PFM EMG or abdominal activation observed during HE in supine [LAM: r=0.079, p=1.0; EAS: r=0.31, p=1.0; RA: r=0.10, p=1.0; EO: r=0.30, p=1.0; IOTrA: r=0.47, p=0.10] or in standing [LAM: r=-0.073, p=1.0; EAS: r=0.08, p=1.0; RA: r=0.03, p=1.0; EO: r=0.11, p=1.0; IOTrA: r=0.13, p=1.0] positions.

3.4 Discussion

Caufriez's theorized mechanism of HEs is founded on the production of a transient reduction in IAP generated through the hypopressive maneuver. To our knowledge, this is the only study that has evaluated changes in IAP during the performance of HEs. We found that women who were originally naïve to HEs and who received individualized instruction and two weeks of practice did not demonstrate a significant reduction in IAP during HEs performed in the beginner-level HPs used here. In standing, there was a tendency for the IAP to reduce, however the effect was not significant (p=0.7) and the effect size was small (d=-0.34; 95% C.I. -0.71 to 0.03). Based on our findings, the theory put forth by Caufriez (1997) is not supported.

We found that the HE did cause consistent activation of the PFMs, however, the underlying mechanism for this is not clear. Caufriez (1997) stated that during the HE, a reduction in IAP causes reflex activation of the type I muscle fibres of the PFMs. Yet because the IAP did not change during the HE, and because the extent of IAP reduction was not correlated with the extent of observed PFM

Table 3.2: Transient changes observed in intra-abdominal pressure (IAP), electromyographic (EMG) activation, and pelvic morphology measured using ultrasound imaging (USI)) during the performance of a hypopressive exercise with and without the hypopressive posture

Measure		**n**	**Supine**		**Standing**		**Position**			**Posture**			**Position*Posture**		
			No Posture mean (SD)	**Posture mean (SD)**	**No Posture mean (SD)**	**Posture mean (SD)**	η_p^2	**p**	**Adjusted p**	η_p^2	**p**	**Adjusted p**	η_p^2	**p**	**Adjusted p**
EMG	*LAM (%MVC)*	*33*	*46 (37)*	*44 (35)*	*49 (49)*	*50 (44)*	*0.008*	*0.617*	*1.0*	*0.002*	*0.786*	*1.0*	*0.027*	*0.363*	*1.0*
	EAS (%MVC)	*33*	*33 (31)*	*27 (24)*	*27 (31)*	*27 (27)*	*0.030*	*0.337*	*1.0*	*0.040*	*0.262*	*1.0*	*0.097*	*0.077*	*0.77*
	RA (%MVC)	*30*	*6(6)*	*5(4)*	*7(5)*	*8(6)*	*0.108*	*0.071*	*0.71*	*0.004*	*0.726*	*1.0*	*0.117*	*0.060*	*0.60*
	EO (%MVC)	*32*	*21(16)*	*20(13)*	*38(36)*	*34(28)*	*0.357*	*<0.001*	*<0.01*	*0.014*	*0.514*	*1.0*	*0.016*	*0.480*	*1.0*
	IOTrA (%MVC)	*32*	*55(50)*	*61(53)*	*51(34)*	*56(43)*	*0.011*	*0.563*	*1.0*	*0.039*	*0.270*	*1.0*	*0.001*	*0.886*	*1.0*
IAP	*ΔIAP* (cmH_20)	*30*	*-2.0 (3.01)*	*-1.1 (3.3)*	*-4.0 (8.0)*	*-2.9 (8.4)*	*0.067*	*0.183*	*1.0*	*0.149*	*0.042*	*0.42*	*0.002*	*0.828*	*1.0*
2D USI	*ΔLPL (mm)*	*36*	*-1.8 (2.9)*	*-1.9 (2.3)*	*-2.1 (2.4)*	*-1.8 (3.30*	*0.002*	*0.784*	*1.0*	*0.005*	*0.687*	*1.0*	*0.008*	*0.598*	*1.0*
	ΔBNH (mm)	*36*	*0.5 (1.67)*	*0.7 (1.5)*	*0.5 (1.7)*	*0.5 (1.5)*	*0.009*	*0.587*	*1.0*	*0.005*	*0.672*	*1.0*	*0.010*	*0.547*	*1.0*
	ΔLPA (degrees)	*36*	*5 (6)*	*5 (5)*	*4 (6)*	*3 (5)*	*0.092*	*0.069*	*0.69*	*0.010*	*0.556*	*1.0*	*0.003*	*0.748*	*1.0*

LAM (levator ani muscle), EAS (external anal sphincter), RA (rectus abdominis), EO (external oblique), IOTrA (internal oblique / transversus abdominis), %MVC (percent maximal voluntary activation), IAP (intra-abdominal pressure), LPL (levator plate length), BHN (bladder neck height), LPA (levator plate angle), Δ (transient change observed during the performance of the hypopressive maneuver), Adjusted p refers to p-value adjusted to account for the multiple statistical tests (px10 to a maximum of p=1.0) activation, this theory is not supported. Because the PFMs and abdominal muscles often contract together (Madill & McLean, 2008), we postulate that the activation of the LAMs and EAS during the HE may be mediated by the abdominal muscle activation required to perform the HE maneuver.

The direction of the transient changes in pelvic floor morphology observed during the HEs is consistent with concentric activation of the LAMs, including reduction in the LPL, increase in the LPA and elevation of the bladder neck. However, the extent of the observed displacement was much smaller than the extent of motion of these landmarks observed during maximal effort voluntary contractions of the LAMs (BNH: 2.41mm; LPL: -9.7mm; LPA: 48 degrees) (Bérubé & McLean, 2024; McLean et al., 2016), suggesting the contraction may be considered isometric

Caufriez's publication outlines the importance of adopting a HP, which includes axial extension of the spine and isometric activation of certain upper and lower limb muscles, followed by the vacuum breath during the HE maneuver (Caufriez, 1997;). To address our second objective, participants performed the HEs in two different body positions (supine and standing) and both with and without the HP. The HP did not enhance the reduction of IAP nor the activation of the PFMs or abdominal muscles during the HE, and there was no effect of body position (supine/standing). Thus, we conclude that in supine and standing, the HP has no significant effect on the extent of change in IAP nor activation of the abdominal or PFMs achieved during the HE. The HP does not appear to be important to the HE mechanism.

Our findings corroborate with the studies conducted by Navarro-Brazalez and colleagues (2017 and 2020b) and Ithamar and colleagues (2018) where they reported that the PFMs and abdominal muscles are active during the HE maneuver. The extent of PFM activation was lower than 50% MVC (Navarro-Brazalez et al., 2017; Navarro-Brazalez, 2020b) and between 44% and 56% MVC (Ithamar et al., 2018), which may support preferential activation of slow-twitch muscle fibres as suggested by Caufriez since slow twitch muscle fibres are normally recruited prior to fast twitch fibres (Henneman et al., 1965;

Gordon et al., 2004). However, at this activation level, HEs are unlikely to induce hypertrophy, and associated increases in strength and power that are superior to targeted, intentional PFM training, which employs maximal effort voluntary contractions and high speed contractions, and is known to be effective for the management of urinary incontinence (Dumoulin et al., 2014; Bø, 2020) and pelvic organ prolapse (Dumoulin et al., 2014; Bø & Herbert., 2013).

The HE mechanism also failed to elucidate any relationship between reductions in IAP and increases in EMG activation across all muscles examined. Specifically, greater reductions in IAP were not associated with more activation of PFMs and abdominal muscles during the HEs.

3.4.1 Strengths and Limitations

To our knowledge, this was the first study where naïve participants were initially trained on HEs for the purposes of the study and whose proper performance of the exercise maneuver was verified prior to data collection, and where IAP, EMG and USI were recorded concurrently. This was also the first study to measure IAP while participants performed HEs in two different HPs [Demeter (supine) and Athenas (standing)].

The EMG electrodes used was a strength. To avoid motion artifact and crosstalk, the electrodes were adhered to the vaginal wall using suction force, and those placed over the EAS were closely spaced on the same side of the anus, in line with the direction of action of the muscle fibres. This approach adheres to current recommendations, which cannot be said of previous studies on PFM EMG activation during HEs.

The results of this study are generalizable to participants who began naïve to HEs and practiced for two weeks. Future studies should investigate participants who are more experienced in HEs and/or the impact of practicing HEs for a longer period. Future studies should also investigate the use of more advanced and dynamic HPs as opposed to only static and basic postures.

Chapter 4: Does hypopressive exercise training impact pelvic floor muscle strength, stiffness or task performance? An interventional cohort study

4.1 Abstract

Questions: Among women previously naïve to hypopressive exercise (HE), after initial instruction and eight to ten weeks of HE training, (1) do the pelvic floor muscles (PFMs) become stronger and/or have higher tone? and/or (2) are there greater effects of the HE maneuver on transient changes in intra-abdominal pressure (IAP) or activation of the levator ani (LAMs) or external anal sphincter (EAS) muscles?

Design: Interventional cohort study.

Participants: Twenty-four volunteers previously naïve to HEs.

Intervention: Two HE training sessions followed by laboratory-based data collection sessions completed after two weeks and after eight to ten weeks of training.

Outcome measures: Primary: LAM strength and tone measured through dynamometry. Secondary: transient changes in IAP, electromyographic (EMG) amplitude of the LAMs and the EAS, and pelvic morphology observed through ultrasound imaging during the performance of the HEs in supine and standing, with and without the hypopressive posture (HP).

Results: While not significant, LAM strength tended to be higher at the first assessment [3.6(2.3)N] compared to the second assessment (2.8(1.4)N, d=0.48, p= 0.32), while LAM tone remained unchanged [baseline: 6.6(1.8)N/mm], follow-up: [6.1(1.6)N/mm, d=0.27, p=1.0]. There was no effect of an additional six to eight weeks of HE training on the magnitude of transient changes observed during the HE in any outcomes measured two weeks after initial instruction; effect sizes were very small ($0.00< \eta_p^2<0.07$).

Conclusion: Eight weeks of HE training did not induce any changes in PFM strength or stiffness and did not result in any learning effect in terms of the exercise mechanism.

Key words: *pelvic floor, stress urinary incontinence, pelvic organ prolapse, physiotherapy, rehabilitation*

4.2 Introduction

Hypopressive exercises (HEs) emerged in the late 1990's, theorized by Caufriez (Caufriez, 1997) as a means of improving core strength and posture, strengthening the pelvic floor muscles (PFMs) and ultimately reducing symptoms associated with pelvic floor disorders (PFDs) such as urinary incontinence (UI) and pelvic organ prolapse (POP). HEs are prescribed by some physiotherapists for the management of PFDs (Bø & Herbert, 2009; Bø & Herbert, 2013) and have gained popularity in countries such as Canada, Spain, Brazil and France (Dumoulin et al., 2014; Bellido-Fernández et al., 2018), despite a lack of empirical evidence to support the intrinsic mechanisms put forth by Caufriez, their effectiveness at strengthening the PFMs, nor their effectiveness in the management of PFDs (Bø & Herbert, 2013; Ruiz de Viñaspre Hernández, 2018; Bø et al., 2023; Katz et al., 2024).

HEs involve a sequence of assuming a "hypopressive posture" (HP) then performing a "hypopressive maneuver" involving an exhalation to end expiratory volume, breath holding, closing the glottis and actively expanding the rib cage. Caufriez theorized that this maneuver would cause a decrease in IAP and subsequent reflex activation of the PFMs. There are several different HPs and body positions, including the Demeter (supine) and Athenas (standing) HPs which are normally considered beginner postures.

Despite Caufriez's theory having been described nearly three decades ago, there it remains a lack of evidence regarding whether the HE reduces IAP and whether there is any role of the HP in the HE mechanism.

In the cross-sectional study described in Chapter 3, we showed that, among 36 individuals with female-typical genital anatomy who were naïve to HEs, there was moderate activation of the LAMs and the EAS during the HE maneuver. We found that there was no significant reduction in IAP during the performance of the HE, and we found no effect of the HP on IAP, LAM or EAS EMG activation or urogenital landmark motion observed during the HE maneuver. Further, there was no association between the extent of reduction in IAP observed during the HE and the extent of LAM activation. Consistent with the findings of Chapter 3, among a group of females who were experienced in HE training, Navarro-Brazalez et al., (2020b) also found that the PFMs and abdominal muscles were active during the HEs, in the order of 35% MVC. Due to the moderate contraction intensity observed, they concluded that HEs are unlikely to cause hypertrophy in the PFMs (Navarro-Brazalez et al., 2020b).

We hypothesized that a period of HE training may lead to motor learning, thus enhancing the reduction of IAP and the contraction of the PFMs when performing the HE maneuver, which could result in improvements in LAM strength or increases in LAM tone. In this study, we aimed to determine whether, after eight to ten weeks of HE training, participants who were previously naïve to HE training would demonstrate (1) changes in LAM strength or tone, and/or (2) greater proficiency in the performance of HEs such that greater reductions in IAP, greater increases in EMG activation of the PFMs and greater motion of the urogenital landmarks would be observed. We also aimed to determine whether, after the longer training period, the HP may become relevant to the HE mechanism where it was not after only two weeks of training.

The specific research questions addressed in this context were as follows:

1. Does the strength or tone of the PFMs change relative to a baseline assessment two weeks after learning the HE approach among a sample of females previously naïve to HEs after practicing HEs in supine and standing positions for a total of eight to ten weeks?
2. Is there evidence of a learning effect after eight to ten weeks of HE training such that (1) transient changes in IAP, or activation of the PFMs, observed during the HE task are different from what was measured two weeks after initial instruction on the HE techniques and (2) the HP becomes relevant to the HE mechanism?

4.3 Methods

4.3.1 Design

This was an interventional cohort study with a repeated-measures design. It received ethics approval from the local institutional research ethics board and all participants provided written informed consent prior to commencing any study activities. Data were collected between November 2021 and June 2022.

4.3.2 Participants

Twenty-four among 37 healthy participants with female-typical pelvic anatomy who participated in a previous cross-sectional study, as described in Chapter 3, were invited to participate. All invited participants had attended two training sessions where they learned from a certified Hypopressive trainer how to perform HEs in supine (using the Demeter HP) and standing (using the Athenas HP), and a data collection session two weeks later. Participants had been recruited from the university community and physiotherapy clinics, and through social media and word of mouth. They were included if they were older than 18 years, premenopausal, and had been fully vaccinated against COVID-19. Participants were excluded if they had POP beyond the introitus, a history of major gynecologic surgery such as POP repair, mid-urethral sling insertion or hysterectomy, reported pelvic pain associated with vaginal insertion during gynecological speculum exam, tampon use or sexual intercourse, were pregnant or less than six months postpartum, had any neurological, metabolic or heart condition, or were deemed unable to perform HEs after two training sessions.

4.3.3 ***Sample size***

A desired sample size of n=30 (α=0.05, power=80%) was determined *a priori* based on Navarro-Brazalez et al. (2020a) who reported moderate effect sizes for increases in PFM tone (d=0.35) and strength (d=0.50) after an 8-week period of HE training. However, only n=24 participants from among n=37 who participated in the cross-sectional study were eligible and agreed to continue to the second assessment (Figure 4.1).

4.3.4 ***Outcome measures***

The primary outcomes were PFM strength and stiffness measured using intravaginal dynamometry. Secondary outcomes included transient changes observed in IAP, EMG amplitude of the LAMs and EAS, and pelvic morphology [levator plate length (LPL), bladder neck height (BNH) and levator plate angle (LPA)] observed on 2D transperineal ultrasound imaging (USI), acquired while participants performed HEs in supine and standing, with and without an associated HP.

4.3.4.1 Dynamometry

A custom, automated dynamometer (Czyrnyj et al., 2021) was used to measure PFM maximum voluntary contraction (MVC) strength and resistance to passive elongation in the antero-posterior plane (tone). Briefly, two single-use dynamometer arms were 3D printed in biocompatible plastic and were anchored to the arm mounts that house the load cells. Each arm was covered in a condom before the device was inserted intra-vaginally. LAM strength was measured as the force measured by the dynamometer when participants were asked to generate a maximal effort closure force against the arms, which were open to a diameter of 35mm (Berube et al., 2018). LAM tone (resistance to passive elongation) was measured as the slope of the force by diameter curve observed while the participant lay in supine and were instructed to keep their PFMs relaxed while the arms of the dynamometer opened from an initial diameter of 10mm to a final diameter of 40mm at a rate of 15mm/s, as described in Berube et al. (2018). These measures have demonstrated good to excellent test-retest reliability (Berube et al., 2018) and are not impacted by task familiarization (Czyrnyj et al., 2019). Three trials of each task were performed and then the dynamometer arms were removed.

4.3.4.2 Intra-abdominal pressure (IAP)

The participant was next instrumented with a single-use IAP sensor (Niederauer et al., 2017). The participant was asked to insert the sensor as deeply as possible into the vagina to reach the posterior fornix. The positioning was then verified by the researcher using palpation and visual inspection. The IAP sensor was interfaced with an instrumentation module which captured pressure data at a sampling frequency of 200Hz (Niederauer et al., 2017; Rosenbluth et al., 2010). The sensor has been validated against atmospheric and temperature offset (Coleman et al., 2012) and demonstrates good test-retest reliability (Rosenbluth et al., 2010).

4.3.4.3 Electromyography (EMG)

A differential suction electrode (DSE) (Keshwani & McLean, 2012; Keshwani & McLean, 2015) was inserted intravaginally and positioned securely against the vaginal wall overlying the right pubovisceralis muscle, following the method described by Keshwani and McLean (2012). The wire terminals of the DSE were connected to alligator clips which interfaced with the input terminals of a Delsys D.E. 2.1 pre-amplified electrode. The selection of the DSE was based on the established validity and high inter-trial reliability when recording LAM activation, as previously documented by Keshwani and McLean (Keshwani & McLean, 2012; Keshwani & McLean, 2015).

Two Kendall H49P cloth electrodes (Cardinal Health, Canada) were affixed to the skin overlying the external anal sphincter (EAS) on the right side, with an interelectrode spacing of 20 mm. A common reference electrode was placed on the skin overlying the right anterior superior iliac spine (ASIS). Prior to executing the HE tasks, three trials of a PFM maximal voluntary contraction (MVC) were performed, so that PFM data could be normalized as a percentage of MVC (% MVC).

