PARITY AND MOTOR CONTROL IN FEMALE RECREATIONAL RUNNERS

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July 2016

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A mini-script submitted in partial fulfilment of the requirements of the ***Master of Science in Physiotherapy, with Specialisation in Clinical Sport Physiotherapy*** in the Faculty of Health Sciences, University of the Free State.

July 2016

DECLARATION

I, Rochelle Bouwer, hereby declare that this dissertation is my own work (except where acknowledgement indicates otherwise), and that neither the whole work or parts thereof has been or will be submitted for another degree in this or any other University. No part of this dissertation may be reproduced, stored in a retrieval system or transmitted in any form or means without prior permission in writing from the author or the University of the Free State.

This dissertation is submitted for the degree, Masters in Physiotherapy in the School of Allied Health, Faculty of Health Sciences of the University of the Free State.

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Rochelle Bouwer

July 2016

I, Corlia Brandt, approve submission of this mini-script as partial fulfilment for the M.Sc. (Physiotherapy) with *Specialisation in Clinical Sport Physiotherapy*, degree at the University of the Free State. I further declare that this mini-script has not been submitted as a whole or partially for examination before.

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Corlia Brandt (Study leader)

July 2016

ACKNOWLEDGEMENTS

I hereby want to acknowledge my study leaders, Corlia Brandt and Marlene Schoeman for all their guidance on a journey of valuable learning and in discovering what research is all about.

I want to thank Christy du Plessis Physiotherapy for allowing me to perform my data collection in their treatment rooms and being able to use the necessary equipment, and to Riette Nel for processing the data.

Then to my loving and caring husband, Darren Bouwer, who had been through this process himself. Therefore, he was able to put everything into perspective when necessary, encourage me and was always willing to do whatever it took to see me succeed.

ABSTRACT

Female recreational runners are more prone to injuries than their male counterparts. Considering the associated risk for sustaining sport-related injuries with impaired core proprioception and the effect pregnancy has on females' core structures, this study aimed to investigate the trunk motor control in parous and nulligravid female recreational runners. A descriptive cross sectional, case-control study was conducted and 29 female recreational runners were assessed. Eight parous participants were matched with eight participants from the nulligravid group. The matched nulligravid participants were significantly younger [95% CI: - 16 ; - 1] compared to the parous group and no significant difference [95% CI: - 45.9% ; 22.8%] was seen in comparison of sport-related injuries. When testing the muscle activation and endurance of the pelvic floor muscles, the nulligravid group performed better during the surface electromyography test, although no difference was found during the PERFECT test. No statistical significance was found between groups during the surface electromyography test for muscle activity of the Transverse Abdominis muscle [95% CI: - 201.3 ; 504.5], activation of local stabilisers using the pressure biofeedback unit test [95% CI: - 1 ; 1] as well as the Sahrmann test [95% CI: - 2.5 ; 2] to assess global mobility. The parous group tended to perform better during the sport specific plank test, to assess global core muscle function, but in contrast performed weaker in the active straight leg raise test used to assess global stability. During the single leg stand test as well as the unilateral squat (balance and control) no significant difference was found between groups. No significant difference was found between the parous and nulligravid group regarding injuries and only a few tests of trunk motor control showed statistical significant differences between the groups. Due to the small sample size of the matched groups and limited statistical differences that were found conclusive recommendations could not be made. Further research is warranted to investigate motor control in parous athletes.

Keywords: female recreational runners, parity, trunk motor control

ABBREVIATIONS

ADL	Activities of Daily Living
ASIS	Anterior Superior Iliac Spine
ASLR	Active Straight Leg Raise
CI	Confidence Interval
COM	Centre Of Mass
DLL	Double Leg Lowering test
EMG	Electromyography
HPCSA	Health Professions Council of South Africa
M	Median
Max	Maximum
Min	Minimum
MRI	Magnetic Resonance Imaging
MVC	Maximal Voluntary Contraction
ODPHP	Office of Disease Prevention and Health Promotion
PBU	Pressure Biofeedback Unit
PERFECT	Power Endurance Repetitions Fast contractions Every Contraction Timed
PFM	Pelvic Floor Muscles
PRPP	Pelvic Related Pelvic Pain
PRLBP	Pelvic Related Lower back Pain
Q_1	First quartile
Q_3	Third quartile

ROM	Range of Movement
SIJ	Sacro-Iliac Joint
TrA	Transverse Abdominis
UFS	University of the Free State

GLOSSARY

DYSFUNCTION	An impairment or abnormality in the operation of a specific bodily system, e.g. motor control (Oxford Dictionaries 2015a).
INJURY	From injured, physically harmed or impaired during a sporting event (Oxford Dictionaries 2015b).
MOTOR CONTROL	Motor control refers to the central nervous system and how it produces purposeful and co-ordinated movements of the body in relation to the environment (Latash et al. 2010). In this study motor control referred to both core strength and stability as a whole around the trunk.
NULLIGRAVID	A woman who has never been pregnant (Merriam-Webster Dictionary 2015).
PAROUS	A woman who has born offspring of a specified number or has reproduced (Oxford Dictionaries 2014).
RECREATIONAL RUNNER	The American office of disease prevention and health promotion classified an adult (between the ages of 18-64 years) to be active when he/she performs moderate intensity aerobic exercises for a minimum of 150 minutes a week (ODPHP 2013). A recreational runner was identified by Gouttebarge et al. (2015) as being part of a running association and being active weekly in running during the past month, whereas Adriaensens et al. (2014) classified a recreational runner as an individual who has run at least 12 sessions of one hour per session in the past year. Ferber et al. (2011)

identified a recreational runner as an athlete who runs at least 30min a day for a minimum of three days a week and therefore for this study a recreational runner will be classified as an individual who is active for a minimum of 150min a week with having run at least once a week for 30min in the past month.

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CHAPTER 1.

