A Comparison of the Lesser Pelvis and Hip's Synergistic Muscular Function between Women with Self-Reported Hip Symptoms and a Control Group

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In fulfilment of the degree MSc Physiotherapy by Dissertation, Faculty of Health Sciences at the University of Witwatersrand

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DECLARATION

I, Mariette Oelofse, declare that the work contained in this research report is my own work, except to the extent indicated in the acknowledgement sections.

This research report is being submitted for a degree of Masters in Physiotherapy at the University of the Witwatersrand, Johannesburg, South Africa.

This work has not been submitted for any other degree or examination in this or any other university.

Mariette Oelofse	11 November 2022
Name Surname	Date

DEDICATION

To my Heavenly Father, Who blessed me with this profession. I love being a physio!
To my precious daughters. Thank you for your faith in me and the enduring love and support throughout this journey. My beautiful, committed mother, my brother and my sisters. I would not have been able to complete the study without your loving encouragement and support.

SUMMARY

Introduction

The pelvic floor muscles (PFM) and the hip's indiscriminate relationship are shown in their anatomical connection.

Excluding PFM function when managing hip symptoms may lead to essential information being overlooked and missed.

This study investigated PFM symptoms, quality of life (QoL) and function in young sportswomen, with self-reported hip symptoms, compared to a non-symptomatic hip group and hypothesised to identify differences between groups.

Method

This observational study compared the stated outcomes between two groups of nulligravida sportswomen aged 18-35 years: Group 1 (n=19) with hip symptoms and a non-symptomatic Group 2 (n=19).

The Self-Administered Co-Morbidity Questionnaire (SCQ) and The Hip And Groin Outcome Score (HAGOS) were utilised to screen and select participants. The HAGOS also measured Group1's hip symptoms. The Australian Pelvic Floor Function Questionnaire measured PFM QoL and symptoms. A transverse, transabdominal sonar application measured bladder base (BB) displacement indicating PFM movement. Furthermore, a practical work/rest surface electromyography (sEMG) test showed the balanced function of the hip's posterior synergies.

The Statistical Package for the Social Sciences (SPSS) version 27 and The Mann–Whitney U test was used. The effect sizes were interpreted according to Cohen's (1992) recommendations.

Results

Group 1 reported PFM symptoms such as incomplete bladder emptying, urgency, frequency and dyspareunia. These symptoms impacted their QoL. Group 2 reported fewer PFM symptoms, which had a lesser effect on their QoL. The strength difference between groups for bladder function was medium (r = -0.340). No significant differences were found in the bowel and sexual function.

The PFM function sonar assessment showed asymmetry of the BB at rest was evident in Group 1, 53% (n = 19), vs Group 2, 31,6% (n = 19). Furthermore, the caudal displacement of the BB during a breathing cycle of high-medium effect (r = - 0.467) and a significant difference in the displacement of the BB in a cephalad direction during a voluntary PFM contraction (r = -0.671).

The sEMG, as a measure of hip muscle function, the posterior synergies of the hip, between groups, showed more imbalance between hips in Group 1 vs Group 2. When considering the median value as a measure of central tendency between Group 1, Mdn = 8.4 (n = 19), and Group 2 Mdn = 3.7 (n = 19), a clinically relevant difference is observed and indicates more imbalance between hips in Group 1.

Conclusion

The hip and PFM dynamic relationship in managing young sportswomen with hip symptoms should be considered as differences in PFM symptoms, QoL and significant differences in PFM function were found between Group 1 and Group 2. Furthermore, clinically relevant hip function differences were found between groups.

Health professionals in the sporting environment can utilise the current study's non-invasive measures and procedures during clinical assessment. The outcomes may lead to the holistic management of hip and PFM symptoms, early referral to relevant health professionals and management of load on the PFM and the hip during sports participation.

ACKNOWLEDGEMENTS

This study would not have been possible without certain people's support and assistance. I want to thank them for their time and expertise on personal and professional levels.

My supervisor, Corlia Brandt. Thank you for your assistance and advice. You were always willing to assist with feedback, weekends and holidays included. I appreciate it! Thank you for being dedicated to promoting women's health in South Africa and beyond our borders. It is much needed, and your initiative and effort are inspiring. I wish you all the best!

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%MVC:	Percentage of the maximum voluntary contraction
ADL:	Activities of Daily Living
Ant:	Anterior
ATLA:	Arcus Tendinous Levator Ani
BB:	Bladder Base
CO:	Non-symptomatic hip participant
CPPS:	Chronic pelvic pain syndrome
COSMIN:	The Consensus-based Standards to select health Measurement Instruments
Dysp D:	Dyspareunia Deep
Dysp S:	Dyspareunia Superficial
FAI Syndrome:	Femoral acetabular impingement syndrome
FPFQ:	The Australian pelvic floor questionnaire or Female Pelvic Floor Questionnaire
Freq:	Frequency
GPPPD:	Genito pelvic pain penetration dysfunction
HAGOS:	Copenhagen Hip and Groin Outcome Score
HS:	Hip Symptom
IBE:	Incomplete Bladder Emptying
IC:	Interstitial Cystitis
ICIQ-VS:	Vaginal Symptoms
IHiPRN:	International Hip-related Pain Research Network
IOC:	International Olympic Committee
L:	Left
Lat:	Lateral
OA:	Osteoarthrosis
ODysp D:	Occasional Dyspareunia
PFM:	Pelvic Floor muscles
PFDI-20:	Pelvic Floor Distress Inventory
PFIQ-7:	Pelvic Floor Impact Questionnaire
Post:	Posterior
QoL:	Quality of Life
R:	Right
ROM:	Range of Movement
SCQ:	The Self-administered Co-morbidity Questionnaire
SD:	Standard Deviation
sEMG:	Surface electromyography
UCPPS:	Urinary Chronic Pelvic Pain Syndrome

CHAPTER 1: INTRODUCTION AND SCOPE OF THE RESEARCH REPORT

Introduction

The pelvic floor muscles (PFM) and the hip's indiscriminate function are shown in their anatomical connection. Essential information may be overlooked and missed when PFM functions are excluded from managing hip symptoms.

This study investigates PFM symptoms, quality of life (QoL) and function in young nulligravida sportswomen, with self-reported hip symptoms, compared to a non-symptomatic hip group.

The drive of leading journals and organisations to report on sportswomen is evident. The Journal of Women's Health Physical Therapy recently called for papers on research in women for a special edition, "The Female Athlete: Elevating Health and Performance". The IOC published a handbook on the sports science of female athletes. Various companies, such as Orreco, present workshops and webinars to enhance female athletes' performance (Costello et al., 2014; Mountjoy, 2015; Orreco, 2020).

Topics currently covered in journals, webinars, and seminars are female athletes' menstrual cycle, contraception, energy sufficiency, bone density, nutrition, pregnancy-related topics and incontinence. There is a lack of reporting on different aspects of PFM and hip muscle functions in sportswomen (Castanier et al., 2021).

Previous studies focused on the continence aspect of PFM in sportswomen (Almousa & Loon, 2019; Arbieto et al., 2021; Bø & Nygaard, 2020; Leitner et al., 2018). Keynotes from these studies were: further studies are needed to understand the influence of strenuous physical activity and different exercises on PFM function and disorders. Furthermore, there is a lack of knowledge regarding factors associated with stress, and urinary incontinence, such as intra-abdominal pressure, slow voluntary contraction of the PFM or an absence of rapid and reflexive co-contractions of the PFM (Bø & Nygaard, 2020; Santos et al., 2018).

Limited studies include PFM and hip muscle function in assessing and managing the sportswomen's pelvic health. Pelvic health refers to the state of wellness, illness, or injury in the pelvic area; therefore, the function of organs, the supporting structures and the neuromusculoskeletal aspects of the pelvis (Chiarello, 2021). This current study draws attention to the function of the lesser pelvis, including the hip, groin, and PFM.

The exclusion of PFM function in the management of a sportswomen's hip symptoms leads to under-reporting of symptoms, and essential information for diagnosis and rehabilitation of the hip, groin and the rest of the pelvis may be missed (Draovitch et al., 2012; Foster et al., 2021; Hulme, 2000). The holistic management of hip and PFM symptoms may be affected, such as managing the load on the PFM and the hip during sports participation and referral to relevant health professionals. Therefore, it impacts the prognosis of hip and PFM function and the participation potential of the sportswomen.

There are several role players in the under-reporting of PFM function in sportswomen. These include various barriers to reporting.

1.1.1 Barrier 1: Young sportswomen's reluctance to report PFM function symptoms

Young sportswomen generally are not empowered and lack knowledge regarding the function and possible symptoms of PFM. Sportswomen find the involuntary loss of urine embarrassing and a cause for hygienic concern. Cardoso and Lima (2018) showed eight of ten sportswomen never spoke to anyone about their symptoms. Furthermore, deep-seated embarrassment surrounding PFM symptoms, upbringing, ethnicity, cultural differences and age are factors. Involuntary urine loss is reported in sportswomen as early as puberty, a self-conscious age (Cox et al., 2021).

The feeling of embarrassment may be deep-seated with far-reaching physical consequences, e.g., managing the sportswomen's hygiene regarding urinary incontinence and menstrual bleeding. The burden may also influence the sportswomen physically and emotionally (Greydanus & Patel, 2004; Rebullido et al., 2020).

1.1.2 Barrier 2: PFM functions are undervalued because of incomplete reporting

The high proportion of articles in journals regarding the continence function of the pelvic floor muscles may lead to overlooking the PFM's integrated function in the hip and pelvis (Foster et al., 2021; Hungerford et al., 2003; Moser et al., 2018).

A high prevalence of urinary incontinence is reported in sportswomen (Almousa & Loon, 2019; Rebullido et al., 2020). Increased tone of PFM function is also reported to a lesser extent and relates to provoked vestibulodynia, dyspareunia and chronic pelvic pain syndrome (CPPS). In these conditions, altered contractibility of the PFM may cause decreased strength, contraction speed, coordination, and endurance of PFM. (Ackerman & Lee, 2016; Clemens et al., 2019; Grinberg et al., 2020; Morin & Binik, 2017).

The above-mentioned altered function of the PFM may affect the pelvis and hip joint's motor control and balanced function and may influence the sportswomen's training and performance (Draovitch et al., 2012).

1.1.3 Barrier 3: Screening and managing pelvic health is seen as an intimate aspect of health care, limited to specialist medical and therapeutic professionals

The researcher considered the word "pelvic" and found Collins' dictionary defines pelvic as "near or relating to the pelvis" (Collins, 2022).

Chiarello, 2021 in her editorial, surveyed an opinion on pelvic health and how it is interpreted. Physiotherapy students shared their thoughts on pelvic health. Pelvic health was described as intimate, a subject not talked about because of shame and fear, and they mentioned that pelvic health is overlooked as a "women's only" topic. They also reported an essential aspect of health not recognised and not integrated into treatment. The all-inclusive description of pelvic health was also mentioned in this survey and included gender, age, diagnosis, and structure in the pelvic area. Furthermore, it should be all-inclusive for all medical professionals, including the role players in the multidisciplinary team of the sportswoman.

1.1.4 **Barrier 4: Sportswomen are reluctant to report hip symptoms**

A high incidence of lower extremity injury in sportswomen is reported. Dr Emery and Lebrun report that female athletes' stress fractures in the pelvis and lower extremities account for a high incidence of injuries treated in sports medicine clinics (Mountjoy, 2015; pp. 9-19). Stress fracture injury usually develops over time and may result from underlying concerns, e.g. bone density, overuse injury or strain because of failed inert, capsular and ligamentous structures (Bishop et al., 2021; Draovitch et al., 2012). This barrier to reporting may lead to overuse hip injury, early-onset degenerative pathology and early retirement from their sport (Kerbel et al., 2018).

Jansen van Rensburg et al. (2021) reported that 80% of general injuries and illnesses in the Netball World Cup 2019 were only documented on matchdays, raising the need for education to encourage sportswomen to report injury and illness as soon as possible.

The barriers in reporting mentioned above and, ultimately, under-reporting of PFM functions and hip muscle function are far-reaching and impact the prognosis of hip function, PFM function, and sportswoman's quality of life. Hip pathology, such as Femoral Acetabular Impingement syndrome (FAI) and labral injury, are pathologies associated with the sports activities of the current study cohort (Griffin et al., 2016). Female patients, who account for 60% of hip arthroscopies, have an average age range from the mid-twenties to the early forties, may report a QoL score in their late twenties, similar to the reported QoL for end-stage osteoarthrosis (Herickhoff & Safran, 2018; Nakano et al., 2017; Palmer et al., 2015).

The current research highlights the dynamic relationship between the PFM and hip muscle function and draws attention to the limited studies on all-inclusive pelvic health. Excluding PFM function when managing hip symptoms may lead to essential information being overlooked and missed. Screening and managing PFM and hip muscle function in sportswomen will prevent the development of hip disease or debilitating pelvic floor muscle function, which may cause dysfunction and impact the sportswoman's performance and quality of life.

1.2 Problem Statement

Under-reported PFM and hip muscle function of sportswomen with hip symptoms lead to missed diagnoses and under-treatment. The prognosis of hip symptoms is affected as under-reporting may lead to overuse injury and chronic hip, groin, and pelvis symptoms (Kerbel et al., 2018; Rebullido et al., 2020).

Under-reporting of pelvic, hip and groin health encloses many facets on different functional levels of the sportswoman. The sportswoman's psychosocial well-being, sports identity and performance in training and competition may be affected. PFM and hip dysfunction may cause sportswomen to abandon their sport.

The significance of early retirement on the sportswoman's life and the costly unsupported effect of early-onset degenerative pathology may significantly affect the sportswoman's psychosocial, socio-economic, and quality of life (QoL) and compromise a continued active lifestyle (Impellizzeri et al., 2020; Kemp et al., 2020).

1.3 Research Questions

Question 1:

Are there differences in the symptoms, quality of life and pelvic floor muscle function between nulligravida sportswomen with self-reported hip symptoms and a group without self-reported hip symptoms?

Question 2:

Are there differences in the symptoms, quality of life and muscle function of the posterior synergies of the hip between nulligravida sportswomen with self-reported hip symptoms and a group without self-reported hip symptoms?

Hypothesis 1:

There are differences to observe and report in the symptoms, QoL and PFM function between young nulligravida sportswomen with self-reported hip symptoms and a group without self-reported hip symptoms.

Hypothesis 2:

There are differences to observe and report in muscle function of the posterior synergies of the hip between a group of active young women, nulligravida, with self-reported hip symptoms and a group without self-reported hip symptoms.

1.4 Aim of the Study

To investigate PFM and hip muscle function, symptoms and QoL in young nulligravida sportswomen, with self-reported hip symptoms, compared to a group without self-reported hip symptoms.

1.5 Objectives of the Study

The objectives of the study were:

1. To determine participant-reported hip symptoms (symptom severity, impact, QoL) in a group of young sportswomen, with self-reported hip symptoms, compared to a group of young sportswomen, without self-reported hip symptoms.
2. To determine participant-reported PFM symptoms-symptom severity, impact, and QoL regarding bladder, bowel, and sexual function in a group of young sportswomen with self-reported hip symptoms compared to a group of young sportswomen without self-reported hip symptoms.
3. To determine PFM function in a group of young sportswomen with self-reported hip symptoms compared to a group of young sportswomen without self-reported hip symptoms; and
4. To determine the balanced function of the posterior synergies of the hip in a group of young sportswomen with self-reported hip symptoms compared to a group of young sportswomen without self-reported hip symptoms.

1.6 Significance of the Study

The study raises awareness among the multidisciplinary team that all aspects of pelvic health should be considered in the screening process of young nulligravida sportswomen with hip symptoms.

The observations mentioned in the objectives above will identify a functional pattern and characteristics of the pelvic floor and hip muscles in young sportswomen with hip symptoms.

Reporting functional patterns and characteristics will contribute to the pool of knowledge in screening and managing young nulligravida sportswomen with self-reported hip and PFM symptoms. Nulligravida is a term used to describe women who have never been pregnant. The physiological and physical changes in the female's bony pelvis and pelvic and abdominal muscles during pregnancy and delivery may result in variables and are further explained in the literature study section.

The study raises awareness among the multidisciplinary team, treating, coaching, and managing young sportswomen regarding PFM function and hip muscle function in young sportswomen with hip symptoms. The female physiotherapist's role in consulting or being part of the multidisciplinary team of sportswomen is emphasised.

The study empowers the participant (sportswomen) with insight and knowledge regarding their pelvic health and raises the following awareness:

- To recognise symptoms related to the function of the hip and to seek treatment
- To recognise symptoms associated with the pelvic floor muscles' function and seek treatment
- To include hip and pelvic floor muscle function in her conditioning program.

This study motivated a standardised reporting tool and assessment for pelvic health in young nulligravida sportswomen. The PFM sonar assessment procedure is a practical and non-invasive assessment to include the PFM function when screening or assessing young sportswomen in general or, specifically, with hip symptoms.

The study's introduction is followed by the problem statement, research questions, aim and literature review. The selected participants for the study were young nulligravida sportswomen with self-reported hip symptoms and a similar group without hip symptoms. In the literature study, the researcher revises the anatomy of the lesser pelvis and emphasises the confounding variables, gender differences, and pregnancy. An overview of the layered anatomy of the pelvis, groin and hip will verify the synergies relevant to the current study. The researcher continues to explain what functional symptoms of the PFM and hip muscles may be reported by participants. The methodology will describe the chosen outcome measures and results as an intervention to screen, report and manage pelvic health in sportswomen. The data analysis, discussion, conclusion, and future research recommendations follow.

The observation, identification, and reporting of function result in an intervention to reduce the sportswomen's pelvic health burden currently and beyond their sports career.

1.7 Organisation of the Research Report

Chapter 1: Chapter one establishes the topic's context, framework, and significance. Discuss the issue, the debates and the knowledge gap. The chapter discusses the research purpose and presents the research questions and hypotheses. The research methodology and design are prescribed. By elaborating on the study's importance, the worth of the study is demonstrated. The chapter is concluded with a brief outline of the dissertation

❖

Chapter 2: The literature study described the study's title, the participant group, and young nulligravida sportswomen. The anatomy of this study is described, and the confounding variables are outlined. The hip and PFM function and possible symptoms the participants may experience are explained. The chapter is concluded with an explanation of the chapters to follow.

❖

Chapter 3: The methodology section explains the participant's screening and selection. Furthermore, the instruments and outcome measures and the study's method. Ethical considerations, data processing, reliability and validity are discussed.

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Chapter 4: The data-analysis section presents the data acquired from the different instruments such as the questionnaires, the sonar and the sEMG. The presentation includes tables, figures and graphs.

❖

Chapter 5: The section discusses the results in the context of previous literature. Furthermore, interesting findings are highlighted and interpreted. The possible implication of the findings is noted

Figure 1.1: Organisation of the Research Report

CHAPTER 2: LITERATURE REVIEW

2.1 **Introduction**

The literature review explores the literature relevant to the study's title, "A comparison of the Lesser Pelvis and Hip's Synergistic Muscular Function between Women with Self-Reported Hip Symptoms and a Control Group". Furthermore, the literature review outlines the participant group, young nulligravidas, who are sportswomen. The anatomy of the lesser pelvis, the confounding variables such as gender differences and the role of pregnancy are reviewed. An overview of the layered anatomy of the pelvis, groin and hip verifies the synergies relevant to the current study. Furthermore, the nature of the PFM and hip function symptoms the study's participants may report are discussed.

Search Strategy:

An online search under the health science platform was used to find relevant publications. Articles in both English and articles translated into English published between 2012 and January 2022 were searched using databases such as PubMed, Science Direct, Google Scholar, and ClinicalKey. The lesser pelvis, pelvic floor muscle, hip muscles, hip stabilisers, transabdominal sonar, surface EMG, sportswomen, hip screening, femoral acetabular impingement, deep rotators of the hip and labral pathology were all utilised as keywords in this study. The sports activities included netball, football, hockey, dancing, and related injuries. The articles included were narrative, systematic, and meta-analysis review articles, randomised controlled trials, and observational studies.

2.2 **The Anatomy of the Lesser Pelvis and The Confounding Variable Gender Differences**

2.2.1 **The boundaries of the lesser pelvis**

The lesser pelvis is the pelvic area below the pelvic brim, reaching down towards the pelvic outlet. The boundaries of the pelvic inlet are anteriorly, the pubic crest and pecten pubis, laterally, the arcuate line and posteriorly, the sacral ala. The pelvic outlet's boundaries are anteriorly the pubic arch, the inferior margin of the pubic symphysis, the pubic rami, and the ischial rami. The lateral border is outlined by the ischial tuberosities, and posteriorly, the sacrotuberous ligaments, the sacrum, and the coccyx (Bazira, 2021) (Figure 2.1).

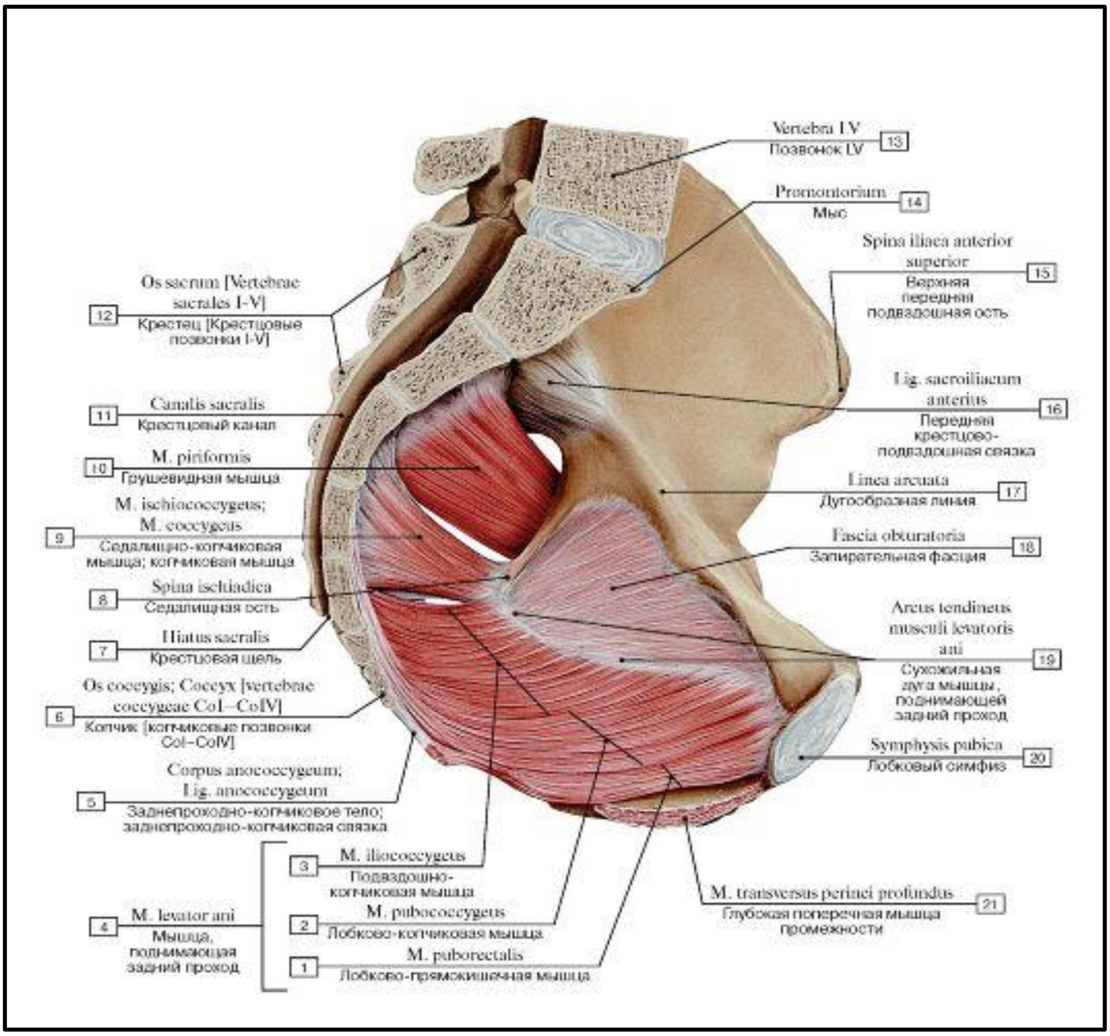


Figure 2.1: The Lesser Pelvis
14 Promontorium, 17 Linea Arcuata, 20 Symphysis Pubic, 6 Coccyx, 8 Ischial Spine, 12 Sacrum.
http://vmede.org/sait/?page=4&id=Anatomija_bili4_t1&menu=Anatomija_bili4_t1

2.2.2 **The ischioanal fossa**

The posterior aspect of the lesser pelvis' outlet accommodates the ischioanal fossa. The fossa is a crucial link between the lower extremity and the pelvis. The boundaries of the ischioanal fossa, the obturator internus, the deep fibres of the biceps femoris, gluteus maximus, and adductor magnus integrate fascially and interact with the PFM. This essential synergy contributes to the functional integration of the pelvic floor muscles and the stability of the pelvis on the hip joint. The function of this synergy is discussed in more detail below (Aldabe et al., 2019; Soljanik et al., 2012; Vleeming et al., 2012) (Figure 2.2).

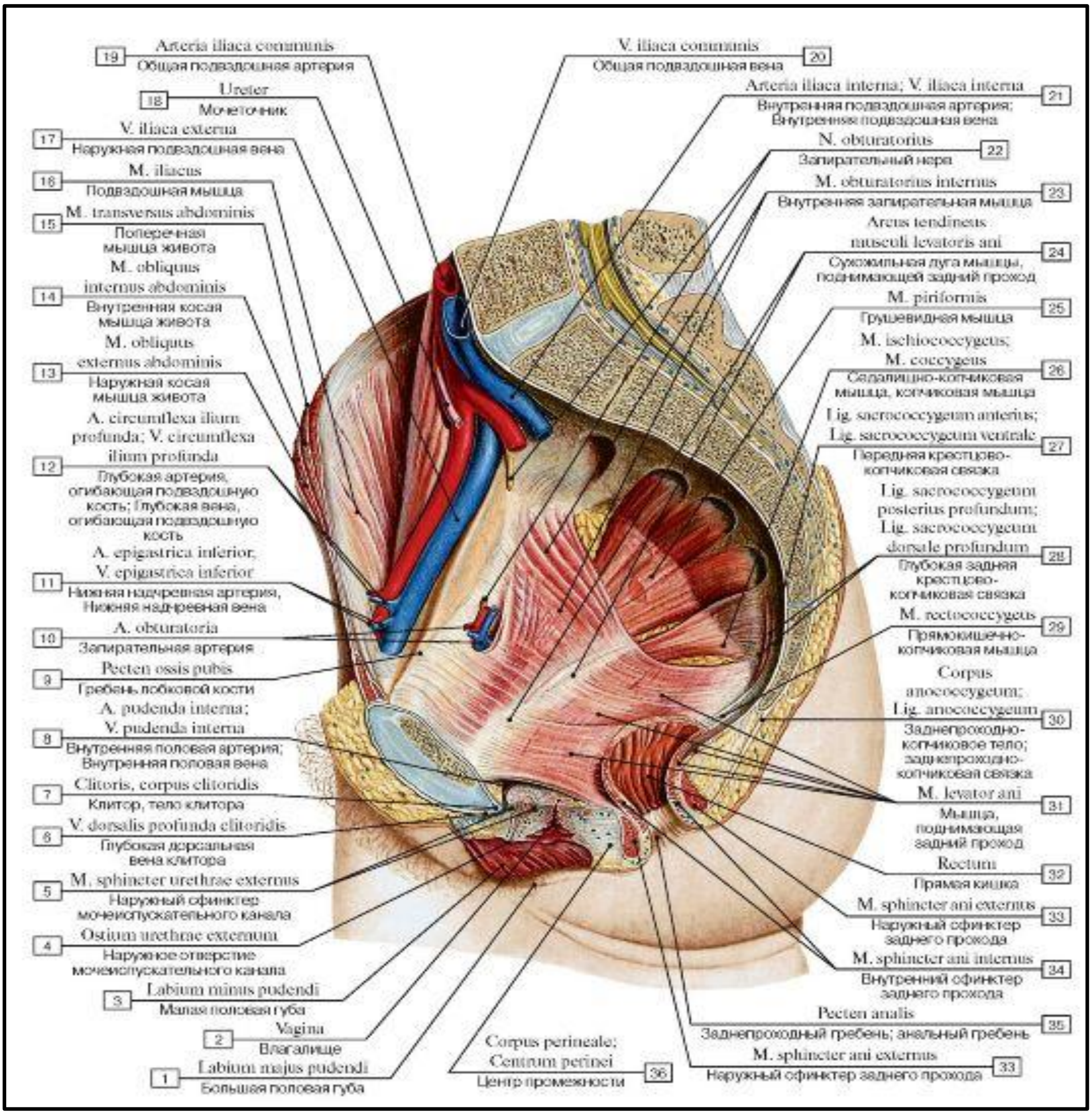


Figure 2.2: The Ischio-Anal Fossa
23 Obturator Internus; 24 Tendinous Arch of Levator Ani; 26 Ischiococcygeus, Coccygeus;
27 Anterior sacrococcygeal ligament; 28 Deep posterior sacrococcygeal ligament;
29 Rectococcygeus; 30 Anococcygeal body, Anococcygeal ligament; 31 Levator ani;
32 Rectum; 33 External anal sphincter.
http://vmede.org/sait/?page=4&id=Anatomija_bili4_t1&menu=Anatomija_bili4_t1

2.2.3 Gender differences in the lesser pelvis and the pelvic floor muscles.

Women were selected as participants of the current study because gender differences are evident in skeletal aspects and the neuromuscular function of the PFM. There are also differences in biomechanical characteristics and body composition between male and female athletes.

In general, the lesser pelvis in women is broader to accommodate the birth canal. The lesser pelvis in women has a wider sacrum, a wider subpubic angle, and less prominent ischial spines than males.

Biomechanically, they contribute to an increased carrying angle of the hip joint and Q-angle at the knees. Body composition differences, such as the height and weight of the male and female athletes, may mask the skeletal differences in function. Hormonal differences between male and female athletes and the different endocrine environments promoted by estrogens, progesterone, testosterone, and their precursors might influence human physiology and pathophysiology. Therefore, functional differences between males and females may not always be due to skeletal differences in the pelvis (Lewis & Laudicina, 2017; Lube et al., 2016, 2017; Lauretta et al., 2018)

Male and female differences in PFM function are observed in a study by Khowailed et al. (2020). The participants conveniently selected were seventy males and a hundred and twenty females. The participants had no reported PFM dysfunction. The researchers reported different activation levels during PFM contraction and relaxation. Gender-based normative values for bladder base (BB) displacement were established using transabdominal ultrasound. BB displacement (cm) was significantly more in the male compared to the female cohort (0.61 ± 0.34 vs 0.35 ± 0.25, $p < .001$, 95% CI: 0.16–0.35)

The study mentioned above reported that hormonal differences, such as testosterone and factors to accommodate the prostate, the taller urethra and micturition in men may result in functional PFM differences between males and females. The BB displacement was significantly greater in males than females (0.65 ± 0.42 vs 0.38 ± 0.35, $p <.001$, 95% CI:0.16–0.38). The study created a general guide for normal percentile values of PFM movement. The importance of the difference is that it may be generally accepted that males will naturally displace the BB more during a PFM contraction than females. The male and female PFM functions can thus not be compared, and differences should be considered in clinical practice, studies, and literature. In clinical practice, the male patient may present with PFM symptoms even with a seemingly good assessment of the BB displacement.

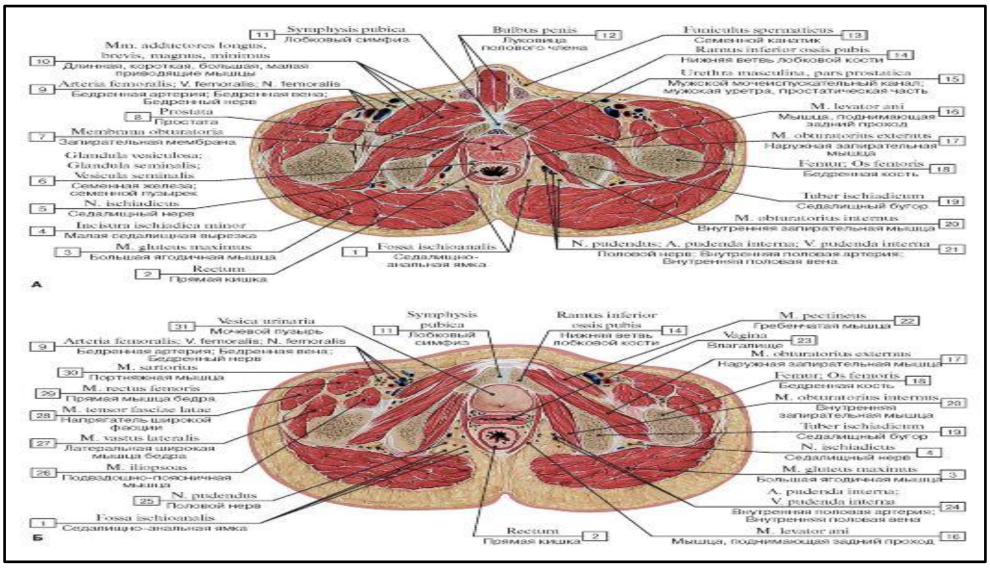


Figure 2.3: A–Male Pelvis B–Female Pelvis.
http://vmede.org/sait/?page=4&id=Anatomija_bili4_t1&menu=Anatomija_bili4_

General gender differences in the body composition of the male vs female athlete are below. These body composition differences further verify the confounding variable of gender differences.