All EMG preamplifiers were interfaced with a Delsys Bagnoli-16 amplifiers system with an overall gain of X1000, common mode rejection ratio of -120 dB at 60 Hz, a bandpass filter from 20 Hz to 450 Hz and a notch filter at 60Hz EMG data were sampled at 2 kHz using a 32-bit National Instruments Analog to Digital Converter (NIDAQ USB3086) and recorded on a personal computer using Powerlab™ LabChart 8 Pro software (ADInstruments, Colorado, USA).

4.3.4.4 Pelvic morphology measured using transperineal ultrasound imaging

Changes in pelvic morphology throughout the HEs were observed using two-dimensional transperineal ultrasound imaging (TP-USI) conducted using a GE Voluson S6 system (GE Canada, Toronto) equipped with a RAB6-D 4D convex curvilinear probe. During imaging, the researcher aimed to maintain visibility of the pubic symphysis, the bladder neck, and the anorectal junction within the frame. Changes in levator plate length (LPL), levator plate angle (LPA), and bladder neck height (BNH) were quantified as the difference between these measurements during the resting condition and the maximum displacement observed during each HE maneuver. Changes in these morphologic measures were used to determine whether the PFMs remained static (isometric), shortened (concentric) or lengthened (eccentric) if/when they were active during the HE.

4.3.5 Intervention

During the initial training session and laboratory assessment for the cross-sectional study as described in Chapter 3, participants underwent a screening examination to rule out POP beyond the introitus and received instructions on how to contract their PFMs, delivered by a researcher who was a registered pelvic health physiotherapist (SS) who had over 10 years of clinical practice experience in this area. They subsequently engaged in a 45-minute HE training session with the same researcher, who was also a certified Hypopressive trainer. This session included theoretical instruction on HEs and practical training on four specific tasks: (1) HE performed in supine without adopting an HP, (2) HE performed supine while adopting an HP (Demeter) (Caufriez, 1997; Rebullido & Pinsach, 2015), (3) HE performed in standing without adopting an HP, and (4) HE performed standing while adopting an HP (Athenas) (Caufriez, 1997; Rebullido & Pinsach, 2015). At the end of the session, participants were asked to perform each task three times per day, requiring an average of 10 minutes of training per day, adhered to at least three times per week over an eight to ten-week period until they returned for reassessment.

After the first week, participants attended a follow-up visit where the trainer verified exercise performance and adherence to the protocol. One week later, participants attended the first data collection session. Those who were eligible to participate were invited to continue training until a second data collection session which was scheduled between six and eight weeks later. The second data collection was the same as the first data collection. Data were collected during HEs performed in supine before those performed in standing to minimize data loss related to sensor disruption during position changes. In random order, participants performed three repetitions of the HE maneuver with and without the HP while EMG, IAP and USI data were acquired [Figure 3.4 (A) and (B) and Figure 3.5 (A) and (B)].

Adherence to the program was monitored through regular email correspondence, and participants completed an adherence report at the end of the second data collection session (Appendix O).

4.3.6 Data processing

Anterior and posterior arm dynamometry load cell forces were smoothed using a 2^{nd} order, dual-pass Butterworth filter with a cutoff frequency of 5Hz, then averaged. Using custom programs generated in MATLAB version R2022a (MathWorks, Inc., Natick, Massachusetts, United States) software, relative peak forces (highest peak – baseline) and resistance to passive elongation (stiffness in N/mm) were retained as outcomes.

All IAP and EMG data were aligned in time, then were bias corrected, full-wave rectified, and smoothed using a 4th order, dual-pass low-pass Butterworth filter (cut-off 6 Hz). The peaks of the LAM and EAS EMG signals observed during each HE task were normalized to the highest peak achieved during the three PFM MVCs.

Ultrasound data were processed using Image J Version 1.53s (U.S. National Institutes of Health, Bethesda, Maryland, USA) software. Bladder neck height (BNH), levator plate length (LPL) and levator plate angle (LPA) were measured as described in previous work (Dietz, 2004; McLean et al., 2016; Berube & McLean, 2024).

4.3.7 Data analysis

Data were analyzed using SPSS v.29 (IBM Statistics, USA). All outcomes were tested for normality (Shapiro-Wilk test, inspection of the Q-Q plots and histograms). Paired t-tests were used to determine whether PFM strength and/or stiffness had changed at the second assessment relative to the first assessment, and Cohen's d effect sizes were computed. Separate two-way, repeated-measures ANOVAs were used to determine whether there were significant effects of testing session (initial or follow-up), the HP (yes or no), or the interaction between testing session and HP on transient changes observed in IAP, EMG amplitude (LAMs or EAS), BNH, LPL, or LPA during the HEs performed in each position (i.e., supine, standing).To correct for the multiple statistical tests (eight outcomes) conducted, the p-values were adjusted by multiplying them by eight. As p-values cannot exceed one, any adjusted p-values greater than one were truncated to p=1.0 (Wright, 1992; Vickerstaff et al., 2019). Partial eta squared (η_p^2) effect sizes were computed for the outcomes tested in Question 2.

4.4 Results

Twenty-four participants completed the study. Mean adherence was 2.9(0.7) HE training sessions per week, with 71% of participants reporting having performed at least three HE training sessions per week over the duration of the study (Figure 4.1).

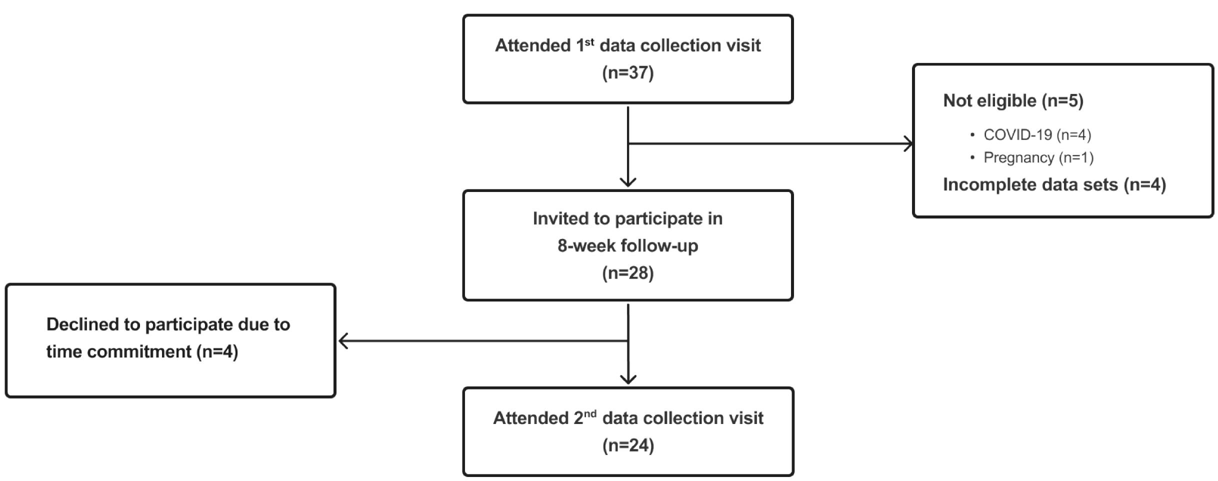

Figure 4.1 STROBE Flowchart for Hypopressive Exercise Intervention

The LAM strength tended to be higher at the first assessment [3.6(2.3)N] than at the second assessment (2.8(1.4)N, d=0.48, p=0.32), while LAM stiffness remained unchanged between the first [6.6(1.8)N/mm] and second [6.1(1.6)N/mm, d=0.27, p=1.0] assessment.

IAP, EMG and USI outcomes are presented by assessment visit in Tables 4.1 (supine) and 4.2 (standing). There were no visit main effects nor significant interactions between visit and posture found for the transient change in IAP observed during the HE in supine or in standing. The effect sizes were very small. In supine, the post hoc test revealed that the study had a power of 2.5% to detect an effect of posture, requiring a sample size of n=192 to achieve a power of 80%. In standing, the power to detect an effect of the HP was only 1% and a sample size of n=702 would have been needed to achieve a power of 80%.

There was activation of the LAMs and EAS during the performance of the HE, but there were no differences in the extent of EMG activation between the first and second assessments regardless of position or posture, and the effect sizes were very small. For instance, in supine the study power was 9.7%; to achieve a power of 80%, a sample of n=92 would have been needed. In standing, the power was higher, at 68%; the sample size needed to achieve 80% was n=24. There was no main effect of visit nor interaction between visit and posture on the extent of morphological change observed on ultrasound imaging during the HE.

4.5 Discussion

Caufriez (1997) proposed HEs as a means of strengthening the PFMs, and some literature has suggested that HEs may increase PFM tone (Navarro-Brazalez et al., 2020b; Soriano, et al., 2020). The eight to ten-week HE training intervention delivered in this study resulted in no increases in LAM strength or tone. While it could be argued that the training period was relatively short, it was longer than the time typically required to see improvements in force generating capacity attributable to improved contractile efficiency (Schoenfeld et al., 2021), and was similar to the eight-week training period used in the RCT by Navarro-Brazalez et al. (2020a), which resulted in moderate improvement (d=0.50) in LAM strength measured using dynamometry. Eight weeks of HE training was also used in a recent RCT by Molina-Torres et al., (2023) who found that the PFMs were stronger after the HE training period among females with UI, yet in this latter study, PFM strength was measured using MOS, which is subjective and inherently unreliable (Bø & Finckenhagen, 2001; Ferreira et al., 2011). While Navarro-Brazalez et al. (2020a) and Molina-Torres et al. (2023) employed RCT designs that are superior to the interventional cohort study described here, it is unlikely that a lack of randomization and blinding would result in a worse outcome than what was observed through RCT, as typically bias due to lack of randomization is thought to increase type I error (Lieberman & Cunningham, 2009). Indeed, two studies have reported that PFMT results in greater PFM strength gains than observed after HE interventions (Jose-Vaz et al., 2020; Resende et al., 2019).

In addition to increases in LAM strength, Navarro-Brazalez et al. (2020a) also reported increases in LAM tone (d=0.35) after the eight-week HE intervention, but this was not observed here. The intervention in Navarro-Brazalez et al. (2020a) included education on PFDs and risk factors, as well as on how to perform the "knack" maneuver during physical efforts such as coughing, laughing, sneezing and jumping. The "knack" involves the performance of a voluntary PFM contraction before all activities that might increase IAP. This instruction is a confounder, as it could have contributed to an improvement in LAM strength or tone observed among those who performed it. Further, it is not clear why PFM tone, recorded in supine as the resistance of the LAMs to passive elongation, would be altered through HE training. Soriano et al. (2020) also suggested that HE training may increase LAM tone with a moderate effect size (d=0.63). Tone was measured intravaginally using a dynamometer in Navarro-Brazalez et al. (2020a) while in Soriano et al. (2020) it was measured at the perineum using a tonometer.

Table 4.1: Transient changes in intra-abdominal pressure (IAP), electromyography (EMG) activation and pelvic morphology during hypopressive exercises performed in supine before (Visit 1) and after (Visit 2) eight weeks of training

Measure		n	Visit 1		Visit 2		Visit			Posture			Visit*Posture		
			Supine no posture mean (SD)	Supine + posture mean (SD)	Supine no posture mean (SD)	Supine + posture mean (SD)	η_p^2	p	Adjusted p	η_p^2	p	Adjusted p	η_p^2	p	Adjusted p
EMG	LAM (%MVC)	20	45 (43)	43 (40)	68 (68)	71 (55)	0.18	0.06	0.48	0.00	0.81	1.0	0.02	0.51	1.0
	EAS (%MVC)	20	35 (38)	28 (26)	36 (45)	4 (52)	0.04	0.37	1.0	0.00	0.82	1.0	0.09	0.19	1.0
	EO (%MVC)	20	23 (17)	2 (13)	32 (45)	34 (41)	0.08	0.21	1.0	0.00	0.85	1.0	0.03	0.50	1.0
	IOTrA (%MVC)	20	59 (53)	58 (55)	64 (73)	58 (65)	0.00	0.87	1.0	0.02	0.58	1.0	0.02	0.57	1.0
IAP	ΔIAP (cmH_20)	15	-1.70 (2.07)	-1.68 (2.10)	-2.03 (2.00)	-2.17 (2.13)	0.14	0.15	1.0	0.02	0.66	1.0	0.01	0.70	1.0
2D USI	ΔLPL (mm)	24	-1.73 (3.01)	-1.78 (2.27)	-1.54 (2.40)	-0.66 (2.12)	0.08	0.18	1.0	0.06	0.26	1.0	0.06	0.26	1.0
	ΔBNH (mm)	24	0.33 (1.33)	0.67 (1.65)	0.36 (1.13)	0.21 (0.97)	0.02	0.48	1.0	0.01	0.66	1.0	0.05	0.29	1.0
	ΔLPA (degrees)	24	4 (6)	4 (5)	4 (6)	2 (6)	0.02	0.46	1.0	0.10	0.13	1.0	0.02	0.52	1.0

LAM (levator ani muscle); EAS (external anal sphincter), IAP (intra-abdominal pressure), LPL (levator plate length), BHN (bladder neck height), LPA (levator plate angle), Δ (transient change observed during the performance of the hypopressive maneuver), Adjusted p refers to p-values multiplied by 8 to account for the multiple statistical tests.

Table 4.2: Transient changes in intra-abdominal pressure (IAP), electromyography (EMG) activation and pelvic morphology during hypopressive exercises performed in standing before (Visit 1) and after (Visit 2) eight weeks of training

Measure		n	Visit 1		Visit 2		Visit			Posture			Visit*Posture		
			Standing no posture mean (SD)	Standing + posture mean (SD)	Standing no posture mean (SD)	Standing + posture mean (SD)	η_p^2	p	Adjusted p	η_p^2	p	Adjusted p	η_p^2	p	Adjusted p
EMG	*LAM (%MVC)*	20	*57 (57)*	*57 (50)*	*87 (85)*	*72 (75)*	*0.05*	*0.31*	*1.0*	*0.07*	*0.24*	*1.0*	*0.09*	*0.19*	*1.0*
	EAS (%MVC)	20	*33 (38)*	*33 (32)*	*40 (37)*	*35 (34)*	*0.04*	*0.41*	*1.0*	*0.09*	*0.20*	*1.0*	*0.03*	*0.46*	*1.0*
	EO (%MVC)	20	*35 (32)*	*36 (31)*	*38 (46)*	*52 (75)*	*0.03*	*0.44*	*1.0*	*0.03*	*0.43*	*1.0*	*0.03*	*0.47*	*1.0*
	IOTrA (%MVC)	20	*53 (32)*	*64 (48)*	*64 (65)*	*80 (73)*	*0.04*	*0.38*	*1.0*	*0.16*	*0.07*	*0.56*	*0.01*	*0.74*	*1.0*
IAP	*ΔIAP (cmH_20)*	17	*-3.24 (6.85)*	*-2.87 (6.27)*	*-4.51 (6.37)*	*-4.38 (6.27)*	*0.18*	*0.08*	*0.64*	*0.01*	*0.71*	*1.0*	*0.00*	*0.84*	*1.0*
2D USI	*ΔLPL (mm)*	23	*-2.10 (2.81)*	*-2.04 (3.58)*	*-0.87 (1.76)*	*-0.84 (1.66)*	*0.12*	*0.10*	*0.80*	*0.00*	*0.89*	*1.0*	*0.00*	*0.95*	*1.0*
	ΔBNH (mm)	23	*0.17 (1.67)*	*0.30 (1.59)*	*0.15 (1.74)*	*0.26 (1.32)*	*0.00*	*0.90*	*1.0*	*0.01*	*0.70*	*1.0*	*0.00*	*0.98*	*1.0*
	ΔLPA (degrees)	23	*4 (7)*	*4 (5)*	*1 (5)*	*1 (5)*	*0.11*	*0.12*	*0.96*	*0.00*	*0.93*	*1.0*	*0.03*	*0.44*	*1.0*

LAM (levator ani muscle); EAS (external anal sphincter), IAP (intra-abdominal pressure), LPL (levator plate length), BHN (bladder neck height), LPA (levator plate angle), Δ (transient change observed during the performance of the hypopressive maneuver), Adjusted p refers to p-values multiplied by 8 to account for the multiple statistical tests.

Caufriez (1997) claimed that the HEs cause a reduction in IAP. We did not find a significant reduction in IAP during the performance of the HE at the first assessment visit, and there was no significant change in the extent of reduction in IAP observed at the second assessment, suggesting that an additional six to eight weeks of practice did not change the physiologic effects of the HE. The effect of the HE on IAP was very small in supine (η_p^2=0.02) and in standing (η_p^2=0.01). No other studies have evaluated IAP during the performance of HEs, and the findings here do not suggest that there is an improvement in the ability to reduce IAP during the HE over a six to eight-week training period.

While the LAMs and the EAS were active during the HEs at the first assessment, the additional training period also failed to enhance the effect of the HE on PFM activation or transient changes in pelvic morphology. Ithamar et al. (2018) and Navarro-Brazalez and colleagues (2017 and 2020b) also reported moderate PFM activation during the performance of HEs among naïve and experienced participants, respectively, but nobody has previously investigated changes in the HE mechanism after a longer period of training.

The HE training period also failed to change the nil effect of incorporating the HP into the HE, as was observed at the initial assessment.

Previous studies on HE interventions have primarily focused on symptoms related to PFDs (Molina-Torres et al., 2023; Soriano et al., 2020), comparing outcomes after an HE intervention to PFMT (Jacomo et al., 2020; Stüpp et al., 2011), or a combination of both (Bernardes et al., 2012; Dierick et al., 2018; Resende et al., 2012). Some RCTs suggest that adding HEs PFMT may generate greater improvements in PFM strength than PFMT alone; however, results have been inconsistent (Bernardes et al., 2012; Dierick et al., 2018; Resende et al., 2012). Three recent randomized controlled trials (RCTs) have found that HE interventions alone may result in improvements in LAM strength (Resende et al., 2019; Navarro-Brazalez et al., 2020a; Jose-Vaz et al., 2020). Others have assessed the quality of life and satisfaction with the intervention (Molina-Torres et al., 2023; Soriano et al., 2020). While we did not investigate the effect of the HE training period on participant satisfaction or quality of life, given that we did not observe increases in LAM strength, it is unclear how HEs may lead to improvements in PFD symptoms or quality of life. Symptomatic improvements reported by Molina-Torres et al. (2023) and Soriano et al. (2020) may not be directly related to the HEs, and may rather be related to a mechanism other than the PFM strength or tones, such as motor control, a placebo effect, or other aspects of the protocol.