INTRODUCTION

1.1. SCOPE OF RESEARCH

Abdominal muscle function is negatively affected by the structural adaptations which occur during pregnancy (Gilleard & Brown 1996). In the study conducted by Gilleard & Brown (1996) the participants’ ability to stabilise the pelvis against resistance decreased during pregnancy, which remained weak until at least eight weeks postpartum. Apart from the visible changes that occur to the abdominal wall during pregnancy, increased pelvic floor distention was found in females after vaginal and caesarean section delivery which can play a role in development of pelvic floor dysfunction (Van Veelen et al. 2014). Pelvic floor dysfunction can lead to urinary incontinence which has been treated effectively in the general parous female population by pelvic floor strengthening exercises, although no trials have been done to test the efficacy in elite female athletes (Bø 2004).

Pelvic floor muscles (PFM) also form an important part of the core musculature (Faries & Greenwood 2007, Table 2.3.1), although emphasis is often placed on the musculature of the abdominal and lower back region (Stephenson & Swank 2004). Core stability has been believed to prevent injuries and enhance performance by actively stabilising the spine during forceful or sudden movements performed by the limbs or trunk during different sporting codes (Brown 2006). Core stabilisation is multifaceted and requires muscle strength, endurance, neuromuscular control and coordination of multiple trunk muscles which creates harmony between osteoligamentous structures and the neuromuscular system, potentially limiting injuries (Dale & Lawrence 2005). However, the importance of core stability and strength training has been questioned in athletic programmes, considering the possibility that too much emphasis has been placed on it with insufficient research (Borghuis et al. 2008).

In general, female athletes tend to score lower in core stability tests when compared to their male counterparts (Sharrock et al. 2011), which could put them at a disadvantage in certain aspects of trunk motor control. Some studies have found female athletes to be at a higher risk for injuries (Taunton et al. 2002, Leetun et al. 2004) and in one specific study an increased risk for knee injuries was predicted in female athletes when impaired core proprioception was present (Zazulak et al. 2007). This was measured by active proprioceptive repositioning of the trunk, following positional perturbations (Zazulak et al. 2007).

1.2. PROBLEM STATEMENT AND SIGNIFICANCE

A dearth in literature exists, identifying parity as a risk factor for injuries in female athletes. The knee joint was found to be the most common anatomical site for injuries in recreational runners (Junior et al. 2013), raising the question whether parity would further increase the injury risk of female recreational runners already predisposed to knee injuries attributed to decreased trunk motor control (Zazulak et al. 2007). Although knee injuries are common in recreational runners, this study did not exclude other injuries. If the risk factors for injury in female recreational runners can be identified and managed accordingly, their performance can potentially be improved (Palmer-Green et al. 2013).

1.3. AIMS

Despite a proliferation of research on injuries in female recreational runners, a dearth in literature exists on parity in relation to sport-related injuries. Considering the associated risk for sustaining sport-related injuries with impaired core proprioception (Zazulak et al. 2007) and the effect pregnancy has on females’ core structures (Gilleard & Brown 1996), this study aimed to investigate the trunk motor control in parous and nulligravid female recreational runners.

1.4. OBJECTIVES

In order to achieve the aims stated in Section 1.3, the following objectives were set:

1.4.1. To determine the level of trunk motor control in parous and nulligravid female recreational runners.

1.4.2. To determine the musculoskeletal injury profile of parous and nulligravid female recreational runners.

1.4.3. To investigate a potential association between the musculoskeletal injury profile and trunk motor control of parous and nulligravid female recreational runners.

1.5. STUDY SYNTHESIS

This dissertation consists of six related chapters. Chapter two comprises an overview of the relevant literature and theory which underpins the motivation for conducting the research and informed the methodological approached used to achieve the aims. Chapter three explains the methods followed for participant selection, data collection and data analysis to achieve the aims set out in Section 1.3. Chapter four is a report on the data collected as well as the statistical analyses of the research. This is followed by a general discussion on the major findings from the study and the implications thereof within the greater body of literature in Chapter five. The dissertation concludes with Chapter six, highlighting the main findings and conclusions drawn while suggesting possibilities for future research.

From the findings of this study, recommendations will be made for future research to further knowledge in the field. Additional material used during the preparation and execution of this research project are attached as appendices.

CHAPTER 2.

LITERATURE REVIEW

In Chapter two the research and literature is discussed with reference to the objectives of the study stated in chapter one. The literature review was an important part in determining the gap in research which motivated the study.

2.1. INTRODUCTION

Time and money have been found to be the most common barriers in sport participation during a study done across three countries (Lim et al. 2011). Running can be seen as a cost and time effective sport as it does not require excessive equipment and can be performed anywhere. Health benefits are often the motivating factor for adults to participate in a certain sport discipline and with recreational running the benefits are numerous including; aerobic fitness, cardiovascular function, metabolic fitness, adiposity, postural balance and running performance (Oja et al. 2015). Psychological benefits of recreational running have also been investigated and found to have a positive impact on participants (Szabo & Abraham 2013). Besides good motivation, running like any other sport requires adequate interaction of the skeletal, muscular and ligamentous structures around various joints to produce the desired motor control.

2.2. MOTOR CONTROL IN RUNNING

Motor control is the production of purposeful, coordinated movements of body segments in relation to the rest of the body and its environment by the central nervous system (Latash et al. 2010). Neuromuscular control of the trunk in response to internal and external forces, which include forces generated from distal body parts and from expected or unexpected perturbations, is vital to core stability (Zazulak et al. 2007) and to facilitate adequate motor control in running. Depending on the task at hand, the complexity of the motor control varies from simple movements to a combination of complex elements found in different sporting codes.