It is not known how these differences reflect on the pelvic floor or hip function of the male or female. Still, since the male's aerobic capacity and muscle strength are generally higher, this may also reflect on the function of the pelvic floor muscles and hip muscles (Mountjoy, 2015, p.1-8) (Table 2.1).

Table 2.1. General gender differences in the body composition of the male vs female athlete

Aerobic capacity (VO2max)	M > F
Blood volume	M > F
Body fat per cent	F > M
Bone mineral density	M > F
Flexibility	F > M
Muscle strength	M > F
Thermoregulation	F=M

2.3 **The Anatomy of the Lesser Pelvis and the Confounding Variable Pregnancy**

The researcher's selected population includes a cohort of nulligravida women. Nulligravida is a term used to describe women who were not pregnant before.

A study by Van Geelen et al., 2018, describes that during childbirth, pregnancy initiates physiological and physical changes in the female's bony pelvis and pelvic and abdominal muscles. It is known that pregnancy, multiple pregnancies, mode of delivery, family history, and a high body mass index are associated with postpartum PFM dysfunction. The PFM's physiological adaptation to mechanical and hormonal alterations in pregnancy and delivery is characterised by the following: bladder-neck descent, increased bladder-neck mobility, decreased structural support for the urethra, trauma to the levator ani muscle, and an increase in the levator hiatus as well as anal sphincter disruption. These physical changes are usually more pronounced in women who gave natural birth vs women who underwent a cesarean. Symptoms such as urinary incontinence, urinary frequency, bowel function difficulty, anal incontinence, pelvic organ prolapses, sexual dysfunction and pelvic pain are reported. Most pelvic floor muscle function improves within the first year postpartum (Bodner-Adler et al., 2019; Durnea et al., 2014).

The effect of physical adaptation during pregnancy and postpartum on the hip joint and hip muscles has not been researched before. Mention was made of the hormonal influence of relaxin on ligamentous changes. The effect of the ligamentous modifications may lead to stability challenges in the pelvis, sacroiliac, and pubic symphysis joints. Weight gain and postural changes during pregnancy may also play a role in developing hip symptoms (Miller et al., 2015; Shi et al., 2016).

The increasing abdominal circumference during the gestation period may cause a separation of the abdominal wall's linea alba, diastasis recti abdominus. The connective tissue between the rectus abdominus may not withstand continuous pressure against the abdominal wall, and separation of the linea alba follows. Minimal separation resolves within 6-8 weeks postpartum. It may take up to six months for the diastasis to improve, or it may not resolve in more severe cases. Standardised methodology to measure diastasis recti abdominus masks distances vs recovery. This incoherent reporting may play a role in the different approaches and opinions in rehabilitating diastasis rectus abdominus (Cavalli et al., 2021) (Figure 2.4).

Gluppe et al. (2021) mentioned the impact of diastasis recti abdominus on the function of the abdominal muscles. They reported that women with diastasis recti have weaker abdominal muscles and more abdominal pain during muscle activity. The study noted that women with diastasis recti abdominus did not have higher pelvic floor muscle dysfunction than those without diastasis recti 12 months postnatal. However, it is unclear how the weaker abdominal muscles and abdominal pain may impact a sportswoman's pelvic health and function.

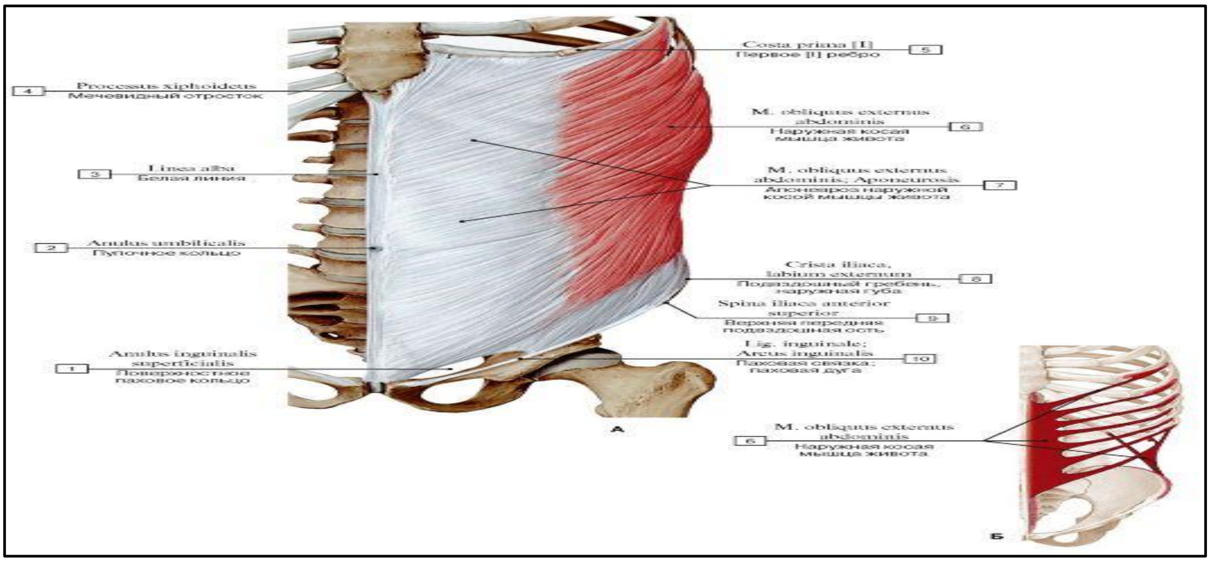


Figure 2.4: Linea Alba
(http://vmede.org/sait/?page=4&id=Anatomija_bili4_t1&menu=Anatomija_bili4_t1)

When considering the various aspects, the pelvis's skeletal and neuromuscular function, body composition and the role of pregnancy, confounding variables were minimised by selecting participants from a female and nulligravida cohort.

2.4 **The Layered Anatomy of the Hip and Pelvis**

The layered anatomy of the hip and pelvis verifies the lesser pelvis and the hip's synergy relevant to the current study (Table 2.2).

The pelvic area functions as a crossroad of activity and load transfer from the lower extremity and hip to the pelvis and upper body, and vice versa. The pelvic area is a complex region with the interplay of forces during function, placing the different anatomical layers of the lesser pelvis, groin, and hip joint under various loads. Pathologies in the pelvic area have often been reported to present simultaneously. The concurrent symptoms and signs contribute to the complexity of a specific diagnosis in the pelvic area (Retchford et al., 2013; Vleeming, 2012). The complexity resonates from the effort of multidisciplinary consensus agreements to standardise terminology and definition in practice and research. Consensus recommendations on the terminology and definitions for groin pain in athletes, FAI syndrome and hip-related pain were reached (Griffin et al., 2016; Reiman et al., 2020; Weir et al., 2015). I observed that no consensus had been reached considering pelvic health and the related function of the lesser pelvis, the groin, and the hip joint as different aspects of pelvic health.

Table 2.2: The Layered Concept of the Hip joint. Including the Pelvic Floor Muscles (Draovitch et al., 2012)

Layer	Name	Structure	Purpose	Pathology	Symptoms
I	Osteochondral	Femur; Acetabulum Innominate	Joint congruence and arthrokinematics movement	Developmental dysplasia, femoral version, acetabular version, femoral inclination, acetabular	Dynamic Cam Impingement Rim Impingement Trochanteric Impingement Delamination Sub-spine impingement
ii	Inert	Capsule and Labrum Ligaments: • Iliofemoral • Ischiofemoral • Pubofemoral Ligamentum Teres	Static stability	Pelvis and Hip joint: Labral tear Ligamentous teres tear Capsular instability Adhesive capsulitis	Possible Symptoms: Pain Hip range of movement impairment Motor control deficiency and compensatory patterns of the pelvis on hip and hip on the pelvis
iii	Contractile	Muscles originate outside the pelvic cavity: • Adductors, hamstrings, the glutei, Rectus femoris • Ilio-capsularis • Pectineus • Obturator externus • Gemelli • Quadratus Femoris Muscles origin inside the pelvic cavity: • Piriformis • Obturator Internus Pelvic Floor Lumbosacral Abdominals	Dynamic stability Osteo-kinematics	Hemi-pelvic pubalgia Ant Enthesopathy: *Hip flexor strain* *Psoas Impingement* *Rectus Femoris Impingement* Medial: *Adductor Tendinopathy* *Rectus Abdominus Tendinopathy* Posterior: *Proximal hamstring strain* Lateral: Glut med tear	Signs and symptoms: Pain. Hip, groin, and pelvis and referred pain Hip joint range movement impairment Pelvic floor muscle symptoms dysfunction Sub-optimal muscle hip function because of muscle stiffness or weakness. Motor control deficiency and compensatory patterns
iv	Neuromechanical	Thoroco-lumbar mechanics Lower extremity mechanics Neuro-vascular structures refer to and regional to the hip Regional mechanoreceptors	Proprioception communication, timing, and sequencing of movement.	Neural Pathology: Nerve entrapment Referred Spinal Pathology Neuromuscular Dysfunction Pain Syndromes	Mechanical: Foot structure and mechanics Scoliosis Pelvic posture over the femur Osteitis Pubis Pubic symphysis pathology SI dysfunction

The layer concept developed by Dr Bryan Kelly is a systematic overview of pelvic structures that may be a source of pathology and cause nociceptive pain. The functional intra-and extra-articular layers of the hip joint are tabled as four layers: the bony layer, the inert tissue layer, the contractile layer and the neuro-mechanical layer (Draovitch et al., 2012).

Layers iii and iv, the contractile and the neuromechanical layers, host the functional synergies of the lesser pelvis and the hip joint, the PFM, and the deep rotators of the hip. These layers represent what was mentioned in the introduction: the indiscriminate function of the PFM and the hip. Layer iii consists of all contractile tissues supporting, controlling and creating movement and ensuring dynamic stability of the hip joint, the pelvis, and the pelvic floor muscles (Table 2.2).

2.5 **Synergies of the Current Study**

Synergy is defined as different muscles relating to an essential performance feature with variability and stability (Latash, 2012; Singh et al., 2018). Compromised synergistic interactions may impact the pelvic and hip joints' dynamic stability and muscle balance. This imbalance may cause postural restrictions, motor control deficits, and compensatory patterns in the pelvic and hip joints. Compensatory patterns can lead to overuse injuries such as tendinopathies and muscle tears due to strained musculoskeletal function in the pelvic area, groin, and hip joint. (Cannon et al., 2020; Diamond & Hoorn, 2019). The injuries mentioned above coincide with what has already been mentioned: lower extremity injuries are common in the female athlete and, more specifically, pelvic enthesopathy and stress fractures (Bishop et al., 2021, Mountjoy, 2015, p. 1-8). Furthermore, urinary incontinence, lower urinary tract symptoms (LUTS) and pelvic pain are reportedly related to muscle constraints and imbalances of the PFM (Cardoso & Lima, 2018).

The current study will observe and report aspects of three synergies in the pelvic area of young nulligravida sportswomen. An ultrasound assessment observes the function of the pelvic floor muscles during a breathing cycle and the function of the pelvic floor muscles during a pelvic floor muscle contraction, and the balanced function of the posterior hip muscles during an electromyography (EMG) standard work-rest assessment.

2.5.1 **Description of the synergies included in the current study**

2.5.1.1 Synergy 1: The PFM and the diaphragm

The diaphragm and the PFM's synchronous, cephalad and caudal movement during tidal and forceful breathing are reported (Talasz et al., 2011). The synergistic function of the diaphragm and pelvic floor muscles contributes to the optimal function of the diaphragm and the pelvic floor muscles. The synergy regulates intra-abdominal pressure. The regulation of inter-abdominal pressure has a protective role on the pelvic organs and contributes to core stability and load transfer from the lower extremity and trunk (Bordoni & Zanier, 2013).

The pelvic floor muscles contract caudally during inhalation when the diaphragm contracts. The diaphragm and pelvic floor muscles return to their original position on exhalation (Hodges et al., 2007). The same pattern of function is exhibited in forceful breathing and coughing. All aspects of this synergy will be challenged during the training and performance of the sportswoman (Hwang et al., 2021) (Figure 2.5).

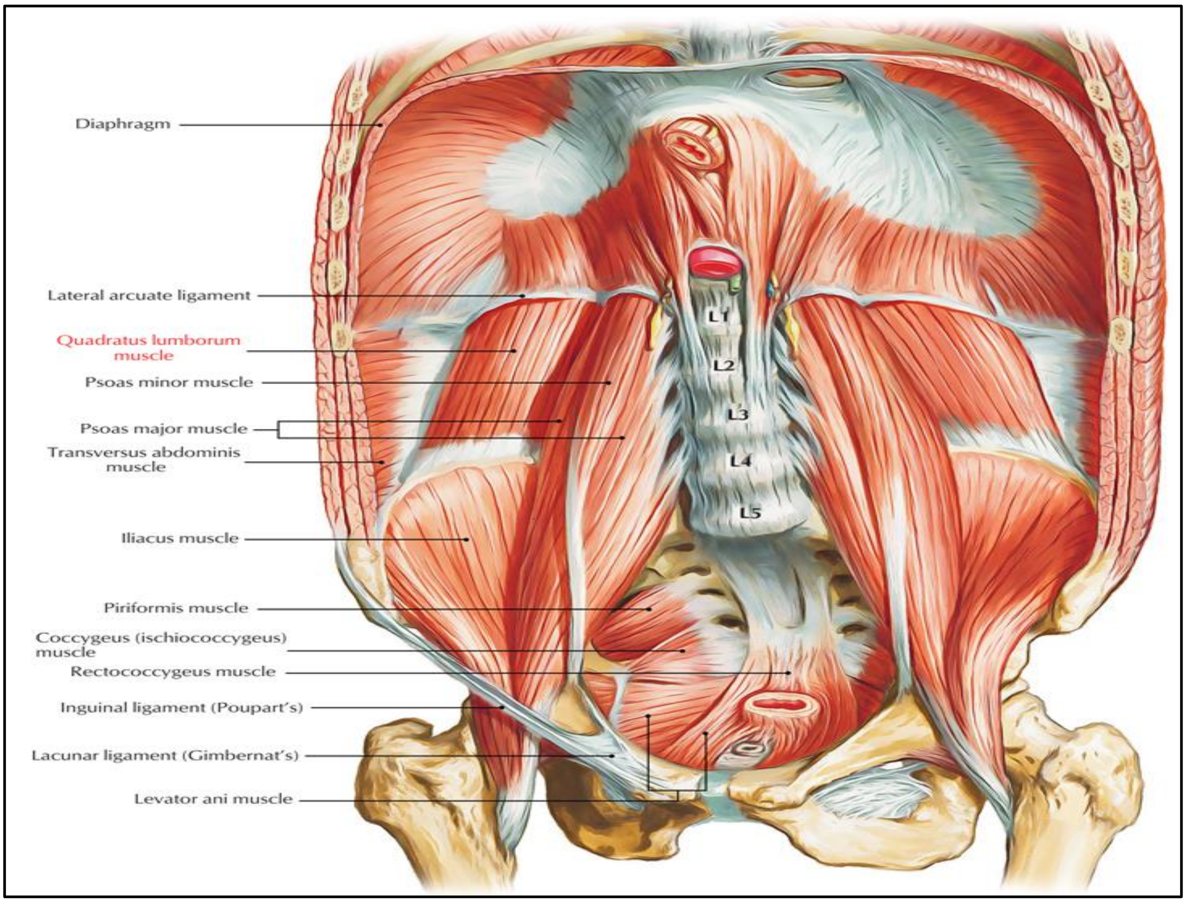


Figure 2.5: Synergy 1–The Diaphragm and the Pelvic Floor Muscles.
https://jennyputtpt.com/2020/05/09/the-diaphragm-more-than-just-a-muscle/

Zachovajeviene et al. (2019) demonstrated the responsiveness of the synergy of the diaphragm and the PFM in their study, comparing three groups to condition the PFM's post-prostatectomy. Groups were compared who predominantly did PFM strengthening and diaphragmatic (breathing) exercises, and the final group did abdominal exercises to strengthen the PFM function. The study showed the highest correlation between PFM strength and endurance in the diaphragmatic exercise group. Although the participant sample can not be compared to the current study's cohort, the result still emphasises this synergy's importance. There are no studies previously done on women.

Hodges et al. (2007) measured both the PFMs postural and respiration functional components and demonstrated the increase in activity of the PFMs during the inhalation phase when the diaphragm descends. This active component of the PFMs confirms PFM function during a breathing cycle and, thereby, the synergistic role of the PFMs and the diaphragm.

2.5.1.2 ***Synergy 2: The PFM in nulligravida sportswomen***

The PFM's functions are factors in various aspects of the pelvic health of sportswomen. The PFMs' role in respiration was discussed previously in the synergy of the PFMs and the diaphragm. During the functional demand of lower quarter dominant sport, the PFMs regulate intra-abdominal pressure and are responsible for continence. Furthermore, known functions of the PFMs allow voiding, defecation, and sexual function (Andrade et al., 2018).

The pelvic floor muscle is divided into three layers (Bazira, 2021) (Table 2.3) (Figure 2.6).

Table 2.3: The pelvic floor muscles (Bazira, 2021)

Layer One	Urogenital Triangle	The external anal sphincter, the bulbocavernosus, the ischiocavernosus, and the superficial transverse perineal sphincter
Layer Two	Urogenital Diaphragm	Sphincter urethrae (urethral sphincter), compressor urethrae (urethral sphincter), sphincter urethral vaginalis (urethral sphincter), deep transverse perineal, and perineal membrane
Layer Three	Pelvic Diaphragm	Coccygeus, piriformis, obturator internus, arcus tendinous of the levator ani, arcus tendinous fasciae pelvis (pubococcygeus aka pubovisceral, pubovaginalis, puboanalis, puborectalis, iliococcygeus), coccygeus, piriformis, obturator internus, arcus tendon

The PFMs play a role in the balanced function of the pelvis on the hip when absorbing ground reaction force and when transferring load from the lower extremity to the pelvis and beyond (Aldabe et al., 2019; Obey et al., 2016; Soljanik et al., 2012).

An automatic pre- or co-contraction function of the PFMs before and during impact activities is reported and may be affected when the PFMs fatigue during strenuous exercise (Constantinou & Govan, 1982; Leitner et al., 2018; Moser et al., 2018; Ree et al.; 2007).

Possible PFM functions shown during the sonar assessment of the young sportswomen are discussed in the paragraphs below.

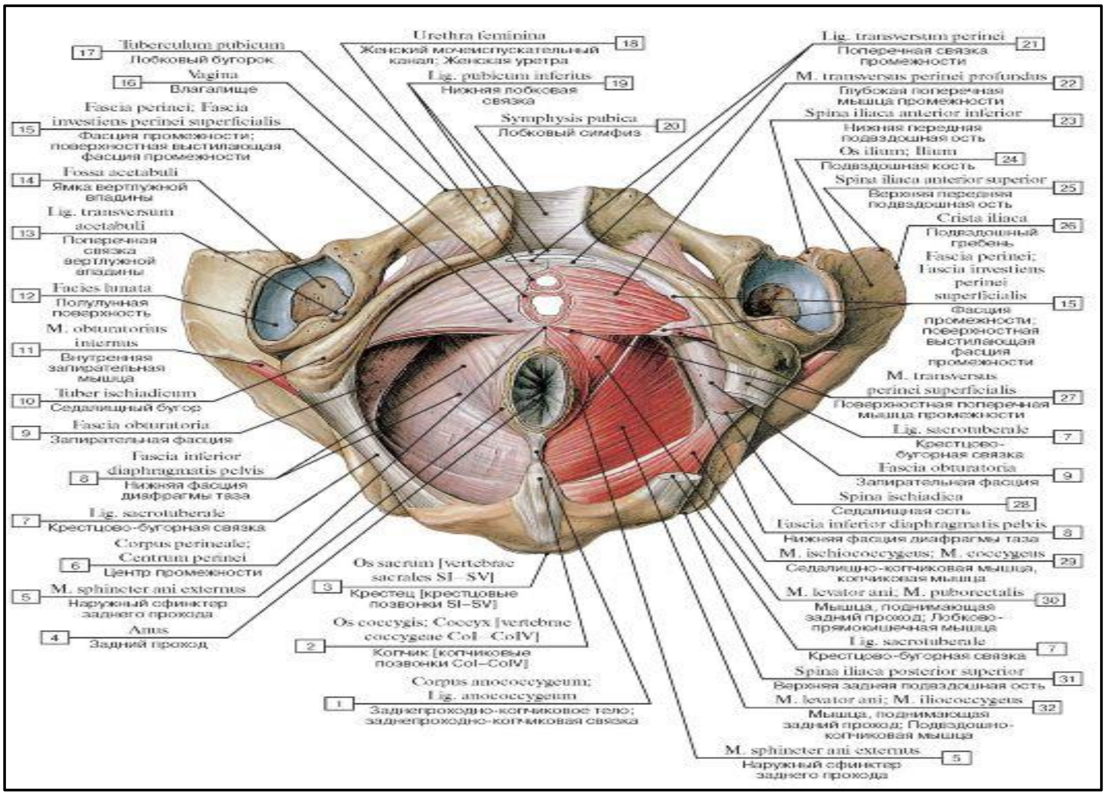


Figure 2.6: Synergy 2. The Pelvic Floor Muscles
29 - Ischiococcygeus; Coccygeus; 30 - Levator ani; Puborectalis; 32 - Levator ani; Iliococcygeus
http://vmede.org/sait/?page=4&id=Anatomija_bili4_t1&menu=Anatomija_bili4_

2.5.1.2.1 ***Possible PFM function Ultrasound Findings***.

2.5.1.2.1 A: *Asymmetry of the BB*

Current literature suggests BB asymmetry may be related to PFM tone differences between sides. The asymmetry may be related to decreased or increased tone in the absence of neurological disorders. Furthermore, the possibility of a structural support deficit may also cause asymmetry (Frawley et al., 2021). Bitti et al. (2014) described a "saddlebag" sign and asymmetry of the BB associated with a structural support deficit of the vagina at the arcus tendinous muscle levator ani (ATLA). The ATLA is the insertion point of the iliococcygeus and the fascia overlying the obturator internus muscle. Both studies emphasised that further research is necessary to clarify BB asymmetry and its role in PFM function and symptoms.

Clinically, when the asymmetry of the BB is observed, further investigation is needed and will assess and confirm increased or decreased PFM tone or the possibility of a structural support deficit. The young sportswomen's training program may accommodate PFM conditioning, and the load on the PFM and the hip can be altered accordingly.

2.5.1.2.1 B: *BB caudal and cephalad displacement*

Sportswomen with altered function of PFMs, such as decreased strength, speed of contraction, coordination, and endurance, are reported (Bø & Nygaard, 2020). The current study will report on the synergy of the PFM and the diaphragm (caudal BB displacement), an involuntary PFM movement and a voluntary PFM contraction (cephalad BB displacement) (Foster et al., 2021; Gordon & Reed, 2018; Ree et al., 2007).

2.5.1.3 Synergy 3. The functional synergies of the hip and the pelvis in nulligravida women

Numerous synergies relate to the hip's optimal function (Retchford et al., 2013).

The deep rotators of the hip, the obturator internus, gemelli, obturator externus and quadratus femoris, function synergistically as dynamic and postural stabilisers of the femoroacetabular joint. The obturator internus and piriformis also relate to the pelvic floor muscles described in the third layer of the PFM, the pelvic diaphragm (Table 2.3; Figure 2.7)

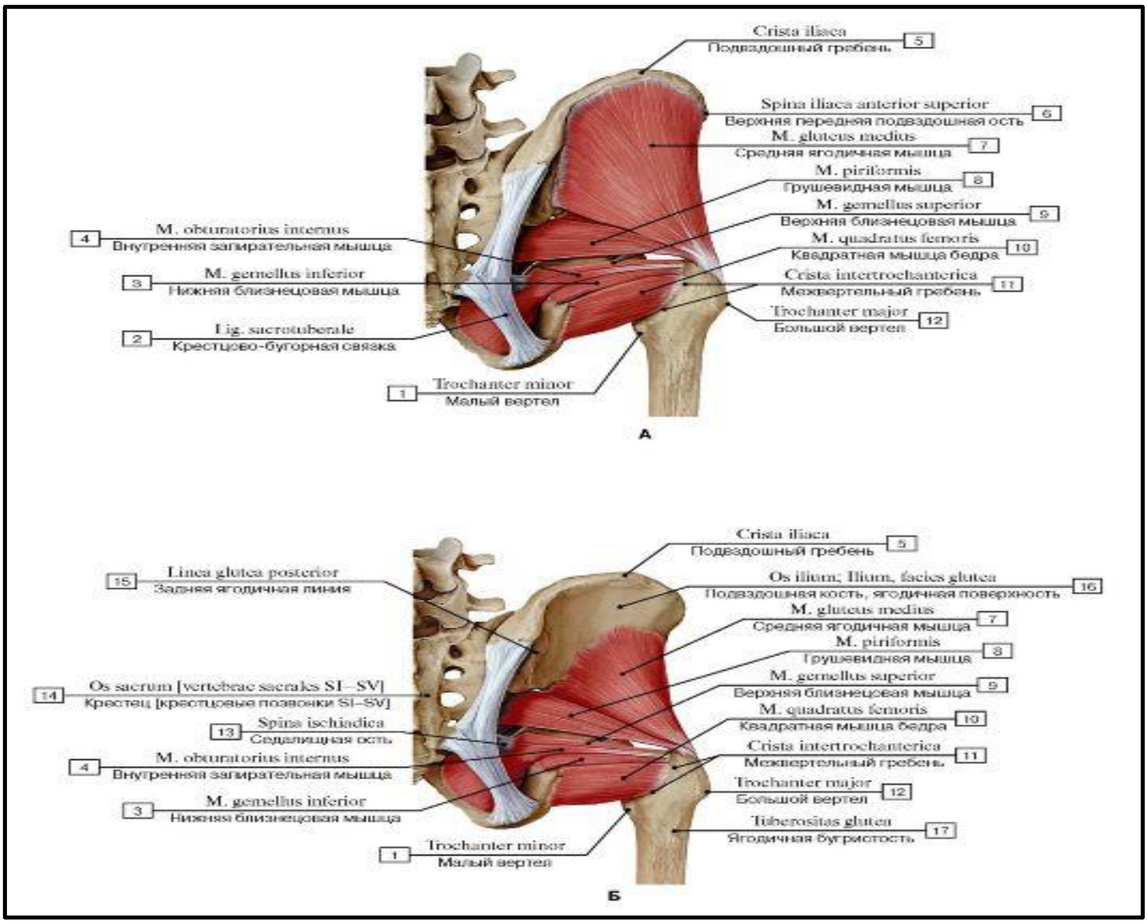


Figure 2.7: The Deep Rotators of the Hip
2 Sacrotuberous ligament; 3 Inferior gemellus; 4 Obturator internus; 7 Gluteus medius; 8 Piriformis; 9 Superior gemellus; 10 Quadratus femoris, 13 Ischial spine
http://vmede.org/sait/?page=4&id=Anatomija_bili4_t1&menu=Anatomija_bili4_t1

The obturator internus, the deep fibres of the biceps femoris, gluteus maximus, adductor magnus and the PFM interact as the boundaries of the ischioanal fossa (Hodges et al., 2014; Soljanik et al., 2012; Walters & Cooper, 2014; Yoo & Dedova, 2015).

The boundaries of the ischioanal fossa are:

1. The Apex: The obturator internus and levator ani muscles intersect at the apex, forming the apex. The obturator internus muscle is covered by the endopelvic fascia (arcus tendinous). The iliococcygeus part of the levator ani muscle enters the arcus tendinous. The sacrospinous ligament defines the lateral-posterior aspect.
2. The Base: The gluteus maximus muscle and the sacrotuberous ligament, coccyx, anococcygeal raphe, external anal sphincter, posterior margin of the superficial perineal fascia, and the posterior border of the transverse superficialis muscle of the perineum define the base's inferior and posterior orientation.
3. The Floor: Consists of the perineum's posterior facial quadrants and the anococcygeal raphe and is limited by the ischial tuberosities and the coccyx.
4. The Roof: The roof is formed by the inferior fascia, which covers the levator ani muscle.
5. The Pyramid wall: The puborectalis muscle, the pubococcygeal muscle covering the anal canal, and the external anal sphincter make up the pyramid wall.
6. The lateral wall: The lateral wall is formed by the medial aspect of the obturator fascia, the ischial tuberosity, and the obturator internus muscle. The fascia covering the lateral wall duplicates the construction of the pudendal vessels' canal. The sacrotuberous ligament inserts on the ischial tuberosity; it blends the fibres with the tendon of the biceps femoris muscle and continues to the inferior pubic angle as the falciform ligament (Soljanik et al., 2012).

The synergistic function of the deep fibres of the gluteus maximus, biceps femoris, obturator internus and levator ani as they interact on the sacrotuberous ligament as the boundaries of the ischioanal fossa contributes to the functional integration of the pelvic floor muscles and the stability of the pelvis on the hip joint (Aldabe et al., 2019; Freeman et al., 2013; Vleeming et al., 2012; Figure 2.8).

Possible hip function symptoms reported by young nulligravida sportswomen are discussed in the paragraphs below.

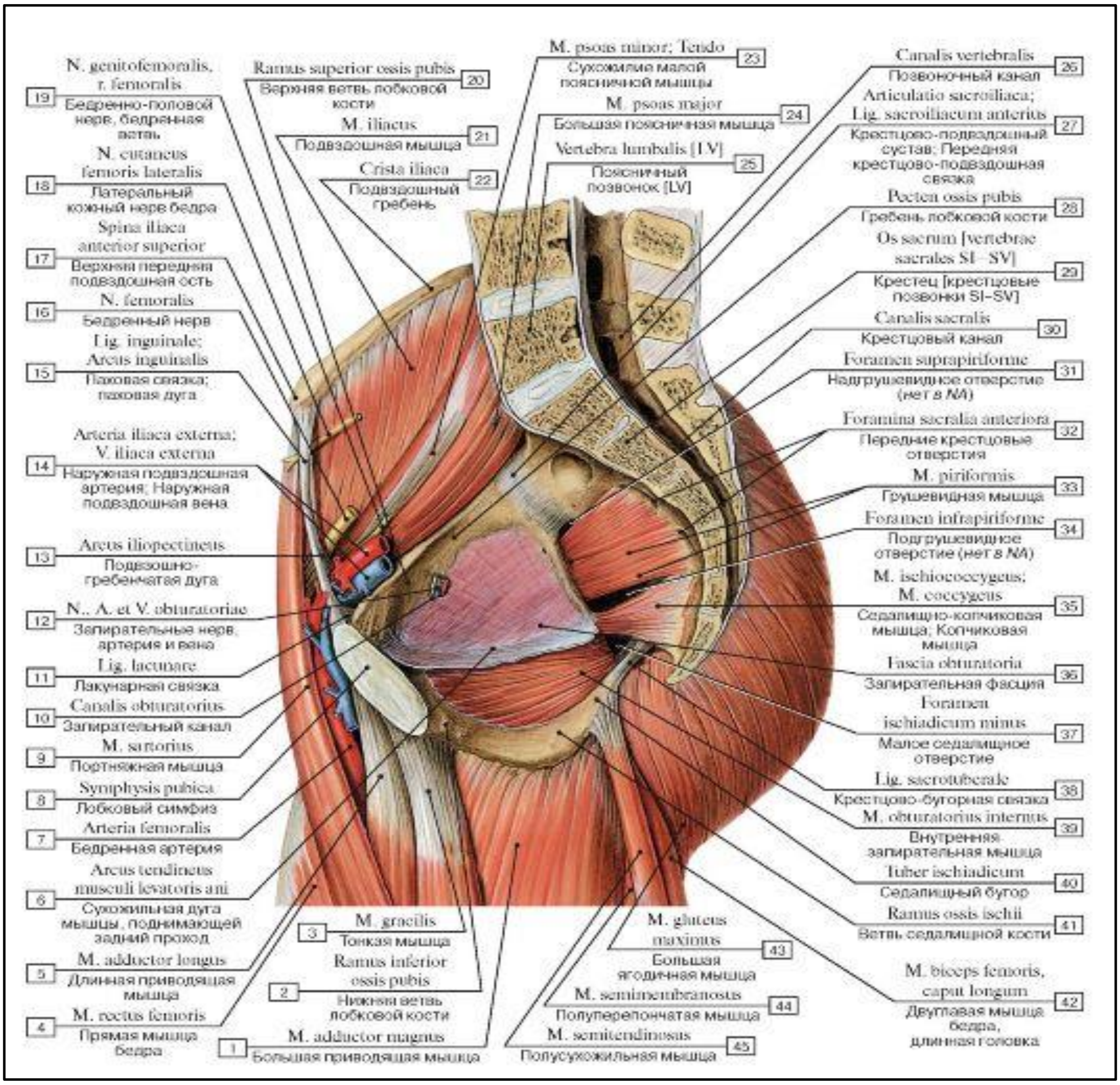


Figure 2.8: Synergy 4. The ischioanal Fossa
1 Adductor Magnus, 6 Tendinous Arch of Levator Ani, 33 Piriformis, 35 Ischiococcygeus Coccygeus, 36 Obturator fascia, 37 Lesser sciatic foramen, 38 Sacrotuberous ligament, 39 Obturator internus, 40 Ischial tuberosity, 41 Ramus, 42 Biceps femoris, long head; 43 Gluteus maximus**.**
http://vmede.org/sait/?page=4&id=Anatomija_bili4_t1&menu=Anatomija_bili4_t1

2.6 The Possible Cause of Hip Symptoms Reported by Participants

The International Hip-related Pain Research Network (IHiPRN) consensus group met in Zurich in November 2018. They classified, defined, and diagnosed disease in young and active adults with hip-related pain as the primary symptom. The IHiPRN identified three groups: FAI syndrome, acetabular dysplasia and hip instability. These conditions may co-exist (Reiman et al., 2020). The researcher concluded that the current study's hip symptom participants might have symptoms related to these pathologies arising from the osteochondral or inert structures discussed above. Their symptoms may also originate from the contractile layer, the groin or pelvic floor structures, as discussed in the previously mentioned synergies (Bishop et al., 2021; Draovitch et al., 2012, Kerbel et al., 2018).