4.5.1 Strengths and limitations

To our knowledge, this is the first study to evaluate the impact of a training period on PFM strength and tone, and on the HE mechanism measured concurrently using IAP, muscle activation and pelvic morphology. The repeated-measures design was a strength and the power analysis suggests that, even though our sample was underpowered (65%) relative to the *a priori* sample size estimation, a larger sample would not have yielded substantively different results.

Because the IAP data were not displayed in real time, challenges arose. Notably, there was a malfunction of the IAP sensor in four participants, resulting in incomplete data sets.

While a randomized controlled trial would provide a higher level of evidence for the impact of HE exercises on PFM strength and tone, we deemed it necessary to first complete this interventional cohort study to determine whether or not findings would support a larger-scale RCT. While there is inherent bias in an interventional cohort design, we found no effect of HE training on our primary outcomes, and thus the findings of this study do not support the implementation of a clinical trial. Indeed, the effect sizes for the impact of HE training on all outcomes were small to very small, rendering an RCT unfeasible.

While it could be argued that the training period of eight weeks was relatively short, it was longer than the time typically required to see improvements in force generating capacity attributable to improved contractile efficiency (Schoenfeld et al., 2021).

Studies involving dynamic and advanced postures other than the basic Demeter (supine) and Athenas (standing) may yield different results. However, since most people who begin HE training start with the basic positions and postures tested here, our findings are generalizable to those who enroll in an HE training program and stick with it for at least eight weeks.

Chapter 5: General discussion

Despite that some evidence has pointed to PFM activity during the performance of HEs, previous research has not thoroughly explored several critical aspects of the HE mechanism. Notably, there has been no previous study verifying the proposed effect of the HEs on IAP. Further, studies have not yet explored the association between IAP and the extent of activation of the PFMs, the type of contraction induced by the HE, nor the impact of a period of motor learning on the HE mechanism. This thesis aimed to fill these gaps.

5.1 Summary of findings

In the study described in Chapter 3, we recruited 36 volunteers who were naïve to HEs, provided them with initial training, and collected data after 2 weeks of familiarization. The aim of this study was to understand the possible mechanisms through which HEs might reduce symptoms associated with PFDs. Specifically, we aimed to verify, as suggested by Caufriez (1997), whether IAP decreases during the HE, to determine if the PFMs and abdominal muscles are activated during the maneuver, and, if so, to determine what type of PFM contraction is performed. To achieve this, we used (1) an IAP sensor to quantify intra-abdominal pressure; (2) EMG to assess PFM and abdominal muscle activity; and (3) two-dimensional TPUSI to evaluate transient changes in pelvic morphology. Our findings indicated that the PFMs and abdominal muscles were indeed active during the HEs when performed in supine [44(35)% (LAM), 61(53)% (IOTrA)] and in standing [50(44)% (LAM), 55(43)% (IOTrA)], but that there was no significant reduction in IAP in supine [$d=0.07$, $p=1.0$] or in standing [$d=0.34$, $p=0.70$].

Additionally, we observed small but significant changes in PFM morphology during the HE, including a shortened LPL (-1.9mm supine; -1.8mm in standing), an increased BNH (0.7mm in supine; 0.5mm in standing), and an increased LPA (4.9° in supine; 3.1° in standing), suggesting that the PFM contraction induced during the HE is concentric. Neither body position (supine vs. standing) nor the presence of a hypopressive posture (HP) influenced any of the outcomes measured, and the effect sizes were very small to negligible [e.g., EMG η_p^2 = 0.027 (LAM); η_p^2 = 0.001 (IOTrA)]. These findings suggest that, at least with the beginner postures studied and with minimal training experience, there is no consistent reduction in IAP during the HE, and that, while the PFMs are active, HEs do not provide an optimal stimulus for PFM hypertrophy, generating activation amplitudes of 61% MVC or less. Further, the HP appears to be unimportant to the exercise mechanism.

In Chapter 4, twenty-four participants from the study described in Chapter 3 were asked to continue the HE training for an additional six to eight weeks. The primary objectives were (1) to determine whether, after this time, the PFMs presented with increased strength (improved recruitment efficiency) or higher tone, and (2) to assess whether the longer training period resulted in more marked effects on IAP or PFM activation.

Our findings revealed no evidence of a change in LAM strength [3.6(2.3)N at the initial assessment compared to 2.8(1.4)N at the follow-up] or tone [6.6(1.8)N/mm at the initial assessment compared to 6.1(1.6)N/mm at the follow up] after the six to eight-week period of additional HE training. The LAMs and EAS remained active during the HEs at the second visit [supine (LAM: 71(55)%MVC; EAS: 45(52)%MVC); standing (LAM: 72(75)%MVC; EAS: 35(34)%MVC), but not significantly more than what was observed at the first visit [supine (LAM: 43(40)%MVC, η_p^2 = 0.18, p=0.48; EAS: 28(26)%MVC), η_p^2 = 0.04, p=1.0; standing (LAM: 57(50)%MVC, η_p^2 = 0.05, p=1.0; EAS: 33(32)%MVC, η_p^2 = 0.04, p=1.0)], and transient changes in pelvic organ morphology induced by the HE again suggested that the PFM contractions were concentric [LPL (-2.2mm supine, η_p^2 = 0.08, p=1.0 ; -4.4mm in standing, η_p^2 = 0.12, p=0.8), BNH (0.2mm in supine, η_p^2 = 0.02, p=1.0; 0.3mm in standing, η_p^2 = 0.00, p=1.0), LPA (2.4° in supine, η_p^2 = 0.02, p=1.0; 1.0° in standing, η_p^2 = 0.11, p=0.96)], but with very little muscle shortening, which did not differ from the initial assessment. Consistent with what was observed at the first visit, neither body position (supine vs. standing) nor posture had a significant effect on any outcomes. This second study was an important contribution to the findings, as HEs involve the performance of a novel and complex task which might require time to master, yet it points to a lack of training effect in terms of PFM strength or tone and in terms of task performance.

Taken together, these studies do not support the mechanism through which Caufriez' proposed that the PFMs would contract during the HE, as IAP was not reduced significantly during the task performance. Further, they do not support HEs as an effective approach to improving PFM strength or altering PFM tone.

The work described in this thesis contributes significantly to our knowledge of the intrinsic mechanism of HEs in individuals with female-typical genital anatomy, who are predominantly parous, premenopausal and have relatively low BMI compared to the population, with and without a history of PFD. The findings of this study are relevant to individuals who are new to HE training and engage in the two basic postures for a period of two weeks or at least eight weeks, thus they may not generalize to those with more extensive experience with HEs. Moreover, investigating the impact of incorporating more dynamic and complex postures, rather than limiting the focus to static and basic positions [Demeter (supine), Athenas (standing)], may yield different information on the effectiveness of HEs and the potential benefits of this method across diverse training contexts.

Studies involving the practice of HEs over the course of several weeks are scarce. Only Navarro-Brazalez et al., 2020a conducted an RCT assessing participants immediately after an eight-week HE regimen, as well as at three, six, and twelve months post-intervention. Additionally, Navarro-Brazalez et al., 2020a, Navarro-Brazalez et al., 2020b, Ithamar et al., 2018 attempted to use advanced HPs in addition to the beginner supine and standing postures. Despite these contributions, there remains a notable gap in the literature regarding the effects of HE practice extending beyond twelve consecutive weeks, and a lack of studies employing robust and reliable research methods. Therefore, this fills some gaps in the literature.

5.2 Strengths and limitations

To the authors' knowledge, this is the first study that has evaluated IAP during the HEs. The concurrent measurement of IAP, PFM EMG, and pelvic morphology provides an opportunity to more fully understand the mechanism of HEs. This comprehensive measurement approach was applied to participants who were initially naïve to HEs and then again after they had practiced the HEs for six to eight weeks, providing adequate time for motor learning to occur (VanBeveren and Avers, n.d., Muratori et at., 2013; Adams, J., 1971).

Because the HPs are said to be important to the HE mechanism (Caufriez, 1997), we chose to study IAP while participants performed HEs in two distinct hypopressive postures: Demeter in supine and Athenas in standing (Caufriez, 1997; Rebullido & Pinsach, 2015); as well as in the same body positions but in the absence of the HP. While this decision was based on clinical practice, as these postures are normally considered beginning postures, it is possible that findings might differ if other, more advanced, HPs are used.

In this study, we used an EMG electrode configuration which has demonstrated superiority over commercial probes in terms of motion artifact and crosstalk contamination (Keshwani & McLean, 2012). A differential suction electrode was located intravaginally over the pubovisceralis muscle (Keshwani & McLean, 2012; Keshwani & McLean, 2015) and adhesive electrodes were placed in a differential configuration over the EAS, in alignment with muscle fibre direction, following current best practices (Besomi et al., 2019; Besomi et al., 2020, Dick et al., 2024). Further, we normalized the EMG amplitudes recorded during the HE tasks to that recorded during maximum voluntary activation. This methodological rigor surpasses that used in previous studies on PFM EMG activation during HEs, both in terms of electrode configurations and EMG normalization. Furthermore, this research is pioneering in its concurrent exploration of the impact of HEs on IAP, muscle activation and pelvic morphology.

One challenge associated with this study was the recruitment and retention of participants, which was completed during the Covid-19 pandemic. While we met our target sample size for the study described in Chapter 3, only 24 of the original 36 participants were eligible and agreed to participate in the study described in Chapter 4, which required them to continue with home-based HE training for an additional six to eight weeks, and return for a second data collection session. Of the initial 36 participants enrolled in the first study, four participants were deemed ineligible to continue due to having acquired Covid-19 infection, one was excluded due to becoming pregnant (an exclusion criterion), and four declined to participate due to the time commitment involved. We had originally planned to collect follow-up data after 12 weeks of training, allowing for an investigation of improvements in PFM force-generating capacity due to hypertrophic changes; however, this was not feasible within the context of the pandemic. We thus reduced the follow-up to a minimum of six and a maximum of eight weeks to mitigate data loss due to illness-related attrition. As such, the extended training period was not long enough to be confident that changes in pelvic floor muscle force-generating capacity were due to training effects (VanBeveren and Avers, n.d.), only improvements in motor control or contractile efficiency (Schoenfeld et al., 2021). It remains possible that the HE training could induce hypertrophy of the PFMs after a longer period of training, however, based on the findings of this study, where the PFMs showed, if anything, a reduction in strength after six to eight weeks, this is unlikely.

While the inclusion of IAP as a primary outcome was a strength, we experienced a malfunction with the IAP sensor in four participants. Although each IAP sensor was calibrated and tested before the start of each data collection session, the IAP data are streamed to an on-board SD card and are later transferred to a computer after the data collection is complete. Consequently, we were unable to verify the data in real-time. Future use of the IAP sensor should include a real-time display of the IAP data, mitigating the risk of data loss.

The researcher conducting this study was not blinded, which introduces a risk of bias. Although an RCT would provide a higher level of evidence regarding the impact of HEs on PFM strength and tone, we opted to begin with this interventional cohort study to assess whether the results would justify a larger-scale RCT. Given that HE training had no significant impact on the primary outcomes and the effect sizes across all outcomes were small to negligible, we conclude that an RCT would not be feasible.

5.3 Clinical implications

The findings of this thesis do not support claims made by Caufriez regarding the mechanism of action of the HEs. Indeed, IAP did not significantly reduce during the respiratory maneuver performed with or outside of the HP, even after a period of training that would be considered adequate to see improvements in motor control. Interestingly, the PFMs are active to a moderate extent throughout the HE, with no additional recruitment associated with a training period beyond the initial two weeks. While the training period was shorter than the minimum normally required to induce hypertrophy, there was no evidence of improved efficiency or effectiveness of voluntary PFM activation, and there were no changes in PFM tone after six to eight weeks of HE training. Further, we found no association between the extent of reduction in IAP achieved during the HE and the amplitude of PFM activation observed concurrently. In sum, HEs do not appear to be an effective way to train PFM strength. The benefits of HE may be unrelated to the impact of the training approach on PFM strength and/or tone.

The findings of this study are consistent with two recent studies (Ithamar et al., 2018; Navarro-Brazalez et al., 2020b) that reported moderate levels of PFM and abdominal muscle activation during the performance of HEs. Ithamar et al. (2018) further observed a correlation between the extent of activation of the PFMs and that of the transverse abdominus muscle, suggesting that these muscles work synergistically during the HE maneuver. The study by Navarro-Brazalez et al. (2020b) also reported PFM activation during the HE. Because they used an electrode configuration that did not follow the current Consensus for Experimental Designs in Electromyography (CEDE) recording guidelines (Besomi et al., 2019; Besomi et al., 2020, Dick et al., 2024), it was important to confirm the results using improved methods. The current study and these two previous studies identified a moderate amount of PFM activation during the HE, which would not be expected to be as effective as deliberate, MVCs to hypertrophy the PFMs. While it is not clear whether there is an optimal functional transfer between voluntary PFMT and automatic activation of the PFMs during tasks that raise IAP, a period of six to eight weeks of HE training did not enhance the extent of PFM activation observed during HE training and did not result in improved PFM force generating capacity.

In contrast to the findings of this study, Molina-Torres et al. (2023) recently reported through a large RCT (n=117) a moderate improvement (Cohen's d=0.79) in PFM strength among women who performed HEs (n=62) for a period of 8 weeks, performed for 20 minutes twice a week compared to a control group (n=55) who did not receive any intervention and were instructed to refrain from engaging in physical activities beyond their routine daily living activities. Similar to the present study, participants in Molina-Torres et al. (2023) began with no experience with the HE technique and engaged in an 8-week training regimen. However, Molina-Torres et al. (2023) employed the MOS for assessing PFM strength, which, as noted previously, is not recommended as an objective outcome (Bø & Finckenhagen, 2001; Ferreira et al. 2011). Additionally, their exercise protocol included nine progressive dynamic postures, performed in various positions—standing, seated, quadruped, and supine. It is not clear how the differences between the study design, measurement approach or exercise program may have contributed to the observed differences in outcomes.

Hypopressive exercises have been suggested as a potentially beneficial tool for improving quality of life based on the Pelvic Floor Impact Questionnaire - Short Form (PFIQ-7) (Navarro-Brazalez et al., 2020a), body image, well-being and satisfaction with PFD symptoms and overall HE training techniques measured by customized questionnaire (Soriano et al., 2020), lumbar spine flexibility (Bellido-Fernández et al, 2018), and respiratory capacity (Barresi-Laloutre & Hernández-Vian, 2021). While the focus of this study was on the exercise mechanism and not its effectiveness for the management of PFDs, based on our findings, it remains unclear how HE training might enhance continence control or pelvic organ support.

It was also important to critically evaluate the use of HPs and assess their actual relevance. According to our findings, the HP appears to be irrelevant to the exercise mechanism, when considering the extent of reduction in IAP, the extent of activation of the PFMs and the extent of transient change in pelvic morphology achieved during the respiratory maneuver. As noted above, these findings are generalizable only to the two HPs studied here.

5.4 Conclusion

Our investigation showed that an eight-week HE training protocol did not result in significant changes in PFM strength or tone among those with female-typical pelvic floor anatomy. Furthermore, when performed two weeks after initial HE training, the HE did not generate a reduction in IAP but did cause activation in the PFMs. The additional six to eight weeks of training did not improve participants' ability to effectively reduce IAP during the HE, nor enhance PFM and abdominal muscle activation during the HE, whether performed in a supine or standing position, with or without the incorporation of an HP. While it is plausible to consider exploring alternative HE training protocols with a longer intervention periods and/or advanced postures, the findings do not support the HE mechanism put forth by Caufriez (1997) nor the utility of HEs for improving contractile force or tone in the PFMs.

References

1) Abrams, P., Avery, K., Gardener, N., & Donovan, J. (2006). The International Consultation on Incontinence Modular Questionnaire: www.iciq.net. *Journal of Urology, 175*(3), 1063–1066. https://doi.org/10.1016/S0022-5347(05)00348-4

2) Adams, J. A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior, 3*(2), 111–149. https://doi.org/10.1080/00222895.1971.10734898

3) Alonso-Calvete, A., Cuña-Carrera, I., & González, Y. (2019). Efectos de un programa de ejercicios abdominales hipopresivos: Un estudio piloto. *Medicina Naturista, 13*, 38–43.

4) Ashton-Miller, Howard, D., & DeLancey, J. O. (2001). The Functional Anatomy of the Female Pelvic Floor and Stress Continence Control System. Scandinavian Journal of Urology and Nephrology, 35(207), 1–7. https://doi.org/10.1080/003655901750174773

5) Aytan, H., Ertunç, D., Tok, E. C., Yaşa, O., & Nazik, H. (2014). Prevalence of pelvic organ prolapse and related factors in a general female population. Turkish Journal of Obstetrics and Gynecology, 11(3), 176–180. https://doi.org/10.4274/tjod.90582

6) Barresi Leloutre, I. M., & Hernández Vian, O. (2021). Efectos de un programa de entrenamiento de Hypopressive RSF Reprogramación Sistémica Funcional en mujeres sanas [Effects of a Hypopressive Exercise training program on healthy women]. *Retos: Nuevas tendencias en educación física, deporte y recreación, 39*(39), 120–124. https://doi.org/10.47197/retos.v0i39.73533

7) Bellido-Fernández, L., Jiménez-Rejano, J. J., Chillón-Martínez, R., Gómez-Benítez, M. A., De-La-Casa-Almeida, M., & Rebollo-Salas, M. (2018). Effectiveness of Massage Therapy and Abdominal Hypopressive Gymnastics in Nonspecific Chronic Low Back Pain: A Randomized Controlled Pilot Study. Evidence-based complementary and alternative medicine: eCAM, 2018, 3684194. https://doi.org/10.1155/2018/3684194

8) Bernard, S., Boucher, S., McLean, L., & Moffet, H. (2020). Mobile technologies for the conservative self-management of urinary incontinence: A systematic scoping review. *International Urogynecology Journal, 31*(6), 1163–1174. https://doi.org/10.1007/s00192-019-04012-w

9) Bernardes, B. T., Resende, A. P., Stüpp, L., & others. (2012). Efficacy of pelvic floor muscle training and hypopressive exercises for treating pelvic organ prolapse in women: Randomized controlled trial. *São Paulo Medical Journal, 130*(1), 5–9. https://doi.org/10.1590/S1516-31802012000100002

10) Bérubé, M. È., Czyrnyj, C. S., & McLean, L. (2018). An automated intravaginal dynamometer: Reliability metrics and the impact of testing protocol on active and passive forces measured from the pelvic floor muscles. Neurourology and urodynamics, 37(6), 1875–1888. https://doi.org/10.1002/nau.23575

11) Bérubé, M. È., & McLean, L. (2023). Differences in pelvic floor muscle morphology and function between female runners with and without running-induced stress urinary incontinence. *Neurourology and urodynamics*, *42*(8), 1733–1744. https://doi.org/10.1002/nau.25274

12) Bérubé, M.-È., & McLean, L. (2024). The acute effects of running on pelvic floor morphology and function in runners with and without running-induced stress urinary incontinence. *International Urogynecology Journal, 35*(1), 127–138. https://doi.org/10.1007/s00192-023-05674-3

13) Besomi, M., Hodges, P. W., Van Dieën, J., Carson, R. G., Clancy, E. A., Disselhorst-Klug, C., & others. (2019). Consensus for experimental design in electromyography (CEDE) project: Electrode selection matrix. *Journal of Electromyography and Kinesiology, 48*, 128–144.