2.2.1. The importance of motor control

In order for the body to produce purposeful and effective movements accurate internal and external sensory information is vital (Bryan & Scott 2002). During running it is vital for information to be processed from both these sources. For example, mechanoreceptors around the ankle detect an uneven surface (external) and then an anticipatory change in the centre of mass (COM) is triggered to prevent falling, stimulated from previous experience (internal) (Bryan & Scott 2002). However, during injury this sensory information can be disturbed leading to incorrect or ineffective motor control. In a systematic review it was found that sensorimotor deficits occurred in joint position sense and postural control in participants with functional ankle instability (Munn et al. 2010). Motor control is often affected as a result of an injury which questions whether uncoordinated and unstable movements caused by lack of motor control, can also lead to injuries. Therefore motor control training plays an important part in physiotherapy treatment of impairments or injuries. This was demonstrated in a study where participants who presented with patellofemoral pain syndrome responded well to an eight week multimodal rehabilitation programme, which included motor control exercises, decreasing their pain during activities of daily living (ADL) and running (Esculier et al. 2016). Having a good knowledge of running biomechanics is vital for a physiotherapist to treat and recognise a disturbance in motor control.

2.2.2. Overview of running biomechanics

The basic phases of running are very similar to walking which include the stance and swing phase, but during running the swing phase becomes longer (Nicola & Jewison 2012). As the transition from walking to running takes place the pelvis is tilted anteriorly in the sagittal plane, the COM is lowered (Novacheck 1998) and the ground reaction forces are increased (Nicola & Jewison 2012). The change in ground reaction forces have implications for increased stress through the lower extremities and a higher risk of injuries (Nicola & Jewison 2012).

As the impact forces are increased during running, more range of movement (ROM) in all lower limb joints is required as well as a greater amount of eccentric muscle contraction (Nicola & Jewison 2012). Hip flexor and extensor muscles play a vital part in the acceleration and deceleration of the legs during running (Novacheck 1998). As the limb is loaded the pelvis remains stable and the hip adducts in relation to the pelvis, resulting in the hip abductors (mainly gluteus medius) to contract eccentrically during the stance phase (Novacheck 1998). The psoas muscle then initiates the swing phase by propelling the thigh forward as the pelvis elevates and the hip abducts (Nicola & Jewison 2012, Novacheck 1998). This coupling movement of the pelvis and hip plays a vital role in minimising motion of the head and trunk allowing balance and equilibrium to be maintained (Novacheck 1998).

The hamstrings and gluteus maximus muscles extend the hip in the middle of the swing phase (Nicola & Jewison 2012) and aid in pulling the body forward when the foot is ahead of the body (Novacheck 1998). The quadriceps and gastroc-soleus complex contract to push the body forward when the foot is behind the body (Novacheck 1998). In recreational runners the hip can go through full ROM of approximately 40˚ from full flexion to extension.

In order for the extremities to perform the running action, stability is needed, which is provided by the pelvis, sacrum and lumbar vertebrae (Nicola & Jewison 2012). Pelvic stability is essential for trunk motor control and when pelvic biomechanical abnormalities are present it can lead to injuries in runners (Nicola & Jewison 2012). Therefore it can be seen that the muscles around the hip and pelvis play a vital role in trunk motor control while running (Novacheck 1998) and if dysfunctions are present it can be linked to specific injuries (Nicola & Jewison 2012, Table 2.2.1).

When compared to walking, forces during running are increased and must be applied in one third of the time (Novacheck 1998). Therefore even a slight biomechanical abnormality can result in injury (Cook et al. 1985). Running injuries are also attributed to repetitive application of relatively small loads over many repetitive cycles (Novacheck 1998). While the effects of foot mechanics on more proximal injuries have received much attention (Kilmartin & Wallace 1994; Nigg 2001; Mundermann et al. 2003), the effect of proximal stability on distal structures is largely unknown. Therefore in the next section the focus is on proximal core stability and strength which could minimize movement in various planes, potentially preventing injuries.

Table 2.2.1: Biomechanical influences of the hip and pelvis on injuries during running (Nicola & Jewison 2012)

	Injury	Pelvis dysfunction	Hip dysfunction
Both pelvis and hip involvement	Iliotibial band syndrome	Increased anterior or posterior tilt	Increased hip adduction Femoral neck anteversion
	Patellofemoral pain	Anterior pelvic tilt	Weak hip abductors
	Low back pain	Anterior pelvic tilt	Leg length discrepancy
Pelvis involvement	Patellar tendinitis	Anterior pelvic tilt	
	Sacroiliac dysfunction	Increased pelvic rotation	
	Hamstring strain	Excessive anterior pelvic tilt	
Hip involvement	Stress fractures		Increased hip adduction

2.3. CORE STABILITY AND STRENGTH

In recent years, core stability has become a fad amongst athletes and sports trainers to the extent that it has been adopted as the default term applied to all motor control training around the trunk (McNeill 2010). This has contributed to the existence of various definitions for core stability, a misrepresentation of what core stability really is, and confusion between definitions of core stability and core strength (Hibbs et al. 2008). Faries & Greenwood (2007) differentiated the concepts of core strength as the ability of the musculature to produce force through contractile forces and intra-abdominal pressure, where core stability refers to the stabilisation of the spine as a result of muscle activity. Core stability was defined by Kibler et al. (2006, p.190) as, “the ability to control the position and motion of the trunk over the pelvis and leg to allow optimum production, transfer and control of the force and motion to the terminal segment in integrated kinetic chain activities”. Core stability is also described as the ability of the lumbo-pelvic-hip complex to prevent buckling and return to equilibrium following a perturbation and therefore forms an important component of gross motor activities involving the trunk (Willson et al. 2005).

The definitions of core stability are very similar to that of motor control described by Latash et al. (2010) as purposeful and co-ordinated movements of the body in relation to the environment. Therefore, to limit confusion in this study and to include the component of core strength as well, trunk motor control will be used to describe both core strength and stability as a whole around the trunk.