2.6.1 **IHiPRN's Group 1: FAI Syndrome**

Femoral Acetabular Impingement (FAI) Syndrome is associated with abnormal bone morphology and symptomatic pre-mature contact of the femur with the acetabulum (cam) or the acetabulum with the femur (pincer). Approximately 50% of patients diagnosed with FAI syndrome are female (Figures 2.9a and 2.9b).

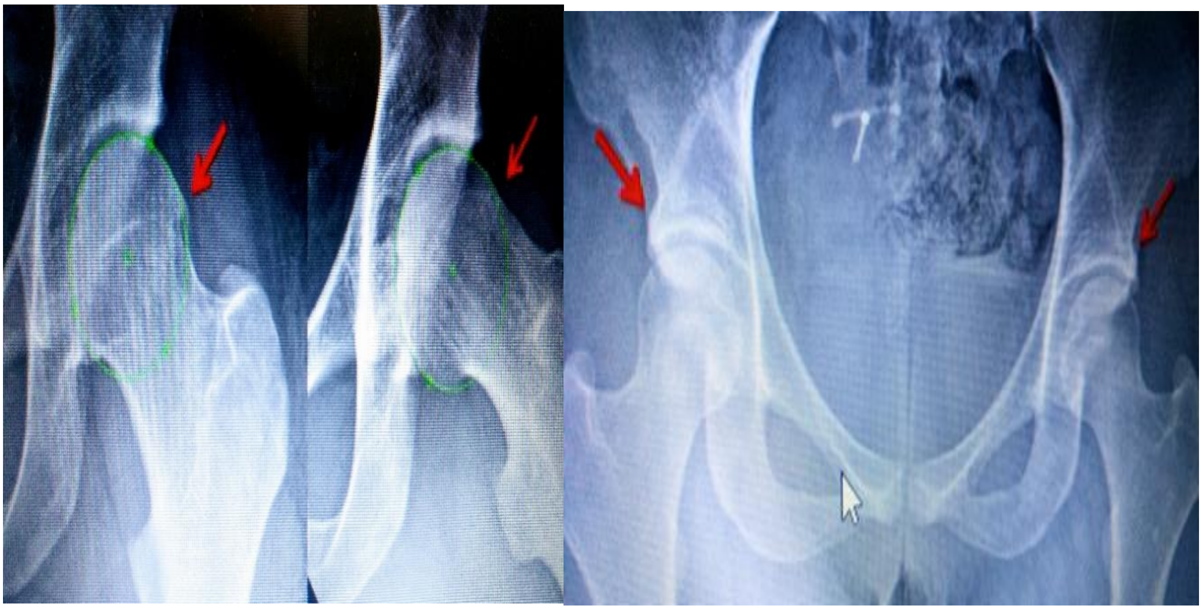


Figure 2.9 a: Cam Morphology **2.9b: Pincer Morphology**
https://josr-online.biomedcentral.com/articles/10.1186/s13018-019-1257-z

The aetiology of FAI syndrome is linked to excessive loading during intensive sport participation by young people at the time of epiphyseal closing of the hip joint. Cam deformity is more prevalent in men, and pincer morphology appears mainly in women. There is limited research and knowledge on the aetiology of pincer morphology. However, the combination of pincer and cam is present in both genders (Draovitch et al., 2012; Grantham & Philippon, 2019). Pincer deformities associated with an impingement in women are the cross-over sign, low-lying anterior inferior iliac spine, and coxa profunda (Halim et al., 2015; Palmer et al., 2015; Rhee et al., 2017). A triad of symptoms, clinical signs and radiology findings is used to diagnose FAI syndrome (Cannon et al., 2020; Griffin et al., 2016).

2.6.2 **IHiPRN's Group 2: Acetabular dysplasia or hip instability**

Hip dysplasia is associated with FAI and osteoarthritic development. General joint instability and a shearing impingement may cause repeated, chronic overload of the acetabular rim. Adjacent cartilage may cause injuries and nociceptive pain. Lack of coverage in dysplasia usually has an anterolateral location, a common location of labral tears (Troelsen, 2012).

McGraw-Hill Education's table illustrates different factors that impact the stability of the hip joint and the development of degenerative hip disease, as it may affect the current study cohort (Figure 2.10).

2.6.3 **IHiPRN's Group 3: Other pathology, such as labral and chondral pathology, without changes in bone shape**

Labral pathology is commonly associated with FAI syndrome. Labral pathology develops first in pincer morphology, followed by cartilage lesions. In cam morphology, the osseous lesion usually emerges first. Impaired load distribution through the hip joint is related to decreased stability due to the failure of the injured labrum's suction-seal effect. Insufficient control through movement and excessive shear force in the hip joint may lead to osteoarthritis (Crawford et al., 2007). Associated pathology detected on MRI, such as enthesopathy, tendinopathies and torn muscles, are shown with "instability" of the hip. (Draovitch et al., 2012). (Figure 2.10).

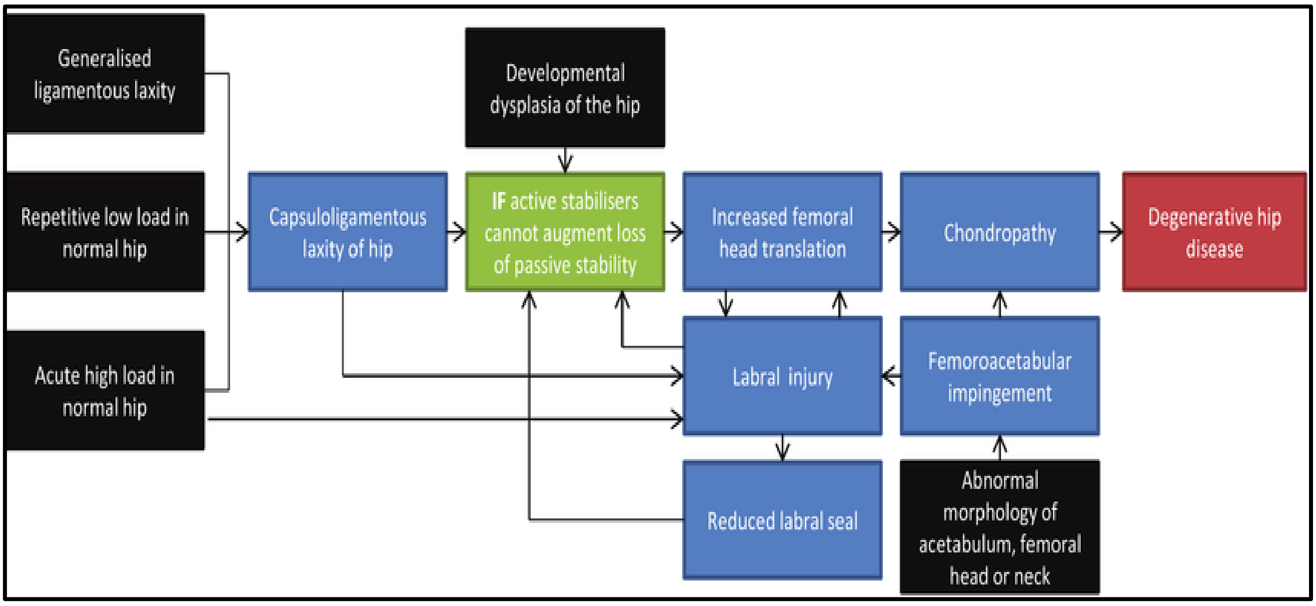


Figure 2.10: McGraw-Hill Education Australia (2012). Proposed development of degenerative disease.

The sub-optimal function of the synergies of the hip and the pelvis may lead to imbalanced hip function and related symptoms and injury risk in sportswomen. Borgstrom and McInnis (2022) reviewed the female hip and mentioned that one of the functional gender differences is asymmetries in biomechanical variables and strength differences between hips. Retchford et al. (2018) also reported strength deficits between hips in most functional directions in patients with hip pain scheduled for hip arthroscopy.

2.7 Netball, Hockey and Football's Physical Demands are a possible Risk for Hip Pathology

Limited studies have been done on sportswomen, specific sports and related hip pathology.

As mentioned in 2.7, Ellapen et al., 2011; Pillay & Frantz, 2012 and Kerbel et al., 2018 reported hip and groin pain in netball and hockey players – but do not refer to specific hip pathologies.

Another relevant study is Borgstrom & McInnis, 2022. Their narrative review regarding the female athlete's hip reported symptomatic labral tears occur more frequently in female athletes, mainly soccer and hockey players, golfers, and dancers, likely due to the extreme hip motion under load required in each sport.

Specific sports of the study's cohort have been linked to labral disease and FAI syndrome. In 2016, the Warwick conference agreed on a definition of FAI syndrome, stating that sports such as football, hockey, netball, and dancing are linked to labral lesions and FAI syndrome (Griffin et al., 2016). These sports demand strength, speed, power, agility, and flexibility and are known for axial loading, repetitive torque, quick footwork, and change of direction. Football also involves kicking and ballet, a supraphysiological range of movement of the hip joint, both risk injury (Ellapen et al., 2011; Pillay & Frantz, 2012; Kerbel et al., 2018). The dominance of the preferred leg and the imbalance of the hip joint and pelvis in the sports mentioned above may increase the risk of impaired function and injury (Rob et al., 2010; Borgstrom & McInnis, 2022).

The level of participation may also play a role. Previous studies on epidemiology, injury rate and self-reporting injuries in high-performance female outdoor team sports, such as football and basketball, have demonstrated an association between training hours, match hours and injury. Studies reported 12.6 to 23.6 injuries per one thousand match hours (Agustin et al., 2021).

2.8 Possible Hip Function Symptoms Reported by Young Sportswomen

Hip symptoms in the current study refer to pain or stiffness in the pelvic area: anterior, medial, lateral, and posterior pelvis, as indicated (Figure 2.11). These symptoms may be from injury or over-use injury related to the demands of the sport, or they may be underlying skeletal or muscle function morphologies or imbalances under the loaded circumstance of competitive sport (Borgstrom & McInnis, 2022).

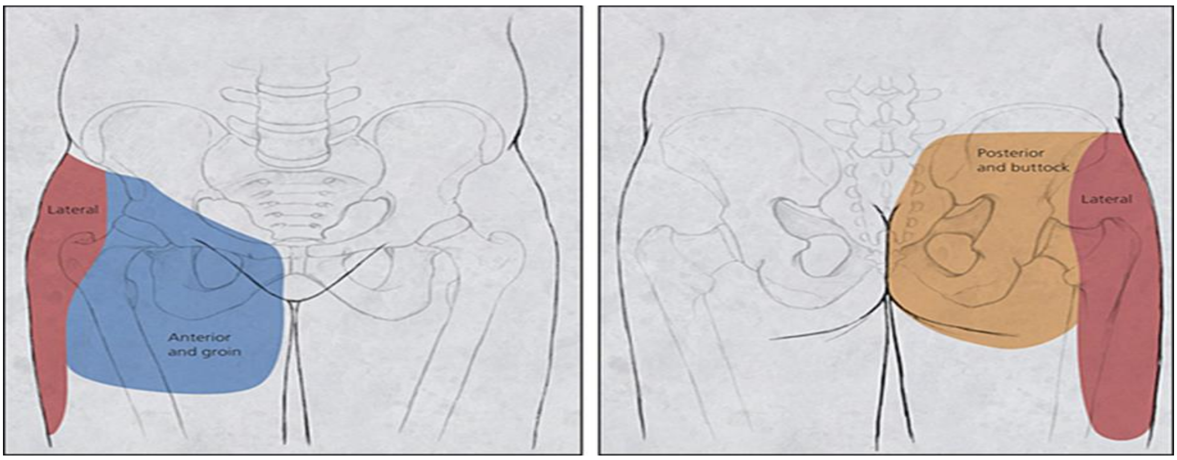


Figure 2.11: The Hip Groin, and Pelvis Area.

A study by Impellizzeri et al.(2020) reported participants' symptoms and determined a Patient Acceptable Symptoms State (PASS) based on the HAGOS. The PASS HAGOS score determines if patients consider their hip state of symptoms and function acceptable twelve to twenty-four months after hip arthroscopy. The cut-off score represents the score beyond which an individual is more likely to have an acceptable hip symptom state. The PASS guideline is irrelevant to the current study's cohort, as they did not receive arthroscopies. Still, as PASS is a reference to an acceptable symptom state, the guideline is used as a reference for Group 1’s reported hip symptoms. No other guidelines are available.

The following possible hip symptoms reported are stiffness during specific movements or positions, e.g., prolonged sitting; deep pain in the hip after strenuous training or matches; difficulty lying on the painful hip; a painful hip at night; symptomatic or non-symptomatic clicking and other sounds from the hip; sharpshooting hip pain on jump landings or twisting. Furthermore, a "give way" feeling and weakness of the hip muscles, pain after prolonged sitting and inability to squat fully (Reiman & Thorborg, 2014; Griffin et al., 2016; Cannon et al., 2020).

2.9 Possible PFM Function Symptoms Reported by Young Sportswomen

The following recent studies were published and reported PFM dysfunction in sportswomen. The symptoms included urinary incontinence, urgency, frequency, pelvic pain, and dyspareunia (Louis-Charles et al., 2019; Rebullido et al., 2020; Santos et al., 2018; Bø & Nygaard, 2020).

The symptoms mentioned above are grouped in terms such as interstitial cystitis (IC), also known as bladder pain syndrome (BPS) (Malde et al., 2018, Grinberg et al., 2020). In the current study's hip symptom cohort, it is essential to consider Urinary Chronic Pelvic Pain Syndrome (UCPPS). UCPPS is an umbrella term for symptoms relating to IC, dyspareunia, and pain beyond the pelvis, including peripheral joint pain. When peripheral pain is evident, increased symptoms related to bladder function are reported (Clemens et al., 2019; Morin & Binik, 2017; Bø & Nygaard, 2020; Ackerman & Lee, 2016) (Figure 2.12).

Lai et al. (2017), in their epidemiology phenotyping study of peripheral pain associated with UCPPS, used a body chart to indicate different zones for peripheral pain. I observed that The Brief Pain Inventory diagram used by The MAPP group to identify regional body pain and symptoms in regions 14,15, and 16, may not only be associated with the bladder or pelvic organs, as mentioned in the infogram (Figure 2.12). The outcome possibly overlooks hip and groin symptoms as a possible source of symptoms for areas 14,15, and 16.

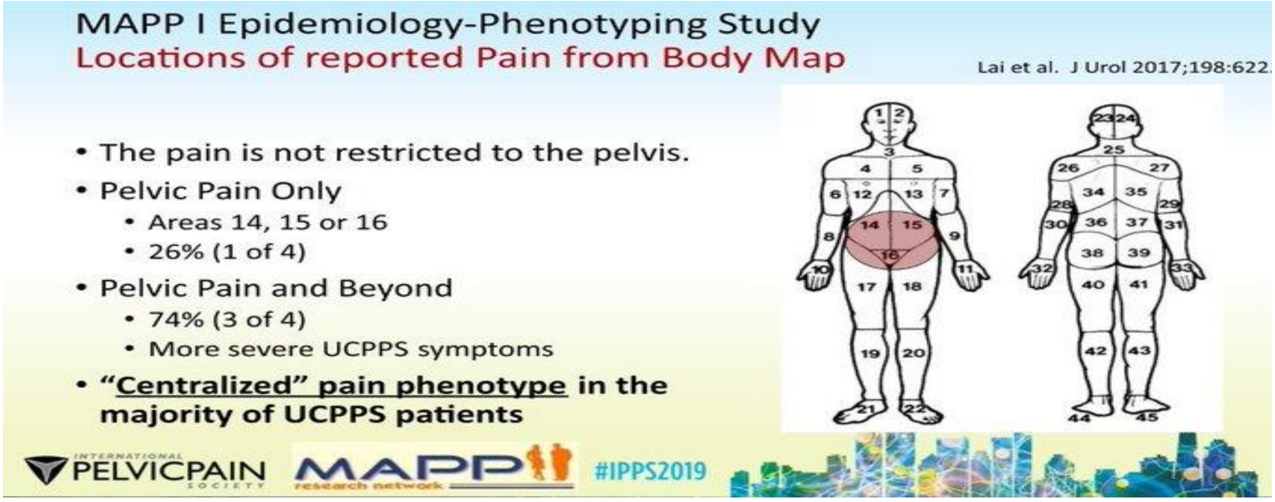


Figure 2.12 Pain Inventory Diagram (Lai et al., 2017).

Dyspareunia is a term to describe the pain associated with intercourse and may be a superficial pain at the introitus of the vagina or a deep penetration pain. Dyspareunia is associated with IC and UCPPS (Ferrero et al., 2008; Grinberg et al., 2020).

Genito pelvic penetration/pain dysfunction (GPPPD) describes PFM dysfunction in women related to pain and fear of vaginal penetration, such as dyspareunia. It also describes pain and discomfort when inserting a tampon. This study's cohort is young, and participants may not be sexually active. GPPPD will be an appropriate term to use and refer to when associations are made with sexual function, as applicable in this study cohort (Confort, 2017).

2.10 Conclusion

The literature review outlined the study's title, A comparison of the Lesser Pelvis and Hip's Synergistic Muscular Function between Women with Self-Reported Hip Symptoms and a Control Group. Furthermore, it explained confounding variables and why young nulligravida sportswomen were selected to participate in the study. A description of the anatomy of the hip and the lesser pelvis emphasised the synergistic functions of the hip and lesser pelvis. Therefore, it gave insight into the origin and nature of the PFM and hip function symptoms the study's participants may report. The aspects related to the participants mentioned above outline the context within which the differences between groups are observed and reported in the data analysis and the study discussion.

CHAPTER 3: METHODOLOGY

The study's title, “A comparison of the Lesser Pelvis and Hips Synergistic Muscular Function between Women with Self-Reported Hip Symptoms and a Control Group”, was outlined in the literature review. It also addressed why young nulligravida sportswomen were chosen to participate in the study and other confounding variables.

The synergistic function of the hip and lesser pelvis was highlighted in a presentation of the hip and lesser pelvis anatomy. The anatomy of the synergies provided insight into the comprehensive function of the hip, groin and pelvis. Furthermore, it provided insight into the possible cause and type of PFM and hip function symptoms reported by current research participants.

The aspects mentioned above establish the framework to identify and present group variations in the study's data analysis and discussion as the study investigates differences in hip and PFM symptoms and QoL, PFM function, and hip muscle function between the two groups. A group with hip symptoms and the other without hip symptoms

The methodology section explains the study type, the participants' screening and selection, instrumentation and outcome measures, and the main study's procedures. Furthermore, the ethical considerations, data analysis, and reliability and validity are explained.

3.1 Type of Study

This study design is quantitative, observational, and comparative.

Symptoms, quality of life, pelvic floor muscle and hip muscle function are compared between two groups: Group 1, nulligravida sportswomen, 18 -35 years, with hip symptoms, and Group 2, a group of nulligravida sportswomen, 18 – 35 years without hip symptoms.

3.2 Participants

Two groups of nulligravida sportswomen, Group 1, with hip symptoms and Group 2, without hip symptoms, were sourced and screened. The process is outlined in the following paragraphs.

3.2.1 Source of participants

I consulted with the University of Witwatersrand Sports office to approach the women's sports team managers and coaches.

The study was discussed with the team managers and coaches, and their players were informed. The sportswomen who indicated they were available and interested in the study provided their contact details. I followed up on the responses and contacted the potential participants.

The head netball coach of the Jaguars, a provincial netball team, indicated that her players were also interested in the research. After team members made their contact details available, I followed up and contacted the potential participants.

The remaining participants were sportswomen referred to the private physiotherapy practice of Mariette Oelofse by colleagues and biokineticists.

Group 1, with hip symptoms, and Group 2, without hip symptoms, were sourced from the same women's sports teams. The researcher anticipated finding a percentage of women in these sports teams with hip or groin symptoms and a portion without symptoms. Tobias et al. (2020), and Kerbel et al. (2018), investigated the injury rate in female sports at the college level. They indicated percentages of the team who reported hip and groin injuries. South African netball and field hockey studies reported a high incidence of hip and groin injuries (Ellapen et al., 2011; Pillay & Frantz, 2012). Therefore, the screening approach was followed.

3.2.2 **The setting of the study**

Assessments were conducted by the researcher at her private practice, Mariette Oelofse Physiotherapy, in Brooklyn, Pretoria. The researcher is a senior physiotherapist, and the private practice focuses on rehabilitating all aspects of pelvic health.

With the permission of Prof Benita Olivier, Dr Corlia Brandt, and physiotherapist and practice manager Clare-Ann Kilroe, I also assessed candidates and participants at the Wits University Sports Clinic. The Wits University Sports Clinic operates within the School of Therapeutic Sciences and is part of the Wits Institute of Sports and Health (WISH). It is located at the Wits Education Campus (Impilo block), Parktown.

3.2.3 **Sample selection**

Two groups of nulligravida sportswomen, 18 - 35 years old, with self-reported hip symptoms, and a group of nulligravida sportswomen, 18 - 35 years without self-reported hip symptoms, were purposively sourced. The aim was to invite and assess an equivalent number of participants from both groups.

The researcher sampled women's sports teams in football, hockey, netball, performing arts, ballet, or other dance forms. These sports and dance are associated with labral pathology and FAI syndrome. The Warwick convention in 2016 reached a consensus on the definition of FAI syndrome, indicating that sporting activities related to the development of labral lesions and FAI syndrome are activities such as football, hockey, netball, and dance (Griffin et al., 2016; Reiman et al., 2020). These activities are known for axial loading and repetitive torque on the hip joint. Ballet expects a super physiological range of hip joint movement, which puts the hip joint at risk.

Included in the study population were provincial netball players from the Jaguar regional netball team and the University of Witwatersrand first team hockey and football players. The final group of participants was referred from strength and conditioning coaches, colleagues, and biokinetics involved in rehabilitation.

The sample group comprised 38 sportswomen across netball, hockey, football, and dance during the 2021 competitive season.

Participants were selected based on screening for Group 1, nulligravida sportswomen with self-reported hip symptoms, or Group 2, without self-reported hip symptoms. The screening and selection criteria were guided by the inclusion and exclusion criteria used by Thorborg et al. (2011) to validate the Copenhagen Hip and Groin Outcome Score Questionnaire (HAGOS).

3.2.3.1 ***Selection criteria***

Table 3.1 summarise the selection criteria for Group nulligravida sportswomen with self-reported hip symptoms and Group 2 nulligravida sportswomen without self-reported symptoms.

Table 3.1: Selection criteria Group 1 and Group 2.

Inclusion Criteria Group 1 vs Group 2	**Group 1**	**Group 2**
Nulligravida sportswomen aged 18-35 years	Yes	Yes
Severe co-morbidity, indicated by The Self-administered Co-morbidity Questionnaire (SCQ)	No	No
Symptoms pre-defined area (Figure 3.1)	Yes	No
Would opt for treatment or receive treatment for their hip and groin symptoms.	Yes	No
Hip symptoms and restricted activities according to the 6 six subscales of The HAGOS	Yes	No
Pain has been evident for more than six weeks duration.	Yes	No
Weekly activity included 150 to 300 minutes of moderate to vigorous physical exercise, 75-150 minutes of vigorous activity, and two additional muscle strength sessions per week (WHO, 2020).	Yes	Yes
Clinical tests to exclude the lumbar spine and SI joint as a possible source	Negative	No tests

The exclusion criteria relevant to both groups were men, women older than thirty-five years or younger than eighteen years, primi- and multigravidas, women who had hip surgery, and women with arthritic pathologies and other neuromusculoskeletal conditions. Furthermore, women who predominantly had lumbar spine and SI joint pain or reported limiting co-morbidities were excluded from the study (Ling et al., 2019).

3.2.4 **Participant screening procedures**

3.2.4.1 ***Screening for red flags****.* Potential red flags were identified with The Self-administered Co-morbidity Questionnaire (SCQ) (Ling et al., 2019). The SCQ represents an efficient method to assess comorbid conditions in clinical and health services research. It is found to be helpful in settings where medical records are unavailable.

The SCQ and Charlson Index were correlated with a Spearman correlation coefficient of 0.32. The association between measures was more significant (Spearman r = 0.55) after limiting each measure to only contain comparable items (Thorborg et al., 2011; Sangha et al., 2003).

The researcher also added a section of relevant questions not included in the SCQ questionnaire, such as trauma, fever, unexplained weight loss, burning urination, night pain, and prolonged corticosteroid use. These additional questions were reported in a study determining a baseline for the thoroughness of therapists' red flag recording. The study involved participants with low back pain. Low back pain is the most significant outpatient physiotherapy population Leerar et al.(2007). The questions are accepted in general physiotherapy practice and asked during the initial subjective assessment of patients to rule out co-morbidity.

3.2.4.2 ***Identification of symptoms in the pre-defined area of reported symptoms****.*

The reported hip symptoms were in one of the pre-defined regions (Figure 3.1). This area represents the pelvic area relevant to this study, including the anterior, lateral, and posterior aspects of the lower abdomen (including the symphysis pubis), the pelvis, groin, and hip joint.

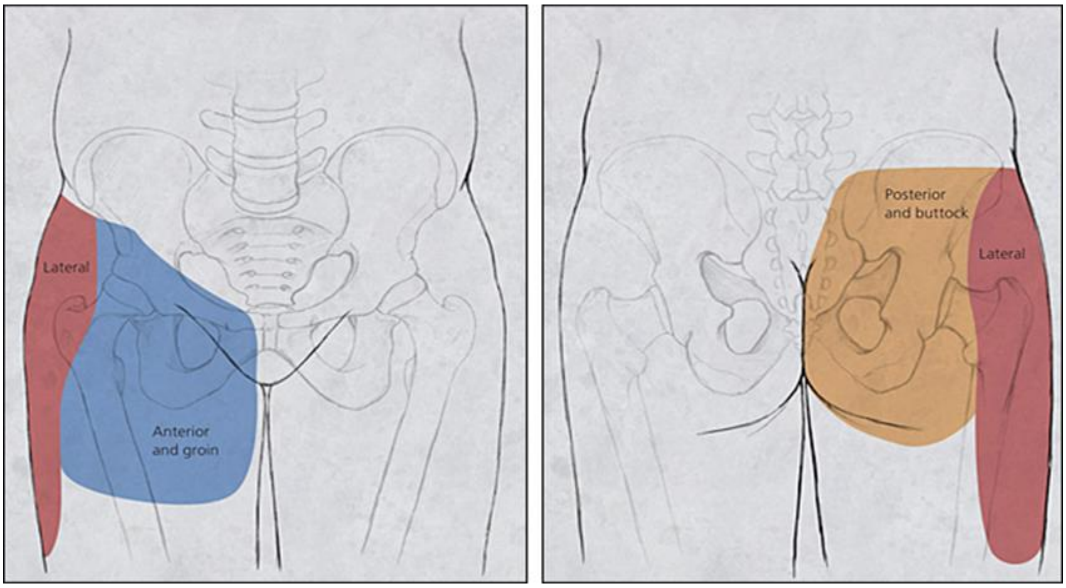


Figure 3.1: Pre-defined hip pain/symptom regions (Thorborg et al., 2011)

3.2.4.3 ***The screening of hip symptoms by administering the HAGOS hip questionnaire.***

Group 1 should indicate hip symptoms, and Group 2 should be non-symptomatic in response to the HAGOS questionnaire (Thorborg et al., 2011) (see 3.3.1).

3.2.4.4 ***Excluding the lumbar spine and SI joint as a possible source of hip symptoms***

Tests to exclude lumbar spine and SI joint involvement in Group 1 were described in the algorithm for pathology screening in the athletic hip (Reiman & Thorborg, 2014).

3.2.4.4.1 Excluding the lumbar spine as a source of hip pain

Possible discogenic involvement was excluded by repeated motions in standing, flexion, extension, side-flexion, and rotation to both sides (SN 92, -LR 0.12) (Windt et al., 2010).

Facet joint involvement was excluded as a source of hip pain. The participant was seated as the researcher stabilised the sacrum the participant. The participant extends into end-range lumbar spine extension and rotation. The researcher provided overpressure if the participant could reach the full range of movement without symptoms. The test was performed on both sides (SN100, -LR 0.00) (Schwarzer et al., 1994).

Possible symptoms of radiculopathy were excluded as a source of hip pain through the straight leg raise test (Lasegue + Braggard's test, SN 91-92, -LR 0.29, 0.35) (Windt et al., 2010). The participant was placed supine with her legs extended on the plinth. In a single motion, the researcher passively flexed, slightly adducted, and internally rotated the participant's leg to be assessed while maintaining the knee in extension. The test was positive when the participant reported her concordant pain. This pain is relieved by decreasing hip flexion; the symptoms will then increase by passive dorsiflexion of the foot or adding head or neck flexion. The test was performed on the left and the right.

The participant was excluded from the study if she reported pain in the lumbar spine and sought treatment for her lumbar spine.

3.2.4.4.2 Excluding the SI joint as a source of hip pain

Possible symptoms of SI joint were excluded as a source of hip pain. The Cluster of Laslett ruled out SI joint pain (distraction, compression, and the sacral thrust tests). As soon as any two tests were positive, it marked a positive SI joint involvement, and the participant was excluded from the study (SN 88, SP 78, -LR 0.16) (Laslett & Charles, 2005).

3.3 **Instrumentation and outcome measures**

The researcher used the HAGOS questionnaire to screen and select participants based on the presence of hip symptoms. Furthermore, the HAGOS was used to clarify the reported hip symptoms and the effect of these symptoms on the QoL.

The Australian Pelvic Floor Function Questionnaire measured PFM symptoms related to bladder, bowel and sexual function and QoL to compare between groups. A transverse, transabdominal sonar application observed bladder base (BB) symmetry. It measured bladder base displacement as a measure for PFM movement: caudal BB displacement during breathing and cephalad BB displacement during a voluntary PFM contraction.

*3.3.1 **The Copenhagen Hip and Groin Outcome Score (HAGOS)***

The researcher used the HAGOS questionnaire to screen and select a participant from Group 1, nulligravida sportswomen with self-reported hip symptoms and Group 2, without self-reported hip symptoms. Furthermore, the HAGOS was used to clarify the reported hip symptoms and the effect of these symptoms on the QoL and participation of young sportswomen.

The HAGOS was identified by The Warwick International Consensus Statement on FAI syndrome as a valid patient-reported outcome measure, together with the International Hip Outcome Tool (iHOT) and the Hip Outcome Score (HOS), for clinical use and research to assess young adults with hip pain (Griffin et al., 2016).

Impellizeri et al. (2020) and Kemp et al. (2020), well-known authors in hip and groin research, also confirmed that HAGOS and the iHOT-33 are recommended as the two preferred questionnaires to assess hip-related pain and function in active young and middle-aged patients.