14) Besomi, M., Hodges, P. W., Clancy, E. A., & others. (2020). Consensus for experimental design in electromyography (CEDE) project: Amplitude normalization matrix. *Journal of Electromyography and Kinesiology, 53*, 102438. https://doi.org/10.1016/j.jelekin.2020.102438

15) Bø, K. (2020). Physiotherapy management of urinary incontinence in females. *Journal of Physiotherapy, 66*(3), 147–154. https://doi.org/10.1016/j.jphys.2020.06.011

16) Bø, K., Anglès-Acedo, S., Batra, A., Brækken, I. H., Chan, Y. L., Jorge, C. H., Kruger, J., Yadav, M., & Dumoulin, C. (2023). Are hypopressive and other exercise programs effective for the treatment of pelvic organ prolapse? *International Urogynecology Journal*, *34*(1), 43–52. https://doi.org/10.1007/s00192-022-05407-y

17) Bø, K., & Finckenhagen, H. B. (2001). Vaginal palpation of pelvic floor muscle strength: Inter-test reproducibility and comparison between palpation and vaginal squeeze pressure. *Acta Obstetricia et Gynecologica Scandinavica, 80*, 883. https://doi.org/10.1080/791200641

18) Bø, K., Frawley, H. C., Haylen, B. T., Abramov, Y., Almeida, F. G., Berghmans, B., & others. (2017). An International Urogynecological Association (IUGA)/International Continence Society (ICS) joint report on the terminology for the conservative and nonpharmacological management of female pelvic floor dysfunction. *Neurourology and Urodynamics, 36*(2), 221–244. https://doi.org/10.1002/nau.23107

19) Bø, K., & Herbert, R. D. (2009). When and how should new therapies become routine clinical practice? *Physiotherapy*, *95*(1), 51–57. https://doi.org/10.1016/j.physio.2008.12.001

20) Bø, K., & Herbert, R. D. (2013). There is not yet strong evidence that exercise regimens other than pelvic floor muscle training can reduce stress urinary incontinence in women: a systematic review. Journal of Physiotherapy, 59(3), 159–168. https://doi.org/10.1016/S1836-9553(13)70180-2

21) Caufriez, M. Gymnastique abdominale hypopressive. Brussels: Ed. Bruxelles, 1997.

22) Caufriez M, Fernández JC, Guignel G, et al. (2007) Comparación de las variaciones de presión abdominal en medio acuático y aéreo durante la realización de cuatro ejercicios abdominales hipopresivos. Rev Iberoam Fisioter y Kinesiol, 10(1):12–23.

23) Charette, M., & McLean, L. (2024). Geographic accessibility to pelvic health physiotherapy services across Ontario: A geographic information system analysis. *Physiotherapy Canada*. https://doi.org/10.3138/ptc-2023-0114

24) Coleman, T. J., Thomsen, J. C., Maass, S. D., Hsu, Y., Nygaard, I. E., & Hitchcock, R. W. (2012). Development of a wireless intra-vaginal transducer for monitoring intra-abdominal pressure in women. *Biomedical Microdevices, 14*, 347–355. https://doi.org/10.1007/s10544-011-9611-x

25) Costa, T. F., Resende, A. P. M., Seleme, M. R., Stüpp, L., Castro, R. A., Berghmans, B., Sartori, M. G. F. (2011). Hypopressive gymnastics as a resource for perineal proprioception in women with urinary incontinence. Fisioterapia Brasil, 365. 10.33233/fb.v12i5.940.

26) Czyrnyj, C. S., Bérubé, M., Varette, K., & McLean, L. (2019). The impact of a familiarization session on the magnitude and stability of active and passive pelvic floor muscle forces measured through intravaginal dynamometry. *Neurourology and Urodynamics, 38*(3), 902–911. https://doi.org/10.1002/nau.23937

27) Czyrnyj, Bérubé, M., Lanteigne, E., Brennan, A., Bader, Y., Lomovtsev, D., Vandermolen, M., Boucher, S., Mitri, L., & McLean, L. (2021). Design and validation of an automated dual-arm instrumented intravaginal dynamometer. Neurourology and Urodynamics, 40(2), 604–615. https://doi.org/10.1002/nau.24600

28) Deslauriers, S., Raymond, M. H., Laliberte, M., Lavoie, A., Desmeules, F., Feldman, D. E., & others. (2017). Access to publicly funded outpatient physiotherapy services in Quebec: Waiting lists and management strategies. *Disability and Rehabilitation, 39*(26), 2648–2656. https://doi.org/10.1080/09638288.2016.1238967

29) Dick JM, Tucker T, Hug F, et al. Consensus for experimental design in electromyography (CEDE) project: Application of EMG to estimate muscle force. J Electromyogr Kinesiol. 2024. doi:10.1016/j.jelekin.2024.102910

30) Dietz HP. Ultrasound imaging of the pelvic floor. I. Two-dimensional aspects. Ultrasound Obstet Gynecol. 2004;23:80-92. doi:10.1002/uog.939

31) Doumouchtsis, S. K., de Tayrac, R., Lee, J., Daly, O., Melendez-Munoz, J., Lindo, F. M., Cross, A., White, A., Cichowski, S., Falconi, G., & Haylen, B. (2023). An International Continence Society (ICS)/ International Urogynecological Association (IUGA) joint report on the terminology for the assessment and management of obstetric pelvic floor disorders. *International Urogynecology Journal*, *34*(1), 1–42. https://doi.org/10.1007/s00192-022-05397-x

32) Dierick, F., Galtsova, E., Lauer, C., & others. (2018). Clinical and MRI changes of puborectalis and iliococcygeus after a short period of intensive pelvic floor muscle training with or without instrumentation: A prospective randomized controlled trial. *European Journal of Applied Physiology, 118*(8), 1661–1671. https://doi.org/10.1007/s00421-018-3899-7

33) Dumoulin C., Hay-Smith E. J., Mac Habée-Séguin G. (2014). Pelvic floor muscle training versus no treatment, or inactive control treatments, for urinary incontinence in women. Cochrane Database of Systematic Reviews 5: CD005654.

34) Dumoulin, C., Morin, M., Danieli, C., Cacciari, L., Mayrand, M. H., Tousignant, M., Abrahamowicz, M., & Urinary Incontinence and Aging Study Group (2020). Group-Based vs Individual Pelvic Floor Muscle Training to Treat Urinary Incontinence in Older Women: A Randomized Clinical Trial. JAMA internal medicine, 180(10), 1284–1293. https://doi.org/10.1001/jamainternmed.2020.2993

35) Dumoulin, C., Cacciari, L. P., & Hay-Smith, E. (2018). Pelvic floor muscle training versus no treatment, or inactive control treatments, for urinary incontinence in women. The Cochrane

database of systematic reviews, 10(10), CD005654. https://doi.org/10.1002/14651858.CD005654.pub4

36) Ferreira, C. H., Barbosa, P. B., de Oliveira, S. F., Antônio, F. I., Franco, M. M., & Bø, K. (2011). Inter-rater reliability study of the modified Oxford grading scale and the Peritron manometer. *Physiotherapy, 97*(2), 132–138. https://doi.org/10.1016/j.physio.2010.06.007

37) Gordon, T., Thomas, C. K., Munson, J. B., & Stein, R. B. (2004). The resilience of the size principle in the organization of motor unit properties in normal and reinnervated adult skeletal muscles. *Canadian Journal of Physiology and Pharmacology, 82*(8-9), 645–661. https://doi.org/10.1139/y04-081

38) Henneman, E., Somjen, G., & Carpenter, D. O. (1965). Functional significance of cell size in spinal motoneurons. *Journal of Neurophysiology, 28*(3), 560–580. https://doi.org/10.1152/jn.1965.28.3.560

39) Hermens, H. J., Freriks, B., Disselhorst-Klug, C., & Rau, G. (2000). Development of recommendations for SEMG sensors and sensor placement procedures. Journal of Electromyography and Kinesiology, 10(5), 361–374. https://doi.org/10.1016/S1050-6411(00)00027-4

40) Hodges, P. W., Sapsford, R., & Pengel, L. H. (2007). Postural and respiratory functions of the pelvic floor muscles. *Neurourology and urodynamics*, *26*(3), 362–371. https://doi.org/10.1002/nau.20232

41) Ithamar, L., de Moura Filho, A. G., Benedetti Rodrigues, M. A., Duque Cortez, K. C., Machado, V. G., de Paiva Lima, C. R. O., Moretti, E., & Lemos, A. (2018). Abdominal and pelvic floor electromyographic analysis during abdominal hypopressive gymnastics. *Journal of Bodywork and Movement Therapies*, *22*(1), 159–165. https://doi.org/10.1016/j.jbmt.2017.06.011

42) Jacomo, Nascimento, T. R., Lucena da Siva, M., Salata, M. C., Alves, A. T., da Cruz, P. R. C., & Batista de Sousa, J. (2020). Exercise regimens other than pelvic floor muscle training cannot

increase pelvic muscle strength-a systematic review. Journal of Bodywork and Movement Therapies, 24(4), 568–574. https://doi.org/10.1016/j.jbmt.2020.08.005

43) Jose-Vaz, L. A., Andrade, C. L., Cardoso, L. C., Bernardes, B. T., Pereira-Baldon, V. S., & Resende, A. P. M. (2020). Can abdominal hypropressive technique improve stress urinary incontinence? an assessor-blinded randomized controlled trial. *Neurourology and Urodynamics*, *39*(8), 2314–2321. https://doi.org/10.1002/nau.24489

44) Juez, Núñez-Córdoba, J. M., Couso, N., Aubá, M., Alcázar, J. L., & Mínguez, J. Á. (2019). Hypopressive technique versus pelvic floor muscle training for postpartum pelvic floor rehabilitation: A prospective cohort study. Neurourology and Urodynamics, 38(7), 1924–1931. https://doi.org/10.1002/nau.24094

45) Katz, C. M. S., & Barbosa, C. P. (2024). Effects of hypopressive exercises on pelvic floor and abdominal muscles in adult women: A systematic review of randomized clinical trials. *Journal of Bodywork and Movement Therapies*, *37*, 38–45. https://doi.org/10.1016/j.jbmt.2023.03.003

46) Kegel, A. H. (1949). The physiologic treatment of poor tone and function of the genital muscles and of urinary stress incontinence. Western journal of surgery, obstetrics, and gynecology, 57(11), 527–535.

47) Keshwani, N., McLean, L., A differential suction electrode for recording electromyographic activity from the pelvic floor muscles: crosstalk evaluation. *J Electromyogr Kinesiol* 2013: 23(2): 311-318. DOI: 10.1016/j.jelekin.2012.10.016. Pubmed ID: 23218961.

48) Keshwani, N., McLean, L. (2015). State of the art review: Intravaginal probes for recording electromyography from the pelvic floor muscles. Neurourology and Urodynamics, 34(2), 104–112. https://doi.org/10.1002/nau.22529

49) Liebergall-Wischnitzer, M., Hochner-Celnikier, D., Lavy, Y., Manor, O., Arbel, R., & Paltiel, O. (2005). Paula method of circular muscle exercises for urinary stress incontinence--a clinical

trial. *International urogynecology journal and pelvic floor dysfunction*, *16*(5), 345–351. https://doi.org/10.1007/s00192-004-1261-6

50) Lieberman, M. D., & Cunningham, W. A. (2009). Type I and Type II error concerns in fMRI research: Re-balancing the scale. *Social Cognitive and Affective Neuroscience, 4*(4), 423–428. https://doi.org/10.1093/scan/nsp052

51) Madill, S. J., & McLean, L. (2008). Quantification of abdominal and pelvic floor muscle synergies in response to voluntary pelvic floor muscle contractions. *Journal of Electromyography and Kinesiology, 18*(6), 955–964. https://doi.org/10.1016/j.jelekin.2007.05.001

52) Martín-Rodríguez, S., & Bø, K. (2019). Is abdominal hypopressive technique effective in the prevention and treatment of pelvic floor dysfunction? Marketing or evidence from high-quality clinical trials? British Journal of Sports Medicine, 53(2), 135–136. https://doi.org/10.1136/bjsports-2017-098046

53) Martins Rodrigues, I., Lopes, A. L., Silvatti, A., & Sarro, K. (2024). Current evidence for hypopressive exercises in healthy women: A systematic review. *Journal of Bodywork and Movement Therapies, 38*, 10–19. https://doi.org/10.1016/j.jbmt.2024.01.012

54) Mateus-Vasconcelos, E. C. L., Ribeiro, A. M., Antônio, F. I., Brito, L. G. de O., & Ferreira, C. H. J. (2018). Physiotherapy methods to facilitate pelvic floor muscle contraction: A systematic review. Physiotherapy Theory and Practice, 34(6), 420–432. https://doi.org/10.1080/09593985.2017.1419520

55) McLean L, Thibault-Gagnon S, Brooks K, et al. Differences in pelvic morphology between women with and without provoked vestibulodynia. J Sex Med. 2016;13:963-971. doi:10.1016/j.jsxm.2016.04.066

56) Molina-Martínez, E., Sánchez-García, J. C., Merino-García, E., Montes-Tejada, A., Rodriguez-Blanque, R. (2019). Hipopressive abdominal exercises in pospartum period. Journal of Negative & No Positive Results, 4(4), 409–421. https://doi.org/10.19230/jonnpr.2951

57) Molina-Torres, G., Moreno-Muñoz, M., Rebullido, T. R., Castellote-Caballero, Y., Bergamin, M., Gobbo, S., Hita-Contreras, F., & Cruz-Diaz, D. (2023). The effects of an 8-week hypopressive exercise training program on urinary incontinence and pelvic floor muscle activation: A randomized controlled trial. *Neurourology and Urodynamics*, *42*(2), 500–509. https://doi.org/10.1002/nau.25110

58) Morin, M., Dumoulin, C., Bourbonnais, D., Gravel, D., & Lemieux, M.-C. (2004). Pelvic floor maximal strength using vaginal digital assessment compared to dynamometric measurements. *Neurourology and Urodynamics*, *23*(4), 336–341. https://doi.org/10.1002/nau.20021

59) Muratori, L. M., Lamberg, E. M., Quinn, L., & Duff, S. V. (2013). Applying principles of motor learning and control to upper extremity rehabilitation. *Journal of Hand Therapy, 26*(2), 94–103. https://doi.org/10.1016/j.jht.2012.12.007

60) Navarro-Brazález, Prieto-Gómez, V., Prieto-Merino, D., Sánchez-Sánchez, B., McLean, L., & Torres-Lacomba, M. (2020a). Effectiveness of Hypopressive Exercises in Women with Pelvic Floor Dysfunction: A Randomised Controlled Trial. Journal of Clinical Medicine, 9(4), 1149–. https://doi.org/10.3390/jcm9041149

61) Navarro-Brazález, Sánchez-Sánchez, B., Prieto-Gómez, V., De La Villa Polo, P., McLean, L., & Torres-Lacomba, M. (2020b). Pelvic floor and abdominal muscle responses during hypopressive exercises in women with pelvic floor dysfunction. Neurourology and Urodynamics, 39(2), 793–803. https://doi.org/10.1002/nau.24284

62) Navarro-Brazález, B., Torres-Lacomba, M., Arranz-Martín, B., & Sánchez-Méndez, Ó. (2017). Muscle response during a hypopressive exercise after pelvic floor physiotherapy: Assessment with transabdominal ultrasound. *Fisioterapia, 39*, 187–194. https://doi.org/10.1016/j.ft.2017.04.003

63) Niederauer, de Gennaro, J., Nygaard, I., Petelenz, T., & Hitchcock, R. (2017). Development of a novel intra-abdominal pressure transducer for large scale clinical studies. Biomedical Microdevices, 19(4), 80–10. https://doi.org/10.1007/s10544-017-0211-2

64) Pilates, Joseph (1998) [1945]. *Pilates' Return to Life through Contrology*. Incline Village: Presentation Dynamics. pp. 12–14. ISBN 978-0-9614937-9-0.

65) Price N, Jackson S, Avery K, Brookes S, Abrams P. Development and psychometric evaluation of the ICIQ Vaginal Symptoms Questionnaire: the ICIQ-VS. BJOG. 2006;113(6):700-712. doi:10.1111/j.1471-0528.2006.00938.x

66) Quartly, Hallam, T., Kilbreath, S., & Refshauge, K. (2010). Strength and endurance of the pelvic floor muscles in continent women: An observational study. Physiotherapy, 96(4), 311–316. https://doi.org/10.1016/j.physio.2010.02.008

67) Rebullido, T., Sousa, L., Garcia, E., & Pinsach, P. (2014). Efectos inmediatos de una sesión de ejercicios hipopresivos en diferentes parámetros corporales. *Cuestiones de Fisioterapia: Revista Universitaria de Información e Investigación en Fisioterapia, 43*, 13.

68) Rebullido, T. R., & Pinsach, P. (2015). *Hypopressive techniques*. Cardeñoso.