The core musculature can be divided into two main categories; (1) the local system, consisting of the muscles responsible for stabilising the spine, and (2) the global system, consisting of the muscles responsible for movement of the spine (Faries & Greenwood 2007, Table 2.3.1). All muscles that attach to the lumbar spine except the psoas muscle forms part of the local system and the global system comprises of the erector spinae, internal and external obliques and rectus abdominis, as well as the intra-abdominal pressure (Bergmark 1989). All muscles surrounding the lumbo-pelvic-hip complex are included in the anatomy of the core when referring to stability training (Oritz et al. 2006).

Although some believe that different core muscles have different functions, Cholewicki et al. (2002) found that when a high-level physical exertion is being performed such as a lift, throw or jump, all the trunk muscles co-contract including the abdominal wall, Erector Spinae and Latissimus Dorsi msucles. This causes an increase in intra-abdominal pressure, intra-thoracic pressure and spine compression leading to functional stability around the lumbo-pelvic-hip complex (Cholewicki et al. 2002). Therefore, integration and simultaneous activation of both the local and global system muscles is required to achieve functional stability during athletic activities (Comerford & Mottram 2001).

Table 2.3.1: Core Musculature (Faries & Greenwood 2007)

Core Musculature		
Local muscles (stabilisation system)		**Global muscles (movement system)**
Primary	**Secondary**	
• Transversus abdominis • Multifidi	• Internal oblique • Medial fibres of external oblique • Quadratus lumborum • Diaphragm • Pelvic floor muscles • Iliocostalis and longissimus (lumbar portions)	• Rectus abdominis • Lateral fibres of external oblique • Psoas major • Erector spinae • Iliocostalis (thoracic portion)

In recent years there has been a frequent inclusion of strength training of the core muscles in athletic training programmes (Hill & Leiszler 2011). The ability to achieve proximal stability despite perturbations from distal forces have been attributed by some to be a result of core strength training, leading to maximised athletic functioning (Kibler et al. 2006). This is displayed in research on a group of recreational and competitive runners who completed a six week core stability training programme and showed an improvement in their performance when running a distance of five thousand metres (Sato & Mokha 2009). However, another study performed on young male athletes showed no improvement in their running economy after a six week swiss-ball training programme, although their core stability had improved (Stanton et al. 2004). This would suggest that only a direct increase in core stability was achieved without an increase in sport performance.

In sports other than running, a core stability programme involving unstable closed kinetic chain exercises performed by female handball players significantly improved their throwing velocity, which therefore positively influenced the outcome measures determining their sporting performance (Saeterbakken et al. 2011). A positive relationship was also found between the double leg lowering (DLL) test, measuring core stability, and the ability to throw a medicine ball (Sharrock et al. 2011). However, this is not adequate evidence to conclude that core stability directly influences athletic performance. Tse et al. (2005) found contrasting evidence that rowers had no improvement in any functional performance test after they underwent an eight week core endurance training programme, but only showed improvement on specific core endurance tests. Hibbs et al. (2008) confirms that more evidence is needed to make clear conclusions regarding the relationship between core stability and athletic performance and states that universally accepted definitions of core stability and strength need to be established in the sporting and rehabilitation sector to decrease contradictory findings. As stated previously, in this study the term trunk motor control is going to be used to assess both core strength and stability as a single interacting entity around the trunk.

2.4. TRUNK MOTOR CONTROL AND SPORT INJURIES

2.4.1. Common injuries in recreational runners

According to Taunton et al. (2002) patellofemoral pain syndrome is the most common injury amongst runners, followed by iliotibial band friction syndrome, plantar fasciitis, meniscal knee injuries and tibial stress syndrome. In a specific survey of recreational runners, where male and female participants were not specified, it was found that muscle injuries were the most frequent type of injury and the knee was the anatomical structure most affected (Junior et al. 2013). Considering the nature of running and the closed kinetic chain from heel strike, through stance and toe-off, it is not surprising that scientists are often focussing on the joint mechanics proximal and distal to the site of common running injuries. This is displayed in a study by Niemuth et al. (2005) who investigated injured recreational runners and found that the affected leg presented with decreased hip abductor and flexor strength, in combination with increased hip adductor strength. While previous running related injuries and speed training were found to be risk factors for subsequent running injuries, interval training seemingly had a protective effect against injuries (Junior et al. 2013).

Balance and stability is closely related and is vital in any activities of daily living, and a key component in the prevention of injuries in many sporting types (Hrysomallis 2007). Kahle & Gribble (2009) found that core stability training increased the dynamic balance in healthy adults therefore, core stability exercises could aid in injury prevention. In sports other than running, a study done by Zealand et al. (2007) found that when the core muscles of cyclists were fatigued it altered the alignment of the knee while pedalling which could increase the risk of injury, although the force of pedalling did not change. Kibler et al. (2006) found that knee injuries have also been associated with weak hip muscles as this affects the position of the trunk. Leetun et al. (2004) performed a study on college athletes over a period of two years and confirmed that participants with lower scores on the core stability tests, specifically weakness of the hip abductors and external rotators, suffered from an injury (varying from back, knee and ankle) in the following season. According to Oritz et al. (2006) muscles that form part of the lumbo-pelvic-hip complex form part of the core musculature and therefore strengthening weak muscles and correcting the motor control around the hip could prevent future injury. The identification of individuals with decreased core stability and the appropriate intervention strategies may be beneficial and better prepare athletes for their specific sport (Willson et al. 2005).

2.4.2. Injuries in female runners and athletes

Female runners were found to be twice as likely to develop patellofemoral pain syndrome, iliotibial band friction syndrome, gluteus medius injuries and sacro-iliac injuries (Taunton et al. 2002). A significantly greater peak hip adduction, hip internal rotation and knee adduction angle was found in female recreational runners when compared to their male counterparts (Ferber et al. 2003), which could be a reason for the increased prevalence of hip and knee injuries.