Because the HAGOS and the iHOT-33 featured in both studies mentioned above, The Consensus-based Standards to select health Measurement Instruments (COSMIN) values of the HAGOS and iHOT-33 questionnaires were compared (Table 3.2). The comparison highlights the qualities of the HAGOS and the iHOT-33.

Table 3.2: Summary of the consensus-based standards HAGOS and iHOT-33

Characteristics and COSMIN checklist	**HAGOS**	**iHOT-33**
Young active population	√	√
Number of questions	37	33
Subscales	6	4
Single subscale reporting	√	x
Test-retest ICC	0.82-0.91 range on all subscales	0.80 reported for 33 questions
Construct validity	(0.37-0.73, $p<.01$)	(0.81, $P \leq .01$)
Responsiveness (Spearman r)	0.56-0.69, $p<.01$	
The minimal clinically important difference	17.7 to 33.8 points, 4 months	6 points, 6 months
Face Value Validity	√	√

The HAGOS was identified as best suited for screening the cohort of the recent research. The reasons are discussed in the following paragraphs.

The HAGOS questionnaire consists of thirty-seven questions. Six subscales measure pain (P1-P10), symptoms (S1-S7), the physical function of daily life (A1-A5), physical function in sport and recreation (SP1-SP8), participation in physical activities (PA1-PA2), and Quality of Life (Q1-Q5). These subscales include thirty-seven activity-related questions and can be measured separately compared to the iHOT's thirty-three questions, which involved a section for the working environment. The HAGOS questionnaire is more comprehensive as far as sporting activities are concerned and suitable for the student cohort of this study.

The HAGOS' rating of symptoms (1-4, from no symptoms to most severe) was practical and time effective. The HAGOS subscale pain and symptoms are well formulated to identify typical symptoms present in sportswomen. The introduction of the HAGOS questionnaire states that if an item does not pertain to a participant or if she did not experience symptoms during the past week, she could make her "best guess" as to which response would apply to her.

The introduction, participation and quality of life questions guided the participant to reflect on her hip symptoms (Thorborg et al., 2011). The reflection was valuable in screening hip and groin symptoms because it is reported that sportswomen will often continue playing sports without seeking treatment or return to sports even if they cannot perform at their expected performance level (Kerbel et al.,2018).

The raw ratings of the six subscales were converted to a 0-100 scale, with zero indicating severe hip or groin pain and 100 indicating no hip or groin pain. A score between 0 and 100 represents the percentage of the total possible score obtained. The data analysis incorporated the score (Thorborg & Christensen, 2013).

3.3.2 **The Australian Pelvic Floor Function Questionnaire**

Various instruments are available to measure pelvic floor function, namely the Pelvic Floor Distress Inventory (PFDI-20), Pelvic Floor Impact Questionnaire (PFIQ-7), and the International Consultation on Incontinence Questionnaire on Vaginal Symptoms (ICIQ-VS).

The Australian pelvic floor questionnaire is also known as the Female Pelvic Floor Questionnaire (FPFQ). The use of the questionnaire was reported in nulliparous women (early gestation, 15 weeks) and postpartum women. The questionnaire is mentioned as more frequently used and translated into Serbian, German, and French (Durnea et al., 2013; Tami et al., 2018).

Baessler et al. (2009) validated the Australian Pelvic Floor Questionnaire as an interviewer-questionnaire for the clinical environment and research. They found that Cronbach's alpha coefficients were acceptable in all domains of this questionnaire, and the Kappa coefficients of the agreement for the test-retest analyses varied from 0.5 to 1.0. The Australian Pelvic Floor Questionnaire was validated as an interviewer- and self-administered questionnaire and demonstrated equivalence. The effect sizes ranged from 0.6 to 1.4. According to Cohen’s (1992) recommendations, the interpretation of the effect sizes is large to very large effect and, therefore, significant.

The researcher chose the Australian Pelvic Floor Questionnaire because the questionnaire reports on all pelvic floor muscle functions, bladder, bowel, prolapse and sexual function. The domains can be measured independently.

The questionnaire measures PFM functions in the different domains, bladder (subscales Q1 – Q15;), bowel (subscales Q16 – Q27), prolapse (subscales Q28 – Q32) and sexual function (subscales Q33-Q42). All domains have a category "other ", and participants can elaborate on symptoms. Genito pelvic pain penetration dysfunction (GPPPD) was added to the sexual function category "other" to accommodate participants who were not sexually active. Each subscale has a graded scale of 0 to 3, (3/3) indicating symptoms are impacting daily on the participant, (2/3) indicating impact once or more per week, (1/3) showing impact less than once a week, (0/3) indicating no impact on the participant.

Clinically the incidence of a specific symptom (subscale) and the severity is relevant. Symptoms (subscales) that featured three times per domain (bladder, bowel, prolapse and sexual function) and were reported daily (3/3) or more than once a week (2/3) were summarised and used in the analysis of the data. Symptoms reported less than once a week (1/3) were not included in this summary as the symptoms may occur from every two weeks to once a year.

3.3.3 **Sonar Assessment for Pelvic Floor Muscle Function**

Transabdominal, transverse ultrasound imaging utilised in the current study is a non-invasive, safe, and valid method of obtaining static and real-time PFM movement-image (Zajac et al., 2021).

The researcher collected ultrasound images using a digital ultrasonic diagnostic imaging system, DUS 60, version 2.2, with a broadband curved array transducer. The frequency range of the transducer is 5 to 2 MHZ. The imaging involves a frozen image and a real-time image of the displacement of the BB in different scenarios. This non-invasive imaging can assess pelvic floor muscle movement in the study's young cohort (Frawley et al., 2021; Whittaker et al., 2019).

The transverse transabdominal placement of the ultrasound probe was centred immediately suprapubic. The caudal inclination of the ultrasound probe towards the inferior posterior aspect of the bladder varies between participants, usually between 40-60 degrees. The inclination of the probe, which allows the most visible displacement on the image, is used for measurement purposes (Bo et al., 2003; Frawley et al., 2021) (Figure 3.2).

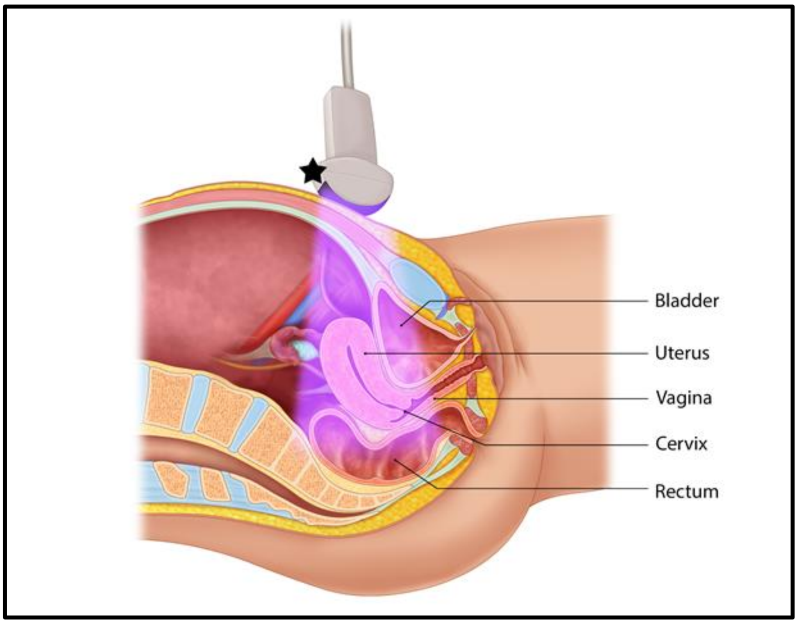


Figure 3.2: Transverse approach and relevant anatomy.
Probe indicator right
https://www.acep.org/sonoguide/basic/early-pregnancy/

The transverse transabdominal placement of the ultrasound captures the caudal and cephalad displacement of the BB during a PFM contraction and a breathing cycle (Figure 3.3). BB displacement was measured in mm and indirectly indicated PFM movement. These measures were included in the data for analysis.

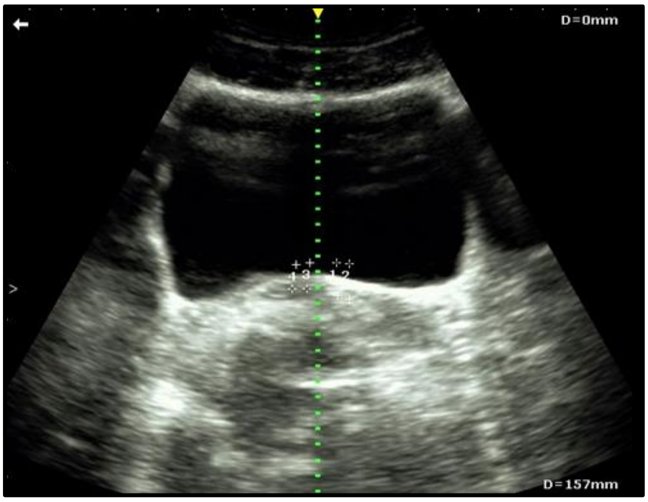


Figure 3.3: Transverse Transabdominal image of the bladder base

The symmetry of the BB was observed on images taken during the assessment. Asymmetry of the BB may indicate a higher tone in the supporting muscles or a defect in the structural, ligamentous support of the deeper pelvic structures (Frawley et al., 2021). Two horisontal lines were drawn through the lateral aspects of the BB's lowest and highest level to depict asymmetry between sides. Symmetry (R=L) was labelled (1), and asymmetry (R</>L) was labelled (2). The numbers were plotted in excel, and the frequencies were calculated.

Whittaker and Thompson (2007) reported that the trans-abdominal sonar was validated with good intra-rater and inter-rater reliability to measure BB displacement. The intraclass correlation coefficient for pelvic floor muscle contraction was 0.81- 0.88. The transverse view had good interrater reliability during functional, active, straight leg raise testing and an intraclass correlation coefficient of 0.98. No value was given for test-retest correlation.

Zajac et al. (2021) confirmed that transabdominal ultrasound was a reliable and non-invasive method to assess pelvic floor muscle function. The cohort of nulliparous women (age 22–27; 168.6 ± 5.1 cm; 57.1 ± 11.8 kg) resembled the age group of the current study's cohort. Their three-point measure (centre, right and left) has proven reliable, and this method allows for the observation of contractibility imbalances between left and right PFM functions. Their intra-rater, as well as their inter-rater values, were good for intra-rater reliability at rest (ICC = 0.98–0.99) and during contraction (ICC = 0.97–0.98); inter-rater at rest (ICC = 0.95–0.96), and contraction (ICC = 0.81–0.87). Their test-retest reliability at rest (ICC = 0.54–0.62) and contraction (ICC = 0.22–0.50) was poor.

Trans-perineal ultrasound (2D or 4D) imaging is also utilised to assess pelvic floor muscle function. The image changes from the above-transverse plane to a mid-sagittal and axial plane. The pubic symphysis visible in this ultrasound application is a bony landmark for accurately measuring pelvic floor muscle function parameters and is widely used by gynaecologists in point-of-care and research. Physiotherapists commonly utilise the 2D mid-sagittal application in research and point-of-care (Frawley et al., 2021).

The researcher agreed with Zajac et al. (2021) that the non-invasive aspect of the transverse, transabdominal approach was best suited for the cohort of this study and the significance of the current study.

3.3.4 **Surface Electromyography (sEMG)**

The sEMG was utilised to report balanced function (muscle excitation) of the posterior synergies between hips in Groups 1 and 2 (Vigotsky et al., 2018). A practical sEMG test, performed with equipment physiotherapists would use in practice, gives a general impression of balanced function potential between hips in Group1 and Group 2.

3.3.4.1 ***The NeuroTrac MyoPlus 2 unit and software***

The NeuroTrac MyoPlus 2 unit and software were used for sEMG of the posterior synergies of the hip. The NeuroTrac unit and internal probe are regularly applied to measure the sEMG activity of the PFM and biofeedback (Frawley et al., 2021).

This unit produces low radiofrequency emissions not influenced by equipment operating in the vicinity. The NeuroTrac Myoplus 2 unit is designed to measure EMG with a precision of 0.1µV.

Guidelines to minimise electromagnetic interference were followed. The computer's power supply was placed as far as possible from the connection wires of the NeuroTrac unit. The NeuroTrac unit was also kept close to the participant during the procedure. A reference electrode was used to normalise the sEMG signal. A new set of five 32 mm disc adhesive electrodes was used per participant. New electrodes were used for hygienic reasons and the continuity of adhesive properties.

The NeuroTrac Myoplus standard pre-programmed EMG work/rest assessment was used for the sEMG assessment. The pre-set work and rest periods and the prompt software instruction to "work" and "rest" assisted with the continuity of the method between repetitions and participants. The sEMG data was captured in %MVC and documented for analyses (Vigotsky et al., 2018).

The balanced function of the posterior synergies between hips, measured as the difference in % MVC between the left and right hip, was calculated per participant. Subsequently, the median was established. The above measure indicates the balanced function (activation potential) between hips in Group 1 and Group 2.

3.3.4.2 ***Aneroid sphygmomanometer. Pressure biofeedback unit (PBU)***

The aneroid sphygmomanometer was used to observe and control the pressure exerted through the heels during the isometric exercise and sEMG measure. This exercise is described in the procedure of the main study.

The aneroid sphygmomanometer consists of an inflatable cuff, a measuring unit (the manometer), a tube to connect the two, and an inflation bulb. The bulb is connected by a tube to the cuff. The inflation bulb contains a one-way valve to prevent pressure leakage.

An aneroid manometer is a mechanical gauge with a round dial and a needle that rotates to indicate pressure in mmHg. The researcher observed a pressure reading on the manometer during the isometric exercise.

The sphygmomanometer is mentioned in a study reporting the minimum reporting guidelines for clinical research in groin pain. The sphygmomanometer was used as an outcome measure in measuring adductor activation in an adductor squeeze test (Delahunt et al., 2015) (see Figure 3.4).

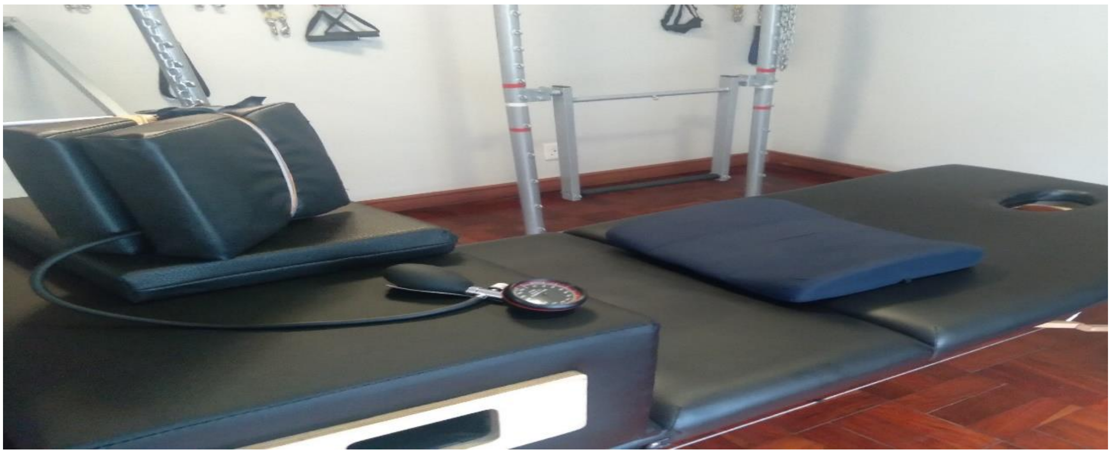


Figure 3.4: Aneroid sphygmomanometer. Pressure biofeedback unit (PBU)

3.4 Procedure

3.4.1 **Pilot Study**

The pilot study was used to test the participant recruitment rate and the time efficiency of the evaluation. Three participants per group were allocated to the pilot study.

3.4.1.1 **Recruitment rate**

The researcher applied for a title change after it became clear that the recruitment rate of participants was too slow to progress. Only six participants were recruited over six months. The researcher was, therefore, concerned that the slow recruitment rate might lead to the termination of the study.

The circumstance that led to the decision is discussed in the subsequent paragraphs.

The original study titled: A Comparison of the Synergistic Muscular Function of the Lesser Pelvis and the Deep Muscles Crossing the Hip between Women Diagnosed with Femoral Acetabular Impingement or Labral pathology and a Control Group was designed to contribute to the ongoing challenge to manage women diagnosed with FAI syndrome or labral pathology. The study aimed to identify these participants' basic functional patterns and characteristics by identifying PFM and hip muscle function (Kemp et al., 2019; Mansell et al., 2018).

3.4.1.2 ***The diagnosis, FAI Syndrome and labral pathology***

The diagnosis, FAI Syndrome and labral pathology posed various challenges, as described below. The researcher saw numerous Orthopaedic Surgeons who specialised in hip arthroscopy and the management of FAI syndrome and labral pathology. I visited their practices multiple times and contacted their practice managers. COVID and the lockdown impacted everyone's practices and resulted in limited referrals. Radiographic imaging was needed to diagnose FAI Syndrome, which would have been included in the specialist's assessment. Any referrals from colleagues without radiographic imaging placed the responsibility on the researcher to cover the cost for an anterior-posterior and a Dunn 45º radiographic image of the hip. The cost was R1600, making this study not feasible and affordable

3.4.1.3 ***Participant selection and time-efficiency of in-practice assessment***

The title change did not change the study's nature but impacted participant selection. Additional inclusion, exclusion and screening criteria affected the time efficiency of the in-practice assessment (see 3.2.3).

The ultrasound assessment's bladder fill procedure was adjusted to accommodate the screening in the first part of the assessment. Furthermore, minor adjustments were made to the PFM contraction repetitions and the instruction (cueing) to facilitate pelvic floor muscle contractions. Therefore, the data obtained from the participants in the pilot study were not included in the data set.

3.4.2 **Main Study Procedure**

The main study procedure outlines the assessment flow and the detailed application of the procedures. The methods mentioned above stayed the same among participants throughout the study.

3.4.2.1 ***Introduction***

The researcher sampled potential participants from women's outdoor sports teams in football, hockey, netball, ballet or dance forms (see 3.2.3).

After the sportswomen indicated their interest in taking part in the study and made their contact details available, the researcher contacted the sportswomen.

Two appointments were arranged: one telephonic and one in-practice appointment.

The study information document, consent form, and COVID form were e-mailed to the potential participant (Appendix 1; 2; 3). The information document included the study's title and detailed description, the bladder fill procedure, the ultrasound, and EMGs assessment. Furthermore, the length of the evaluation, confidentiality and reimbursement for data and travel costs were explained in the information document. Contact details of the study supervisor and the ethical committee were included.

During the first telephonic consultation, any queries regarding the research and assessment were answered. The potential participant was informed that the evaluation would be two and a half hours. The candidate was reminded of the consent and COVID form.

Extra copies of the consent and COVID forms were available on the assessment day.

A WhatsApp message was forwarded to the candidate before the assessment. This What's/App message described the bladder fill procedure, dress code and necessities of the in-practice evaluation. The directions to Mariette Oelofse Physiotherapy in Brooklyn or Wits Sports Clinic at Wits Parktown Campus were included in the What's/App (Appendix 4).

During the in-practice assessment, the researcher presented a professional clinical environment where participants could be secure and comfortable regarding privacy (Figure 3.5)

Figure 3.5: Research station.

The candidate signed the research consent form and submitted her signed COVID form on arrival at the practice.

The assessment procedure was explained to the participant, and any questions were answered.

The selection and screening process for Groups 1 and 2 followed.

*3.4.2.1 **Initial Screening***

The screening of the participants and the initial part of the assessment are discussed in detail in previous paragraphs (see 3.2.4).

The screening included the inclusion criteria in Table 3.1, the selection criteria for Group 1 and Group 2 (Appendix 5). The thirty-six-question HAGOS was administered (Appendix 6), followed by the SCQ questionnaire to detect co-morbidities (Appendix 7).

*3.4.2.2 **Clinical tests to exclude the lumbar spine and SI joint***

The participants in Group 1, the symptomatic group, continued the following two tests: Tests to clear the SI joint and the lumbar spine as a possible source for reported symptoms (Appendix 8).

Tests to exclude spinal and SI joint involvement are described by Reiman and Thorborg (2014) as an algorithm for hip pathology screening in the athletic hip. These tests have high sensitivity and a low, negative likelihood ratio (-LR), indicating the probability that if a test is negative, there is a high likelihood that the condition does not exist. If a test were positive, it would serve as a screening test rather than a diagnostic test, and further examination is necessary for a diagnosis.

The lumbar spine was excluded as a source of hip pain: Possible discogenic involvement was excluded by repeated motions in standing, flexion, extension, side-flexion, and rotation to both sides (SN 92, -LR 0.12) (Windt et al., 2010).

In sitting, possible lumbar facet joint involvement was excluded by extension, rotation, and side-flexion with overpressure of the lumbar spine (SN100, -LR 0.00) (Schwarzer et al., 1994).

Possible radiculopathies were screened with the straight leg raise test, supine (Lasegue + Braggard's test, (SN 91-92, -LR 0.29, 0.35) (Windt et al., 2010).

The participant was excluded from the study if she had back pain and restricted activities.

Possible SI joint involvement was excluded as a source of pain by The Cluster of Laslett: SI joint distraction, compression, and sacral thrust tests rule out pelvic girdle pain (SN 88, SP 78, -LR 0.16), Laslett & Charles, 2005). The participant was excluded from the study when two tests were positive.

3.4.3 **Ultrasound imaging**

The screening procedures were followed by ultrasound imaging, used as an outcome measure to assess PFM function (Whittaker et al., 2019) (see Figure 3.6 and Appendix 9).

3.4.3.1 ***Bladder-fill procedure***

The participants received a follow-up WhatsApp message the day before the assessment as a reminder of the bladder-fill procedure.

The participant's bladder was emptied 30 min-45 min before the assessment, followed by drinking 300-400ml water in the time leading up to the session. A remaining 200-300ml of water was taken at the in-practice evaluation during the initial screening process (Kim et al., 2015).

The participant should perceive a comfortable bladder fullness before the ultrasound assessment. The urge to hold should not be a factor because the urge to hold a full bladder impacts the release phase after the pelvic floor muscle contraction.

I modified the bladder-fill procedure to manage the final water intake during the screening process. The participant could stop the screening process whenever she considered her bladder comfortably full.

The participant was positioned supine, pelvis neutral, hips 60 degrees flexed, and her feet neutral, supported on the plinth. A pillow supports the participant's head while she faces upward (Kim et al., 2015).

The sonar procedure was revised with the participant. Any questions were answered.

3.4.3.2 ***PFM contraction technique. Instruction (Cueing)***

The participant's knowledge and ability to contract her pelvic floor muscles were checked, and instructions and cueing followed. All participants received the same instruction (Santos et al., 2018).

A cue to contract posterior around the anus proves to be the most effective in asking a participant to contract her pelvic floor muscles. The participant was instructed to hold or squeeze around the anus (Am & Dar, 2018; Crotty et al., 2011).

There are no research or guidelines on when the pelvic floor muscles should be contracted during a breathing cycle. The position of the pelvic floor changes during the breathing cycle. The synchronous pelvic floor and diaphragm movement is well documented (Zachovajeviene et al., 2019). The researcher anticipated that the measures might differ if the first measurement is taken on inhalation and the following measure on exhalation. Therefore, the researcher familiarised the participant with a cue to contract her pelvic floor muscles following a comfortable exhalation.

I standardised the measurement by establishing a breathing rhythm for the participant. A comfortable breathing cycle suitable for the participant was rehearsed. A 3-4 second inhalation and 3-4 second exhalation were comfortable for most participants.

Junginger et al. (2018) also observed that the breathing cycle plays a role. The breathing cycle was accommodated by cueing a sub-maximal contraction of the pelvic floor muscles. The researchers found that during a sub-maximal contraction, the displacement of the BB was similar, the breathing cycle was not impacted, and the participant showed superior endurance scores compared to when a maximal contraction was cued.

Cueing a comfortable breathing cycle and the posterior contraction of the pelvic floor muscles also prevented the participant from a forced contraction, breath-holding or bearing down. Furthermore, muscles such as the transverse abdominus, gluteus, and adductors assist PFM contraction. The actions mentioned above would either enhance the displacement of the BB or minimise the displacement (Bo et al., 2003).

3.4.3.3 ***Collection of ultrasound images***

Ultrasound images were collected using a digital ultrasonic diagnostic imaging system, DUS 60, version 2.2, with a broadband curved array transducer and a frequency range of 5 to 2 MHz. The imaging involved a frozen image and a real-time image of the displacement of the BB(Zajac et al., 2021).

Figure 3.6 Photo: Unit and transabdominal ultrasound probe position

The ultrasound probe was centred suprapubic and inclined as described in section 3.3.3 and held in position during the different assessments (Figure 3.6).

3.4.3.3.1 BB Symmetry

The symmetry of the BB at rest was observed, documented, and analysed (see section 3.3.3, Figure 3.7)

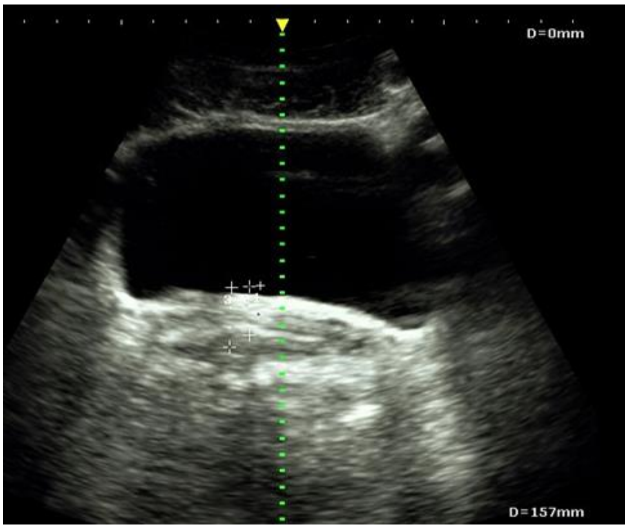


Figure 3.7: BB Symmetry/Asymmetry

The BB displacement was measured with on-screen callipers. A marker was placed at rest, and the final position of displacement. The distance was measured in mm (Kim et al., 2015).

3.4.3.3.2 Caudal BB displacement.

The caudal displacement of the BB was measured after comfortable inhalation (Approximately 3-4 seconds). Three breathing cycles were observed. The measures were captured, and the average of three measured observations was documented for data analysis.

3.4.3.3.3 Cephalad BB displacement.

The second set of measurements was the cephalad displacement of the BB:

The cephalad displacement of the BB was measured after exhalation (Approximately 3-4 seconds). Rest to final BB position was measured during an isolated PFM contraction.

Three sets of three repetitive PFM muscle contractions were observed. A short rest interval (2-3 comfortable breathing cycles) followed each contraction.

The first set of contractions was used to educate the participant on the contraction of the PFM.

The final two sets of three repetitions were documented. An average measure of the last two sets of contractions was calculated and recorded for the outcome and data analysis (Crotty et al., 2011).

After completing the repetitions, a single real-time video image of the PFM contraction was taken.

3.4.4 **Surface electromyography (sEMG)**

Following the ultrasound imaging, sEMG of the posterior synergies of the hip was performed (Vigotsky et al., 2018) (Appendix 10).

The electrodes were placed on the inferior gluteus, overlying the quadratus femoris and gemelli complex (Balius et al., 2018; Hernando et al., 2015; Retchford et al., 2013).

The participant position was a modified version described by Bennell et al. (2017) in their Femoral Acetabular Impingement Rehabilitation Trial (FAIR) (Figure 3.8).

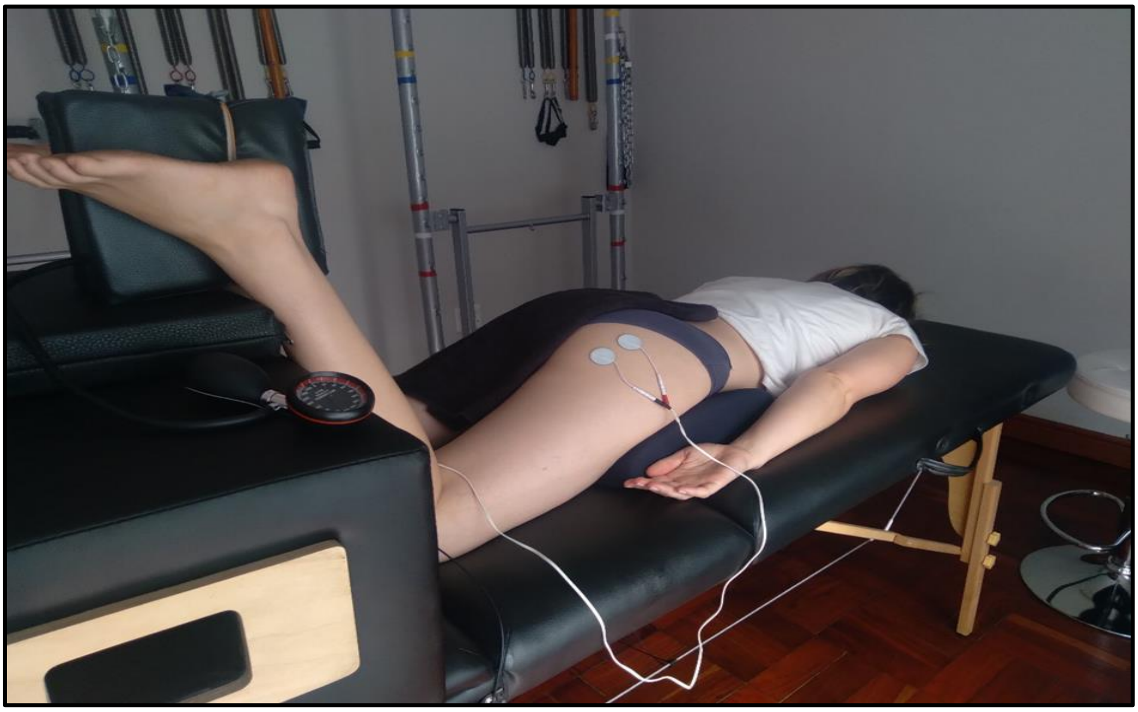


Figure 3.8: sEMG participant position & electrode placements (excl reference electrode)

The participant was prone, face forward, arms next to her sides. Foam support was placed below the participant's pelvis. The researcher modified the prone position to release the tension on the anterior hip, possible tightness in the psoas or anterior hip capsule, and support the participant's lumbar lordosis.

The participant's lower legs were positioned against the support of a deep plyometric box, her knees 15cm apart. The support of the lower legs minimised possible crosstalk from the biarticular hamstrings to sustain knee flexion during the contraction.

The pressure biofeedback unit (PBU) was an aneroid sphygmomanometer inflatable cuff (pressure gauge) secured between two small triangular foam wedges. The triangular sponges assisted in the orientation and direction of the activity. The triangular PBU was secured and stayed in this position throughout all the assessments. The participant's forefoot held the broader part of the PBU, and her heels the narrow region of the PBU.

Disc electrodes of 32 mm were placed strategically on the left and right posterior pelvis. The researcher palpated the ischial tuberosity to identify the most lateral aspect. The first electrode was placed 2 cm lateral and 2 cm cephalic of the ischial tuberosities (underlying structures– inferior fibres gluteus, quadratus femoris, and gemelli). Another electrode was positioned 2 cm cephalic to the first electrode (underlying structures–inferior fibres gluteus, quadratus femoris, gemelli and possibly inferior fibres of piriformis). The electrodes covered a substantial area of the underlying muscle. A reference electrode was positioned on the proximal third of the thigh.

The researcher inflated the PBU to 20 mm Hg. The participant was instructed to squeeze both heels simultaneously and gradually increase the pressure to what they would perceive as a 30% contraction. The participant was asked to stop when pressure on the manometer was measured at 30 mm Hg (20 mm Hg + 10 mm Hg). The participant held this contraction for the remainder of 20 seconds. A rest phase of 20 seconds followed (Figure 3.8).

The isometric exercise was repeated in two sets of five repetitions. The Neurotrac Myoplus 2's software standard work/rest assessment was used for this test. The voluntary contraction was the isometric bilateral, and an equal squeeze on the heels caused an indirect isometric contraction of the muscles in the posterior synergies of the hip.

No voluntary activation apart from the gradual squeeze of the heels was encouraged.

The sEMG % MVC of the posterior synergies between the left and right hip per participant in Group 1 and between the left and right hip in Group 2 were measured, documented, and used for data analyses. This measure the balanced function of the posterior synergies of the hips (left and right) in Group 1 vs Group 2 (Vigotsky et al., 2018).

3.4.5 **Administration of the Pelvic Floor Function Questionnaire**

The evaluations were concluded by administering the Australian Pelvic Floor Function Questionnaire (Appendix 11). The questionnaire was discussed in previous paragraphs (see 3.3.2).