69) Resende, Stüpp, L., Bernardes, B. T., Oliveira, E., Castro, R. A., Girão, M. J. B. C., & Sartori, M. G. F. (2012). Can hypopressive exercises provide additional benefits to pelvic floor muscle training in women with pelvic organ prolapse?: Hypopressive Exercises and Pelvic Floor. Neurourology and Urodynamics, 31(1), 121–125. https://doi.org/10.1002/nau.21149

70) Resende, A. P. M., Bernardes, B. T., Stüpp, L., Oliveira, E., Castro, R. A., Girão, M. J. B., & Sartori, M. G. (2019). Pelvic floor muscle training is better than hypopressive exercises in pelvic organ prolapse treatment: An assessor-blinded randomized controlled trial. Neurourology and Urodynamics, 38(1), 171–179. https://doi.org/10.1002/nau.23819

71) Rosenbluth EM, Johnson PJ, Hitchcock RW, Nygaard IE. Development and testing of a vaginal pressure sensor to measure intra-abdominal pressure in women. Neurourol Urodyn. 2010;29(4):532-535. doi:10.1002/nau.20794

72) Ruiz de Viñaspre Hernández, R. (2018). Efficacy of hypopressive abdominal gymnastics in rehabilitating the pelvic floor of women: A systematic review. *Actas Urológicas Españolas (English Edition)*, *42*(9), 557–566. https://doi.org/10.1016/j.acuroe.2018.09.001

73) Sáez, M., Rebullido, T., Chulvi-Medrano, I., Luis, J., Soidán, J. L., & Cortell-Tormo, J. (2016). Can an eight-week program based on the hypopressive technique produce changes in pelvic floor function and body composition in female rugby players? *Retos: Nuevas tendencias en educación física, deporte y recreación, 30*, 26-29.

74) Shaw, C., Cahill, J., & Wagg, A. (2020). The current state of continence in Canada: a population representative epidemiological survey. *The Canadian journal of urology*, *27*(4), 10300–10305.

75) Schoenfeld, B. J., Grgic, J., Van Every, D. W., & Plotkin, D. L. (2021). Loading Recommendations for Muscle Strength, Hypertrophy, and Local Endurance: A Re-Examination of the Repetition Continuum. *Sports (Basel, Switzerland)*, *9*(2), 32. https://doi.org/10.3390/sports9020032

76) Soriano, L., González-Millán, C., Álvarez Sáez, M. M., Curbelo, R., & Carmona, L. (2020). Effect of an abdominal hypopressive technique program on pelvic floor muscle tone and urinary incontinence in women: A randomized crossover trial. *Physiotherapy, 108*, 37–44. https://doi.org/10.1016/j.physio.2020.02.004

77) Stokes, Gardner-Morse, M. G., & Henry, S. M. (2011). Abdominal muscle activation increases lumbar spinal stability: Analysis of contributions of different muscle groups. Clinical Biomechanics (Bristol), 26(8), 797–803. https://doi.org/10.1016/j.clinbiomech.2011.04.006

78) Stüpp, L., Resende, A. P. M., Petricelli, C. D., Nakamura, M. U., Alexandre, S. M., & Zanetti, M. R. D. (2011). Pelvic floor muscle and transversus abdominis activation in abdominal hypopressive technique through surface electromyography. Neurourology and Urodynamics, 30(8), 1518–1521. https://doi.org/10.1002/nau.21151

79) Subak, L. L., Waetjen, L. E., van den Eeden, S., Thom, D. H., Vittinghoff, E., & Brown, J. S. (2001). Cost of pelvic organ prolapse surgery in the United States. Obstetrics and Gynecology (New York. 1953), 98(4), 646–651. https://doi.org/10.1016/S0029-7844(01)01472-7

80) The Canadian Continence Foundation (2007) Incontinence: a Canadian Perspective.

81) Updated cost figures from The Canadian Continence Foundation (2007) Incontinence: a Canadian Perspective.

82) VanBeveren, P. J., & Avers, D. (n.d.). Exercise and physical activity for older adults. In *Geriatric physical therapy* (pp. 64–85). https://doi.org/10.1016/B978-0-323-02948-3.00014-6

83) Vickerstaff, V., Omar, R. Z., & Ambler, G. (2019). Methods to adjust for multiple comparisons in the analysis and sample size calculation of randomised controlled trials with multiple primary outcomes. *BMC Medical Research Methodology*, *19*(1), 129–129. https://doi.org/10.1186/s12874-019-0754-4

84) Wright, S. P. (1992). Adjusted P-Values for Simultaneous Inference. *Biometrics*, *48*(4), 1005–1013. https://doi.org/10.2307/2532694

Appendix A: Certificate of Ethics Approval

09/03/2022

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE I CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number	H-12-19-5270
Titre du projet / Project Title	What transient effects does the performance of a hypopressive exercise have on intra-abdominal pressure and on pelvic floor muscle activation in females?
Type de projet / Project Type	Recherche de professeur / Professor's research project
Statut du projet / Project Status	Renouvelé / Renewed
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	11/03/2020
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	10/03/2023

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Linda MCLEAN	École des sciences de la réadaptation / School of Rehabilitation Sciences	Chercheur Principal / Principal Investigator
Flavia ANTONIO	École des sciences de la réadaptation / School of Rehabilitation Sciences	Assistant de recherche / Research Assistant
Silvia SARAIVA	École des sciences de l'activité physique / School of Human Kinetics	Assistant de recherche / Research Assistant

Conditions spéciales ou commentaires / Special conditions or comments

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Université d'Ottawa

Bureau d'éthique et d'intégrité de la recherche

University of Ottawa

Office of Research Ethics and Integrity

Le Comité d'éthique de la recherche (CÉR) de l'Université d'Ottawa, opérant conformément à l'*Énoncé de politique des Trois conseils* (2014) et toutes autres lois et tous règlements applicables, a examiné et approuvé la demande d'éthique du projet de recherche ci-nommé.

L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout évènement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completedfour weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

Safaa LAMHOUJEB
Coordonnateur de l'éthique / Ethics Coordinator
Pour/For **Daniel LAGAREC** Président(e) du/ Chair of the **Comité d'éthique de la recherche en sciences de la santé et sciences / Health Sciences and Sciences Research Ethics Board**

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Appendix B: Recruitment E-mail (English)

Hello [participant's name],

Thank you for your interest in participating in our research entitled " What transient effects does the performance of a hypopressive exercise have on intra-abdominal pressure and on pelvic floor muscle activation in females?"

Inclusion criteria:

- Female (AFAB)
- > 18 years old and not yet premenopausal
- Not experience pelvic pain during gynecological speculum exams, tampon insertion or intercourse
- No history of pelvic surgery (e.g.: prolapse repair or mesh)
- Not being pregnant or been pregnant for the past 6 months
- Not be experienced with hypopressive exercise OR have practiced hypopressive exercise for at least 12 weeks
- Be fully vaccinated against COVID-19.

The commitment:

For participants without previous experience with hypopressive exercises, the study will involve 4 sessions: 1 exercise familiarization session (45 mins), 1 follow up to ensure that the exercises are being performed correctly (15 mins) and 2 data collection sessions (2-2.5 hours each) 12 weeks apart.

For participants who regularly practice hypopressive exercises, 1 data collection session (2-2.5 hours).

All visits will be at the MFM Laboratory at the University of Ottawa Lee's Campus, except visit 2 (15min) which can be offered via Zoom.

Next steps:

If you would like to participate and are within our inclusion criteria, I will send you the Letter of Information and will book your first appointment.

Should you have any questions, please do not hesitate to contact me.

Thank you,

Silvia Saraiva

Appendix C: Letter of Information (English)

uOttawa

Labo Lab McLean Function & Measurement

Université d'Ottawa
Faculté des sciences de la santé

École des sciences de la réadaptation

University of Ottawa
Faculty of Health Sciences

School of Rehabilitation Sciences

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Letter of Information

Title of the Study: What transient effects does the performance of a hypopressive exercise have on intra-abdominal pressure and on pelvic floor muscle activation in females?

Principal Investigator: Linda McLean, PhD, Full Professor, School of Rehabilitation Sciences, University of Ottawa. 613-562-5800 ext 2544.

Study investigators: Post-doctoral fellow Flavia Ignacio Antonio and the research assistant Silvia Saraiva, School of Rehabilitation Sciences, University of Ottawa, 613-562-5800 ext 4102.

Background Information

The pelvic floor muscles, which are located at the base of the pelvis, are important in helping to maintain bladder control and to support the pelvic organs, but their role is not well understood. Pelvic floor disorders primarily include involuntary leakage of urine and pelvic organ descent, and they affect the health and quality of life of many women. Intra-abdominal pressure may be linked to the development of pelvic floor disorders, as increases in intra-abdominal pressure during activities such as coughing or lifting heavy objects may strain the pelvic floor muscles and connective tissues.

Pelvic floor muscle exercises have been shown to be effective in the prevention and treatment of pelvic floor disorders. A newer form of exercise, called hypopressive exercises, a postural and respiratory training with abdominal voluntary suction, has been adopted in Europe as an alternative to traditional pelvic floor muscle training. This modality is described as a relaxation of the breathing muscles followed by the performance of a maneuver to reduce intra-abdominal pressure, which is said to activate both the abdominal muscles and the pelvic floor muscles through reflex pathways. Despite this, current research into the effectiveness of Hypopressive Exercises as a means of managing pelvic floor disorders is limited and results are varied. Indeed the proposed mechanism of action of this maneuver has yet to be demonstrated. Thus, the purpose of this study is to determine whether the abdominal hypopressive maneuver indeed reduce intra-abdominal pressure or activate the abdominal and pelvic floor muscles.

The research ethics board from the University of Ottawa has reviewed the ethical components of this study and has found it to be in compliance with national standards. If you choose to participate in the study, you will be required to sign the consent form that follows, indicating your consent to undergo the assessment procedures described here.

We aim to recruit a total of 60 female volunteers to participate in this study on a first-come, first- served basis. If you are interested in participating, you must be over the age of 18, and you must not experience pain with tampon insertion or during a gynecological speculum exam.

The study will involve four visits to the laboratory if you are not already familiar with hypopressive exercises and regularly practicing them, or one visit to the laboratory if you have experience with hypopressive exercise and have been training using this approach for at least 3 months on average 2-3 times per week. The laboratory visits will occur at the McLean Function & Measurement Lab (MFM Lab) at the University of Ottawa at 200 Lees Ave. in Room E155D. The sessions will be scheduled at your convenience. If you are required to undergo training, the first two visits will be training sessions lasting 45 minutes then 15-30 minutes, respectively. The third and fourth sessions will be the data collection sessions and will last approximately two hours. Women who regularly perform hypopressive exercises will only attend one session in the laboratory for data collection and will fill out questionnaires on the same day. These sessions are described in more details below:

1) **First training session:** The first session will be scheduled with a qualified instructor on the theory of Hypopressive Exercises and you will learn how to do the exercises. You will need to wear clothes appropriate for exercise. At the end of the session, you will be asked to practice the exercises around 5-10 minutes daily, over the course of the week. On this session, you will also be asked to fill out 2 questionnaires: International Consultation on Incontinence Questionnaire Female Lower Urinary Tract Symptoms Module (ICIQ-FLUTS) and International Consultation on Incontinence Questionnaire Vaginal Symptoms Module (ICIQ-VS). These short questionnaires should take no more than 10 minutes to

complete.

2) **Second training session:** a refresher session will be scheduled to correct any mistakes you have in the performance of the maneuvers, and to answer questions you have about the technique. Again, you will be asked to practice the exercises around 5-10 minutes daily, before you return for the data collection session.

These training sessions will not involve invasive/physical manipulation.

3) **Laboratory assessment (1st data collection):** A two-hour assessment session will be scheduled for data collection. You will be asked to provide information such as your age and we will measure your height, weight, waist and hip circumference. After this, we will follow the steps below. If you are an experienced participant, you will fill out the ICIQ-FLUTS and ICIQ-VS before we start the session.

4) **Laboratory assessment (2nd data collection):** A two-hour assessment session will be scheduled for the second data collection 3 months after the first training session for the novices. The same steps bellow will be followed:

Pelvic floor examination (20 minutes)

You will undergo a pelvic floor physical examination by an experienced female pelvic floor physiotherapist (Flavia Antonio or Silvia Saraiva) while a research assistant operates the computers used to collect your data. First, you will be left in a private area to undress from your waist down, to lie on an examination table with your head supported by a pillow and to cover yourself with a gown and a sheet. The physiotherapist will enter the room. She will wear examination gloves and will insert an instrument, called a dynamometer, into your vagina. You will be asked to perform three pelvic floor muscle contractions according to instructions, then to relax your pelvic floor muscles while the device arms open slightly so that we can determine the stiffness of your muscles. After three repetitions of each task, the dynamometer will be removed.

Sensor placement (20 minutes)

The same physiotherapist will next provide you with a sensor to put into your vagina. This sensor is inserted much like a tampon and you will be able to place it yourself. After the sensor is in the correct place, the physiotherapist will place a single electrode into your vagina at the level of the pelvic floor muscles. When the sensor is in the correct position, the physiotherapist will ask you to withdraw a small amount of air from a chamber – this action will cause a suction force to hold the sensor in place so that it can record the activity of your pelvic floor muscles. Six other sticky electrodes will be placed, 1 around the anal canal, 3 in abdominal muscle, 1 next to your ribs and finally, a sticky electrode will be placed on the skin over your right hip.

Sensor calibration (15 minutes)

After this, in order to calibrate the instruments, you will go through a series of tasks before beginning the study data collection. First you will lie on your back to allow the sensor to warm up to body temperature. After this, you will be asked to lie on your right side for 30 seconds and then to stand still for 30 seconds. Once these tasks are completed, the position of the intra-abdominal sensor will be checked by the physiotherapist to ensure that it has not descended during the calibration activities. If the sensor has moved it will be replaced and the calibration tasks will be repeated. Once the calibration is complete and the sensor is deemed to be adequately placed, data collection will begin.

Intra-abdominal pressure and muscle activity during hypopressive exercises (30 minutes)

Next, you will be asked to perform the hypopressive exercises you have practiced. You will be asked to perform the exercise in 4 different postures: lying on the examination table in a relaxed posture, lying on the examination table in a hypopressive posture (you will just change the position of your arms and feet according to instructions), standing in a relaxed posture and standing in a hypopressive posture (again, just changing the position of your arms and feet according to instructions). You will repeat the exercise three times in each position. Between trials, you will move out of the posture and rest comfortably.

We will ask you to cough in the start and end of each trial so that we can mark our intra-abdominal pressure data to facilitate our work after you have left.

Ultrasound assessment during hypopressive exercises (15-20 minutes)

After you have performed the exercise in all four positions, you will be asked to repeat them while one of the physiotherapists will measure your bladder movement through placing an ultrasound sensor with gel over your perineum.

Repeat calibration (2 minutes)

Following this, you will repeat the calibration positions (lying down, lying on the right side, standing) to ensure that the sensor maintained its proper positioning throughout the tasks. This will complete the data collection session; you will be left in a private area to dress yourself.

Potential harms

There are no known risks associated with any of the testing procedures used in this study. To limit any risk of infection, devices and supplies (examination gloves, dynamometer arms and sensors) are used only once and are discarded after use. The recording devices and their wires (including the system that records muscle activity and the ultrasound system) are disinfected after each use and all sheets, gowns and pillowcases are laundered after each use.

Although unlikely, in the event of any research-related injury (for example, slip or fall while you are attending the laboratory assessment session), you will be referred to your regular health care provider to receive appropriate medical treatment/care through your provincial health plan. If urgent care is required while you are in the Lab, we will contact University of Ottawa Campus security and you will be escorted by the research staff to the Emergency Department of the Ottawa General Hospital to receive care. You are not waiving your legal rights by agreeing to participate in this study.

Discomfort

You may experience some muscle fatigue over the course of the study since you will be asked to repeatedly perform hypopressive exercises. To minimize fatigue, rest periods will be allowed during testing whenever you request them. Feel free to ask to slow the testing down at any time.

The intravaginal devices should not cause any discomfort at any time. If they do, please let the researchers know immediately.

You may experience the sensation of stretching when the dynamometer opens, as it applies a stretch to your pelvic tissues. This should feel the same as stretching any other muscle or tissue in your body but will not cause injury. The arms do not physically open wide enough to damage any tissues. While using this device, you will be provided with a shut off switch, which will allow you to close the device at any time if you feel worried or uncomfortable.

Inconvenience

If you do not already regularly perform hypopressive exercises, we will need to teach you how to perform the exercises properly before we collect data. This will require you to attend four visits at our laboratory. The first session is quite lengthy (around 45 minutes) because we will teach you the theory behind hypopressive exercises as well as how to perform them. The second visit is much shorter as we will only verify that you are practicing the exercises correctly. The data collection protocol is approximately 2 hours, which may be inconvenient. For those who learn the exercises through this study, a second data collection will be schedules 3 months after the first training session, so that we can see whether people perform the exercises differently after becoming familiar with them. You will be able to schedule your assessment outside of regular work hours, during the evening or on weekends if you prefer.

Benefits

Participation in this study will allow you to learn about your pelvic floor musculature which is important to your health. You will be taught how to perform a proper pelvic floor muscle contraction and how to relax your pelvic floor muscles. You will receive feedback and advice from a pelvic floor physiotherapist on how to control your pelvic floor muscles. If you have not already learned how to perform hypopressive exercises, you will learn this through this study. We do not yet know if these exercises are effective in the prevention and/or management of pelvic floor disorders.

Compensation

You will not be paid to participate in this research.

Withdrawal from Study

You have the right to withdraw your participation from this study at any time and without providing any reason. If you choose to withdraw from the study, any data provided by you will be destroyed unless you provide permission to our team to retain and use them.

Confidentiality

Your name and contact information will be securely stored by the researchers at the University of Ottawa. You will not be identifiable in any publications or presentations resulting from this study. No identifying information will leave the University of Ottawa. There will be one password-protected electronic file, stored on a password secured computer that will remain in the Motor Function & Measurement Lab, that links your name to your participant number. This file will only be accessible by Dr. McLean and her delegated research staff and students at The University of Ottawa who have all been instructed on proper procedures for protecting privacy and confidentiality and who have provided signed confidentiality agreements. Data will be used for research proposes. All electronic records will be stored in a secure database at the University of Ottawa and will be protected by a user password, again only accessible by Dr. McLean, her students and staff. All paper records will be stored in a filing cabinet within the Motor Function & Measurement Lab, which is a restricted access area. All files will be kept for a period of 10 years after the study has been completed. At the end of the retention period, all paper records will be disposed of in confidential waste or shredded, and all electronic records will be permanently deleted from the data server.

Participant Rights

Your participation in this study is voluntary. You may withdraw from this study at any time and without consequences. You are free to choose not to answer any questions and to refuse to undergo any aspect of the testing, without giving any reason. The researchers may withdraw you from the study for scientific reasons at any time. In this case, they would give you a clear and valid reason. You have the right to obtain copies of any study forms that contain your personal information. As a participant in this study, you have the right to an environment that you feel comfortable in. For your safety and for the safety of our team, we will have a third person (female student research assistant) present in the evaluation room during all assessment procedures. You may also bring a friend or family member with you to be present in the room if this makes you feel more comfortable.