Leetun et al. (2004) not only found a correlation between weak core stability and an increased risk of injury but also that female athletes in general demonstrated lower core stability measures than their male counterparts, putting them at a higher risk for injury. Zazulak et al. (2007) supported the theory that female athletes are at a higher risk of knee injuries when they present with decreased core proprioception and it was recommended that neuromuscular core exercises be included in training to greatly reduce the risk of injury. In a review on core stability for the female athlete, Oritz et al. (2006) came to the conclusion that there is a strong correlation between a higher incidence of lower extremity injuries in female athletes and weak core stability in certain sports and that more research is needed in this field.

A physiological difference was investigated as a possible cause of injury in a controlled laboratory study. It was concluded that oestrogen found in higher quantities in a female does not have a direct effect on ligament properties in and around the knee joint (Wentorf et al. 2006). However anatomical differences between the male and female pelvis have been found, mainly that a female has a wider bony pelvis (Salerno et al. 2006). Although this could influence certain biomechanical factors around the hip complex, there can also be other contributing factors increasing the risk of injuries in female athletes such as training errors or decreased motor control.

2.5. PREGNANCY AND FEMALE RUNNERS

2.5.1. Effect of pregnancy on core musculature

Stephenson & Swank (2004) very basically describe the core as the musculature of the abdominal and back region with emphasis on the transverse abdominis (TrA) and multifidi muscles whereas Faries & Greenwood (2007) divide the core musculature into different systems with certain functions (Table 2.3.1).

Pregnancy has a direct effect on the abdominal muscles, which form part of the core, and Gilleard & Brown (1996) studied these changes in six participants. As the study was done on a very small study sample, the results cannot be generalised but can give a good indication of what to expect. All participants were involved in aerobic exercises, two to three times a week on average, during their pregnancy. At 26 weeks gestation all subjects experienced separation of the rectus abdominis muscle which increased gradually until full term and this was parallel with the decrease in functional pelvic stability. Pelvic stability remained low in the postpartum period of up to eight weeks compared to the tests conducted at 14 weeks gestation.

Van Veelen et al. (2014) discovered that pelvic floor distensibility is increased during first pregnancy and the postpartum period with vaginal or caesarean section delivery, but was not specified for how long distensibility persists. One would presume that pelvic floor strength would decrease during pregnancy but Caroci et al. (2010) found that it did not significantly change during pregnancy or after delivery. This was contradicted by Hilde et al. (2013) that found reduced vaginal resting pressure, pelvic floor muscles (PFM) strength and endurance after vaginal delivery.

Lee et al. (2008) explored the role and effects of fascia during pregnancy and delivery and found the following. During expansion of the abdomen the anterior abdominal fascia is stretched affecting the TrA and linea alba that connects the left and right abdominal walls. The PFM contributing to optimal lumbo-pelvic load transfer is impacted during pregnancy, labour and delivery leading to possible stretching or tearing of these tissues. The thickness of the Rectus Abdominis muscle and Internal Obliques was decreased in postpartum women in the first month after delivery (Weis et al. 2015). There are also other factors to consider during pregnancy like weight gain. This might not have a direct effect on the muscles of the core but can influence the joints around the area. As weight is gained during pregnancy, the forces across joints in weight bearing activities increase. This could be harmful to already arthritic or unstable joints especially at the hips and knees during activities like running (Artal & O'Toole 2003).

Therefore, structural changes of the core during pregnancy do not occur in isolation but are paired with decreased functional abilities (Gilleard & Brown 1996). It can be questioned if appropriate strengthening exercises are done postpartum to ensure that the core musculature is functioning optimally and sport specifically when returning to sport.

2.5.2. Retraining of trunk motor control following pregnancy

As seen above many changes occur in and around the core during pregnancy which could lead to disruptions in the motor control around the trunk. Up to 45% of pregnant woman struggle with pregnancy related pelvic pain (PRPP) and/or pregnancy related lower back pain (PRLBP) and 25% of woman experience pain in the postpartum period as well (Wu et al. 2004). Lower back pain has been found to have an effect on trunk co-ordination and control during gait resulting in decreased kinematic co-ordination in the transverse plane, more variable co-ordination in the frontal plane accompanied by poorly co-ordinated activity in the lumbar erector spinae (Lamoth et al. 2006).

A relationship was found between asymmetric laxity of the sacro-iliac joint (SIJ) and moderate to severe PRPP (Damen et al. 2001) as well as a clear indication that this laxity predicted PRPP in the postpartum period (Damen et al. 2002). When the drawing-in technique is performed, activating the TrA in co-contraction with the multifidus, it provided better results in decreasing the laxity of the SIJ when compared to a bracing technique (Richardson et al. 2002). Therefore strengthening the TrA activation by teaching woman the drawing-in technique postpartum can be of great value in decreasing PRPP, as the TrA can be weakened after undergoing severe changes during pregnancy (Lee et al. 2008). Physiotherapy can play a vital role in the treatment of pelvic girdle pain/PRPP as recommended in the European Guidelines, including individualised exercise and treatment programmes specifically focussing on stabilising exercises for dynamic control of the lumbar spine and pelvis (Vleeming et al. 2008).

Specific interventions are needed in the postpartum period to strengthen and improve functional core stability as this can decrease pain and prevent future injuries for women returning to sport. In the guidelines for exercise in the postpartum period, Artal & O'Toole (2003) recommended that women should gradually return to sport as physiological and physical changes of pregnancy can take four to six weeks to normalise. Although no evidence of adverse effects have been recorded with rapid return to sport each woman should be treated individually, receiving specific prescribed specific exercises taking into account relevant medical and training histories.