The questionnaire measured symptoms, severity, and the impact on the quality of life in the bladder (Q1 - Q15;), bowel (Q16 - Q27), prolapse (Q28 - Q32) and sexual function (Q33-Q42). The different subscales could be measured independently.

The participants answered the sections dedicated to the bladder, bowel, and sexual function. At the end of each section, the questionnaire allows the participant to elaborate on other symptoms not covered in the questionnaire. GPPPD was included in the sexual function section. Participants who were not sexually active were asked if they used a tampon to manage menstrual bleeding. Data was documented for analysis when a participant indicated that impossible to sustain an inserted tampon because of pain, anxiety, or any related symptom (Confort, 2017).

3.4.6 **Concluding the main procedure**

The participant was asked if she had any questions or concerns following the assessments. She was also asked what her travelling and data expenses were, and the participant was refunded.

3.5 **Ethical Considerations**

The University of the Witwatersrand Human Research Ethics Committee reviewed and approved the study (Appendix 11). The contact details for the Committee secretariat are 011 717 2700/1234, and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Potential participants indicated their willingness to participate in the research by making their phone numbers available. The researcher then contacted the candidates.

The participant received an e-mail and information document from the researcher, explaining the research in detail (Appendix 1). She also received a copy of the consent form (Appendix 2).

The study was discussed during a telephonic conversation, and any queries were answered.

The researcher repeated the information of the study procedure when the candidate came for her assessment. The participant's consent form was received before the assessment.

The researcher explained that the participant could discontinue the evaluation at any point.

All information was kept confidential. The allocation of a participant code ensured confidentiality. The code on all the relevant documentation could not be associated with a specific participant. It was explained to the participant that her identity would not be disclosed in the study's reports or any research publications.

Given the nature of the pelvic health questionnaire, the participant understood that she was under no obligation to answer the questions.

The researcher created a comfortable, trustworthy, and empathetic environment for the participants. The researcher presented a professional and organised assessment room in a professional clinical setting, including the assessment rooms at Mariette Oelofse Physiotherapy private practice and Wits University Sports Clinic.

The researcher was the primary researcher, and there were no field workers in this research. The researcher is a skilled senior physiotherapist with experience managing the pelvis and pelvic floor muscle functions. She uses the Neurotrac Myoplus2 EMG unit and ultrasound unit in her daily practice setting, both in an assessment and biofeedback function.

The process following the assessment was explained to the participant. The write-up of the dissertation and submission for examination was explained. Throughout any submission or publication, confidentiality will not be affected.

The assessment allowed the participant to gain insight into her hip and pelvic floor muscle function. The assessment results were discussed with the participant. The participant was encouraged to visit the WISH sports clinic when dysfunction was observed for assessment and rehabilitation. Furthermore, the participant had the opportunity to ask questions and ask for advice.

The participant's travelling expenses were reimbursed.

3.6 **Data Analysis**

The current study selected non-parametric statistics to analyse the small, non-representative sample. The Statistical Package for the Social Sciences (SPSS) version 27 was used to conduct the tests (IBM Corp., 2021). The Mann–Whitney U test is the non-parametric equivalent of the independent *t*-test. When results are statistically non-significant ($p > 0.05$), there is no detectable difference between the two groups. However, when the test returns a significant result ($p < 0.05$), the two groups differ beyond chance (Field, 2018). The strength of the difference was calculated with the formula for effect sizes recommended by Field (2018) and based on Cohen's seminal work (Cohen, 1988): $r = z / \sqrt{n}$

The interpretation of the effect sizes is according to Cohen’s (1992) recommendations, where:

.100 – .299 = small effect

.300 - .499 = medium effect

.500 - .699 = large effect

>.700 = very large effect

3.7 **Conclusion of the methodology**

The methodology was chosen to identify differences in the pattern of function and features of the PFM and hip muscles between Group 1 and Group 2. The groups were purposively sourced from sports teams, such as football and netball, associated with labral pathology and FAI syndrome (Griffin et al., 2016). The goal was to invite and assess an equivalent number of participants from both groups.

Groups were compared in hip and PFM symptoms, QoL and PFM and hip muscle function. The different outcome measures and procedures were discussed in detail in the paragraphs above and included: the HAGOS (see 3.3.1), the Australian Pelvic Floor Function Questionnaire (see 3.3.2; 3.4.5), the sonar assessment (see 3.3.3; 3.4.3), followed by the sEMG assessment (see 3.3.4; 3.4.4).

The different outcome measures and procedures were chosen to accommodate and support investigation and observation between groups. The results in Chapter 4 will be a detailed presentation of the differences between the groups.

CHAPTER 4: RESULTS

This study compared two groups of nulligravida sportswomen, Group 1 with hip symptoms and Group 2 without hip symptoms, to identify a pattern of function and characteristics between groups. The researcher investigated differences in PFM symptoms, QoL, PFM function and hip muscle function.

The data set is based on the findings from the different outcome measures described in Chapter 3. The SCQ was used as a screening and selection tool for co-morbidities in potential participants. None of the participants showed co-morbidity. Data obtained from The HAGOS (see 3.3.1) and the Australian Pelvic Floor Function Questionnaire (see 3.3.2; 3.4.5) will be explained before discussing the remaining data. The remaining data will be addressed in the same order as the procedure of the main study. Data were obtained from the sonar assessment (see 3.4.3), followed by the surface electromyography (sEMG) tests (see 3.4.4).

4.1 **Participants' Profile**

Tables 4.1 and 4. 2 summarise the physical characteristics of the hip symptom sportswomen Groups 1 and 2.

Table 4.1 shows the mean, median, range and standard deviation (SD) of the physical characteristics–weight, height, and age–of Group 1 and Group 2.

Table 4.1: Participant's Physical Characteristics: weight, height, and age.

		Mean	Median	Range	SD*	Valid N
Group 1	Weight (kg)	67.34	68.00	49.00 - 90.00	10.04	19
	Height (meters)	1.68	1.68	1.47 -1.81	0.08	19
	Age (years)	22.53	23.00	18.00 - 30.00	3.49	19
Group 2	Weight (kg)	67.36	63.00	53.00 - 94.60	11.69	19
	Height (meters)	1.68	1.67	1.51 - 1.83	0.09	19
	Age, years	23.79	24.00	19.00 - 34.00	3.69	19

*SD = Standard Deviation

Group 1 weighed on average 67.34kg (SD = 10.04) their mean height was 1.68m (SD = 0.08), and age was 22.53 years (SD = 3.49), compared to Group 2 who weighed on average 67.36kg (SD = 11.69), their mean height was 1.68m (SD = 0.09), and age was 23.79 years (SD = 3.69).

The physical characteristics indicate similar mean values for weight, height, and age and demonstrate the group's homogeneity.

Table 4.2 shows lower extremity dominance, distribution of symptoms, type of sport, and level of competition.

Table 4.2: Participant Characteristics–Lower extremity dominance, distribution of symptoms, area of symptoms, type of sport, and level of competition.

Group	Characteristic	Category	Frequency	Percentage
Group1: Hip symptom (n=19)	Dominance	Left	3	16%
		Right	14	74%
		Ambidextrous (both)	2	11%
	Symptoms	Left	3	16%
		Right	9	47%
		Both sides	7	37%
	Area of Symptoms	Ant Groin Only	3	16%
		Ant Groin + Prox Hamstring	6	31.5%
		Ant Groin + Lat, Post Hip	6	31.5%
		Lat / Post Hip	4	21%
	Sport	Dancing	2	11%
		Outdoor team sport	15	79%
		Combination of sports	2	11%
	Level of Competition	First team player	9	47%
		National or provincial player	9	47%
		Other	1	5%
Group 2: Non-symptomatic (n=19)	Dominance	Left	6	32%
		Right	13	68%
	Sport	Dancing	2	11%
		Outdoor team sport	15	79%
		Combination of sports	2	11%
	Level of Competition	First team player	9	47%
		National or provincial player	8	42%
		Other	2	11%

Lower extremity dominance was identified on the right side for both groups, namely, in Group 1, 74% (n = 19) vs 68% (n = 19) in Group 2.

Most hip symptoms were shown on the dominant right side in Group 1. The distribution of symptoms was 47% on the right side or 37% on both sides (n = 19).

Group 1's reported symptoms were mainly in the anterior and anterior hip and groin areas with additional symptoms. The symptoms were reported in the groin area, only 16% (n = 19); or the groin area, with additional symptoms reported in the proximal hamstring area, 32% (n = 19); groin symptoms with additional symptoms in the lateral or posterior hip, 32% (n = 19). Furthermore, lateral and posterior hip symptoms reported were only 21% (n = 19). Group 2 did not report any symptoms.

'Type of sports' was categorised as dancing, outdoor team sports (netball, field hockey, or football) and a combination of sports. Most participants, 79% (n = 19) in Groups 1 and 2, played an outdoor team sport. The level of participation further emphasised the homogeneity between groups. In Group

1, 47% (n = 19) participated on a provincial or national level, 47% (n = 19) at the first-team school or university level and 5% (n = 19) danced at a high-performance level. Also, in Group 2, 47% (n = 19) participated at the national or provincial level; 42% (n = 19) at first-team school or university level and 11% (n = 19) performed at high level professional dancing.

4.2 **The HAGOS Questionnaire Hip Symptoms Reported by Group 1**

Table 4.3 summarises the participants' hip symptoms reported in Group 1.
The HAGOS questionnaire was used as an outcome measure in screening and selecting Group 1, participants with hip symptoms, and Group 2, participants who did not report any symptoms. Furthermore, it was used to measure reported hip function and Group 1's QoL. The questionnaire is discussed in Chapter 3.3.1 Instrumentation and Outcome Measures

Table 4.3: Participant reported symptoms–pain, symptoms, ADL, sport and recreation, participation, QoL

	HAGOS Reported Symptoms	Mean (%)	Median (%)	Range	SD.	N
Group1 Symptomatic	Pain	64	65	33-88	16.94	19
	Symptoms reported	58	61	29-82	15.56	19
	Function in daily living	72	75	30-100	22	19
	Sport and Recreation functioning	60	66	20-90	21.17	19
	Participation in sports	60	50	25-100	24.5	19
	Quality of Life	54	55	15-90	20.06	19
Group 2 Non-symptomatic	Pain reported	100	100	100-100	0	19
	Symptoms reported	100	100	100-100	0	19
	Function in daily living	100	100	100-100	0	19
	Sport and Recreation functioning	100	100	100-100	0	19
	Participation in sports	100	100	100-100	0	19
	Quality of Life	100	100	100-100	0	19

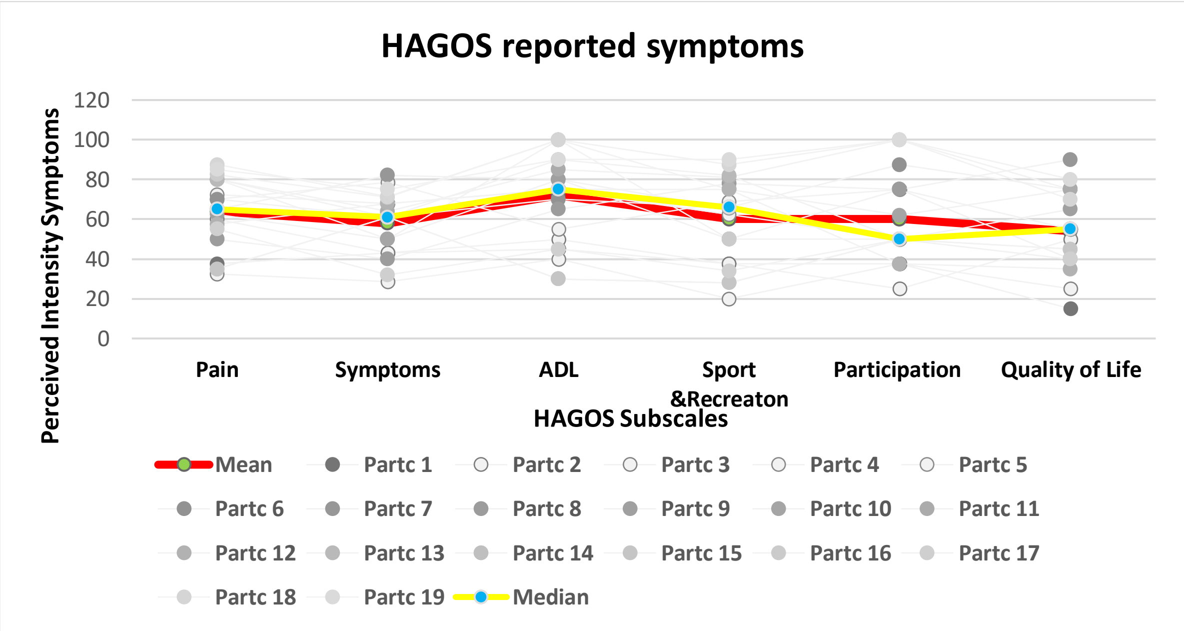
*SD. = Standard Deviation

Group 2 reported no pain, symptoms, daily function, participation in sports and no loss of QoL indicated by the score of 100, SD = 0 (see 3.3.1).

Group 1 reported the following hip function in HAGOS subscales: pain M = 64%, SD =16.94; symptoms M = 58%, SD = 15.56; activities of daily living (ADL) M = 72%, SD = 22; sport and recreation M = 60%, SD = 21.17; participating in sports M = 60%, SD = 24.5; and QoL M = 54%, SD = 20.06 (N = 19) (see 3.3.1).

Outliers influenced the mean in the critical subscale relevant to the cohort, participation in training and competition, mean vs median M = 60%, SD = 21.17 and Mdn = 50%, SD = 24.5. Therefore, median values as a measure of central tendency were summarised in Graph 4.1.

Graph 4.1 shows a large difference between the median values for ADL Mdn = 75%, SD = 22 and participation in sport Mdn = 50%, SD = 24.5.



Graph 4.1: Median values for ADL and Participation in Sport

4.3 **Participants' Reported Pelvic Floor Muscle (PFM) Symptoms**

Descriptive statistics for PFM symptoms are based on the Australian Pelvic Floor Questionnaire outcome discussed in Chapter 3.3.2 Instrumentation and Outcome Measures, and the procedure of the main study, Chapter 3.4.5.

Table 4.4 shows PFM function bladder, bowel, and sexual function measures converted to a percentage.

Table 4.4: Descriptive statistics of reported PFM function symptoms Group 1 and Group 2.

Group	Function	Mean	SD.	Min	Percentile 25	50th (Median)	Percentile 75	Max
Group1 (n = 19)	Bladder %	11%	9%	0%	2%	9%	18%	29%
	Bowel %	7%	9%	0%	0%	3%	15%	24%
	Sexual %	16%	22%	0%	0%	0%	38%	62%
Group 2 (n = 19)	Bladder %	5%	5%	0%	0%	4%	7%	16%
	Bowel %	4%	7%	0%	0%	0%	9%	26%
	Sexual %	11%	18%	0%	0%	0%	24%	57%

Based on the Australian Pelvic Floor Function Questionnaire, Group 1 reported PFM function symptoms: bladder, M = 11% (n = 19); bowel function, M = 7% (n = 19) and sexual functioning M = 16% (n = 19). Group 2 reported PFM symptoms as: bladder, M = 5% (n = 19); bowel function, M = 4% (n = 19), and sexual functioning, M = 11% (n = 19) respectively (Table 4.4).

Table 4.5 shows PFM function and QoL ranks, comparisons between Group 1, and Group 2.

A lower mean rank indicates the group with the lowest scores, and the group with the highest mean rank has higher scores. Higher bladder, bowel, and sexual functioning scores indicate more PFM symptoms in the current study. Group 2 had lower mean ranks compared to Group 1. The ranks show that hip pain may be associated with a higher incidence of bladder, bowel and sexual functioning problems (Table 4.5).

Table 4.5: PFM function and QoL ranks, comparisons between Group 1 and Group 2

Group		N	Mean Rank	Sum of Ranks
Bladder Function Percentage	Group 1	19	23.24	441.50
	Group 2	19	15.76	299.50
	Total	38		
Bowel Function Percentage	Group 1	19	21.55	409.50
	Group 2	19	17.45	331.50
	Total	38		
Sexual Function Percentage	Group 1	19	20.13	382.50
	Group 2	19	18.87	358.50
	Total	38		

Table 4.6 shows the significance of the differences in PFM function in Group 1 and Group 2 for bladder, bowel and sexual functioning.

Table 4.6: The Mann-Whitney U test, exact significance for bladder, bowel and sexual function, Group 1 vs Group 2.

	Bladder %	Bowel %	Sexual %
Mann-Whitney U	109.500	141.500	168.500
Z	-2.097	-1.235	-0.390
Exact Sig. (2-tailed)	0.036*	0.222	0.705
Effect size (*r*)	-0.340	-0.200	-0.063

*$p < 0.05$

The strength of the difference between Group 1 and Group 2 for bladder functioning (r = -0.340) was medium (U = 109.500, z = -2.097, r = -0.340, p < 0.05). No significant differences were shown for bowel function (r = - 0.200) with a small effect size (U = 141.500, z = - 1.235, r = -0.200, p < 0.05) and no significant difference in sexual functioning (r = -0.063) with a small effect (U = 168.500, z = -0.390, r = -0.063, p < 0.05) (Table 4.6).

4.3.1 **The frequency of reported symptoms per bladder, bowel, prolapse and sexual function**

The frequency and severity of a specific symptom is clinically relevant in this study; therefore, the symptoms of each domain (bladder, bowel, prolapse and sexual function) are summarised in Table 4.7 and Graph 4.2 (see 3.3.2).

Table 4.7 shows the quantitative results from the Australian Pelvic Floor Questionnaire.

The frequency of symptoms (subscales) for the domains–bladder, bowel, and sexual function– is shown. Participants reported more than one symptom per domain. No symptoms of prolapse were reported. Participants who were not sexually active were asked if they inserted a tampon to manage menstrual bleeding. The candidates who did not insert tampons because of persistent pain and discomfort during the attempt were categorised GPPPD (see 3.4.5).

Table 4.7: PFM symptoms and frequency of symptoms reported by Group1 and Group2

	Group	Group 1		Group 2	
Domain	Symptom	Frequency	%	Frequency	%
Bladder:	Incomplete bladder empty	8	42%	4	21%
	Strained bladder emptying	5	26%	0	0%
	Lower urinary tract symptoms (LUTS) Frequency and Urgency	7	37%	0	0%
	Urinary Incontinence (UI)	4	21%	4	21%
	Weak Urinary Flow	3	16%	0	0%
	QoL Bladder function	6	32%	0	0%
Bowel :	Incomplete bowel emptying	3	16%	0	0%
Sexual:	Dyspareunia Deep	5	26%	0	0%
	Dyspareunia Superficial	0	0%	3	16%
	Vaginal Tightness	5	26%	3	16%
	QoL Sexual function	5	26%	3	16%
	Vaginal Lubrication	3	16%	0	0%
GPPPD:	Penetration disorder e.g. painful tampon insertion	4	21%	2	10,5%

4.3.1.1 ***Bladder function***

The most frequent symptom reported by Group 1 was incomplete bladder emptying, 42% (n = 19). Furthermore, 37% (n = 19) reported lower urinary tract symptoms (LUTS), urgency and frequency, and 26% (n = 19) experienced strain to empty their bladder. Twenty-one per cent (21%; n = 19) of

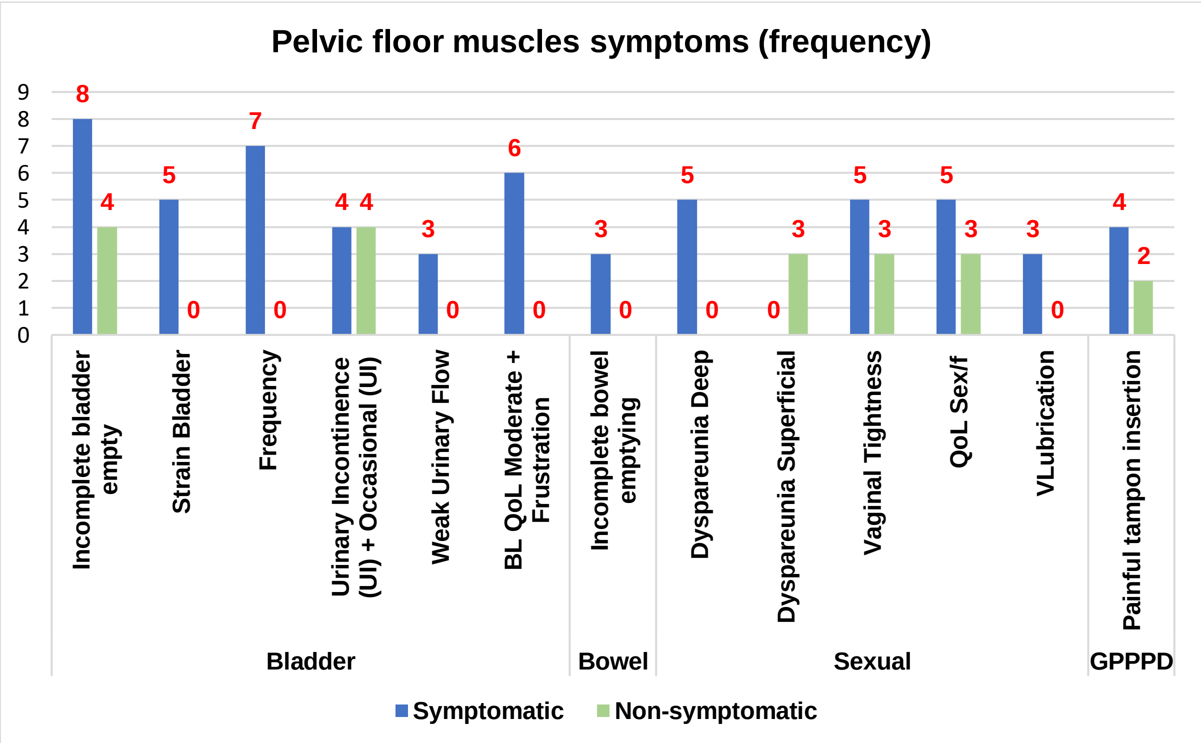
Group 1 reported urinary incontinence, and 16% (n = 19) indicated weak urinary flow. Furthermore, 26% (n = 19) expressed frustration and impact on QoL. Compared to Group 2, 21% (n = 19) reported incomplete bladder emptying, and 21% (n = 19) reported occasional urinary incontinence (Table 4.7, Graph 4.2).

*4.3.1.2 **Bowel function***

Minimal impairment of bowel functions was reported in both groups. Group 1 reported 16% (n = 19) incomplete bowel emptying. Group 2 reported no bowel function challenges (Table 4.7, Graph 4.2).

*4.3.1.3 **Sexual function***

Deep dyspareunia, 26% (n = 19) together with vaginal tightness 26% (n = 19) was reported in Group 1. Furthermore 21% (n = 19) of Group 1 experienced GPPPD, and 26% (n = 19) mentioned that they experience significant discomfort with intercourse, affecting their QoL. Compared to Group 2, 16% (n = 19) experienced superficial dyspareunia and vaginal tightness; 16% (n = 19) mentioned that they experience discomfort with intercourse affecting their QoL and 10.5% (n = 19) experienced GPPPD. (Table 4.7, Graph 4.2).



Graph 4.2: The PFM symptoms and frequency of PFM symptoms reported by Group 1 and Group 2.

The overall results of reported PFM symptoms between groups indicated that Group 1 had significantly more reported PFM symptoms regarding their bladder function,
M = 11.00% (n = 19) when compared to Group 2 who had fewer bladder symptoms, M = 5.00% (n = 19) (Table 4.4). Clinically, Group 1 reports more PFM symptoms in all domains (Table 4.7; Graph 4.2).

4.4 **The ultrasound assessment and function of the PFM**

The function of the pelvic floor muscles was observed with an ultrasound assessment described in the Instrumentation and Outcome Measures Chapter in Section 3.3.3 and the procedure of the main study in Section 3.4.3.

Three functional aspects were analysed:

- The resting symmetry of the BB
- Caudal BB displacement and indirect caudal PFM movement during a breathing cycle
- Cephalad BB displacement and indirect cephalad PFM movement during a pelvic floor muscle contraction

4.4.1 ***The symmetry of the BB at rest, based on sonar imaging of participants Groups 1 and 2.***

A transverse transabdominal sonar image of the BB was taken during a sonar assessment, and the results are summarised in tables 4.8a and 4.8b (see 3.3.3).

Appendix 13 shows a few of the asymmetry images taken from Group 1 and Group 2.

Tables 4.8a and 4.8b show BB symmetry in Groups 1 and 2.

Table 4.8 a: Sonar: BB Symmetry Group 1, symptomatic hip group

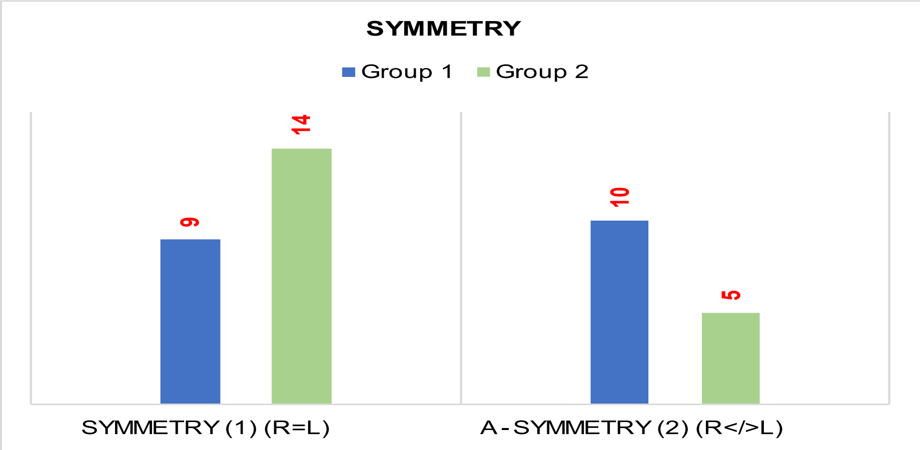
Symmetry/Asymmetry	Frequency	Percentage	n=19
Symmetry (1) (R=L)	9	47.4%	19
Asymmetry (2) (R</>L)	10	53%	19

Table 4.8b: Sonar: Symmetry Group 2, non- symptomatic group

Symmetry/Asymmetry	Frequency	Percentage	n=19
Symmetry (1) (R=L)	13	68.4%	19
Asymmetry (2) (R</>L)	6	31.5%	19

There is a marked difference in the asymmetry between Group 1 and Group 2. The asymmetry was more prevalent in Group 1, 53% (n =19), vs Group 2, 31.5% (n = 19) (Table 4.8a, 4.8b).

Graph 4.3 shows the symmetrical differences between Group 1 and Group 2.



Graph 4.3: Sonar: Symmetrical difference of BB Group1 vs Group 2 (n=19)

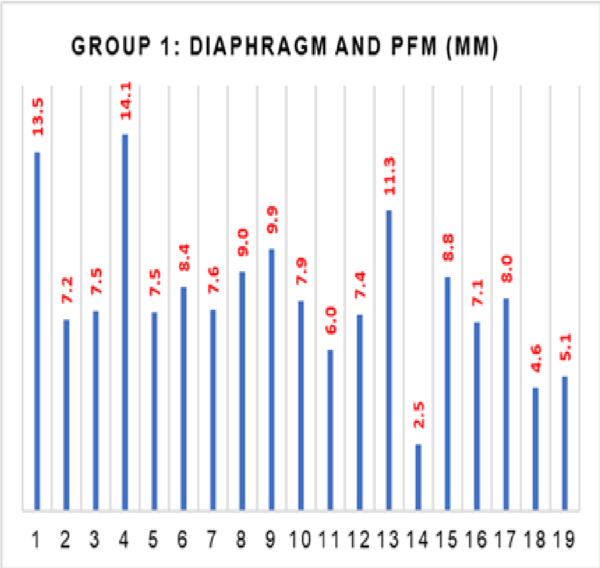
4.4.2 **Sonar assessment of PFM movement during a breathing cycle**

Table 4.9 shows the average caudal BB displacement (caudal PFM movement) during a breathing cycle for the hip symptomatic and non-symptomatic groups.

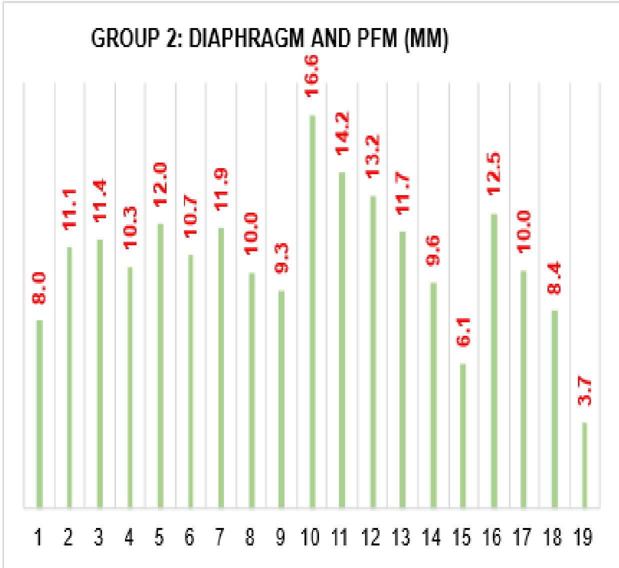
Table 4.9: Sonar: Descriptive statistics of caudal BB displacement (caudal PFM movement) (mm) during a breathing cycle between Group 1 and 2.

Group:	Measure:	Mean	Max	Min	SD.	Percentile 25	50th (Median)	Percentile 75
Group 1	BB, (PFM), (mm)	8.07	14.14	2.50	2.79	7.10	7.57	9.00
Group 2	BB, (PFM), (mm)	10.57	16.60	3.69	2.87	9.27	10.72	12.03

Group 1's caudal BB displacement (caudal PFM movement) during a breathing cycle was lower, M = 8.07 (n = 19), when compared with Group 2 who showed more caudal BB displacement, M = 10.57 (n = 19) (Table 4.9, Graph 4.4a+b).



Graph 4.4a Group 1 Caudal BB displacement



Graph 4.4b: Group 2 Caudal BB displacement

4.4.2.1 ***Sonar: The Mann-Whitney U test results for caudal BB displacement (caudal PFM movement) during a breathing cycle***

Table 4.10 summarises the mean and sum of ranks for Groups 1 and 2.

A higher score in caudal BB displacement (mm) indirectly indicates more PFM (mm) movement during a breathing cycle.

Group 1 had lower mean ranks than Group 2, indicating less caudal PFM movement during a breathing cycle is shown with hip symptoms (Table 4.10).

Table 4.10: Sonar–Ranks for caudal BB displacement (caudal PFM movement) (mm), comparisons between Groups 1 and 2, during a breathing cycle.

Group		N	Mean Rank	Sum of Ranks
BB displacement (PFM, movement, mm)	Group 1	19	14.32	272.00
	Group 2	19	24.68	469.00

Table 4.11 shows the significance of the differences between Groups 1 and 2, for caudal BB displacement (caudal PFM movement, mm), during a breathing cycle.

Table 4.11: Sonar–Mann-Whitney test exact significance for caudal BB displacement (caudal PFM movement) during a breathing cycle.

	Caudal BB displacement sonar average(mm)
Mann-Whitney U	82.000
Z	-2.876
Exact Sig. (2-tailed)	0.003*
Effect size (*r*)	-0.467

*$p < 0.05$

The strength of the difference between Group 1 and Group 2 for caudal BB displacement (caudal PFM movement) (mm) during a breathing cycle (r = -0.467) was a high medium (U = 82.000, z = -2.876, r = -0,467, p < 0.05). A high effect size will be r = -0.5, and a small effect size will be r = -0.3.