If at any time, you have further questions or problems you can contact the study investigators:

Silvia Saraiva, BSc at 613-562-5800 ext 4102
Flavia Ignacio Antonio, PhD at 613-562-5800 ext 4102
Linda McLean, PhD at 613-562-5800 ex 2544

If you have any questions about this study or if you feel that you have experienced a research-related injury, please contact Dr. Linda McLean at 613-562-5800 ex 2544 at your earliest convenience.

The University of Ottawa Sciences and Health Sciences Research Ethics Board has reviewed this protocol and has found it to comply with standards for ethical aspects of research studies involving human participants at The University of Ottawa. If you have any questions about your rights as a research participant, you may contact the Protocol Officer for Ethics in Research at the University of Ottawa, at 613- 562-5387 or ethics@uottawa.ca.

Consent to Participate in Research

Title of Study: What transient effects does the performance of a hypopressive exercise have on intra-abdominal pressure and on pelvic floor muscle activation in females?

I understand that I am being asked to participate in a research study and that my participation is voluntary. This study protocol has been explained to me by a research assistant. I have read this 8 page Participant Information Sheet or have had this document read to me. All of my questions have been answered to my satisfaction. If I decide at a later stage in the study that I would like to withdraw my consent, I may do so at any time.

I voluntarily agree to participate in this study. A copy of the Participant Information Sheet and the signed Consent Form will be provided to me for my records.

Signatures

______________________________ ______________________________

Participant's Name (Please Print) Participant's Signature

____

Date

Investigator Statement (or Person Explaining the Consent)

I have carefully explained to the research participant the nature of the above research study. To the best of my knowledge, the research participant signing this consent form understands the nature, demands, risks and benefits involved in participating in this study. I acknowledge my responsibility for the care and well-being of the above research participant, to respect the rights and wishes of the research participant, and to conduct the study according to applicable Good Clinical Practice guidelines and regulations.

____

Name of Investigator/Delegate

____________________________________ __________________

Signature of Investigator/Delegate Date

Appendix D: Letter of Information (French)

uOttawa

Labo Lab
McLean
Function & Measurement

Université d'Ottawa
Faculté des sciences
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Lettre d'information

Titre de l'étude : Quels effets transitoires la réalisation d'un exercice hypopressif a-t-elle sur la pression intra-abdominale et sur l'activation des muscles du plancher pelvien chez les femmes ?

Chercheuse principale: Linda McLean, PhD, Professeure, École des Science de la Réadaptation, Université d'Ottawa. 613-562-5800 ext 2544.

Chercheurs de l'étude: Stagiaire post-doctorale : Flavia Ignacio Antonio et assistant de recherche: Silvia Saraiva, École des Science de la Réadaptation, Université d'Ottawa, 613-562-5800 ext 4102.

Informations Contextuelles

Les muscles du plancher pelvien sont situés à la base du bassin et sont impliqués dans le maintien du contrôle de la vessie ainsi que du soutien des organes pelviens, mais leur rôle n'est pas bien compris. Les troubles du plancher pelvien comprennent principalement les fuites urinaires et la descente d'organes pelviens. Ces troubles affectent donc la santé et la qualité de vie de nombreuses femmes. La pression intra- abdominale peut être liée au développement de troubles du plancher pelvien, car l'augmentation de la pression intra-abdominale lors d'activités telles que la toux ou le soulèvement d'objets lourds peuvent fatiguer les muscles du plancher pelvien et les tissus conjonctifs.

L'entrainement des muscles du plancher pelvien sont efficaces dans la prévention et le traitement des troubles du plancher pelvien. Une nouvelle forme d'exercices, appelée exercices hypopressifs, est un entraînement postural et respiratoire avec une aspiration abdominale volontaire. Cette dernière a été adoptée en Europe comme alternative à l'entraînement musculaire traditionnel du plancher pelvien. Ceux-ci sont décrits comme une relaxation des muscles respiratoires suivie de l'exécution d'une manœuvre pour réduire la pression intra-abdominale. Cette manœuvre activerait les muscles abdominaux et les muscles du plancher pelvien par des voies réflexes, mais les recherches actuelles sur l'efficacité des exercices hypopressifs comme moyen méthode de gestion des troubles du plancher pelvien sont limitées et les résultats sont variés. En effet, le mécanisme d'action proposé pour cette manœuvre reste à démontrer. Ainsi, le but de cette étude est de déterminer si la manœuvre hypopressive abdominale réduit effectivement la pression intra-abdominale ou active les muscles abdominaux et les muscles du plancher pelvien.

Le comité d'éthique de la recherche de l'Université d'Ottawa a examiné les composantes éthiques de cette étude et l'a jugée conforme aux normes nationales. Si vous choisissez de participer à l'étude, vous devrez signer le formulaire de consentement qui suit, indiquant votre consentement à subir les procédures d'évaluation décrites ici.

L'objectif serait de recruter un total de 60 cis-femmes volontaires pour participer à notre étude selon le principe de première arrivée, première servie. Si vous êtes intéressée à la participation de cette étude, vous devez être âgée de 18 ans ou plus et ne pas expérimenter de douleur pendant l'insertion d'un tampon ou pendant un examen gynécologique.

Pour les participantes qui n'ont aucune expérience préalable, ni aucune pratique régulière, cette étude va impliquer trois visites au laboratoire. Pour les participantes qui ont de l'expérience avec la manœuvre hypopressive et qui la pratique depuis une durée d'au moins 3 mois, pour une fréquence de 3 fois par semaine, une seule visite sera nécessaire. Les visites auront lieu au Laboratoire de Mesure de la fonction Motrice (MFM Lab) de l'Université d'Ottawa située au 200 Lees Avenue, local E155D. Les séances seront prévues selon vos disponibilités. Pour les participantes sans expérience, les 2 premières visites seront orientées sur l'apprentissage et l'entraînement de l'exercice hypopressif. Elles auront une durée respective d'environ 45 minutes pour la première séance, et d'environ 15-30 minutes pour la deuxième séance. La troisième séance va être la collecte de données, et aura une durée d'environ une heure. Ainsi, les cis-femmes expérimentées ont seulement besoin d'assister à la séance de collecte de donnée. Les trois séances sont décrites ci-dessous :

1) **Première visite:** La première visite vous permettra d'apprendre la manœuvre d'exercice hypopressif en compagnie d'un instructeur qualifié. Vous devrez porter des vêtements appropriés pour l'exercice. À la fin de la séance, nous vous demanderons de pratiquer 5 à 10 minutes par jour au courant de la semaine suivante. Lors de cette session, vous allez être demandez de remplir deux questionnaires: International Consultation on Incontinence Questionnaire Female Lower Urinary Tract Symptoms Module (ICIQ-FLUTS) and International Consultation on Incontinence Questionnaire Vaginal Symptoms Module (ICIQ-VS). Ces questionnaires sont courts et ne devraient pas prendre plus que 10 minutes à compléter

2) **Deuxième visite :** : Une séance de rappel sera planifiée afin de corriger les erreurs potentielles de votre technique d'exécution de la manœuvre hypopressive et répondre à vos questions. Nous vous demanderons de pratiquer 5 à 10 minutes par jour avant de retourner pour votre séance de prise de données au laboratoire.

Noté que ces séances d'entrainement n'impliquent pas de manipulations physiques/invasives.

3) **Évaluation en laboratoire (1ère collecte de données):** Une séance d'évaluation d'environ une heure sera prévue pour la collecte de données. Nous vous demanderons de fournir des informations telles que votre âge, nous mesurerons votre taille et votre poids, ainsi que votre circonférence de taille et de hanche. Par la suite, nous allons suivre les étapes ci-dessous. Si vous êtes un participant expérimenté, vous allez remplir le ICIQ-FLUTS et le ICIQ-VS avant de commencer la session.

4) **Évaluation en Laboratoire (2e collecte de données) :** Une évaluation d'une durée de deux heures sera cédulée, 3 mois après la première session d'entraînement pour les novices. Les mêmes étapes vont être suivit :

Examen du plancher pelvien (20 minutes)

Une évaluation physique de votre plancher pelvien sera effectuée par une physiothérapeute expérimentée (Flavia Antonio ou Silvia Saraiva) pendant que l'assistante de recherche s'occupera de la gestion du programme informatique pour la prise de données sur l'ordinateur. Premièrement, nous vous laisserons seule dans une pièce privée afin de vous dévêtir de la taille jusqu'aux pieds, enfiler la jaquette fournie et vous allonger sur la table d'examen avec votre tête supportée par un oreiller et vous couvrir avec le drap fourni. La physiothérapeute entrera dans la pièce. Elle portera des gants d'examen et insèrera un instrument de mesure appelé dynamomètre à l'intérieur de votre vagin. On vous demandera d'effectuer 3 contractions du plancher pelvien selon des instructions précises, puis de détendre les muscles pendant que les bras de l'appareil se séparent légèrement afin que nous puissions déterminer la flexibilité de vos muscles. Après trois répétitions de chaque tâche, le dynamomètre sera enlevé.

Placement des capteurs (20 minutes)

La même physiothérapeute vous remettra un capteur à insérer dans votre vagin. Le capteur s'insère de la même façon qu'un tampon que vous pourrez placer vous-même. Une fois le capteur est dans la bonne position, la physiothérapeute placera une électrode unique à l'intérieur de votre vagin au niveau de votre plancher pelvien. Une fois que ce deuxième capteur sera dans la bonne position, la physiothérapeute vous demandera d'enlever une petite quantité d'air afin de provoquer une petite succion qui permettra de maintenir le capteur en place pour permettre l'enregistrement de l'activité musculaire de vos muscles. Six autres électrodes collantes seront placées: 1 autour du canal anal, 3 au niveau des muscles abdominaux, 1 près de vos côtes and finalement, 1 au-dessus de votre hanche droite.

Calibration du capteur à pression (15 minutes)

Afin d'effectuer la calibration des capteurs, vous devrez effectuer une série de tâches avant de commencer la prise de données. Premièrement, vous devrez vous coucher sur le dos pour 10 minutes afin que le capteur se réchauffe à votre température corporelle. Par la suite, vous devrez vous coucher sur le côté droit pour 30 secondes et debout pour 30 secondes sans bouger. Par la suite, vous devrez faire trois répétitions des activités suivantes : assise à debout, un saut sur une plate-forme de 30 cm de haut et une toux. Une fois que les tâches sont complétées, la physiothérapeute vérifiera la position du capteur intra-vaginal afin de s'assurer qu'il ne soit pas descendu lors des activités de calibration. Si le capteur est déplacé, il sera replacé et nous répéterons les activités de calibration. Une fois que ces dernières sont complétées et que le capteur est adéquatement positionné, la collecte de données débutera.

Pression intra-abdominale et activité musculaire pendant les exercices hypopressifs (10 minutes).

Pour la prise des données, vous devrez effectuer les exercices hypopressifs que vous avez pratiqués dans 4 postures différentes : couchée sur le dos dans une posture reposée sur la table d'examen, couchée sur le dos dans la posture de l'exercice hypopressif (vous devrez changer la position de vos bras et pieds selon les instructions données), debout dans une posture reposée et finalement, debout dans la posture de l'exercice hypopressif (encore une fois, vous devrez changer la position de vos bras et pieds selon les instructions données). Vous devrez répéter les exercices 3 fois dans chaque posture. Entre chacun des essais, vous devrez relâcher la posture afin de vous reposer confortablement. Nous vous demanderons de tousser volontairement au début et à la fin de chaque essai afin de nous permettre d'identifier les essais et ainsi faciliter notre analyse des données après votre départ.

L'évaluation par ultrason pendant les exercices hypopressifs (10 minutes)
Après avoir effectué les exercices dans les 4 postures, vous devrez répéter chacune d'elle alors que la physiothérapeute mesurera le mouvement de votre vessie en plaçant un appareil d'ultrason avec gel au niveau de votre périnée.

Évaluation d'ultrasons lors des exercices hypopressifs (15-20 minutes)

Après avoir effectué les exercices dans toutes les quatre positions, vous allez être demandés de les répétés pendant que le physiothérapeute tien une sonde à ultrasons recouverte de gel sur votre périnée. Ceci va nous permettre de voir si les muscles de votre plancher pelvien se contractent ou s'étirent lorsque vous effectuez les exercices.

Répéter la calibration (2 minutes)

Suivant la prise de données, vous devrez répéter les étapes de calibration (couchée sur le dos, couchée sur votre côté droit, debout), afin de s'assurer que le capteur de pression est resté en place pendant les différents essais. Ceci complètera la prise de données; nous vous laisserons seule afin de remettre vos vêtements dans la salle d'examen privée.

Risques potentiels

Il n'y a pas de risques connus associés aux procédures utilisées dans cette étude. Pour limiter tout risque d'infection, les appareils et accessoires (gants d'examen, bras du dynamomètre et capteurs) ne sont utilisés qu'une seule fois et sont jetés après usage. Les appareils d'enregistrement et leurs fils (y compris le système qui enregistre l'activité musculaire et l'appareil d'échographie) sont désinfectés après chaque utilisation et tous les draps, robes et taies d'oreiller sont lavés après chaque utilisation.

Bien que cela soit peu probable, en cas de blessure liée à la recherche (par exemple, glissade ou chute pendant que vous assistez à la séance d'évaluation en laboratoire), vous serez référée à votre fournisseur de soins de santé habituel pour recevoir des soins médicaux appropriés. Si des soins urgents sont nécessaires pendant que vous êtes dans le laboratoire, nous communiquerons avec la sécurité du campus de l'Université d'Ottawa et vous serez escortée par le personnel de recherche au service des urgences de l'Hôpital Général d'Ottawa pour recevoir des soins. Vous ne renoncez pas à vos droits légaux en acceptant de participer à cette étude.

Possible inconfort

Il est possible que vous ressentiez de la fatigue musculaire pendant l'étude en raison de la fréquence de répétitions de l'exercice hypopressif que nous vous demandons de pratiquer. Pour minimiser la fatigue, des périodes de repos seront possibles à tout moment pendant la période de collecte de données à votre demande. Sentez-vous à l'aise de demander de ralentir le protocole d'évaluation à tout moment.

Le capteur de pression intra-vaginal ne devrait pas provoquer d'inconfort à aucun moment. Si c'est le cas, nous vous prions d'en avertir immédiatement les chercheurs présents.

Il est possible que vous ressentiez une sensation d'étirement au moment où les bras du dynamomètre ouvrent et appliquent un étirement des tissus du plancher pelvien. Cette sensation devrait être semblable à tout autre étirement musculaire ou tissulaire de votre corps, mais ne causera aucune blessure.

Les bras du dynamomètre ne se séparent pas suffisamment pour provoquer un dommage tissulaire. Au moment de l'utilisation de l'appareil, on vous remettra un bouton contrôlant un arrêt d'urgence qui vous permettra de fermer le dynamomètre à tout moment si vous sentez trop d'inconfort ou d'anxiété.

Inconvénients

Si vous ne pratiquez pas déjà de manière régulière des exercices hypopressifs, nous aurons besoin de vous enseigner la bonne technique d'exécution avant la prise de données. Ceci vous demandera d'assister à trois visites à notre laboratoire. La première visite est un peu plus longue (environ 45 minutes), car nous allons vous enseigner la théorie derrière les exercices hypopressifs, ainsi que comment les exécuter. La deuxième visite sera beaucoup plus courte car nous allons seulement vérifier votre technique et corriger celle-ci si nécessaire. Le protocole de collecte de données est plus long, d'une durée d'environ une heure, ce qui peut être plutôt inconvénient. Vous serez donc en mesure de choisir le moment de vos sessions. Ceci peut être après vos heures de travail, ou bien lors des soirées ou des fins de semaines si ces derniers sont plus convenables pour vous.

Bénéfices

La participation à l'étude vous permettra d'en apprendre plus sur la musculature de votre plancher pelvien ce qui est une notion importante pour votre santé. Vous apprendrez comment effectuer une contraction efficace et la relaxation volontaire des muscles de votre plancher pelvien. Vous recevrez de la rétroaction et des conseils de la part de la physiothérapeute spécialiste sur la méthode de contrôle de vos muscles pelviens. Vous apprendrez au courant de l'étude comment effectuer les exercices hypopressifs, si vous ne l'avez pas déjà appris.

Nous ne savons pas à ce jour si ces exercices sont efficaces dans la prévention et/ou la gestion des troubles du plancher pelvien.

Compensation

Vous ne serez pas rémunérée pour votre participation dans cette recherche.

Retrait de l'étude

Vous avez le droit de retirer votre participation de l'étude à tout moment sans même devoir fournir d'explications. Si vous choisissez de vous retirer, toutes les données que vous nous aurez fournies seront détruites, à moins que vous nous fournissiez la permission formelle à notre équipe de recherche de les garder et de les utiliser.

Confidentialité

Votre nom et vos coordonnées seront conservés en toute sécurité par les chercheurs à l'Université d'Ottawa. Il sera impossible de vous identifier dans les publications ou présentations résultant de cette étude. Aucune information d'identification ne quittera l'Université d'Ottawa. Il y aura un fichier électronique protégé par mot de passe, stocké sur un ordinateur sécurisé par un mot de passe qui restera dans le Laboratoire de Mesure de la Fonction Motrice, qui relie votre nom à votre numéro de participant. Ce dossier ne sera accessible que par la Dre McLean et son personnel de recherche délégué et les étudiants de l'Université d'Ottawa participant à la recherche, qui ont tous reçu des instructions sur les procédures appropriées pour protéger la vie privée et la confidentialité et qui ont signé des accords de confidentialité. Les données seront utilisées pour la recherche et les données des participantes 1 à 10 seront utilisées par les étudiantes en physiothérapie pour leur court rapport de recherche. Tous les dossiers électroniques seront stockés dans une base de données sécurisée à l'Université d'Ottawa et seront protégés par un mot de passe d'utilisateur, encore une fois accessible uniquement par la Dre McLean, ses étudiants et son personnel. Tous les dossiers en format papier seront entreposés dans un classeur du Laboratoire de Mesure de la Fonction Motrice, qui est une zone d'accès restreint. Tous les dossiers seront conservés pendant une période de 10 ans après la fin de l'étude. À la fin de la période de rétention, tous les renseignements en format papier seront éliminés dans des déchets confidentiels ou déchiquetés, et tous les renseignements électroniques seront supprimés de façon définitive du serveur de données.