2.6. METHODOLOGICAL CONSIDERATIONS

2.6.1. Measuring core strength, stability and endurance

The need for a standardised and reliable core stability test has been widely recognised (Borghuis et al. 2008, Liemohn et al. 2005 & Kibler et al. 2006), although certain studies have recommended specific tests. The purpose of research done by Liemohn et al. (2005) was to develop a measurement tool that would quantify core stability. From their study it was found that an effective way not only to measure core strength but also core stability is to use a four item battery including; bridging, two versions of the quadruped arm raise test, and a kneeling test on a stability platform. The exercises used by Liemohn et al. (2005) were adapted from the San Francisco Spine Institute lumbar stabilisation programme, which emphasised core strength, endurance, balance and co-ordination. To test core proprioception in athletes Zazulak et al. (2007) used a motorised apparatus to produce passive motion of the lumbar spine in the transverse plane after which participants had to return their spine to the neutral position following the perturbation.

Testing core stability in a functional position has been in the spotlight and Kibler et al. (2006) suggested it must be dynamic and in all planes of motion to incorporate strength and stability. The tests used in their study were one-leg standing, unilateral squat and movement in the frontal, sagittal and transverse plane. However a study done by Weir et al. (2010) examined the inter- and intra-observer reliability of six clinical core stability tests, which included some of the tests Kibler et al. (2006) used. The unilateral squat, lateral step-down, frontal, sagittal and transverse plane testing as well as the bridge (plank) were described as unreliable and not suitable to be used in a clinical setting (Weir et al. 2010). However, these tests are very useful in clinical experience since they allow specific rehabilitation protocols to be followed (Kibler et al. 2006).The active straight leg raise (ASLR) has been found to be reliable and valid when testing lumbo-pelvic stability (Mens et al. 2001). Finding tests that measure individual core muscles or groups is questionable as co-contraction is expected (Borghuis et al. 2008, Cholewicki et al. 2002). Therefore if all components of core stabilisation are to be tested, no single test is sufficient and a variety of tests need to be selected to assess the different components separately (Aggarwal et al. 2012).

The most accurate way to measure activity of the TrA (local stabiliser) is through fine wire electromyography (EMG) and ultrasound imaging. However, both are associated with high cost and the EMG with risk of causing infection and being painful (Oliveira & Costa 2006, Lima et al. 2011). Therefore, an alternative approach is needed like the indirect measurement of TrA activity through surface EMG. Surface EMG was found to be a reliable method of assessing abdominal activation of TrA and internal obliques (Marshall & Murphy 2003) as well as identifying PFM activity (Grape et al. 2009). Reliability of the probe/surface electrode was found when testing the activation of the PFM on the same day between trials (Auchincloss & Mclean 2009). Another method of evaluating the activation of local stabilisers is through abdominal wall pressure changes using the pressure biofeedback unit (PBU) or assessed by palpation (Oliveira & Costa 2006). On evaluation of TrA dysfunction, a laboratory EMG investigation and a clinical prone PBU test was found to be accurate (Hodges et al. 1996). This is confirmed by Cairns et al. (2000) that found the PBU to be a useful tool in quantification of abdominal muscular function. Garnier et al. (2009) also used the PBU prone test which yielded good test-retest reliability but unfortunately the inter-observer reliability was low. The PBU may have a role in the clinical setting, however the intra-tester reproducibility was questioned for scientific purposes (Storheim et al. 2002). The PERFECT (Power Endurance Repetitions Fast contractions Every Contraction Timed) test/scale has also been demonstrated to be a reliable and valid assessment tool for the PFM (Laycock & Jerwood 2001).

Global stability and mobility also play a vital role in lumbo-pelvic stability and need to form part of the assessment. A sport specific plank test was used effectively by Tong et al. (2014) to measure global core muscle function in athletes. Stanton et al. (2004) used the Sahrmann core stability test to assess global mobility in a group of athletes, pre and post swiss ball training. In a another study Sharrock et al. (2011) described the DLL test as the most appropriate way to measure core stability as it requires a high level of intrinsic trunk stabilisation. When comparing these two tests a similarity is seen between the DLL and Level 5 of the Sahrmann test.

It can be noted that there is a lack of consensus as to which measures or tools are most accurate to measure trunk motor control. Therefore, for the purposes of this study, the tests most appropriate from a subjective view were chosen.

2.7. SUMMARY

Trunk motor control plays an important role in the functioning of an athlete, whether in injury prevention or improving athletic performance. However an area of concern has been recognised in the weakness of core strength and stability in female athletes. Female parous athletes seemingly have an even higher risk of injury due to decreased abdominal strength and pelvic stability postpartum if not managed appropriately. Therefore this study investigated trunk motor control and parity in female recreational runners.

CHAPTER 3.

RESEARCH METHODOLOGY

In Chapter three a detailed account is given of the study performed. Once the study was motivated by the literature found in Chapter two the methodology was written including; the research design, study population and sample, measurements, pilot study and ethical aspects.

3.1. RESEARCH DESIGN

This research project was a descriptive cross sectional, case-control study.

In case-control studies, persons are identified with a condition (parity) and labelled as a case and then compared to a series of persons without the condition (nulligravid) who are labelled as the controls (Lichtenstein et al. 1987). This study design provides advantages of being flexible and efficient (Lichtenstein et al. 1987) as well as yielding important scientific findings with relatively little time, money and effort (Schulz & Grimes 2002). To limit bias both groups came from the same population and the criteria for comparison were well stated (Section 3.3.3). During the data processing, statistical significance was only discussed when the case group was compared to the control group that matched the criteria. This provided accurate and valid results for the case-control design. Advantages of the case-control are determining the relative importance of a predictor variable and generating a lot of information from relatively few subjects (Mann 2003).