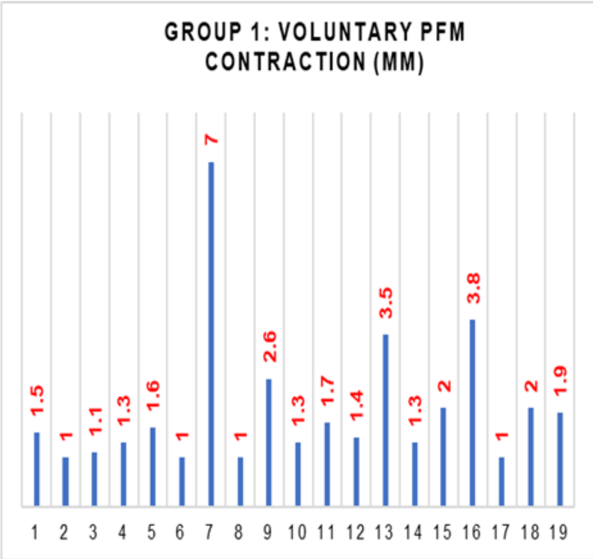
4.4.3 **Sonar assessment of cephalad BB displacement (mm) and indirect cephalad PFM movement during a PFM Contraction.**

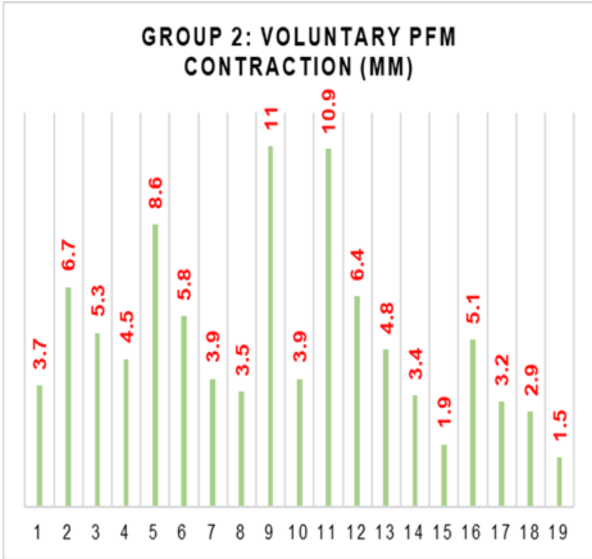
Table 4.12 shows the mean and other descriptive statistics for Groups 1 and 2 cephalad BB displacement (cephalad PFM movement) during PFM contraction.

Table 4.12: Sonar: Descriptive statistics of cephalad BB displacement (cephalad PFM movement) during a PFM contraction between Group 1 and Group 2 (mm).

Measure	**Group 1 (mm)**	**Group 2 (mm)**
Mean	2.00	5.10
Maximum	7.00	11.00
Minimum	1.00	1.50
Standard Deviation	1.45	2.67
Percentile 25	1.10	3.40
50th (Median)	1.50	4.50
Percentile 75	2.00	6.40

Group 1 had a lower mean, M = 2.00 (n = 19), than Group 2, M = 5.10 (n = 19) (mm) (Table 4.12, Graph 4.5 a + b).





Graph 4.5a: Group 1 Cephalad BB displacement–Graph 4.5b. Group 2 Cephalad BB displacement

4.4.3.1 ***Sonar: The Mann-Whitney U test results for cephalad BB displacement (cephalad PFM movement) during a pelvic floor muscle contraction***

Table 4.13 shows the ranks derived for the non-parametric comparison of the cephalad BB displacement during a PFM contraction for Group 1 and Group 2.

A higher score in cephalad BB displacement (mm) indirectly indicates more cephalad movement of the PFM during a voluntary PFM contraction. Group 1 had lower mean ranks, M = 12.05 (n = 19), than Group 2, M = 26.95 (n = 19). The above finding indicates that hip symptoms are shown with less cephalad BB displacement (mm) and indirect cephalad PFM movement during a PFM contraction (Table 4.13).

Table 4.13: Sonar: Ranks for cephalad BB displacement (cephalad PFM movement; mm) comparisons between Group 1 and Group 2 during a PFM contraction.

Group		N	Mean Rank	Sum of Ranks
PFM Movement (mm)	Group 1	19	12.05	229.00
	Group 2	19	26.95	512.00

Table 4.14 shows the test difference between Groups 1 and 2 for cephalad BB displacement (cephalad PFM movement) (mm).

The cephalad BB displacement (mm) and indirect cephalad PFM movement in Group 2, M = 5.10 (n=19), was significantly higher (p = .000) than the cephalad BB displacement of Group 1, M = 2.00 (n = 19).

Table 4.14: Sonar: The Mann–Whitney U test exact significance for cephalad BB displacement (cephalad PFM movement) during a PFM contraction.

	Cephalad BB Displacement Sonar Average
Mann-Whitney U	39.000
Z	-4.135
Exact Sig. (2-tailed)	0.000*
Effect size (*r*)	-0.671

* $p < 0.05$

The strength of the difference between Group 1, the symptomatic hip group and Group 2, the non-symptomatic group, for cephalad BB displacement (mm) and indirect cephalad PFM movement during a PFM contraction (r = -0.671) was high (U = 39.000, z = -4.135, r = -0.671, p<0.05) (Table 4.14). A large effect size will be r = -0.5, and a small effect r < -0.3.

In comparison, the transverse trans-abdominal ultrasound results of the pelvic floor muscles show more BB asymmetry in Group 1 and less BB displacement in the caudal direction during a breathing cycle and cephalad direction during a PFM contraction.

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4.4.4**. Surface electromyography (sEMG) of the posterior synergies of the hip**

A standard, Neurotrac work-rest sEMG assessment measured the balanced function between the left and right hip in Groups 1 and 2.

The sEMG assessment is discussed in Section 3.3.4, Instrumentation and Outcome Measures, and Section 3.4.4, the procedure of the main study.

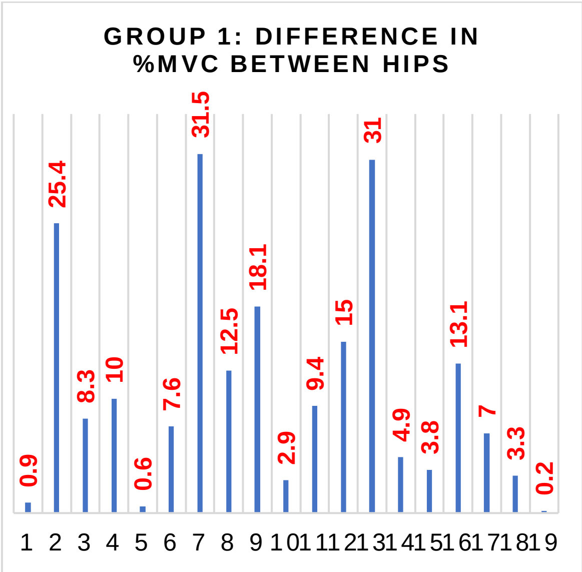
Table 4.15 shows sEMG descriptive statistics for balanced function between the left and right hip between groups.

The balanced function is measured as the difference in the percentage of the maximum voluntary contraction (% MVC) between hips, calculated per participant. The measure indicated balanced function (activation potential/excitation) between the hips in Groups 1 and 2.

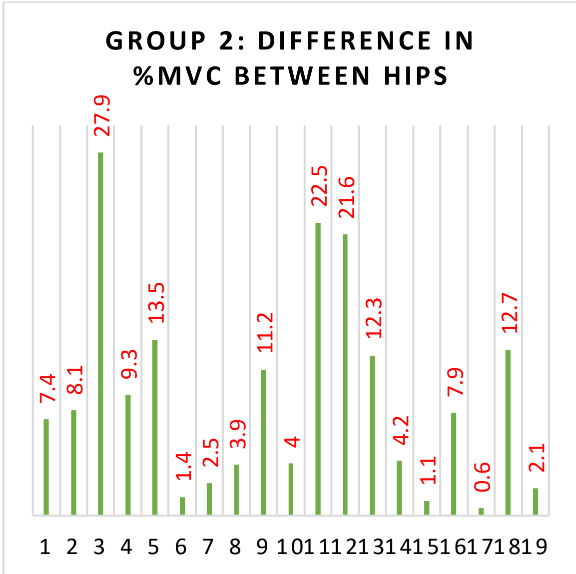
Table 4.15: sEMG: Descriptive statistics of the balanced function, %MVC difference between hips for Group 1 and 2.

Group		The balance between hips,% MVC			
		Mean	Percentile 25	Median	Percentile 75
Group	Group 1	12.7	3.0	8.4	24.5
	Group 2	6.4	2.0	3.7	8.5

Group 1 had a higher mean, M = 12.7 (n = 19) than Group 2, M = 6.4 (n = 19) (%MVC) (Table 4.15, Graph 4.6 a + b).



Graph 4.6a: sEMG: Group 1, %MVC difference



Graph 4.6b: sEMG: Group 2, %MVC difference

4.4.4.1 ***The Mann-Whitney U test results for sEMG of balanced function between hips Group 1 and Group 2***

Table 4.16 shows the mean ranks for balanced function between hips in Groups 1 and 2.

A higher score in % MVC difference between left and right hips indicated more imbalance between hips. Sportswomen in Group 1, with hip symptoms, had higher mean ranks, M = 22.6 (n = 19), than sportswomen in Group 2, with no hip symptoms M = 16.37 (n = 19). The finding mentioned above indicates that an increase in imbalance between hips are found in participants presenting with reported hip symptoms.

Table 4.16: sEMG Mean ranks for balanced function, %MVC difference between hips for Groups1 and 2

Ranks				
	Group	N	Mean Rank	Sum of Ranks
Group %MVC Difference L&R	Group 1	19	22.63	430.00
	Group 2	19	16.37	311.00

Table 4.17 shows the test difference between the groups for balanced function between hips in hip symptomatic Group 1 and non-symptomatic Group 2.

Table 4.17 sEMG: Mann–Whitney test exact significance for balanced function, % MVC difference, between hips, Groups 1 and 2

Test Statistics	
Mann-Whitney U	121.000
Z	-1.737
Exact Sig. (2-tailed)	.084
Effect size *r*	-0.282

The Mann-Whitney test for balanced function between hips (r = -0.282) showed a small effect between the groups (U = 121.000, z = -1.737, r = -0.282, p<0.05). A large effect size will be r = -0.5, and a small effect size r < -0.3.

The sEMG test results show a small effect between groups. The small sample may influence the statistical test because considering the median value as a measure of central tendency between Group 1, Mdn = 8.4 (n = 19), and Group 2 Mdn = 3.7 (n = 19), a clinically relevant difference is observed and indicates more imbalance between hips in Group 1.

4.5 Summary of Results

The results provide essential insights into the differences in symptoms, QoL, PFM and hip muscle function between Group 1 and Group 2.

Group 1 had more PFM symptoms: bladder, bowel, sexual functions (M = 11%, 7%, 16%) as indicated in Table 4.4, and clinically more reported PFM symptoms (Table 4.7, Graph 4). Furthermore, more asymmetry of the BB, 53% (n = 19) (Table 4.8a, Graph 4.3), less caudal BB displacement (mm) M = 8.07 (n = 19) during the breathing cycle, as shown in Table 4.9, Graph 4.4a, with a high -medium effect (U = 82.000, z = -2.876, r = -0,467, p < 0.05), and lower range of cephalad BB displacement (mm) during a PFM contraction, M = 2.00 (n = 19) as indicated in Table 4.12 and Graph 4.5a, with a high effect (U = 39.000, z = -4.135, r = -0.671, p<0.05). Clinically more imbalances are shown in muscle function (excitation) between hips, %MVC M = 12.7 (n =19) (Table 4.15, Graph 4.6a), with the test indicating a small effect (U = 121.000, z = -1.737, r = -0.282, p<0.05).

Group 2 had minor PFM symptoms: bladder, bowel, sexual functions (M = 5%, 4%, 11%) as indicated in Table 4.4, and clinically less reported PFM symptoms (Table 4.7, Graph 4). Furthermore, less asymmetry of BB 31.6%, (n = 19) (Table 4.8b, Graph 4.3) higher caudal BB displacement (mm) M = 10.57, (n = 19), during a breathing cycle as shown in Table 4.9 and Graph 4.4b, and more cephalad BB displacement (mm) during a PFM contraction M = 5.10 (n = 19), as indicated in Table 4.12 and Graph 4.5b. Furthermore, clinically less imbalance is shown in muscle function (excitation) between hips %MVC, M = 6.4, (n = 19) (Table 4.15, Graph 4.6b).

In the following chapter, a discussion of the results will be presented and related to supporting literature.

CHAPTER 5: DISCUSSION

5.1 **Introduction**

The present study was designed to investigate differences in PFM, hip symptoms, QoL and muscle function when comparing Group 1, young nulligravida sportswomen with self-reported hip symptoms, and Group 2, without self-reported hip symptoms.

The first question in this study sought to investigate possible differences in the symptoms, QoL and PFM function between Group1 and Group 2. It was hypothesised that there are differences. The second question was to investigate possible differences in the symptoms, QoL, and the balanced function (excitation), of the posterior synergies between hips in Group 1 and Group 2. It was hypothesised that there are differences.

During the participant selection process, the different subscales of the HAGOS indicated that Group 1’s reported hip symptoms were tolerable during their daily life activities, Mdn = 75% (SD = 22) but less acceptable during their sports activities, Mdn = 50% (SD = 24.5), and QoL Mdn = 55% (SD = 20.06) (see 4.2).

The differences in reported PFM symptoms between groups were mainly bladder symptoms with a medium effect, r = -0.340. Both groups reported minimal bowel function symptoms with a small effect (r = - 0.200), and both groups reported more sexual function symptoms; therefore, no significant difference (r = -0.063). The groups reported no prolapse symptoms (see 4.3; Graph 4.2; Table 4.7).

Clinically the results showed that the PFM function symptoms reported between groups differed. The reported bladder function symptoms in Group 1 were a feeling of incomplete bladder emptying, 42% (n = 19), and lower urinary tract symptoms (LUTS), frequency and urgency, 32% (n = 19) that affected their QoL 32% (n = 19). Group 2 reported a feeling of incomplete bladder emptying, 21% (n=19), no LUTS and no effect on their QoL (Graph 4.2; Table 4.7). Dyspareunia and vaginal tightness were reported in both groups. Though there was no significant difference in the sexual function domain (r = -0.063), dyspareunia presented differently between groups. In Group 1, 26% (n = 19) experienced deep dyspareunia and vaginal tightness, and 26% (n = 19) experienced an impact on QoL. In Group 2, 16% (n = 19) experienced superficial dyspareunia and vaginal tightness, and 16% (n = 19) of the participants reported an effect on QoL (see 4.3.1.3; Graph 4.2; Table 4.7).

Participants who were not sexually active reported GPPPD in both groups, Group 1, 21% (n = 19), and Group 2, 10,5% (n = 19) (see 4.3.1.3; Graph 4.2; Table 4.7).

The results in PFM function between groups showed the following differences between Groups 1 and 2: Group 1 presented with more asymmetry of the BB (see 4.4.1), with less caudal BB displacement (caudal PFM movement) during a breathing cycle, with medium-high effect (r = -0.467; see 4.4.2) and less cephalad BB displacement (cephalad PFM movement) during a PFM contraction with high effect (r = -0.671; see 4.4.3).

The current study also found more imbalanced hip muscle function between hips during an isometric contraction of the posterior synergies of the hip, Group 1 vs Group 2. The small samples may influence the statistical test. The test showed no significant difference between the groups (r = -0.282). Still, when considering the median value as a measure of central tendency between Group 1, Mdn = 8.4, and Group 2, Mdn = 3.7; clinically relevant % MVC differences are observed, indicating more imbalance between hip muscle function in Group 1 (see 4.4.4). The study's sample was homogenous but small and should be considered when interpreting the results of the study's hip and PFM symptoms, QoL, and function.

5.2 **Participants' Profile**

The participant profile included young, nulligravida South African sportswomen.

When considering the female lifecycle graph (TAKEDA, 2010; Graph 5.1), the current study's nulligravida cohort with a mean age between 22 and 24 is illustrated. The nulligravida sportswomen were from various backgrounds and upbringings and belonged to different ethnic groups. The sportswomen were primarily students. Most participants were university residents who received bursaries, including their residence, food, and transport.

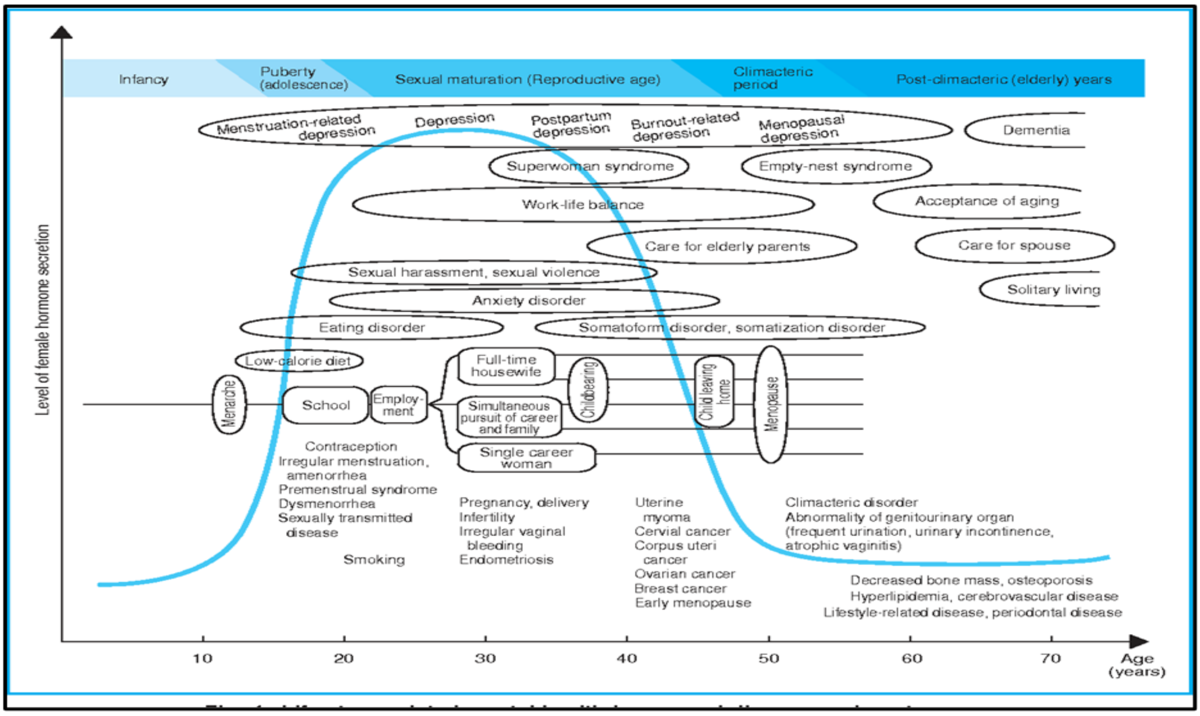


Figure 5.1: Life stage-related health and diseases unique to women (TAKEDA, 2010)

The physical characteristics of the groups indicated similar mean values for weight, height, and age and demonstrated the groups' homogeneity. Group 1, aged M = 22.53 years, SD = 3.49; weighed on average M = 67.34 kg, SD =10.04, and their mean height was M = 1.68m, SD = 0.08. In comparison, Group 2, aged M = 23.79 years, SD = 3.69, weighed on average M = 67.36kg, SD = 11.69 with a mean height of M = 1.68m, SD = 0.09 (see 4.1; Table 4.1).

The sports teams were assessed during their training and competitive season, with a high load in training and competition. The dancers were performers with high-volume training. Most participants, 79% (n = 19), in Group 1 and Group 2 participated in outdoor team sports, netball, hockey, and football (see 2.7; 4.1; Table 4.2).

The level of participation further emphasised the homogeneity between groups, with 47% (n = 19) in Group 1 and 42% (n = 19) in Group 2 participating at the national or provincial level. Previous epidemiology studies, injury rates and self-reporting injuries in high-performance female outdoor team sports demonstrated an association between training hours, match hours and injury. Studies reported 12.6 to 23.6 injuries per one thousand match hours (Agustin et al., 2021). The participants in Groups 1 and 2 participated in the same university teams, but the teams performed on different levels as participants also took part on provincial and national levels (see 2.7; 4.1; Table 4.2). According to previous studies, there is an association between training hours, match hours and injuries. In the current cohort, Group 1 would be the Group to represent a higher level of participation.

Interestingly, the level of participation between groups does not differ. The reason may be that level of participation at university may already be loaded as far as training and match hours are concerned. Furthermore, the sportswomen's coaching and conditioning quality may be of a high standard, or the outcome may differ when larger study samples are assessed.

5.2.1 **Group 1–reported hip symptoms**

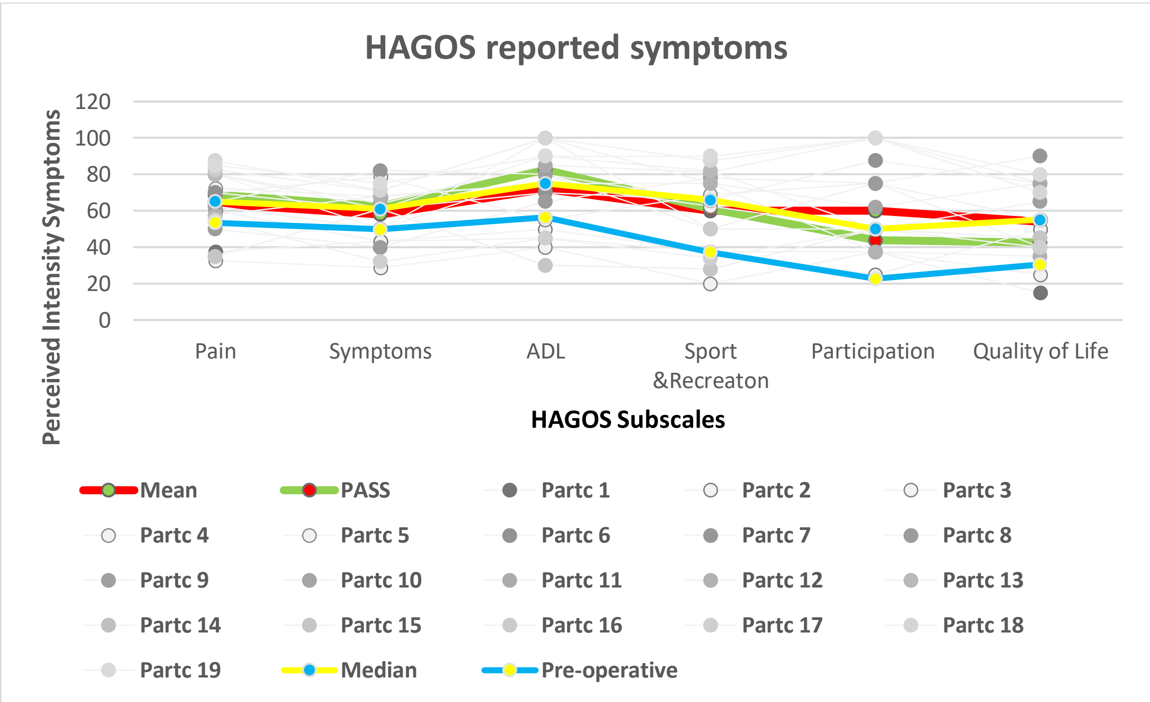
Participants were screened and selected for Group 1 because of their reported hip symptoms. Group 2 did not report hip symptoms (see 3.2.3.1; Table 3.1).

All symptoms reported by participants were related to pre-defined areas presented in Figure 3.1. The pain drawing was adapted from methods for determining the location of pain used in the study by Thorborg et al. (2011). The symptoms were mainly in the anterior or anterior hip and groin areas with additional symptoms. Sixteen per cent (16%) (n = 19) of the participants reported symptoms only in the groin area, 31.5% (n = 19) of the participants reported symptoms in the groin area and additional symptoms in the proximal hamstring area, with 31.5% (n = 19), reporting groin symptoms with additional symptoms in the lateral or posterior hip. Furthermore, only 21% (n = 19) reported lateral and posterior hip symptoms (see 2.8; Table 4.2).

The results further indicated that the similarity between Group 1 and Group 2 was continuous in characteristics such as right lower extremity dominance, 74% (n = 19) vs 68% (n = 19), respectively (see 4.1; Table 4.2).

Dominance was shown with reported symptoms in Group 1. An essential clinical finding was the distribution of most symptoms on the dominant right side (Table 4.2). This finding correlated with a study by Maulder (2013), who found an unambiguous relationship between lower extremity injury and dominance in twenty-four provincial Netball players followed during a season. The injury rate was 37%, and 100% of injuries were related to the dominant side. In another study involving football players, De Lang et al. (2021) found a 1.6 times higher risk for lower extremity dominant leg injury across all levels of play, all genders included (see 2.8).

The reported hip symptoms in Group 1 of the current study are shown in Graph 5.1. The HAGOS values for reported pre-operative pain (blue bar) and Patient Acceptable Symptoms State (PASS) (green bar) were included as a reference to Group 1's reported symptoms (Impellizzeri et al., 2020).



Graph 5.1: The participant reported HAGOS Hip scores.

The PASS HAGOS score (green bar) determines if patients consider their symptoms and function acceptable twelve to twenty-four months after hip arthroscopy. The cut-off score represents the score beyond which an individual is more likely to have an acceptable symptom state; in other words, according to this report, below the bar would not be considered an acceptable functional state.

Comparing Group 1's reported hip symptoms values (yellow bar) with the HAGOS PASS score (green bar) brought insight into the severity of the hip symptoms participants are prepared to endure while training and competing at provincial and national levels. Nine of the nineteen participants in Group 1 participated on a provincial and national level in football, hockey, or netball, with reported symptoms averaging the HAGOS PASS values. Comparing PASS and pre-operative values above showed the importance and value of reported symptoms and the management of these symptoms.

An intervention may prevent the yellow bar from sloping downwards toward the pre-surgery symptoms (blue bar) (see 2.8; Graph 5.1).

5.2.2 **Group 1 and Group 2’s reported PFM symptoms**

PFM symptoms between the groups were primarily found in the bladder and sexual function domains of the Pelvic Floor Function Questionnaire (see 4.3.1, Table 4.7, Graph 4.2).

5.2.2.1 ***Bladder function***

The most prominent finding regarding bladder function reported in groups 1 and 2 was a feeling of incomplete bladder emptying. The incidence in Group 1 was 42% (n = 19), and in Group 2, 21% (n = 19). Group 1's feeling of incomplete bladder emptying was related to LUTS, frequency and urgency, 37% (n = 19), and an urge to strain while emptying the bladder, 26% (n = 19). To empty their bladder, participants would strain, with no effect. Group 2's perceived incomplete bladder emptying, 21% (n = 19), was unrelated to LUTS.

The results mentioned above are also shown bladder function symptoms classified as interstitial cystitis (IC), also known as bladder pain syndrome (BPS) (Lin et al., 2022; see 2.9).

Various organisations, such as the Asian Urologic Association (AUA), Canadian Urological Association (CUA), European Association of Urology (EAU), and the International Consultation on Incontinence (ICI), describe ICS in more or minor detail in their definitions. The CUA endorsed the detailed description of the AUA, "An unpleasant sensation (pain, pressure, discomfort) perceived to be related to the urinary bladder, associated with LUTS with more than six weeks duration, in the absence of infection or other identifiable causes" (Malde et al., 2018).

The bladder function symptoms reported by Groups 1 and 2 could be associated with the CUA and the AUA’s definition of IC. Urinary tract infections reported in both groups were lower than two participants per group and, therefore, not included in Table 4.7 (see 3.2.2).

When considering the reported hip symptoms of Groups 1 and 2 (Table 4.2), similarities between the current study's Group 1 and Urinary Chronic Pelvic Pain Syndrome (UCPPS) are seen. UCPPS are associated with bladder symptoms and symptoms beyond the pelvis, including peripheral pain (Adamian et al., 2020, Clemens et al., 2019; Grinberg et al., 2020, see 2.9; 2.9.1.2). PFM symptoms reported between groups were bladder symptoms with medium effect (r = -0.340) (see 4.3). The symptoms included urinary incontinence, urgency, frequency, pelvic pain, and dyspareunia (Louis-Charles et al., 2019; Rebullido et al., 2020; Santos et al., 2018; Bø & Nygaard, 2020). The clinical difference in PFM function symptoms between groups was of interest. Group 2's bladder function symptoms, 32% (n = 19) (Table 4.7), may be related to IC, but none of the remaining PFM symptoms was associated with IC, as described by Ferrero et al. (2008). Group 2's dyspareunia was superficial, and the group did not report bladder symptoms affecting their QoL (see 2.9 and 4.3.1).

5.2.2.2 ***Dyspareunia***

Dyspareunia was divided into three different categories. Two of these categories, deep and superficial dyspareunia, were already included in the sexual function domain of the Australian Pelvic Floor Function Questionnaire. The third category Genito Pelvic Pain Penetration Dysfunction (GPPPD), was not a domain in the Australian Pelvic Floor Function Questionnaire.

The Australian Pelvic Floor Questionnaire, at the end of each domain (bladder, bowel, prolapse and sexual function), does allow additional information related to that domain as “other”. I considered Genito pelvic pain penetration dysfunction (GPPPD) as a third dyspareunia category to accommodate participants in the sexual function domain who were not sexually active. 53% in Group 1 and 31,6% in Group 2 (n = 19) (see 3.4.5). GPPPD is a relatively new umbrella term for dyspareunia related to vaginismus. GPPPD also refers to pain and discomfort when inserting a tampon or during a gynaecological examination. In Group 1, 21% (n = 19), and in Group 2, 10.5% (n = 19) did not use tampons because of continuous painful tampon insertion (see 2.9, 3.4.5).

Differences in the prevalence of dyspareunia were seen in the sexually active participants in Group 1, who experienced deep vaginal pain, 26% (n = 19), and Group 2, who mainly experienced superficial dyspareunia, 16% (n = 19). Ferrero et al. (2008) mentioned that clinically, deep dyspareunia was associated with IC, whereas superficial dyspareunia was usually linked to vulvodynia and vaginismus (see 2.9).

The current study showed what was mentioned by Confort (2017) in her report, that sexual function does impact QoL. The sexual function impact on QoL was more evident in Group 1, 26% (n = 19) vs Group 2, 16% (n = 19) (see 2.9, 4.3.1, Table 4.7).

5.3 **The Ultrasound Assessment of the Function of the PFM**

The transverse, transabdominal ultrasound assessment measured BB symmetry at rest, caudal displacement of the BB during a breathing cycle (mm) and cephalad displacement of the BB during a voluntary PFM contraction (mm). The displacement of the BB (mm) was an indirect measure of PFM movement, and the results and differences between groups are discussed below (Frawley et al., 2021, see 3.3.3; 3.4.3).

5.3.1 **Sonar: Asymmetry of BB and structural support of the BB**

Asymmetry of the BB base at rest was evident in Group 1, 53% (n = 19) vs Group 2, 31,6% (n = 19) (Table 4.8a+b, Graph 4.3).

Bitti et al. (2014) describe the bilateral loss of support of the posterior bladder wall, a finding known as the "saddlebag" sign (Fig 5.2). The axial MRI bladder image mentioned above resembles the BB transverse trans-abdominus sonar image of the current study (Fig 5.3, see 2.5.1.2.1 A).

Asymmetry of BB indicates unilateral structural support deficit or tonal variances of the PFM reflecting on the BB at rest. The asymmetry of the BB and possible tonal variances coincides with the altered function of the PFM seen in the limited caudal and cephalad BB displacement and the possibility that the limited displacement may be due to the increased tone of the PFM. However, as mentioned in the International Continence Society Report, there is the possibility that a structural support deficit may cause the BB asymmetry (Frawley et al., 2021; see 2.5.1.2, 2.9).

It is essential that this finding should be further investigated to clarify a possible lesion at the arcus tendinous musculi levatoris ani (ATLA), a junction also related to the fascia overlying the obturator internus muscle (see 2.5.1.2.1 Appendix 13). The possibility that repetitive and continuous sport loading on the PFM and its support system may lead to a support deficit of the bladder and other pelvic organs should be considered. Based on trans-labial sonar assessment, Pires et al., 2020 in a small study on the pelvic floor function of elite sportswomen, reported a rectocele in 3 of 8 participants and a paravaginal defect in 4 of 8 participants. Should the BB asymmetry in the current cohort relate to a paravaginal defect and not an increased tone of the PFMs, Group 1's reported LUTS and dyspareunia might be associated with a paravaginal defect. The abovementioned symptoms are also a known complaint of patients presenting with pelvic organ prolapse, as described by the International Urogynecology Committee. The committee reported prolapse associated with lower urinary tract symptoms and vulvovaginal, lower abdominal and back pain (Harvey et al., 2021).