Droits des participantes

Cette étude est sous une base volontaire. Vous avez le droit de vous retirer de celle-ci à tout moment sans conséquence. Vous êtes libre de choisir de ne pas répondre à quelques questions que ce soit et de refuser de procéder à certains aspects de l'évaluation sans avoir à donner une raison. Les chercheurs peuvent vous retirer de l'étude pour des raisons scientifiques à tout moment. Dans ce cas, ils vous donneront une explication claire et valide de leur décision. Vous avez le droit d'obtenir des copies de tous les documents qui contiennent vos informations personnelles. Comme participante dans cette étude, vous avez le droit à un environnement ou vous vous sentez confortable. Pour votre sécurité et celle de notre équipe, une troisième personne (étudiante assistante de recherche) sera présente dans la salle d'évaluation pendant la procédure d'évaluation.

Vous pouvez aussi venir accompagnée d'un/une amie ou membre de votre famille qui pourra être présent dans la pièce au moment de l'évaluation si cela vous rend plus confortable.

Si à tout moment, vous avez des questions ou problèmes, vous pouvez contacter les chercheurs responsables de l'étude:

Silvia Saraiva, BSc at 613-562-5800 ext 4102
Flavia Ignacio Antonio, PhD au 613-562-5800 ext 4102
Linda McLean, PhD au 613-562-5800 ex 2544

Si vous avez des questions à propos de l'étude ou si vous pensez avoir subi des blessures dans le cadre de la recherche, nous vous prions de contacter Dre. Linda McLean au 613-562-5800 ex 2544 le plus rapidement possible.

Le Comité d'éthique de recherche en sciences et en sciences de la santé de l'Université d'Ottawa a examiné ce protocole et l'a jugé conforme aux normes relatives aux aspects éthiques des études de recherche impliquant des participants humains à l'Université d'Ottawa. Si vous avez des questions sur vos droits en tant que participante à la recherche, vous pouvez communiquer avec le responsable du protocole d'éthique en recherche à l'Université d'Ottawa au 613- 562-5387 or ethics@uottawa.ca.

Consentement de participation à l'étude

Titre de l'étude: Les exercices hypopressifs ont-ils un impact sur la réduction de la pression intra-abdominale et l'activation des muscles du plancher pelvien chez les cis-femme en santé?

Je comprends qu'on me demande de participer dans une étude de recherche et que ma participation est volontaire. Le protocole de l'étude en question m'a été expliqué par un assistant de recherche. J'ai lu les 9 pages du document intitulé Lettre d'information ou celles-ci m'ont été lues. Toutes mes questions ont été répondues de façon satisfaisante. Si je décide à un moment ultérieur de l'étude de retirer mon consentement, j'ai le droit de le faire à tout moment.

J'ai volontairement accepté de participer à cette étude. Une copie de la lettre d'information et du formulaire de consentement signé me sera remise pour mes dossiers.

Signatures

______________________________ ______________________________

Nom de la participante (Lettres Moulées) Signature de la participante

____

Date

Déclaration du chercheur (ou personne expliquant le consentement)

J'ai soigneusement expliqué au participant de recherche la nature de l'étude ci-dessus. À ma connaissance, le participant de recherche qui signe ce formulaire de consentement comprend la nature, les exigences, les risques et les bénéfices liés à la participation à cette étude. Je reconnais ma responsabilité pour les soins et le bien-être du participant à la recherche ci-dessus, pour respecter les droits et les souhaits du participant à la recherche et pour mener l'étude conformément aux directives et réglementations applicables en matière de bonnes pratiques cliniques.

____

Nom du chercheur/Délégué

____________________________________ ____________________

Signature du chercheur/Délégué Date

Appendix E: ICIQ-FLUTS (English)

Initial number

ICIQ-FLUTS 08/04

CONFIDENTIAL

DAY MONTH YEAR

Today's date

Urinary symptoms

Many people experience urinary symptoms some of the time. We are trying to find out how many people experience urinary symptoms, and how much they bother them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

1. Please write in your date of birth:

DAY MONTH YEAR

2a. During the night, how many times do you have to get up to urinate, on average?

none 0
one 1
two 2
three 3
four or more 4

2b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all a great deal

3a. Do you have a sudden need to rush to the toilet to urinate?

never 0
occasionally 1
sometimes 2
most of the time 3
all of the time 4

3b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all a great deal

4a. Do you have pain in your bladder?

never 0
occasionally 1
sometimes 2
most of the time 3
all of the time 4

4b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all a great deal

5a. **How often do you pass urine during the day?**

1 to 6 times	☐	0
7 to 8 times	☐	1
9 to 10 times	☐	2
11 to 12 times	☐	3
13 or more times	☐	4

5b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

F score: sum scores 2a-5a ☐ ☐

6a. **Is there a delay before you can start to urinate?**

never	☐	0
occasionally	☐	1
sometimes	☐	2
most of the time	☐	3
all of the time	☐	4

6b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

7a. **Do you have to strain to <u>urinate</u>?**

never	☐	0
occasionally	☐	1
sometimes	☐	2
most of the time	☐	3
all of the time	☐	4

7b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

8a. Do you stop and start more than once while you urinate?

never	☐	0
occasionally	☐	1
sometimes	☐	2
most of the time	☐	3
all of the time	☐	4

8b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

V score: sum scores 6a+7a+8a ☐ ☐

9a. Does urine leak before you can get to the toilet?

never	☐	0
occasionally	☐	1
sometimes	☐	2
most of the time	☐	3
all of the time	☐	4

9b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

10a. How often do you leak urine?

never	☐	0
once or less per week	☐	1
two to three times per week	☐	2
once per day	☐	3
several times per day	☐	4

10b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

11a. Does urine leak when you are physically active, exert yourself, cough or sneeze?

never	☐	0
occasionally	☐	1
sometimes	☐	2
most of the time	☐	3
all of the time	☐	4

11b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

12a. Do you ever leak urine for no obvious reason and without feeling that you want to go?

never	☐	0
occasionally	☐	1
sometimes	☐	2
most of the time	☐	3
all of the time	☐	4

12b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

13a. Do you leak urine when you are asleep?

never	☐	0
occasionally	☐	1
sometimes	☐	2
most of the time	☐	3
all of the time	☐	4

13b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

I score: sum scores9a-13a ☐ ☐

Thank you very much for answering these questions.

Appendix F: ICIQ-FLUTS (French)

ICIQ-FLUTS (Canada/French) 07/06

Numéro du participant | **CONFIDENTIEL** | JOUR MOIS ANNÉE **Date d'aujourd'hui**

Symptômes urinaires

Plusieurs personnes éprouvent de temps en temps des symptômes urinaires. Nous tentons de déterminer combien de personnes éprouvent ces symptômes et à quel point ces symptômes les dérangent. Veuillez répondre aux questions suivantes en pensant à ce que vous avez vécu au cours des QUATRE DERNIÈRES SEMAINES.

1. Veuillez inscrire votre date de naissance : JOUR MOIS ANNÉE

2a. Combien de fois, en moyenne, devez-vous vous lever pendant la nuit pour uriner?

- Aucune ☐ 0
- Une ☐ 1
- Deux ☐ 2
- Trois ☐ 3
- Quatre ou plus ☐ 4

2b. À quel point cela vous dérange-t-il?
Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).

0 1 2 3 4 5 6 7 8 9 **10**
Pas du tout … Beaucoup

3a. Ressentez-vous le besoin soudain de courir aux toilettes pour uriner?

- Jamais ☐ 0
- Occasionnellement ☐ 1
- Quelquefois ☐ 2
- La plupart du temps ☐ 3
- Tout le temps ☐ 4

3b. À quel point cela vous dérange-t-il?
Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).

0 1 2 3 4 5 6 7 8 9 **10**
Pas du tout … Beaucoup

4a. Avez-vous des douleurs à la vessie?

- Jamais ☐ 0
- Occasionnellement ☐ 1
- Quelquefois ☐ 2
- La plupart du temps ☐ 3
- Tout le temps ☐ 4

4b. À quel point cela vous dérange-t-il?
Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).

0 1 2 3 4 5 6 7 8 9 **10**
Pas du tout … Beaucoup

5a.	**Combien de fois par jour urinez-vous?**		
		1 à 6 fois ☐	0
		7 à 8 fois ☐	1
		9 à 10 fois ☐	2
		11 à 12 fois ☐	3
		13 fois ou plus ☐	4
5b.	**À quel point cela vous dérange-t-il?** *Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).* **0** 1 2 3 4 5 6 7 8 9 **10** Pas du tout ... Beaucoup		

Score F : additionnez les scores de 2a à 5a ☐ ☐

6a.	**Y a-t-il un délai avant que vous commenciez à uriner?**		
		Jamais ☐	0
		Occasionnellement ☐	1
		Quelquefois ☐	2
		La plupart du temps ☐	3
		Tout le temps ☐	4
6b.	**À quel point cela vous dérange-t-il?** *Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).* **0** 1 2 3 4 5 6 7 8 9 **10** Pas du tout ... Beaucoup		

7a.	**Devez-vous forcer pour <u>uriner</u>?**		
		Jamais ☐	0
		Occasionnellement ☐	1
		Quelquefois ☐	2
		La plupart du temps ☐	3
		Tout le temps ☐	4
7b.	**À quel point cela vous dérange-t-il?** *Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).* **0** 1 2 3 4 5 6 7 8 9 **10** Pas du tout ... Beaucoup		

8a. Lorsque vous urinez, le jet s'arrête-t-il et recommence-t-il plus d'une fois?

Jamais	☐	0
Occasionnellement	☐	1
Quelquefois	☐	2
La plupart du temps	☐	3
Tout le temps	☐	4

8b. À quel point cela vous dérange-t-il?
Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).

0 1 2 3 4 5 6 7 8 9 **10**
Pas du tout — Beaucoup

Score V : additionnez les scores de 6a à 8a ☐ ☐

9a. Avez-vous des pertes d'urine avant d'arriver aux toilettes?

Jamais	☐	0
Occasionnellement	☐	1
Quelquefois	☐	2
La plupart du temps	☐	3
Tout le temps	☐	4

9b. À quel point cela vous dérange-t-il?
Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).

0 1 2 3 4 5 6 7 8 9 **10**
Pas du tout — Beaucoup

10a. À quelle fréquence avez-vous des pertes d'urine?

Jamais	☐	0
Une fois par semaine ou moins	☐	1
Deux ou trois fois par semaine	☐	2
Une fois par jour	☐	3
Plusieurs fois par jour	☐	4

10b. À quel point cela vous dérange-t-il?
Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).

0 1 2 3 4 5 6 7 8 9 **10**
Pas du tout — Beaucoup

11a. Avez-vous des pertes d'urine lorsque vous pratiquez une activité physique, lorsque vous faites un effort, ou lorsque vous toussez ou éternuez ?

Jamais	☐	0
Occasionnellement	☐	1
Quelquefois	☐	2
La plupart du temps	☐	3
Tout le temps	☐	4

11b. À quel point cela vous dérange-t-il?
Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).

0 1 2 3 4 5 6 7 8 9 **10**
Pas du tout — Beaucoup

12a. Avez-vous parfois des pertes d'urine sans raison apparente et sans ressentir le besoin d'aller aux toilettes?

Jamais	☐	0
Occasionnellement	☐	1
Quelquefois	☐	2
La plupart du temps	☐	3
Tout le temps	☐	4

12b. À quel point cela vous dérange-t-il?
Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).

0 1 2 3 4 5 6 7 8 9 **10**
Pas du tout — Beaucoup

13a. Avez-vous des pertes d'urine pendant votre sommeil?

Jamais	☐	0
Occasionnellement	☐	1
Quelquefois	☐	2
La plupart du temps	☐	3
Tout le temps	☐	4

13b. À quel point cela vous dérange-t-il?
Veuillez encercler un numéro entre 0 (pas du tout) et 10 (beaucoup).

0 1 2 3 4 5 6 7 8 9 **10**
Pas du tout — Beaucoup

Score I : additionnez les scores de 9a à 13a ☐ ☐

Merci d'avoir répondu à ces questions.

Appendix G: ICIQ-VS (English)

☐☐ ☐☐ ☐☐ ☐☐☐ ICIQ-VS 10/05

Initial number **CONFIDENTIAL**

VAGINAL SYMPTOMS QUESTIONNAIRE

Many people experience vaginal symptoms some of the time. We are trying to find out how many people experience vaginal symptoms, and how much they bother them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

Please write in today's date: ☐☐ DAY ☐☐ MONTH ☐☐ YEAR

Please write in your date of birth: ☐☐ DAY ☐☐ MONTH ☐☐ YEAR

Vaginal symptoms

1a. Are you aware of dragging pain in your lower abdomen?

never ☐ 0
occasionally ☐ 1
sometimes ☐ 2
most of the time ☐ 3
all of the time ☐ 4

1b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

2a. Are you aware of soreness in your vagina?

never ☐ 0
occasionally ☐ 1
sometimes ☐ 2
most of the time ☐ 3
all of the time ☐ 4

2b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

3a.	**Do you feel that you have reduced sensation or feeling in or around your vagina?**
	not at all ☐ 0
	a little ☐ 1
	somewhat ☐ 2
	a lot ☐ 3
3b.	**How much does this bother you?**
	Please ring a number between 0 (not at all) and 10 (a great deal)
	0 1 2 3 4 5 6 7 8 9 **10**
	not at all … a great deal

Prolapse is a common condition affecting the normal support of the pelvic organs, which results in descent or 'dropping down' of the vaginal walls and/or the pelvic organs themselves. This can include the bladder, the bowel and the womb. Symptoms are usually worse on standing up and straining (e.g. lifting, coughing or exercising) and usually better when lying down and relaxing.

Prolapse may cause a variety of problems. We are trying to find out how many people experience prolapse, and how much this bothers them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

4a.	**Do you feel that your vagina is too loose or lax?**
	not at all ☐ 0
	a little ☐ 1
	somewhat ☐ 2
	a lot ☐ 3
4b.	**How much does this bother you?**
	Please ring a number between 0 (not at all) and 10 (a great deal)
	0 1 2 3 4 5 6 7 8 9 **10**
	not at all … a great deal

5a.	**Are you aware of a lump or bulge coming down in your vagina?**
	never ☐ 0
	occasionally ☐ 1
	sometimes ☐ 2
	most of the time ☐ 3
	all of the time ☐ 4
5b.	**How much does this bother you?**
	Please ring a number between 0 (not at all) and 10 (a great deal)
	0 1 2 3 4 5 6 7 8 9 **10**
	not at all … a great deal

6a.	**Do you feel a lump or bulge come out of your vagina, so that you can feel it on the outside or see it on the outside?**	
	never ☐	0
	occasionally ☐	1
	sometimes ☐	2
	most of the time ☐	3
	all of the time ☐	4
6b.	**How much does this bother you?** *Please ring a number between 0 (not at all) and 10 (a great deal)*	
	0 1 2 3 4 5 6 7 8 9 **10** not at all … a great deal	

7a.	**Do you feel that your vagina is too dry?**	
	never ☐	0
	occasionally ☐	1
	sometimes ☐	2
	most of the time ☐	3
	all of the time ☐	4
7b.	**How much does this bother you?** *Please ring a number between 0 (not at all) and 10 (a great deal)*	
	0 1 2 3 4 5 6 7 8 9 **10** not at all … a great deal	

8a.	**Do you have to insert a finger into your vagina to help empty your bowels?**	
	never ☐	0
	occasionally ☐	1
	sometimes ☐	2
	most of the time ☐	3
	all of the time ☐	4
8b.	**How much does this bother you?** *Please ring a number between 0 (not at all) and 10 (a great deal)*	
	0 1 2 3 4 5 6 7 8 9 **10** not at all … a great deal	

9a.	**Do you feel that your vagina is too tight?**	
	never ☐	
	occasionally ☐	
	sometimes ☐	
	most of the time ☐	
	all of the time ☐	
9b.	**How much does this bother you?** *Please ring a number between 0 (not at all) and 10 (a great deal)*	
	0 1 2 3 4 5 6 7 8 9 **10** not at all … a great deal	

Sexual matters

We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

10. Do you have a sex life at present?

yes	☐	1
no, because of my vaginal symptoms	☐	0
no, because of other reasons	☐	2

If NO, please go to question 14

11a. Do worries about your vagina interfere with your sex life?

not at all	☐	0
a little	☐	1
somewhat	☐	2
a lot	☐	3

11b. How much does this bother you?

Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**

not at all — a great deal

12a. Do you feel that your relationship with your partner is affected by vaginal symptoms?

not at all	☐	0
a little	☐	1
somewhat	☐	2
a lot	☐	3

12b. How much does this bother you?

Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**

not at all — a great deal

13. How much do you feel that your sex life has been spoilt by vaginal symptoms?

Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**

not at all — a great deal

Quality of life

We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

14. Overall, how much do vaginal symptoms interfere with your everyday life?

Please ring a number between 0 (not at all) and 10 (a great deal)

0	1	2	3	4	5	6	7	8	9	**10**
not at all										a great deal

Thank you very much for answering these questions.

VAGINAL SYMPTOMS QUESTIONNAIRE

SCORING

(This section is for administrative use only)

Patient number

Vaginal symptoms score

Vaginal symptom score = 2×(dragging pain) + 2×(soreness in vagina) + (reduced sensation) + 2×(vagina too loose) + 2×(lump felt inside) + 2×(lump seen outside) + 2×(vagina too dry) + (faecal evacuation)

symptom*	score	weighted score
Q1. 'dragging pain'		x 2 =
Q2. 'soreness in vagina'		x 2 =
Q3. 'reduced sensation'		x 1 =
Q4. 'vagina too loose'		x 2 =
Q5. 'lump felt inside'		x 2 =
Q6. 'lump seen outside'		x 2 =
Q7. 'vagina too dry'		x 2 =
Q8. 'faecal evacuation'		x 1 =
	Total vaginal symptoms score	

*(Note: Q9, 'vagina too tight', is primarily for detecting a potential post-treatment complication and is therefore not included in the scoring)

Sexual matters score

Sexual matters score = (sex-life spoilt) + 8×(worries about vagina interfere with sex-life) + 8×(relationship affected)

sexual matter	score	weighted score
Q11. 'worries about vagina interfere with sex-life'		x 8 =
Q12. 'relationship affected'		x 8 =
Q13. 'sex life spoilt'		x 1 =
	Total sexual matters score	

Quality of life score

quality of life	score
Q14. 'quality of life affected'	

Appendix H: Recruitment Poster Naïves (English)

Labo MFM Lab

Have you heard of Hypopressive Exercises?

uOttawa

Are you wondering how to contract your pelvic floor muscles correctly? Do you want to learn about a breathing and postural technique called **Hypopressive Exercises** that is being used by therapists to treat pelvic floor disorders? Join us!

What is involved?