3.2. STUDY POPULATION AND STUDY SAMPLE

3.2.1. Description of the study population

The study population included parous and nulligravid female recreational runners in Bloemfontein, Free State. A survey conducted in 2013 estimated that there were approximately 400 female runners affiliated with Athletics Free State accredited running clubs in Bloemfontein (Coetzer 2013). An approximation of a hundred social runners were added to that number, therefore the target population consisted of an estimated five hundred female recreational runners. However the estimated population included all age groups but the study only included women between the ages of 18 to 45 years old which limited the population. Due to the above reasons, the population was estimated at 100 recreational runners.

3.2.2. Sample

Convenience sampling was used. Advertisements were sent electronically to various running clubs and put up in two gymnasiums (Appendix A). A contact number was provided on the advertisement and any person who met the criteria and was interested in participating in the study could contact the researcher. The researcher then made an appointment with the potential participant, documented their name and contact details and explained that the study would take place at the premises of Christy du Plessis Physiotherapy, Universitas Ridge.

The data collection took place from September to November 2015. It was possible to see an estimated 100 participants in this time period if enough interest was available. As many participants as possible were included in the study to allow the results from the case and control group to be as valid as possible. At the end of the data collection process 29 participants were evaluated.

3.2.3. Inclusion criteria for the parous group

- The participant had to be between the ages of 18 and 45 years. This age was chosen to ensure that the participant could give consent for the study and to avoid the effects of menopause.
- The participant had to have given birth (including both vaginal and caesarean delivery) to a child/children.
- The participant had to understand English or Afrikaans.
- The participant had to be physically active at the time of the study for 150 minutes per week including at least 30 minutes of running once a week for the past month.

3.2.4. Inclusion criteria for the nulligravid group

- The participant had to be between the ages of 18 and 45 years old due to reasons explained in paragraph 3.2.3.
- The participant could not have been pregnant before.
- The participant had to understand English or Afrikaans.
- The participant had to be physically active at the time of the study for 150 minutes per week including at least 30 minutes of running once a week for the past month.

3.2.5. Exclusion criteria

- A female recreational runner less than eight weeks postpartum.
- A female recreational runner who was currently pregnant.
- Participants who had a current injury (from 0 to 6 weeks after the injury).

3.3. MEASUREMENT

3.3.1. Measuring instruments

3.3.1.1. Measurement of trunk motor control

The tests performed in this study were selected to include local stability, global stability, global mobility and functionality (Aggarwal et al. 2012). The tests are however described by type, due to difficulty of classifying it according to muscle contraction, as co-contraction is expected in all tests (Borghuis et al. 2008, Cholewicki et al. 2002). The tests were performed in the same sequence for each participant.

3.3.1.1.1. Surface EMG of PFM

A Neurotrac Myoplus^{TM} 2 was used to measure the electromyography (EMG) of the pelvic floor muscles (PFM) and the abdominal muscles (Section 2.6.1). For more precise measurement, a wide filter was used (19-375Hz). PFM muscle activation and endurance was assessed by means of surface EMG which has shown to have good to high reliability (Grape et al. 2009). Surface electrodes, by means of a Periform™ intra-vaginal probe, were used. This method has also been described by several authors such as Auchincloss & Mclean (2012) and Thompson et al.(2006b) to measure the activity of the PFM.

The Periform™ probe is a pear shaped device and has a length of 8 cm and is 3.4 cm wide in the medial lateral diameter, at its peak width (Auchincloss & Mclean 2012). The probe was inserted, with the opposing electrodes in contact with the lateral vaginal walls, in the supine position with the legs slightly bent and abducted (Thompson et al. 2006b). Participants were allowed the choice of inserting the electrode themselves, in which case the position would be checked by the researcher before measurement. The reference electrode was placed on the ulna, distal to the olecranon. The participant was then verbally instructed to contract their PFM as strongly as possible for 10 seconds (Grape et al. 2009). This was repeated three times and the average of the peak activation was recorded in uV (Thompson et al. 2006a). Reliability of the probe electrode was found when testing the activation of the PFM on the same day between trials (Auchincloss & Mclean 2009). During a study of 17 healthy nulliparous females, between the age of 20 to 35 years, an average strength of 22.2 uV was found for PFM strength using surface EMG (Grape et al. 2009) (Section 2.6.1).

Afterwards the PFM endurance was assessed by calculating 60% of the maximum voluntary contraction (MVC) and setting it as a target value on the computer. Endurance was recorded as the time the participant was able to hold the contraction above 60% of her MVC up to a maximum period of one minute. This recommendation is in accordance with the guidelines of the American College of Sport`s Medicine physical activity and health guidelines (Quartly et al. 2010).

3.3.1.1.2. PERFECT test for PFM

The PERFECT (Power Endurance Repetitions Fast contractions Every Contraction Timed) test was also used to assess the fast and slow twitch fibres of the PFM (Laycock & Jerwood 2001). The patient lay in the same position as the surface EMG test. The PFM was examined by placing the index finger approximately 4 - 6cm inside the vagina and palpating the muscles and their reaction during the tests. Surgical gloves were used to ensure hygiene. The power of the PFM was tested using the modified Oxford scale during a MVC as the participant was asked to perform a lift action, as if she wanted to stop urinating. The power was rated as a number out of 5. Endurance was expressed as the length of time in seconds that the MVC could be sustained with a maximum of 10 seconds. Repetitions were recorded as the specific holding time for the MVC with a rest period of four seconds between each contraction. Repetitions were rated as a number out of 10.The fast contractions were instructed as a contract-relax of the PFM as quickly and strongly as possible with a maximum of 10 (Laycock & Jerwood 2001). Inter-examiner and test-retest reliability of these tests have been found to be high (Laycock & Jerwood 2001). If the participant did not give consent for testing of the PFM, they started with the next test.