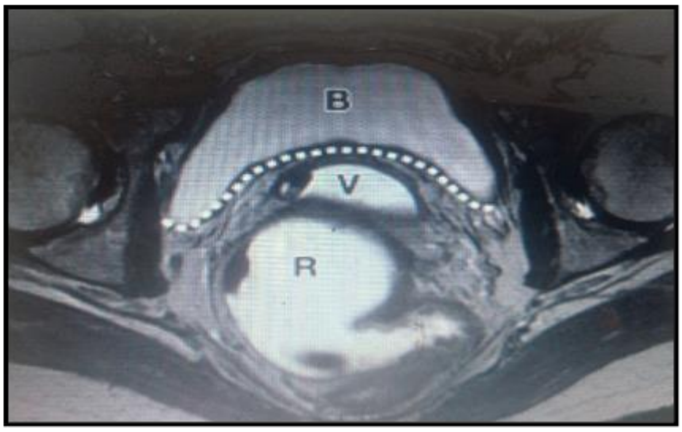


Figure 5.2: Saddlebag" sign (Bitti et al., 2014)

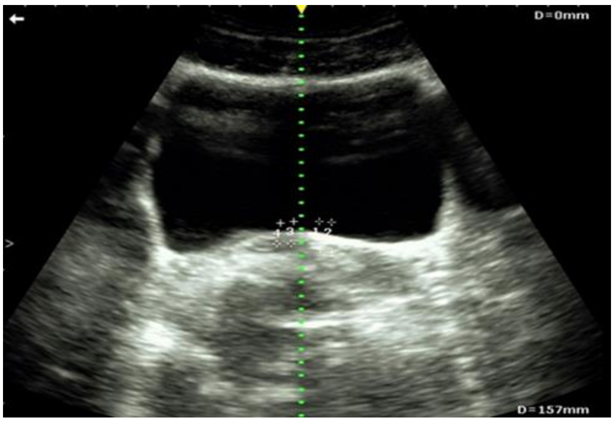


Figure 5.3: Unilateral "saddlebag" sign

5.3.2 **Sonar: Asymmetry of the BB, caudal and cephalad displacement of the BB related to increased or decreased PFM tone**

This study utilised the sonar assessment as a non-invasive tool for PFM function in sportswomen with hip symptoms and found the sonar technique effective and non-invasive, as shown by Zajac et al. (2021). I standardised the transverse transabdominal measurement by establishing a breathing rhythm for the participant. A comfortable breathing cycle suitable for the participant was rehearsed (see 3.4.3.2). Furthermore, the present study found similar values for BB displacement during a PFM contraction, as shown in a recent study by Khowailed et al. (2020). Their study aimed to establish gender-based normative values for BB displacement using transabdominal ultrasound (see 2.2.3). As a general reference, the value (0.35 +- 0.25 cm) for the BB displacement in the female cohort coincides with the current study's median value for BB displacement in Group 2, Mdn = 0.45 cm (4.4.3; Table 4.12; Graph 4.5b). When using the general reference value mentioned above, the current study's Group 1's altered PFM function is even more noticeable with an Mdn = 0.15 cm (see 4.4.3; Table 4.12; Graph 4.5a). This study identified decreased caudal displacement of the BB during a breathing cycle of high-medium effect (r = -0.467) and a significantly reduced displacement of the BB in a cephalad direction during a voluntary PFM contraction (r = -0.671) (see 4.4.2; 4.4.3). Utilising the sonar assessment to identify altered PFM function in young sportswomen contributes to this cohort's management of PFM function.

The International Continence Society's report on PFM function terminology defines PFM tone as the tone of the PFM at rest, against passive resistance. Furthermore, non-neurogenic PFM tones are described as decreased or increased tone in the absence of neurological disorders (Frawley et al., 2021; see 2.5.1.2.1 B, 2.9). When considering the type of reported PFM symptoms (Table 4.7, Graph 4.2), it is most likely that the non-neurogenic PFM symptoms reported in Groups 1 and 2 are related to the increased tone of the PFM (Ackerman & Lee, 2016; Morin & Binik, 2017; see 2.5.1.2.1, 2.9).

When considering Group 1’s cephalad BB displacement during a voluntary PFM contraction, a typical response would be displacement of the BB in a cephalad direction (Khowailed et al., 2020, see 2.2). Decreased displacement of the BB cephalad during a voluntary contraction of the PFM may result from the weakness of the PFM, an inability to contract the PFM or increased tone in the PFM (Frawley et al., 2021).

In consideration of those mentioned above, I addressed the potential inability of the participant to effectively contract the PFM during the procedure of the US assessment. The technique is explained thoroughly in the methods section (see 3.4.3.2). The remaining question is, is the reduced cephalad BB displacement weakness of the PFMs or an increased tone of the PFMs? The current study's caudal BB measure *(r = - 0.47)* during a breathing cycle was during an involuntary movement of the PFMs (Hodges et al., 2007; Bordoni & Zanier, 2013; Talasz et al., 2011) and the cephalad BB measure *(r = - 0.671)* during a voluntary PFM contraction. Group 1’s decreased displacement of the BB caudally during a breathing cycle (involuntary movement) and cephalad during a PFM contraction (voluntary contraction)**,** together with the reported PFM symptoms, mimics increased tone in PFM function (Bo & Nygaard, 2020; Confort, 2017; Frawley et al., 2021) (see 1.1.2, 4.4.2, 4.4.3).

The altered caudal and cephalad PFM movement and PFM symptoms in Group 1 resemble reported PFM symptoms described in UCPPS. UCPPS are characterised by chronic pain in the pelvis, urogenital floor, and external genitalia frequently accompanied by other urologic symptoms such as urinary urgency and frequency. (Frawley et al., 2021; Lai et al., 2017, see 2.9).

5.4 **sEMG as a measure of balanced function between hips in Group 1 vs Group 2**

The sEMG measured balanced function (muscle excitation) between hips in Group 1 vs Group 2, with no significant difference (r = -0.282) found between groups (U = 39.000, z = -1.737, r = -0.282, $p<0.05$) (Vigotsky et al., 2018).

Borgstrom and McInnis (2022) mentioned that one of the functional gender differences resulting in risk for hip injury is the asymmetry in biomechanical variables such as strength differences between legs in hip and knee muscle function. Variability between hip function in patients with hip pain scheduled for hip arthroscopy was reported to affect strength deficits between hips in most functional directions (Retchford et al., 2018; see 2.6.3).

When considering the median sEMG scores as a measure of central tendency, Group 1's % MVC, Mdn = 8.4 (n=19), and Group 2's % MVC, Mdn = 3.7 (n = 19), resulted in more imbalance between hips in Group 1 vs Group 2 (Graph 4.6a+b). The median value agrees with the variabilities in hip muscle function in hip pain patients mentioned in the abovementioned studies by Borgstrom & McInnis (2022) and Retchford et al. (2018).

5.5 **Conclusion**

Hip and PFM symptoms, QoL and function, were compared between two groups of nulligravida sportswomen aged 18-35. Group 1 (n=19) with hip symptoms and a non-symptomatic Group 2 (n=19).

Groups 1 and 2 reported no co-morbidities according to the Self-Administered Co-Morbidity Questionnaire (SCQ).

Groups 1 and 2 were primarily students with the same physical characteristics in weight, height, and age. They were first or provincial team players in university hockey, netball and football. These sports are reportedly demanding on the hip and pose a possible risk for a hip injury. Other than those reported in previous studies, Groups 1 and 2's participation levels did not make them more susceptible to injury. Various reasons were mentioned.

Group 1's hip symptoms were reported in a pre-defined area and were mainly symptomatic in the anterior or anterior hip and groin areas with additional symptoms. An essential clinical finding which correlates with various studies was the distribution of most symptoms on the dominant right side.

Comparing Group 1's reported hip symptoms values with the HAGOS PASS score brought insight into the severity of the reported symptoms of the participants and the importance of identifying and managing these symptoms.

The Pelvic Floor Function Questionnaire measured PFM symptoms related to bladder, bowel and sexual function and QoL. Group 1 reported LUTS such as incomplete bladder emptying, urgency, frequency and dyspareunia, resembling symptoms reported under the umbrella term UCPPS and impacting their QoL. Clinically symptoms between Groups 1 and 2 differed markedly as far as bladder and sexual functions were concerned. However, the statistical outcome showed the most difference between groups was in the domain of bladder function, with a medium effect (r = -0.340). Group 2 reported fewer PFM symptoms, and these symptoms had a lesser impact on their QoL.

The PFM function sonar assessment showed asymmetry of the BB base was more evident in Group 1 than in Group 2. This finding should be further investigated to clarify a possible lesion at the arcus tendinous musculi levatoris ani (ATLA), a junction related to the fascia overlying the obturator internus muscle. The possibility that repetitive and continuous sport loading on the PFM and its support system may lead to a support deficit of the bladder and other pelvic organs should be considered.

The PFM function sonar assessment also resulted in the involuntary caudal displacement of the BB during a breathing cycle of high-medium effect (r = -0.467) and a significant difference in the cephalad displacement of the BB during a voluntary PFM contraction (r = -0.671). Group 1's decreased displacement and the reported PFM symptoms resemble symptoms associated with an increased tone in PFM function.

Furthermore, more imbalance in function between hips was shown in Group 1 than in Group 2. Group 1 with Mdn = 8.4 (n = 19), vs Group 2 with Mdn = 3.7 (n = 19). This finding correlates with reported strength deficits between hips, as discussed previously in chapter 5. The statistical test showed no significant difference between the groups (r = -0.282) and could have been influenced by the small sample size.

CHAPTER 6 CONCLUSION

6.1 **Conclusion**

This chapter concludes the study by summarising the key research findings concerning the research aims and questions and discussing the value and contribution of the study. The chapter also reviews the study's limitations and proposes recommendations for future research.

The present study aimed to investigate PFM and hip muscle function, symptoms and QoL in Group 1, young nulligravida sportswomen, with self-reported hip symptoms, compared to Group 2, young nulligravida sportswomen without self-reported hip symptoms and hypothesised to identify differences between groups.

The objectives were to identify and report the differences between the groups in PFM and hip muscle symptoms, QoL and function and thereby contribute to the under-recognised and sub-optimal management of PFM function in sportswomen with hip symptoms. Excluding PFM function when managing hip symptoms and vice-versa may lead to essential information being overlooked and missed.

Regarding their stated symptoms, the following distinctions were clear: Hip symptoms were reported by Group 1 as affecting their ability to train and compete and their quality of life. The group's reported PFM symptoms in the bowel, sexual, and bladder function were associated with LUTS (urgency and frequency), incomplete bladder emptying, vaginal tightness, and dyspareunia, and also affected their quality of life. Group 2 had fewer PFM function symptoms, no hip symptoms, and symptoms that had less impact on QoL. The most difference in reported symptoms between groups was bladder symptoms of medium effect (r = -0.340).

Regarding identifying differences in PFM function between groups, the current study used the sonar assessment as a non-invasive tool for assessing PFM function in sportswomen with hip symptoms and found the sonar technique effective and non-invasive, as shown by Zajac et al. (2021). Furthermore, I standardised the transverse transabdominal sonar measurement by establishing a consistent breathing rhythm during the assessment.

The following PFM functions were identified by observing the symmetry of the BB, caudal displacement of the BB during a breathing cycle and the cephalad displacement of the BB during a PFM contraction: Group 1 demonstrated more asymmetry of the BB than Group 2. Asymmetry of the BB at rest was evident in Group 1, 53% (n = 19), vs Group 2, 31,6% (n = 19) (Table 4.8a+b, Graph 4.3).

BB asymmetry may indicate PFM tonal differences between the left and right sides of the PFM or structural deficit in support of the BB. Further investigation of BB asymmetry in this cohort is advised.

Concerning the sonar observations in BB displacement: The most significant difference between groups was found in the cephalad BB displacement (PFM movement) during a voluntary contraction of the PFM (r = -0.671) (see 4.4.3), followed by the caudal displacement of the BB during a breathing cycle (r = -0.47) (see 4.4.2).

As a point of comparison, the median value for cephalad BB displacement in Group 2 of the current study, Mdn = 0.45 cm (4.4.3; Table 4.12; Graph 4.5b), corresponds to the value (0.35 +/- 0.25 cm) for the BB displacement in the female cohort in a study by Zajac et al. (2021). With an Mdn = 0.15 cm (see 4.4.3; Table 4.12; Graph 4.5a), the altered PFM function in Group 1 of the current study is discernible compared to the previously described general reference value and resembles symptoms associated with an increased tone in PFM function.

The sonar assessment was practical and effective as a non-invasive assessment to identify altered PFM function in young sportswomen.

In addition to reported PFM function symptoms, the altered caudal and cephalad PFM function in Group 1 is also demonstrated in symptoms referred to as UCPPS in research by Frawley et al. (2021) and Lai et al. (2017) (see 2.9). Therefore, the present study's findings may help recognise and comprehend UCPPS in athletes with hip complaints. I observed, as a consideration, that the body chart depicting peripheral symptoms in UCPPS (Lai et al., 2017) might conceal symptoms from the hip and groin (see 2.9; 2.5.1.2.1).

The balanced function of the posterior synergies between hips was assessed with sEMG. Clinically, Group 1, with an Mdn = 8.4 (n = 19), showed more imbalance in hip function between hips than Group 2, with an Mdn = 3.7 (n = 19) (Table 4.15; Graph 4.6a+b). The imbalance between hips corresponds to variabilities in hip muscle function in hip pain patients mentioned in previous studies (Retchford et al., 2018). The sEMG was a practical assessment with an sEMG instrument physiotherapists would have access to and apply in clinical practice.

Significant differences in hip and PFM symptoms and functions were found between Group 1 and Group 2, indicating their collaborative function apart from their anatomical connection. It is unknown what influence the PFM function has on hip function or the hip on PFM function.

The results mentioned above show that while treating patients with hip and groin symptoms or PFM symptoms, all structures and functions of the pelvis must be included in the examination and management plan.

Health professionals in the sporting environment can utilise the present study's non-invasive measures and procedures. The outcomes may lead to the holistic management of hip and PFM symptoms, early referral to relevant health professionals and management of load on the PFM and the hip during participation in training and competition.
Young sportswomen should be educated to report PFM and hip muscle symptoms to impact the prognosis of their hip and PFM function.

These efforts mentioned above may prevent chronic injury and hip and PFM symptoms leading to early sports retirement and a compromised active lifestyle beyond the sportswomen's sporting career.

Further research is advised, and recommendations are made in forthcoming paragraphs.

6.2 **Study Limitations, Strengths, and Clinical Recommendations**

6.2.1 **Participant selection**

The current study's cohorts were screened and allocated to Group 1, the symptomatic group or Group 2, the non-symptomatic group. Group 2 also presented with PFM function symptoms to a lesser extent, influencing the statistical difference between groups. Although the altered PFM function in both groups is a natural occurrence of symptoms in young sportswomen, outliers should be considered and accommodated in the statistical tests.

6.2.2 **Instrumentation**

6.2.2.1 ***Questionnaires***

The possibility of researcher bias was considered and avoided while administering the HAGOS questionnaire. Researcher bias was minimised by not lingering on a question or responding to an answer given by the participant. The participants were from different backgrounds and circumstances, and there were differences in language and understanding. The participants were assisted when they indicated that they did not understand.

The informal interview is indicated for observational studies such as the current study. I followed a structured approach by following the HAGOS questionnaire and the instructions and anticipated that the structured interview would apply to time management and standardisation of questions. Furthermore, it increased the reliability and validity of the current study's methods (see 3.3.1).

During administering the Australian PFM function questionnaire, interviewee bias was anticipated, as the young participants might not want to answer the personal questions of the questionnaire. The researcher placed the questionnaire at the end of the evaluation session when the participant had time to get to know and trust the researcher (see 3.4.5).

6.2.2.2 ***The ultrasound assessment***

Ultrasound imaging is a validated assessment technique for collecting pelvic floor muscle function data. (Whittaker & Hodges, 2019; Whittaker & Thompson, 2007; Zajac et al., 2021).

The researcher considered the bladder fill procedure and the PFM contraction instruction and accommodated the breathing cycle during the PFM contraction. These aspects mentioned minimised measurement error and contributed to test-retest reliability and the consistency of data collection (inter-rater reliability).

The sonar assessment is described in the procedure of the main study (see 3.4.3).

6.2.2.3. ***The sEMG test***

A practical sEMG test, performed with equipment physiotherapists would use in practice, gave a general impression of a balanced function potential of the posterior synergies of the hip between hips in Groups 1 and 2 (see 3.4.4; 4.4.4). More specific changes in the deeper synergies of the hip would be detected with fine-needle EMG and research-level EMG units. The fine needle EMG study did not fall into the current research scope of practice (Meinders et al., 2022).

6.3 **Recommendations for Future Studies**

6.3.1 **The role of BB Asymmetry**

The asymmetry of the BB was shown to differ between Groups 1 and 2. BB asymmetry was previously linked to tone differences between sides or a unilateral or bilateral BB passive support deficit (Bitti et al., 2014; Frawley et al., 2021; see 2.5.1.2.1 A). Further examination is needed to determine the role and significance of a probable endo-pelvic fascial insufficiency in sportswomen's reported hip and PFM function (Pires et al., 2020).

6.3.2 **The role of the synergistic function of the PFM and the diaphragm**

Both groups of participants presented with PFM symptoms. The difference in bladder function between groups was moderate (r = -0.340; see 4.3). There was no noticeable difference in bowel and sexual function. The synergistic function of the diaphragm and the PFMs during a breathing cycle may have been influenced by the PFM symptoms of Group 2 (r = -0.47; see 4.4.2). Group'2's PFM symptoms reduced the difference between groups compared to the significant difference between groups during a voluntary PFM contraction (r = -0.671; see 4.4.3). The current study results may emphasise the importance of the synergistic activity between the diaphragm and PFMs in the PFM's function. In a study by Zachovajeviene et al. (2019), the importance of the PFM and diaphragm's synergistic function was demonstrated. Further research is needed regarding the relevance of this finding in the current cohort.

6.3.3 **The need for an all-inclusive pelvic health questionnaire**

The all-inclusive nature of pelvic symptoms and functions was demonstrated during this research. A questionnaire to utilise during screening and clinical purposes, including all aspects of pelvic function, the hip, groin, and PFM function, must be developed to ensure a comprehensive approach to assessing and managing PFM and hip symptoms in sportswomen with hip symptoms.

6.3.4 **EMG assessment**

More imbalance in hip function was found in Group 1 vs Group 2. The sEMG was a practical assessment with an EMG instrument physiotherapists would have access to in clinical practice. More pertinent, changes in the deeper posterior synergies of the hip may be detected with fine-needle EMG and research-level EMG units.

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APPENDICES

APPENDIX I: PARTICIPANT INFORMATION SHEET AND COVID FORM

WITS UNIVERSITY

University of the Witwatersrand,
Department of Physiotherapy
Health Sciences Department

17 September 2021

Dear participant,

You are invited to take part in my research project. I am an MSc student enrolled at Wits University. The title of my study is ‘A Comparison of the Lesser Pelvis and the Hip's Synergistic Muscular Function between Women with Self-Reported Hip Symptoms and a Control Group'.

This study compares two groups of young sportswomen. One group with hip symptoms and one group without hip symptoms. The study aims to investigate pelvic floor muscle symptoms and function in these two groups.

The importance of a conditioned and balanced relationship between the hip muscles and the pelvic floor muscles is optimal load transfer from the lower limb to the pelvis and the spine. Compensatory movement patterns may occur when the load transfer is not optimal because of hip or pelvic floor muscle function. These altered movement patterns may lead to injuries and influence training and competition.

Women's health challenges in sportswomen, such as bladder function and pelvic pain, have been described in many studies, are under-reported and impact sportswomen's performance.
By taking part in the assessments, you will have the opportunity to gain insight into your pelvic floor function, and hip function as your results will be discussed with you. If you do not have symptoms,

insight into the function of the pelvic floor and hip muscles may lead to awareness and the prevention of injury in the future.

Participant selection:

You are selected to participate in the study if you are not pregnant or were not pregnant before and are between 18 and 35 years old. You may have hip symptoms or no hip symptoms.

Procedure:

Consultation:
This assessment will be approximately two and a half hours, excluding travel time.

The assessment involves the following:

Dress comfortably and bring two towels with you to the assessment. The towels are a requirement to cover the treatment bed because of COVID. Because of the assessment duration, water and a light snack will be provided at the assessment.

Please follow the bladder-fill procedure before the session:

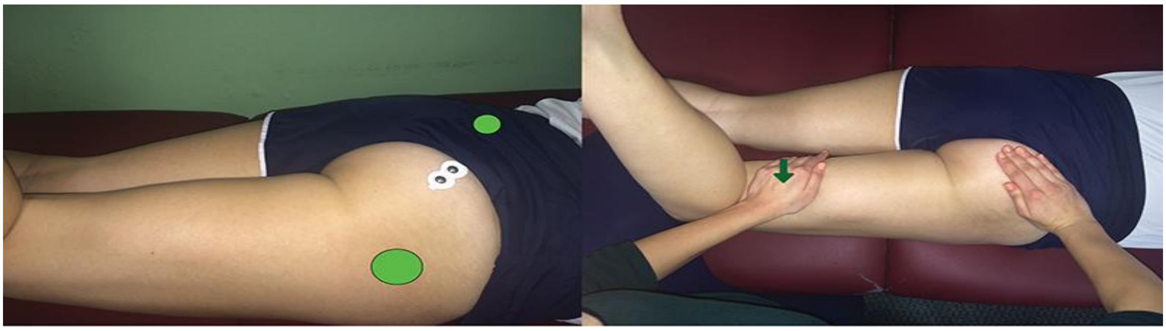
Empty your bladder 45min-1hr before the session. Drink 300-400 ml of water in the time leading up to the session. More water will be taken at the practice to fill the bladder for sonar assessment.

On arrival, consent and covid forms will be signed. If possible, you can print and bring these signed documents with you.

Questionnaires:
At the start of the consultation, two questionnaires will be completed. The HAGOS Hip Function Questionnaire and a questionnaire to indicate serious illness will also be completed. When you show hip symptoms, the lumbar spine will be cleared as a source of hip pain. The sonar assessment will follow.

The pelvic floor muscle test: sonar assessment.
The sonar assessment is a transabdominal, transverse sonar of the bladder base.
The transabdominal transverse sonar is non-invasive, and the head of the sonar is placed just above the pubic bone. Activation of the pelvic floor muscles will cause movement of the bladder base. The movement of the BBwill be measured as an indication of pelvic floor muscle movement.

The hip assessment: surface electromyography assessment.



<u>**Gluteus Maximus**</u>
Location: ½ way between sacrum and greater trochanter
Direction: from PSIS to posterior aspect of thigh
Test: prone, extend and external rotate at hip, palpate lateral to sacrum, slight resistance at distal thigh

A surface EMG posterior pelvis, with electrodes positioned on the lower gluteus (buttock muscle), will detect activity in this region during the isometric contraction.

Two sets of five repetitions of a hold-and release contraction will be facilitated and monitored by the sEMG. The balanced function between hips will be measured.

Comparisons between Group 1, Group 1 and Group 2, Group 2's sonar results and EMG values will be made.

The pelvic floor questionnaire:

The pelvic floor questionnaire will be completed following the sonar and EMG assessment.

Following the assessments, your results and any queries will be discussed.

Reimbursement

You will be reimbursed for travel costs and 80 cents per minute for data usage.

Confidentiality of participants:

The confidentiality of each participant will be maintained as your name and personal details will be concealed. To ensure confidentiality, you will receive a participant code. The data obtained from you will stay confidential throughout the study, and the data will be utilised for the study only. Personal information may, however, be disclosed if required by law.

Participation in the study is voluntary, and you are under no obligation to participate. You may withdraw from the study at any time.

Required Consent:

Consent will be signed as mentioned previously in the letter. Find the consent form attached. A COVID form is also included.

Contact investigator:

Please call me, Mariette Oelofse, the researcher, if you have any questions or complaints at 0823762442 or m.oelofse13@gmail.com

Contact supervisor:

My study supervisor is Dr Corlia Brandt of the Department of Physiotherapy of the University of Witwatersrand. She can be contacted at 011 7172014 or corlia.brandt@wits.ac.za

Contact Ethical Committee:

If you have any concerns about how the study is being performed, please contact Professor Clement Penny, the Chairperson of this Committee, at 011 717 2301 or Clement.Penny@wits.ac.za.The telephone numbers for the Committee secretariat are 011 717 2700/1234, and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

This study has been approved by the Human Research Committee (medical) of the University of the Witwatersrand, Johannesburg. I am attaching a supporting document from the Ethical Committee. A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

Kind regards

Mariette Oelofse

APPENDIX 2: COVID INFORMATION AND COVID FORM

Find COVID document below.

We are trying to reduce any potential and undue infection risks and trust that you will understand our approach.

We want to protect our patients and therefore wish to communicate the following:

Please complete the Wits University COVID-19 Screen and forward the document to me together with the consent document (see last page below).

If you have been in contact with a suspected or confirmed positive case of the Coronavirus – please notify me, and I will reschedule your appointment.

If you have flu-like symptoms or a temperature above 37 degrees or cough, please inform me before your appointment, reschedule, and contact your doctor.

If you have travelled abroad in the past 20 days of contact with someone who had - please contact me via e-mail/SMS and discuss the possible need to reschedule your appointment.

Additionally:

We will require you to wipe your hands with an antiseptic upon entering the practice before handling any equipment (files).

Bring your shorts and towels for assessment.

Bring a mask to wear – we will be wearing one.

Please complete and sign the Wits University COVID Screening Tool.

Thank you for your cooperation.

Mariette Oelofse (Researcher)

0823762442

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

SCREENING TOOL FOR COVID -19

Participant: ______________________**Cellphone Number:** ______________________

Please conduct a daily self-screening assessment as per the criteria mentioned in the below table:

No.	CONDITION / SYMPTOM	YES	NO
A	SYMPTOM CHECK		
1	Are you suffering from fever / high temperature or temperature fluctuations?		
2	Do you have a dry cough?		
3	Do you have a sore throat?		
4	Do you have redness of eyes?		
5	Do you experience shortness of breath / difficulty in breathing?		
6	Have you got unusual body aches / muscle pain?		
7	Do you experience a loss of smell / taste?		
8	Are you nauseous and/or do you experience unusual vomiting?		
9	Have you got diarrhoea?		
10	Do you suffer from fatigue / physical weakness / tiredness?		
B	CONTACT / EXPOSURE RISK		
1	Have you been exposed to someone diagnosed with Covid-19 or had recent contact with someone who is self-isolating whilst waiting for a Covid-19 test result?		
2	Have you been in quarantine / self-isolation for the past 14 days?		
C	OTHER RISK FACTORS		
1	Do you suffer from any pre-existing medical condition / chronic illness that may have compromised your immune system, i.e. respiratory disease, diabetes, heart disease, or any other chronic illness that could compromise one's immune system?		
2	Are you 65 years of age or older?		

If any symptoms mentioned in questions **A1** to **A10** are experienced, then:

Don't attempt to attend the assessment.

Consult your Healthcare Worker to find out if testing / self-quarantine will be necessary.

If you experience any symptoms mentioned in questions **A1** to **A10** then this does not mean that you definitely have Covid-19. This screening questionnaire is used as precautionary indicator to establish whether you should be quarantined and if tests are required to make a definite diagnosis.

If you are tested positive for Covid-19 isolate for 14 days. Follow your Healthcare Worker's advice.

I hereby attest that the information provided above is a true reflection of my screening results.

Signature: ________________________________ **Date**: ______________________

APPENDIX 3: CONSENT FORM

Mariette Oelofse MSc. Research Project. Consent Form

Title of project:

A Comparison of the Lesser Pelvis and the Hip's Synergistic Muscular Function between Women with Self-Reported Hip Symptoms and a Control Group.

Name of researcher: Mariette Oelofse

Consent:

I, ……………………………………….., agree to participate in this research project. The research has been explained to me, and I understand my participation. I agree to the following

(Please circle the relevant options below).

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his / her research report	YES	NO
I agree that the interview may be audio recorded	YES	NO
I agree that the information I provide may be used anonymously after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.	YES	NO

…………………………………… (signature)
…………………………………… (name of participant)
…………………………………… (date)

…………………………………… (signature)
…………………………………… (name of person seeking consent)
…………………………………… (date)

APPENDIX 4: PARTICIPANT WHATSAPP MESSAGE

Hallo ….

I've mailed the researched information. Find directions and address of the practice.
NB. Please remember the bladder fill procedure. Your bladder needs to be filled before the sonar. The bladder fill procedure for the sonar is as follows. Empty bladder 45min -60min before the session. Drink 300- 400ml of water in the time leading up to the assessment session. More water will be available during the first part of the assessment session. Please bring two towels with you for the treatment plinth. Also, dress comfortably. Loose-fitting clothes are appropriate. Let me know if you have any queries. See you tomorrow at 10 AM. Thank you. Regards Mariette
Address: Body Intellect Pilates Studio. no3 14th Street, Menlo Park, Pretoria

APPENDIX 5: CHECK LIST INCLUSION CRITERIA

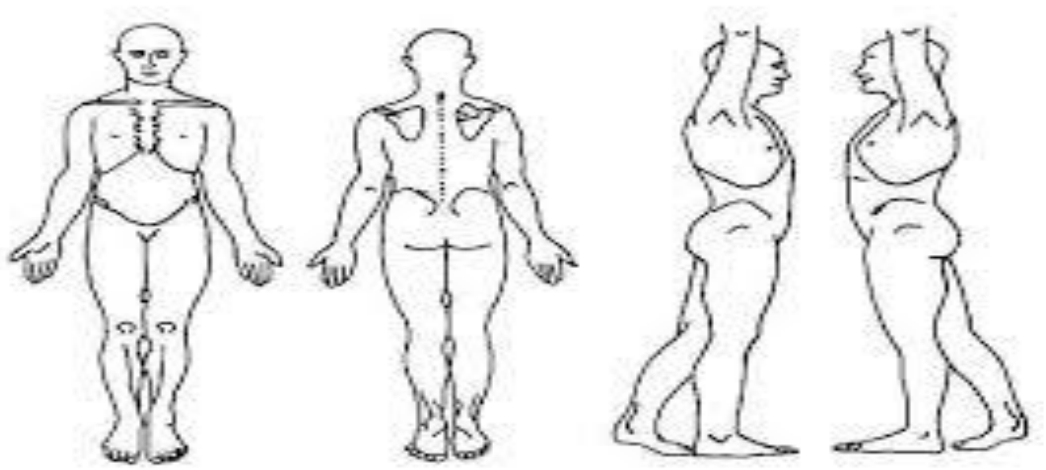
<u>Check List Inclusion Criteria Group 1</u>

Participant Code:

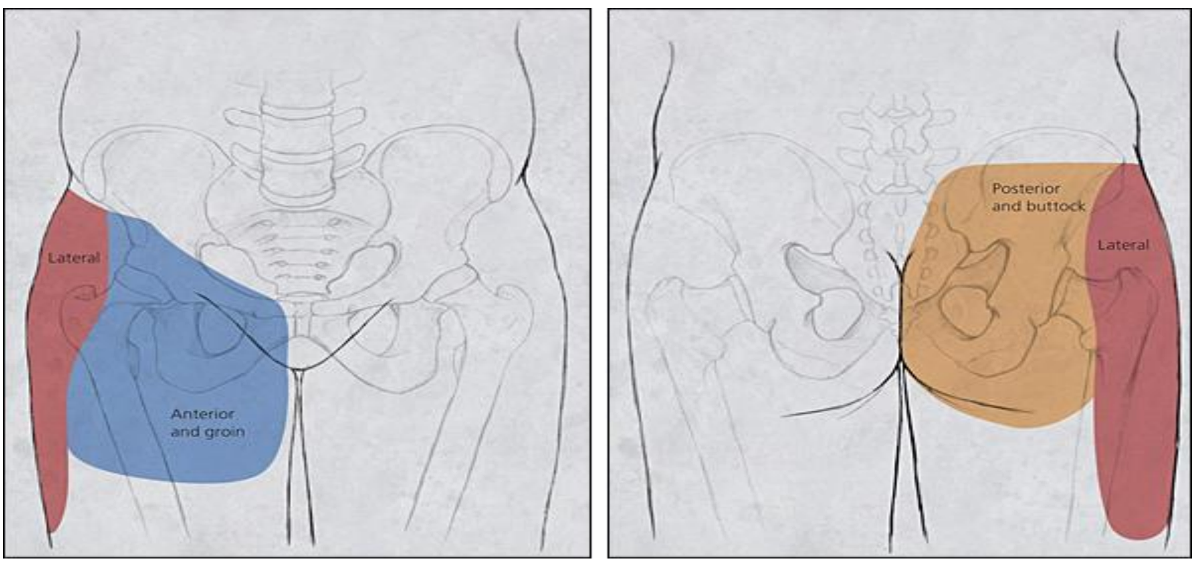
Inclusion Criteria:

- Participants who have predominantly hip and/groin pain and the following criteria: Yes/No
- Received treatment for their hip and groin pain (or seek treatment): Yes/No
- Restricted activities for the past 14 days.: Yes/No
- Pain more than six weeks' duration: Yes/No
- Pain located in one of five predefined regions: Yes/No
- Physically active for at least 2.5 h per week: Yes/No
- Nulligravida: Yes/No

Body Chart: Participant's reported symptoms



Area of Symptoms: Area of symptoms(Including anterior abdomen and symphysis pubis)



APPENDIX 6: THE HAGOS QUESTIONNAIRE

HAGOS Questionnaire

Today's date:

Participant number:

Answer **every** question. If a question does not pertain to you or you have not experienced it in the past week please make your "best guess" as to which response would be the most accurate.

Symptoms

These questions should be answered considering your hip and/or groin **symptoms** and difficulties during the **past week**.