- Exercise familiarization session (45min)
- Refresher session (15min)
- Two data collection sessions (2h)
  - 10 weeks apart
- Completion of 2 questionnaires (20min)

Who is eligible?

- ✓ Female ≥ 18 years old and not in menopause
- ✓ Do not experience pelvic pain during gynecological speculum exams, tampon insertion or intercourse
- ✓ No history of pelvic surgery
- ✓ Not pregnant or have not been pregnant in the past 6 months
- ✓ No experience with Hypopressive Exercises
- ✓ Fully vaccinated against COVID-19

As a volunteer you will learn:

- How to perform Hypopressive Exercises
- About your pelvic floor muscles and how to effectively activate them

No compensation is provided for participation

Participants will be accepted on a first-come, first-served basis.

The protocol has been reviewed for compliance by the University of Ottawa Health Sciences and Sciences Research Ethics Board and has been found to comply with national standards for the ethical conduct of research on humans.

Contact: **Silvia Saraiva, PT**
Research Assistant, MFM Lab
School of Human Kinetics, University of Ottawa
Principal Investigator: Linda McLean, Ph.D.
School of Rehabilitation Sciences, University of Ottawa

Tel: 613-562-5800 ext 7438
200 Lees Avenue,
Building E, room E155D
Ottawa, ON, Canada

Scan with phone!

Appendix I: Recruitment Poster Naïves (French)

Labo Lab MFM

Avez-vous entendu parler des exercises hypopressifs?

uOttawa

Êtes-vous curieux à propos de comment contracter vos muscles du plancher pelviens correctement? Voulez-vous en savoir plus sur les techniques de respiration et de posture appelées Exercices Hypopressifs qui sont utilisées par les thérapeutes pour traiter les troubles du plancher pelviens? Rejoignez-nous!

Qui est éligible?

- ✓ Femme ≥ 18 ans qui n'a pas atteint la menopause
- ✓ Ne ressent pas de la douleur pelvienne pendant les examens gynécologiques avec spéculum, l'insertion de tampons ou les activités sexuels
- ✓ Pas d'antécédents de chirurgie pelvienne
- ✓ N'est pas enceinte et n'a pas été enceinte dans les 6 derniers mois
- ✓ Aucune expérience avec les exercices hypopressifs
- ✓ Complètement vacciné contre le COVID-19

En quoi consiste cette étude ?

- Séance de familiarisation aux exercices (45 minutes)
- Séance pour rafraîchir la mémoire (15 minutes)
- Deux séances de collecte de données (2 heures) avec 10 semaines d'intervalles entre chaque.
- Compléter 2 questionnaires en ligne (20 minutes)

En tant que participante, vous en apprendrez :

- Comment correctement effectuer des exercices hypopressifs
- À propos de vos muscles du plancher pelvien et comment les activer efficacement

Aucune compensation n'est offerte pour la participation

Les participantes seront sélectionnées selon le principe de première arrivée, première servie

Le protocole a été évalué par le Comité d'éthique de la recherche en sciences et en sciences de la santé de l'Université d'Ottawa et a été jugé en conformité avec les normes nationales pour la conduite éthique de la recherche sur les humains.

Contact **Silvia Saraiva, PT**
Assistante de recherche, Labo MFM
L'École des sciences de l'ativité physique, l'Université d'Ottawa
Chercheuse principale : Dre. Linda McLean, Ph.D.,
L'École des sciences de la réadaptation, l'Université d'Ottawa

Courriel: mfmlab@uottawa.ca
Tel: 613-562-5800 poste 7438
200 Ave Lees
Bâtiment E, Salle E155D
Ottawa, ON, Canada

Scanner avec le telephone!

Appendix J: Recruitment Poster Experienced (English)

Labo MFM Lab

Do you train using Hypopressive Exercises?

uOttawa

We are trying to understand what happens to your abdominal and pelvic floor muscles when you perform **Hypopressive Exercises** and how they might result in improvement in the signs and symptoms of pelvic floor disorders. Join us!

What is involved?

- One data collection session at the McLean Function & Measurement Laboratory in Ottawa – ON (2h)
- Completion of 2 questionnaires about your pelvic health and symptoms (20min)

Who is eligible?

- ✓ Female ≥ 18 years old and not in menopause
- ✓ Do not experience pelvic pain during gynecological speculum exams, tampon insertion or intercourse
- ✓ No history of pelvic surgery
- ✓ Not pregnant or have not been pregnant in the past 6 months
- ✓ Experienced with Hypopressive Exercises > 12 weeks
- ✓ Fully vaccinated against COVID-19

As a volunteer you will learn:

- About your pelvic floor muscle anatomy
- How to perform a pelvic floor muscle contraction effectively
- The training effect induced by Hypopressive Exercises

No compensation is provided for participation

Participants will be accepted on a first-come, first-served basis.

The protocol has been reviewed for compliance by the University of Ottawa Health Sciences and Sciences Research Ethics Board and has been found to comply with national standards for the ethical conduct of research on humans.

Contact: **Silvia Saraiva, PT**
Research Assistant, MFM Lab
School of Human Kinetics, University of Ottawa
Principal Investigator: Linda McLean, Ph.D.
School of Rehabilitation Sciences, University of Ottawa

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Ottawa, ON, Canada

Scan with phone!

Appendix K: Recruitment Poster Experienced (French)

Labo MFM Lab

Vous entraînez-vous à l'aide d'exercices hypopressifs?

uOttawa

Nous essayons de comprendre ce qui arrive à vos muscles abdominaux et pelviens lorsque vous effectuez des exercices hypopressifs et comment ces exercices pourraient entrainer une amelioration des signes et symptômes des troubles du plancher pelvien. Rejoignez-nous!

Qui est éligible?

- ✓ Femme ≥ 18 ans qui n'a pas atteint la menopause
- ✓ Ne ressent pas de la douleur pelvienne pendant les examens gynécologiques avec spéculum, l'insertion de tampons ou les activités sexuels
- ✓ Pas d'antécédents de chirurgie pelvienne
- ✓ N'est pas enceinte et n'a pas été enceinte dans les 6 derniers mois
- ✓ A de l'expérience avec les exercices hypopressifs > 12 semaines
- ✓ Complètement vacciné contre le COVID-19

En quoi consiste cette étude ?

- Une séance de collecte de données au Laboratoire McLean Function & Measurement à Ottawa, ON (2 heures)
- Compléter 2 questionnaires en ligne à propos de votre santé pelvienne et vos symptômes (20 minutes)

En tant que participante, vous en apprendrez :

- À propos de l'anatomie de vos muscles du plancher pelvien
- Comment efficacement effectuer une contraction des muscles du plancher pelvien
- À propos de l'effet d'entraînement induit par les exercices hypopressifs

Aucune compensation n'est offerte pour la participation

Les participantes seront sélectionnées selon le principe de première arrivée, première servie

Le protocole a été évalué par le Comité d'éthique de la recherche en sciences et en sciences de la santé de l'Université d'Ottawa et a été jugé en conformité avec les normes nationales pour la conduite éthique de la recherche sur les humains.

Contact: **Silvia Saraiva, PT**
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Chercheuse principale : Dre. Linda McLean, Ph.D.,
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200 Ave Lees
Bâtiment E, Salle E155D
Ottawa, ON, Canada

Scanner avec le telephone!

Appendix L: Screening Form (English)

McLean Function & Measurement Lab

Title of the study : What transient effects does the performance of a hypopressive exercise have on intra-abdominal pressure and on pelvic floor muscle activation in females?

Date: ___________________________ (yyyy-mm-dd) **Time:__________**

Description and explanation of the study will be given to the potential participant, identical to what is written in the study information document. If the woman is interested in participating, the following questions will be asked:

1) Are you 18 years old or over? ☐ Yes ☐ No
2) Do you have any known health conditions? ☐ Yes ☐ No

If Yes, specify: ____

3) Do you have or have you had any symptoms such as leaking urine or feeling a bulge in your vagina? ☐ Yes ☐ No
4) Do you experience pain at or near your genitals when you insert a tampon, engage in sexual activity, or undergo a pap test? ☐ Yes ☐ No
5) Have you ever learned and practiced Hypopressive Exercises (HE)? ☐ Yes ☐ No

If Yes, for how many months? ____________________

How many times per week, on average, do you currently perform these exercises?____________________

6) What is the typical time you spend training on hypopressive exercises when you perform them? _________________

Researcher: Is this participant considered experienced (3 months, 2x/week) or novice?

EXPERIENCED (   )   NOVICE (   )

If participant is novice to the HE, they will be scheduled for 4 sessions: an initial training session lasting 45 minutes, a refresher session lasting 15-30 minutes, and 2 laboratory assessments (data collection sessions) separately by 12 weeks. If the participant is considered experienced, they will be scheduled for 1 laboratory assessment (data collection session) lasting 2 hours.

Day/time of assessment :

Type of visit :

Appendix M: Screening Form (French)

<u>Formulaire de dépistage</u>

Laboratoire de mesure de la fonction motrice

Titre de l'étude: Quels effets transitoires la réalisation d'un exercice hypopressif a-t-elle sur la pression intra-abdominale et sur l'activation des muscles du plancher pelvien chez les femmes ?

Formulaire de vérification des critères de sélection

Date: __________________________ (aaaa-mm-jj) Heure:_________

La description et les explications concernant l'étude seront données aux participantes potentielles et seront identiques à celles écrites dans le document d'information de l'étude. Les questions suivantes seront posées à toute femme voulant participer :

1) Êtes-vous âgée de 18 ou plus? ☐ Oui ☐ Non
2) Avez-vous des problèmes de santé connus? ☐ Oui ☐ Non

Si oui, spécifiez: ____

3) Avez-vous présentement ou avez-vous déjà eu des symptômes tels que des fuites urinaires, une bosse ou une boule au niveau du vagin? ☐ Oui ☐ Non
4) Avez-vous déjà ressenti de la douleur dans la région de vos organes génitaux lors de l'insertion d'un tampon, pendant une activité sexuelle ou pendant un pap test? ☐ Oui ☐ Non
5) Avez-vous déjà appris à faire des exercices hypopressifs? ☐ Oui ☐ Non

Si oui :

Depuis combien de mois les pratiquez-vous? ___________________

Combien de fois par semaine faites-vous ces exercices en moyenne? _______________

6) Pendant combien de temps faites-vous vos exercices à chaque entrainement?

   ____

Chercheur: La participante est-elle considérée comme expérimentée? (Expérience minimum de 3 mois , 2x/semaine) ou novice?

EXPÉRIMENTÉE (   )   NOVICE (   )

Si la participante est considérée comme novice dans sa pratique des EH, elle devra participer à 4 sessions dont : deux sessions d'entrainement pour apprendre la technique d'une durée de 45 minutes et 15 à 30 minutes respectivement, et deux session d'évaluation en laboratoire d'une heure (2 hours) (collecte de données) 12 semaines d'intervalle. Si le participant est considéré comme expérimenté, il sera programmé pour 1 évaluation en laboratoire (session de collecte de données).

Jour/heure de l'évaluation:

Type de visite:

Appendix N: Data Collection Form (English)

Data Collection Form

uOttawa
Faculté des sciences de la santé
Faculty of Health Sciences

Labo Lab McLean Function & Measurement

McLean Function & Measurement Lab

Title of the study : What transient effects does the performance of a hypopressive exercise have on intra-abdominal pressure and on pelvic floor muscle activation in females?

Laboratory Physical Assessment

Study ID:__________
Date: _________________________ (yyyy-mm-dd)
Time:_________

❑ Consent form completed and signed

Age: ___________
Menopausal status? ____
Smoker? ____
If yes, # packs per day? ____
Paratity: ____
Delivery method : ____
PFD (UI / POP) : ____
Other relevant information? ____
Oral contraceptive medications ☐ Yes ☐ No
Which one? _____________
Profession/ occupation :
Highest level of education completed:

Anthropometric measures:

1. Body weight: _____(kg)

2. Height: _____(m)

3. BMI: _______________(Kg/m^2) (calculated)

4. Hip circumference at level of greater trochanters: _____(cm)

5. Waist circumference at its smallest: _____ (cm)

6. Waist/Hip ratio: ________ (calculated)

Participant set up

Visual inspection of the perineum and vulva – Select all that apply

1 O Color: Erythema/redness

2 O No abnormalities apparent

3 O Scarring

4 O Fissure

5 O Lichen signs

6 O Prolapse that goes beyond hymen

Reflexes:

Anal wink	O present	O absent

Instruction on how to correctly contract their PFMs

"To do a Pelvic floor muscle contraction you are going to imagine trying to stop the flow of urine; and then lift the muscles inside the pelvis as hard and as fast as you can. Take a big breath in, breath out, ready…set… go… squeeze, squeeze, squeeze"

Visual observation of the pelvic floor muscle responses – Select all that apply

1. PFM response when asked to perform a voluntary contraction:

Antero-posterior movement ☐ Yes ☐ No

Cranial movement ☐ Yes ☐ No

Compensations ☐ Yes ☐ No *If yes, which ones?*

Inversion of command ☐ Yes ☐ No

2. PFM response when asked to cough:

Contraction reflex present? ☐ Yes ☐ No

Caudal descent ☐ Yes ☐ No *Degree?* mild 1☐ mod 2 ☐ severe 3 ☐

Intra-vaginal palpation: 2 Fingers

1. Bi-digital palpation to rule out pelvic pain:

Any pain? ☐ Yes ☐ No

2. PFM strength <u>evaluation</u>:

Modified Oxford Scale (MOS)

☐ 0 No palpable contraction

☐ 1 Trace contraction

☐ 2 Weak contraction – able to constrict around finger, but weak

☐ 3 Moderate – able to constrict around finger, but not lift

☐ 4 Good – able to constrict around finger and lift, but not hold against resistance

☐ 5 Strong - able to constrict and lift, hold against strong resistance

Intra-vaginal dynamometer
Calibration file saved (arms open before dynamometer inserted in position)

❑ 3 at rest measurements (stiffness) – write settings in here (Active#)
1:________ 2:________ 3:________
❑ 3 measurement at MVC – write settings in here (Passive#)
1:________ 2:________ 3:________

Instrument participant with IAP sensor

Calibration protocol (IAP sensor must be in for at least 10 minutes before beginning data collection)
❑ Begin calibration: _________
❑ Patient stands for 30 seconds
❑ Patient lies on right side 30 seconds
❑ Patient lies on back (supine) for 30 seconds

Instrument participant with electrodes (Six EMG channels):
Pubovisceralis muscle
External Anal sphincter muscle
Rectus abdominis muscle
External oblique muscle
Transversus abdominis muscle
Diaphragm muscle

Open "HypopressiveProtocol.adiset"
Comments (Keys): F5 = Hypo_Start, F6 = Hypo_End, F7 = Cough

Calibration of EMG:

EMG recorded at rest in supine (EMG_Rest_#)

EMG recorded during three trials of MVC (EMG_MVC_#)

EMG recorded during three trials of abdominal contractions (EMG_Abs_#)

Tasks – Supine position
3 trials – in resting position while doing Hypopressive maneuver (HypoSupine_No_#)
3 trials – in hypopressive posture while doing Hypopressive maneuver (HypoSupine_Yes_#)

Tasks – Standing position
3 trials – in resting position while doing Hypopressive maneuver (HypoStanting_No_#)
3 trials – in hypopressive posture while doing Hypopressive maneuver (HypoStanding_Yes_#)

Ultrasound
Transperineal ultrasound in supine
3 trials – in resting position while doing Hypopressive maneuver (HypoSupine_No_US_#)
3 trials – in hypopressive posture while doing Hypopressive maneuver (HypoSupine_Yes_US_#)

Transperineal ultrasound and standing
3 trials – in resting position while doing Hypopressive maneuver (HypoStanting_No_US_#)
3 trials – in hypopressive posture while doing Hypopressive maneuver (HypoStanding_Yes_US_#)

EMG channel recalibration:

EMG recorded at rest (EMG2_Rest_#)

EMG recorded during 3 trials of MVC (EMG2_MVC_#)

EMG recorded during 3 trials of abdominal contractions (EMG2_Abs_#)

EMG channel test:
Calibration protocol (continued)
❑ end of calibration: _________

Recalibration of IAP sensors

General Observation for Hypopressive maneuver performance:
____
____

Completed by (Print Name/Signature):
_____________________________________ Date:___________________

Signature of principal investigator (Dr. Linda McLean):
_____________________________________ Date:___________________

Appendix O: Adherence Tracking Tool (English)

Hypopressive Protocol - Adherence Tracking Tool

uOttawa
Faculté des sciences de la santé
Faculty of Health Sciences

Labo Lab McLean Function & Measurement

McLean Function & Measurement Lab

Date: _________________________ (yyyy-mm-dd) **Time:_________**

Participant ID: __________

Please fill out the form below as honestly as possible. As part of a research study, knowing how often people practiced the exercises is important when we interpret our outcomes. Your answers will remain confidential. Your answers will not impact any future interactions we have with you.

1) How frequently did you practice hypopressive exercises the week prior to the second data collection?

   a) None
   b) 1-2x/week
   c) 3x/week
   d) 4-5x/week
   e) Above 5x/week

2) Overall, how frequently did you practice hypopressive exercises in the past 12 weeks prior to the second data collection?

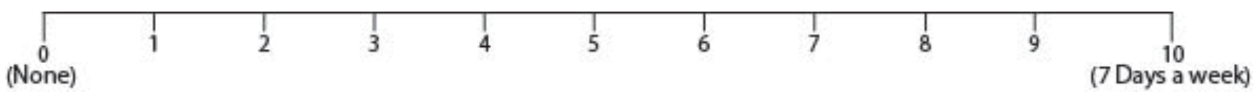
   a) None
   b) 1-2x/week
   c) 3x/week
   d) 4-5x/week
   e) Above 5x/week

3) When you did practice, during a usual practice session, how many repetitions of each task did you practice (i.e., lying without posture, lying with posture, standing without posture and standing with posture)?

   a) 1-2 repetition of at least three of the tasks
   b) 3-5 repetitions of at least three of the tasks
   c) More than 5 repetitions of at least three of the tasks
   d) 1-2 repetitions of one or two of the tasks

e) 3-5 repetitions of one or two of the tasks
f) More than 5 repetitions of one or two of the tasks
g) I did not practice

4) On a scale of 0 (none) to 10 (7 days/week), please rate your overall adherence to the hypopressive protocol.



5) Overall, how satisfied are you with the hypopressive exercises?

6) Do you intend to continue performing the hypopressive exercises after you have completed this study?

7) Do you have any comments you would like to share about the exercises?