S1 Do you feel discomfort in your hip and/or groin?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S2 Do you hear clicking or any other type of noise from your hip and/or groin?

Never	Rarely	Sometimes	Often	All the time
☐	☐	☐	☐	☐

S3 Do you have difficulties stretching your legs far out to the side?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

S4 Do you have difficulties taking full strides when you walk?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

S5 Do you experience sudden twinging/stabbing sensations in your hip and/or groin?

Never	Rarely	Sometimes	Often	All the time
☐	☐	☐	☐	☐

Stiffness

The following questions concern the amount of stiffness you have experienced during the **past week** in your hip and/or groin. Stiffness is a sensation of restriction or slowness in the ease with which you move your hip and/or groin.

S6 How severe is your hip and/or groin stiffness after first awakening in the morning?

None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐

S7 How severe is your hip and/or groin stiffness after sitting, lying or resting **later in the day**?

None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐

Pain

P1 How often is your hip and/or groin painful?

Never ☐ Monthly ☐ Weekly ☐ Daily ☐ Always ☐

P2 How often do you have pain in areas other than your hip and/or groin that you think may be related to your hip and/or groin problem?

Never ☐ Monthly ☐ Weekly ☐ Daily ☐ Always ☐

The following questions concern the amount of pain you have experienced during the **past week** in your hip and/or groin. **What amount of hip and/or groin pain have you experienced during the following activities?**

P3 Straightening your hip fully

None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐

P4 Bending your hip fully

None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐

P5 Walking up or down stairs

None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐

P6 At night while in bed (pain that disturbs your sleep)

None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐

P7 Sitting or lying

None ☐ Mild ☐ Moderate ☐ Severe ☐ Extreme ☐

The following questions concern the amount of pain you have experienced during the **past week** in your hip and/or groin. **What amount of hip and/or groin pain have you experienced during the following activities?**

P8 Standing upright

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P9 Walking on a hard surface (asphalt, concrete, etc.)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P10 Walking on an uneven surface

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Physical function, daily living

The following questions concern your physical function. **For each of the following activities please indicate the degree of difficulty you have experienced in the past week due to your hip and/or groin problem.**

A1 Walking up stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A2 Bending down, e.g. to pick something up from the floor

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A3 Getting in/out of car

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A4 Lying in bed (turning over or maintaining the same hip position for a long time)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A5 Heavy domestic duties (scrubbing floors, vacuuming, moving heavy boxes etc)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Function, sports and recreational activities

The following questions concern your physical function when participating in higher-level activities. Answer **every** question by ticking the appropriate box. If a question does not pertain to you or you have not experienced it in the past week please make your "best guess" as to which response would be the most accurate. **The questions should be answered considering what degree of difficulty you have experienced during the following activities in the past week due to problems with your hip and/or groin.**

SP1 Squatting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP2 Running

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP3 Twisting/pivoting on a weight bearing leg

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP4 Walking on an uneven surface

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP5 Running as fast as you can

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP6 Bringing the leg forcefully forward and/or out to the side, such as in kicking, skating etc.

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP7 Sudden explosive movements that involve quick footwork, such as accelerations, decelerations, change of directions etc.

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP8 Situations where the leg is stretched into an outer position
(such as when the leg is placed as far away from the body as possible)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Participation in physical activities

The following questions are about your ability to participate in your preferred physical activities. Physical activities include sporting activities as well as all other forms of activitywhere you become slightly out of breath. **When you answer these questions consider to what degree your ability to participate in physical activities during the past weekhas been affected by your hip and/or groin problem.**

PA1 Are you able to participate in your preferred physical activities for as long as you would like?

Always	Often	Sometimes	Rarely	Never
☐	☐	☐	☐	☐

PA2 Are you able to participate in your preferred physical activities at your normal performance level?

Always	Often	Sometimes	Rarely	Never
☐	☐	☐	☐	☐

Quality of Life

Q1 How often are you aware of your hip and/or groin problem?

Never	Monthly	Weekly	Daily	Constantly
☐	☐	☐	☐	☐

Q2 Have you modified your life style to avoid activities potentially damaging toyour hip and/or groin?

Not at all	Mildly	Moderately	Severely	Totally
☐	☐	☐	☐	☐

Q3 In general, how much difficulty do you have with your hip and/or groin?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Q4 Does your hip and/or groin problem negatively affect your mood?

Not at all	Rarely	Sometimes	Often	All the time
☐	☐	☐	☐	☐

Q5 Do you feel restricted due to your hip and/or groin problem?

Not at all	Rarely	Sometimes	Often	All the time
☐	☐	☐	☐	☐

APPENDIX 7: CO-MORBIDITY QUESTIONNAIRE

List of Comorbidities and Red Flags **Participant Code:…………………………**

SCQ	Do you have the problem?	Do you receive treatment for it?

Medical Condition	Yes	No	Yes	No
Anaemia/other blood				
Back pain				
Cancer				
Depression Diabetes				
Heart disease				
High blood pressure				
Kidney disease				
Liver disease				
Lung disease				
Osteoarthritis, degenerative conditions				
Rheumatoid arthritis				
Ulcer, stomach disease				
Others: Please state:				
History of trauma				
Fever				
Unexplained weight loss				
Burning with urination				
Night pain				
Prolonged corticosteroid use				

APPENDIX 8: HIP INFORMATION AND ASSESSMENT

Hip Assessment: **Group 1&2:** **Participant Code:** **Date:**

Age: **Weight:** **Height:**

Subjective:

History & Info:

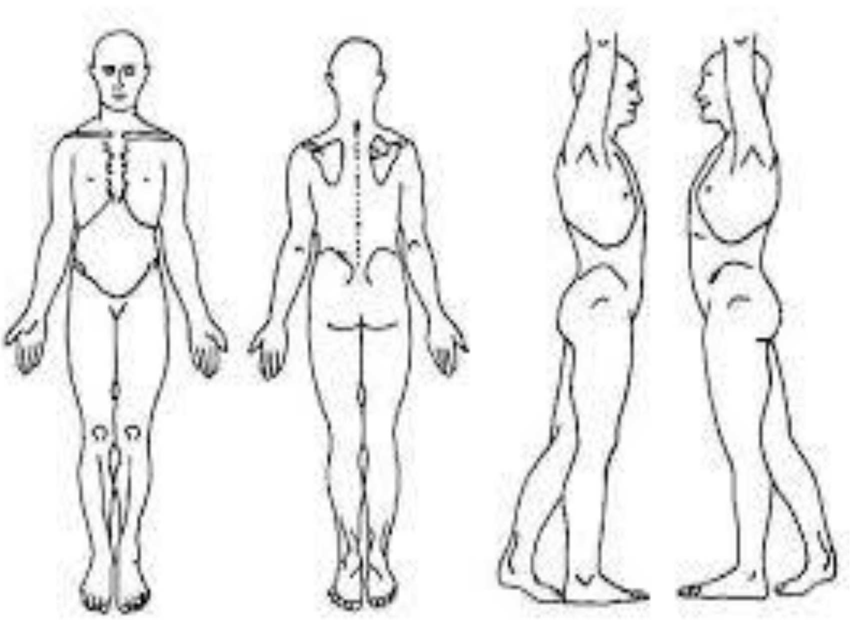
- Inclusion document:
- List of red-flags and co-morbidities: SCQ Questionnaire

Profession:

Activity/Sport:

Weekly Activity:

Pain/Symptoms



Dominance:

Current pain level: Yes/No

Group 1 :

Special Tests to test Lumbar Spine Contribution to Hip Pain (Rule out).

Lumbar Spine. Active physiological movements (5x)

Standing:	Flex (5x)	Rot R (5x) +	Rot L (5x) +	Side flex R (5x)	Side flex L (5x)
		+Rot Pelvis back to neutral	+Rot Pelvis back to neutral		
Sitting:	Ext	Rot R	Rot L	Ext + Rot R	Ext +Rot L
Supine:		Right	Left		
Lasegue +Braggard's	SLR+ DF				

Special Tests to Rule out Pelvic Girdle Contribution to Hip Pain (Rule out)

SI joint:

The Cluster of Laslett (6 reps /thrusts. Progress intensity) 2/3 (+); 1/3 (maybe); 0/3 (not likely)

Special Test	Right side	Left side
Distraction Test +		
SI Compression test in side-lying		
Sacral Thrust test. Prone		

Appendix 9: SONAR ASSESSMENT

Date: ___________ Participant code: ____________

Sonar Assessment: Supine

Participant supine, pelvis neutral, hips 60 degrees flexed, and feet in neutral, supported on bed.	**BBdisplacement: mm**	**AVG displacement**
(a) Diaphragm and PFM Inh (3-4s) + Exh (3-4s) 1. 2. 3.	1. 2. 3.	
(b) PFM activation after exhalation (3-4s) Cueing posterior pelvic compartment 1. 2. 3.	1. 2. 3.	
(c) PFM activation after exhalation (3-4s). Cueing posterior pelvic compartment 1. 2. 3.	1. 2. 3.	
d) PFM activation after exhalation (3-4s). Cueing posterior pelvic compartment 1. 2. 3.	1. 2. 3.	
e) Bladder & Cough reflex		
(d) Bladder Volume: Incomplete Bladder Emptying:		

APPENDIX 10: sEMG

Hip muscle isometric contraction. 10, 20, 30% = 10mmHg, hold 20s, rest 20s.	**2x 5 Reps, 20s, Hold and release.**
	Ten repetitions at 10mmHg, pain free movement.

%MVC Group 1	**%MVC Group 2**

Right	**Left**	**Total**	**Right**	**Left**	**Total**
%MVC Actv -Rest	**%MVC Actv-Rest**	**R-L/ L-R**	**%MVC Actv -Rest**	**%MVC Actv-Rest**	**R-L/ L-R**

APPENDIX 11: PELVIC FLOOR FUNCTION QUESTIONNAIRE

AUSTRALIAN PELVIC FLOOR QUESTIONNAIRE	Participant Code: ______________________ Date completed: ______________________

Please circle your most applicable answer. Consider your experience during the last month.

BLADDER FUNCTION		(____/ 45)
Q1. How many times do you pass urine in a day? 0 Up to 7 1 Between 8-10 2 Between 11-15 3 More than 15	**Q2. How many times do you get up at night to pass urine?** 0 0-1 1 2 2 3 3 More than 3 times	**Q3. Do you wet the bed before you wake up at night?** 0 Never 1 Occasionally - less than once per week 2 Frequently - once or more per week 3 Always - every night
Q4. Do you need to rush/hurry to pass urine when you get the urge? 0 Can hold on 1 Occasionally have to rush – less than once/week 2 Frequently have to rush – once or more/week 3 Daily	**Q5. Does urine leak when you rush or hurry to the toilet or can't you make it in time?** 0 Not at all 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily	**Q6. Do you leak with coughing, sneezing, laughing or exercising?** 0 Not at all 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily
Q7. Is your urinary stream (urine flow) weak, prolonged or slow? 0 Never 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily	**Q8. Do you have a feeling of incomplete bladder emptying?** 0 Never 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily	**Q9. Do you need to strain to empty your bladder?** 0 Never 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily
Q10. Do you have to wear pads because of urinary leakage? 0 None - Never 1 As a precaution 2 When exercising / during a cold 3 Daily	**Q11. Do you limit your fluid intake to decrease urinary leakage?** 0 Never 1 Before going out 2 Moderately 3 Always	**Q12. Do you have frequent bladder infections?** 0 No 1 1-3 per year 2 4-12 per year 3 More than one per month
Q13. Do you have pain in your bladder or urethra when you empty your bladder? 0 Never 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily	**Q14. Does urine leakage affect your routine activities like recreation, socializing, sleeping, shopping etc?** 0 Not at all 1 Slightly 2 Moderately 3 Greatly	**Q15. How much does your bladder problem bother you?** 0 Not at all 1 Slightly 2 Moderately 3 Greatly
Other symptoms (haematuria, pain etc.) ____________________ ____________________		

BOWEL FUNCTION		(____/ 34)
Q16. How often do you usually open your bowels? 0 Ever other day or daily 1 Less than every 3 days 2 Less than once a week 0 More than once per day	**Q17. How is the consistency of your usual stool?** 0 Soft 0 Firm 0 Hard (pebbles) 1 Variable 2 Watery	**Q18. Do you have to strain to empty your bowels?** 0 Never 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily
Q19. Do you use laxatives to empty your bowels? 0 Never 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily	**Q20. Do you feel constipated?** 0 Never 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily	**Q21. When you get wind or flatus, can you control it, or does wind leak?** 0 Never 1 Occasionally – less than once per week 2 Frequently – once or more per week 3 Daily

AUSTRALIAN PELVIC FLOOR QUESTIONNAIRE

Participant Code: ______________________

Date completed: ______________________

Q22. Do you get an overwhelming sense of urgency to empty bowels?
0 Never
1 Occasionally – less than once per week
2 Frequently – once or more per week
3 Daily

Q23. Do you leak watery stool when you don't mean to?
0 Never
1 Occasionally – less than once per week
2 Frequently – once or more per week
3 Daily

Q24. Do you leak normal stool when you don't mean to?
0 Never
1 Occasionally – less than once per week
2 Frequently – once or more per week
3 Daily

Q25. Do you have a feeling of incomplete bowel emptying?
0 Never
1 Occasionally – less than once per week
2 Frequently – once or more per week
3 Daily

Q26. Do you use finger pressure to help empty your bowel?
0 Never
1 Occasionally – less than once per week
2 Frequently – once or more per week
3 Daily

Q27. How much does your bowel problem bother you?
0 Not at all
1 Slightly
2 Moderately
3 Greatly

PROLAPSE SYMPTOMS **(____/15)**

Q28. Do you have a sensation of tissue protrusion/lump/bulging in your vagina?
0 Never
1 Occasionally – less than once per week
2 Frequently – once or more per week
3 Daily

Q29. Do you experience vaginal pressure or heaviness or a dragging sensation?
0 Never
1 Occasionally – less than once per week
2 Frequently – once or more per week
3 Daily

Q30. Do you have to push back your prolapse in order to void?
0 Never
1 Occasionally – less than once per week
2 Frequently – once or more per week
3 Daily

Q31. Do you have to push back your prolapse to empty your bowels?
0 Never
1 Occasionally – less than once per week
2 Frequently – once or more per week
3 Daily

Q32. How much does your prolapse bother you?
0 Not at all
1 Slightly
2 Moderately
3 Greatly

Other Symptoms: (problems: walking / sitting, pain, vaginal bleeding)
____
____
____

SEXUAL FUNCTION **(____/21)**

Q33. Are you sexually active?
□ No
□ Less than once per week
□ Once or more per week
□ Daily or most days

If you are not sexually active, please continue to answer questions 34 & 42.

Q34. If you are not sexually active, please tell us why?
□ Do not have a partner
□ I am not interested
□ My partner is unable
□ Vaginal dryness
□ Too painful
□ Embarrassment due to the prolapse/incontinence
□ Other reasons: ______________

Q35. Do you have sufficient vaginal lubrication during intercourse?
0 Yes
1 No

Q36. During intercourse vaginal sensation is:
0 Normal / pleasant
1 Minimal
1 Painful
3 None

Q37. Do you feel that your vagina is too loose or lax?
0 Never
1 Occasionally
2 Frequently
3 Always

Q38. Do you feel that your vagina is too tight?
0 Never
1 Occasionally
2 Frequently
3 Always

Q39. Do you experience pain with sexual intercourse?
0 Never
1 Occasionally
2 Frequently
3 Always

Q40. Where does the pain during intercourse occur?
0 Not applicable, I do not have pain
1 At the entrance to the vagina
1 Deep inside, in the pelvis
2 Both at the entrance & in the pelvis

Q41. Do you leak urine during sexual intercourse?
0 Never
1 Occasionally
2 Frequently
3 Always

Q42. How much do these sexual issues bother you?
□ Not applicable
0 Not at all
1 Slightly
2 Moderately
3 Greatly

Q43. Other symptoms?
(faecal incontinence, vaginismus etc)

APPENDIX 12: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Mrs Mariette Oelofse

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M200954

NAME: (**Principal Investigator**)	Mrs Mariette Oelofse
DEPARTMENT:	Physiotherapy Mariette Oelofse Physiotherapy Practice Brooklyn, Pretoria Martin Van Heerden Physiotherapy Practice, Groenkloof
PROJECT TITLE:	A Comparison of the Synergistic Muscular Function of the Lesser Pelvis and the Deep Muscles Crossing the Hip, between Women Diagnosed with Femoral Acetabular Impingement Syndrome or Labral Pathology and a Control Group
DATE CONSIDERED:	02/10/2020
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Mrs C. Brandt
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	30/11/2020

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **October** and will therefore be due in the month of **October** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature ____________ Date ____________

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix 13: Asymmetry of the Bladder Base

Ant: Anterior
Dysp D: Dyspareunia Deep
Dysp S: Dyspareunia Superficial
Freq: Frequency
GPPPD: Genito Pelvic Pain/Penetration Disorder
IBE: Incomplete Bladder Emptying
Lat: Lateral
L: Left
ODysp D: Occasional Dyspareunia Deep
Post: Posterior
R: Right
ROM: Range of Movement
St: Strain bladder empty
Strain BL: Strain to empty bladder
UI: Urinary Incontinence

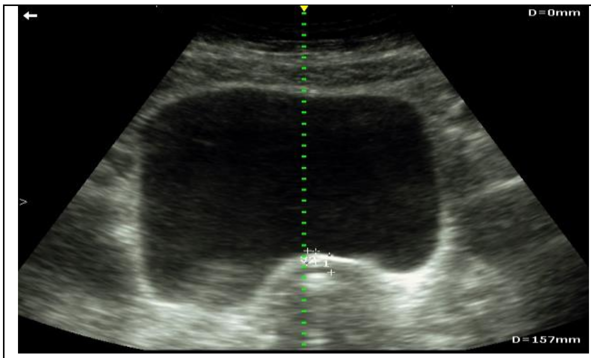


Fig A 9.1: Participant Pilot study

(HP Pilot) Symptoms R>L, Dominance L,

Diagnosed with hip dysplasia (Pilot study participant).PFM Limited Eccentric and Concentric ROM.PFM symptoms: Weak urinary flow, feeling of incomplete bladder emptying, strain to empty bladder. Frustration. QoL. Most symptoms before fall asleep.

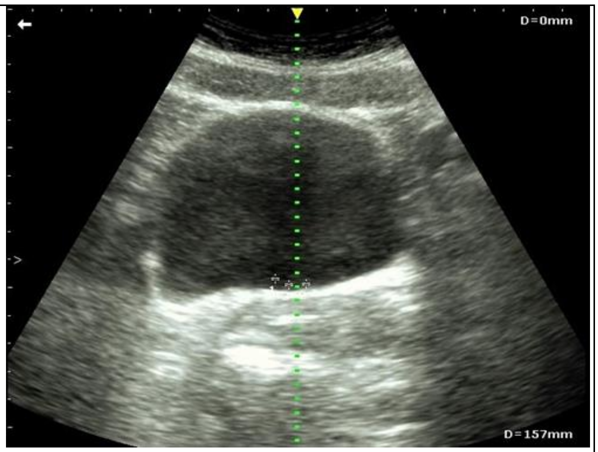


Fig A 9.2 Group 1, 02.
Dominance: R
Hip Symptom L/R: R
Symptom Area: Ant Groin R
PFM Symptoms: IBE, Dysp. D
Cephalad/Caudad 1.0 /7.2mm
Sport: Dance, Athlete
HAGOS: 60; 43; 50; 37.5; 25; 50

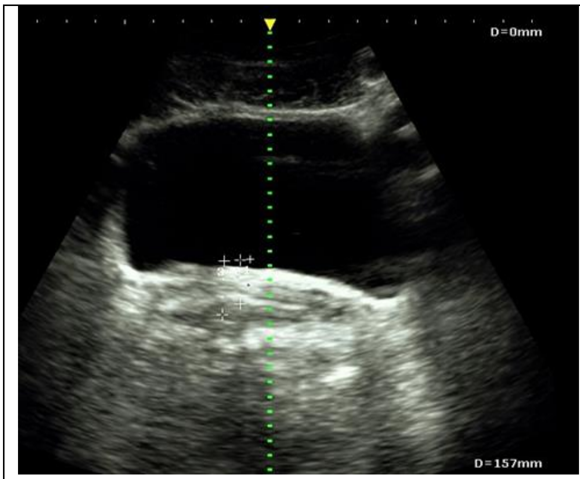


Fig A 9.3 Group 1, 04

Dominance: R

Hip Symptom L/R: L
Symptom Area: Post hip L
PFM Symptoms: No symptoms
Cephalad/Caud 1.3 /14.1mm
Sport: Netball
HAGOS: 70; 78.6; 55; 68.7; 75; 55

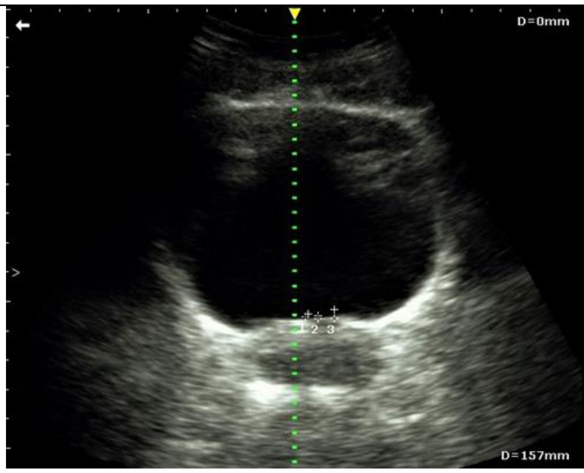


Fig A 9.4 Group 1, 05

Dominance: R
Hip Symptom L/R: R
Symptom Area: Ant Groin R
PFM Symptoms: Frequency
Cephalad/Caud 1.6/7.5mm
Sport: Netball
HAGOS: 72.5; 67.9; 75; 62.5; 50; 55

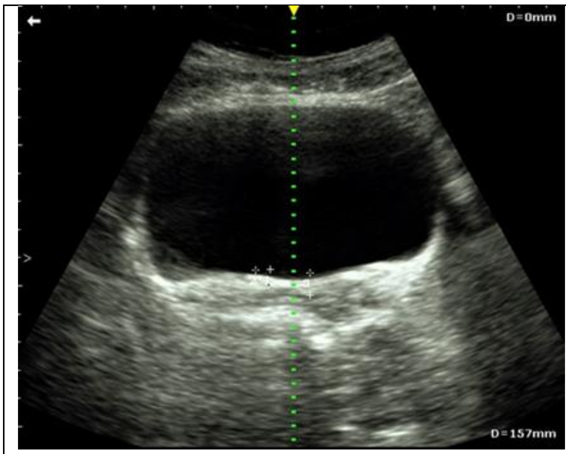


Fig A 9.6 Group1, 11

Dominance: R
Hip Symptoms L/R: R
Symptoms Area: Ant groin R
Post hip R
PFM Symptoms: Freq, IBE, ODysp D
Cephalad/Caud: 1.7 /6.0mm
Sport: Hockey
HAGOS: 80; 64; 85; 81; 100; 75

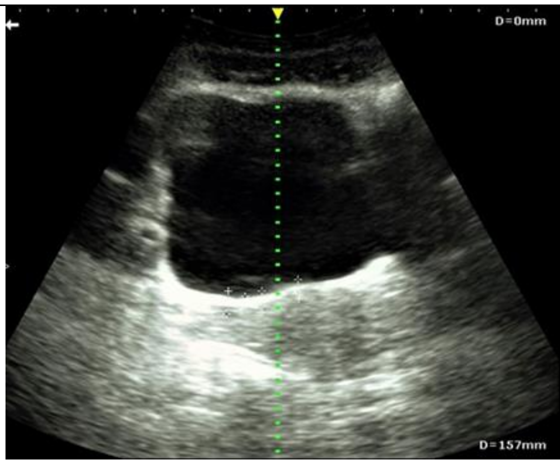


Fig A 9.7 Group 1, 12

Dominance: R+L
Hip Symptoms L/R: R>L
Symptoms Area: Ant groin R
Post hip R
PFM Symptoms: Urgency
Cephalad/Caud: 1.4 /7.4mm
Sport: Netball, Gym
HAGOS: 57.5; 68; 75; 75; 37.5; 35

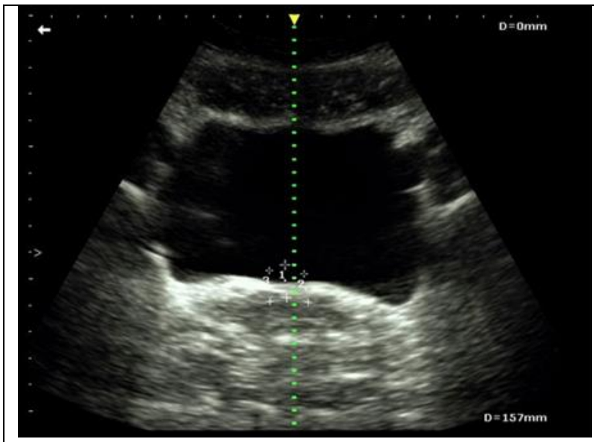


Fig A 9.8 Group 1, 13

Dominance: R
Hip Symptoms L/R: R
Hip Symptoms Area: Ant groin R
Lat +Post R + <L
PFM Symptoms: Strain BL, ODysp D
Cephalad/Caud: 3.5 / 11.3mm
Sport: Hockey
sEMG: 33.00
HAGOS: 80; 61; 90; 82; 50; 55

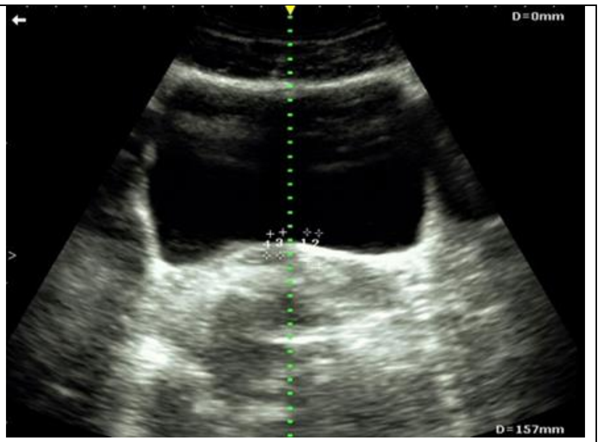


Fig A 9.9 Group 1, 15

Dominance: R
Hip Symptom L/R: R
Hip Symptom Area: Ant Groin R
Lat +Post R + <L
PFM Symptoms: UI, IBE, GPPPD
Cephalad/Caud 2.0 /8.8mm
Sport: Football
sEMG: 3.80
HAGOS: 82.5; 71; 100 50; 50;55

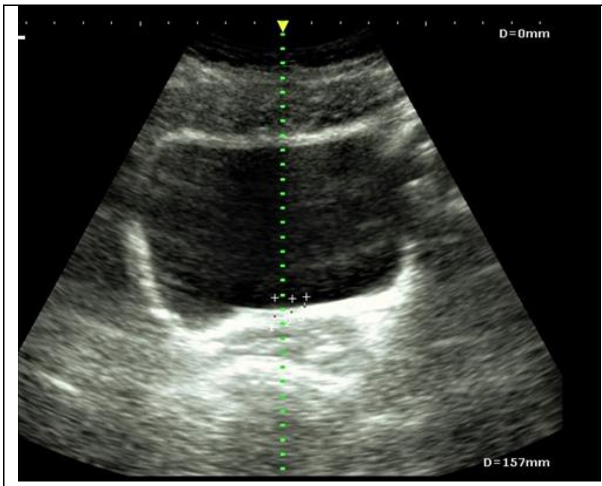


Fig A 9.10 Group 1, 16

Dominance: R+L
Hip Symptom L/R: R+L
Hip Symptom Area: Ant Groin R+L
Ischia R+L
PFM Symptoms: UI, OcDysp Deep
Cephalad/Caud 3.8 /7.1mm
Sport: Football
sEMG: 13.10
HAGOS: 55; 32; 45 34; 50; 40

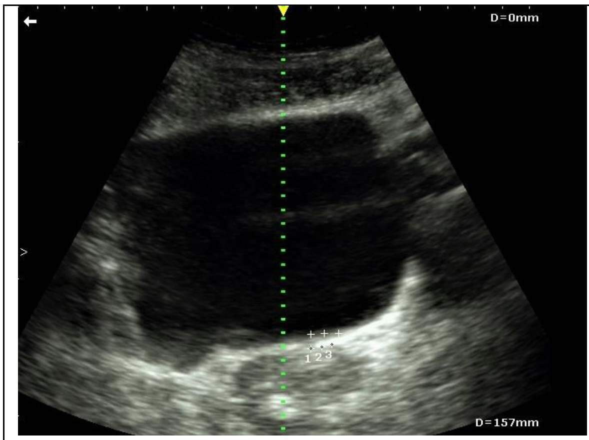


Fig A 9.11 Group 2, 03

Dominance:	R
Hip Symptom L/R:	No Symptoms
Hip Symptom Area:	No Symptoms
PFM Symptoms:	No Symptoms
Cephalad/Caud	5.3/11.4mm
Sport:	Hockey

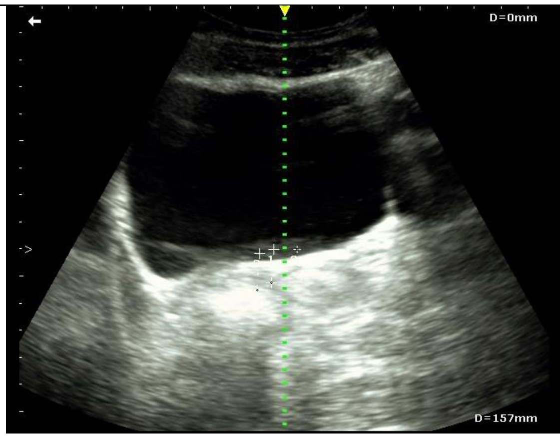


Fig A 9.12 Group 2, 05

Dominance:	R
Hip Symptom L/R:	No Symptoms
Hip Symptom Area:	No Symptoms
PFM Symptoms:	No Symptoms
Cephalad/Caud	8.6/12.0mm
Sport:	Netball

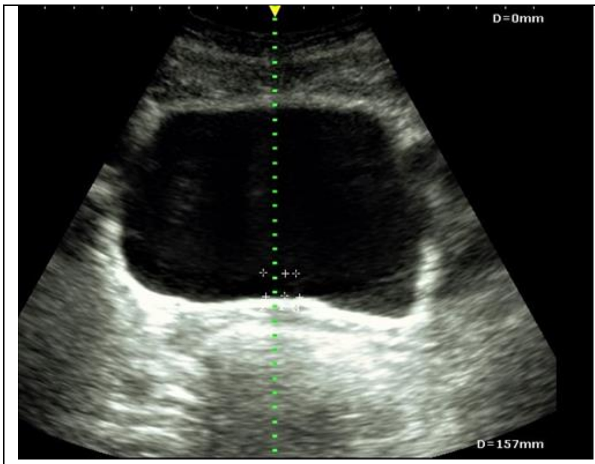


Fig A 9.13 Group 2, 12

Dominance:	L
Hip Symptom L/R:	No Symptoms
Hip Symptom Area:	No Symptoms
PFM Symptoms:	GPPPD
Cephalad/Caud	6.4 /13.2mm
Sport:	Dance

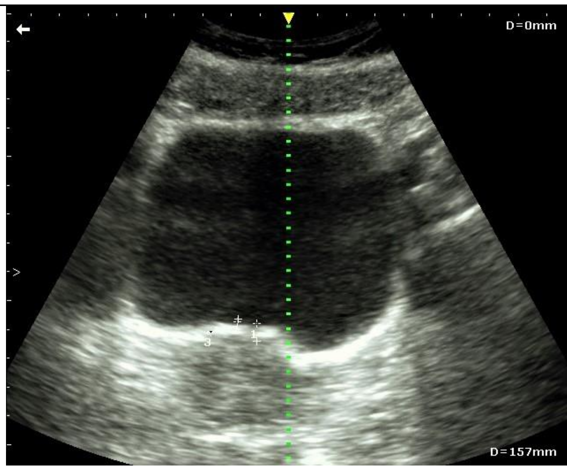


Fig A 9.12 group 2, 15

Dominance:	L
Hip Symptom L/R:	No Symptoms
Hip Symptom Area:	No Symptoms
PFM Symptoms:	Dysp. Superf
Cephalad/Caud	1.9 /6.1mm
Sport:	Football

APPENDIX 14: TURNITIN SUMMARY

A comparison of the Lesser Pelvis and Hip's Synergistic Muscular Function between Women with Self-Reported Hip Symptoms and a Control Group

by Mariette Oelofse

Submission date: 31-Mar-2022 05:27PM (UTC+0200)
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A comparison of the Lesser Pelvis and Hip's Synergistic Muscular Function between Women with Self-Reported Hip Symptoms and a Control Group

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