3.3.1.1.3. Surface EMG of the TrA

Surface EMG of the Transverse Abdominis (TrA) muscle was measured by two electrodes placed approximately 2cm medial and inferior to the anterior superior iliac spine (ASIS), which was found to be a reliable measure for the activation of the TrA muscle (Marshall & Murphy 2003). A ground electrode was placed on the olecranon. The participant performed the drawing-in technique in supine as described by Marshall & Murphy (2003). The participant had three trials and then the average activation was recorded in uV (Thompson et al. 2006a). Nulliparous female physical therapists were tested for TrA activation, using surface EMG, and an average of 35.3uV was found using the abdominal hypopressive/drawing-in technique (Stupp et al. 2011) (Section 2.6.1).

3.3.1.1.4. Prone PBU test

Local stability was further assessed by means of the pressure biofeedback unit (PBU). The PBU was placed under the abdomen and the participant performed the drawing-in technique again with normal breathing. The device was initially inflated to 70mmHg and for each 2mmHg that the participant could decrease the pressure, a level was recorded (Garnier et al. 2009). The levels started at one and went up to five, indicating the participant decreased the pressure by

10mmHg. Level 5 was the highest (Appendix B). According to Storheim et al. (2002) the prone position is easier to standardise and an average decrease in pressure between 4.6 - 5.3mmHg was measured. Excellent reliability (intra-class correlation coefficient of 0.74) was found with the prone PBU test for both intra and inter-examiner conditions (De Paula Lima et al. 2012). The prone PBU test also has a good test-retest reliability with an intra-class correlation coefficient of 0.81 and a 95% confidence interval of 0.67 - 0.90 (Garnier et al. 2009). The participant had three trials (Thompson et al. 2006a) and all three measurements of the PBU were noted by the researcher. The average of the three trials was used for data analysis.

3.3.1.1.5. Sahrmann core stability test

The Sahrmann core stability test used to assess global mobility of the core, as described by Stanton et al. (2004), was performed in supine with the PBU placed under the lumbar spine. The PBU was inflated to 40mmHg and the test consisted of five levels, with each level increasing in difficulty (Appendix C). The Sahrmann test has been reported to have a reliability coefficient of 0.95 (Stanton et al. 2004).

The participant had three trials for the Sahrmann test which were recorded, but only the average level was used for data analysis (Thompson et al. 2006a).

3.3.1.1.6. The ASLR

The active straight leg raise (ASLR) was performed to assess global stability. The participant lay in supine with straight legs in lateral rotation and feet 20cm apart. The participant was asked to raise their straight leg 5cm above the bed, each leg separately. The researcher then assessed the velocity, impairment and quality of movement according to a four point scale namely;

Level 0: The patient feels no restriction

Level 1: The patient reports decreased ability to raise the leg but the examiner assesses no sign of impairment

Level 2: The patient reports decreased ability to raise the leg and examiner assesses signs of impairment

Level 3: Inability to raise leg

The movement was repeated with pressure given around the ASIS and the movement was rated again (Mens et al. 1999). The participant was given one trial for the ASLR without pressure, and one with pressure which were both recorded.

3.3.1.1.7. Sport specific plank test

The sport specific plank test has been found valid and reliable in testing the global core muscle stability and endurance with a test-retest reliability showing an intra-class correlation coefficient of 0.99 and a 95% confidence interval of 0.98 - 0.99 (Tong et al. 2014) (Section 2.6.1).

Participants started the sport specific plank by holding a basic plank position, a prone bridge supported by the forearms and feet. The elbows were vertically below the shoulders with the forearms and fingers extending straight forward. The neck was kept neutral so that the body remained straight from the head to the heels. Participants were required to maintain the prone bridge in a good form throughout the following levels with no rest in between (Tong et al. 2014):

Level 1: Hold the basic plank position for 60secs.
Level 2: Lift the right arm off the ground and hold for 15secs.
Level 3: Return the right arm to the ground and lift the left arm for 15secs.
Level 4: Return the left arm to the ground and lift the right leg for 15secs.
Level 5: Return the right leg to the ground and lift the left leg for 15secs.
Level 6: Lift both the left leg and right arm from the ground and hold for 15secs.
Level 7: Return the left leg and right arm to the ground, and lift both the right leg and left arm off the ground for 15secs.
Level 8: Return to the basic plank position for 30secs.
Level 9: Repeat the steps from level 1 to 9 until the maintenance of the prone bridge failed.

The participant was rated according to which level they could maintain. The participant only had one trial and a five minute rest before the following tests to prevent fatigue.

3.3.1.1.8. Single leg standing and unilateral squat

Single leg standing and a unilateral squat was used to test functionality (Kibler et al. 2006). Each test was performed on both the left and right hand side and the movement rated as good, average or poor by the examiner subject to the presence of deviations (Kibler et al. 2006). During one leg standing the participant was asked to stand on one leg without any other verbal cues and deviations were noted for e.g. Trendelenburg posture or internal and external rotation of the weight bearing leg. The time was recorded as to how long the participant could stand on one leg but nothing more than 60 seconds was recorded. Then the participant progressed to unilateral squats in a quarter to half range of movement (ROM) and similar deviations were noted as well as using their arms for balance or an exaggerated flexion/rotation posture (corkscrewing) (Kibler et al. 2006). The participant was given one trial for each test.

3.3.1.2. Questionnaire content

The questionnaire was divided into four sections. Section A covered the demographics of the participants which included two questions. This was to gather general information concerning the participants and to determine if they were a member of a running club. Section B gathered information about the participants' training and what cross training methods she used. The birth history of the participants' children was covered in Section C, including the type of birth and how many children she had given birth to. The nulligravid participants moved directly to Section D. Section D enquired about the participants' injury profile and history. It contained six questions regarding the type of injuries incurred (Appendix D).

3.3.1.3. Data form

The data form followed below the questionnaire. It was clearly specified that it was for the researcher's use only. All the results of the specific tests were captured on the data form as the tests were being performed. The result of the first test was recorded by the experienced clinician and then the following tests were all recorded by the researcher (Appendix D).

3.3.2. Data collection procedure

3.3.2.1. Study Procedure

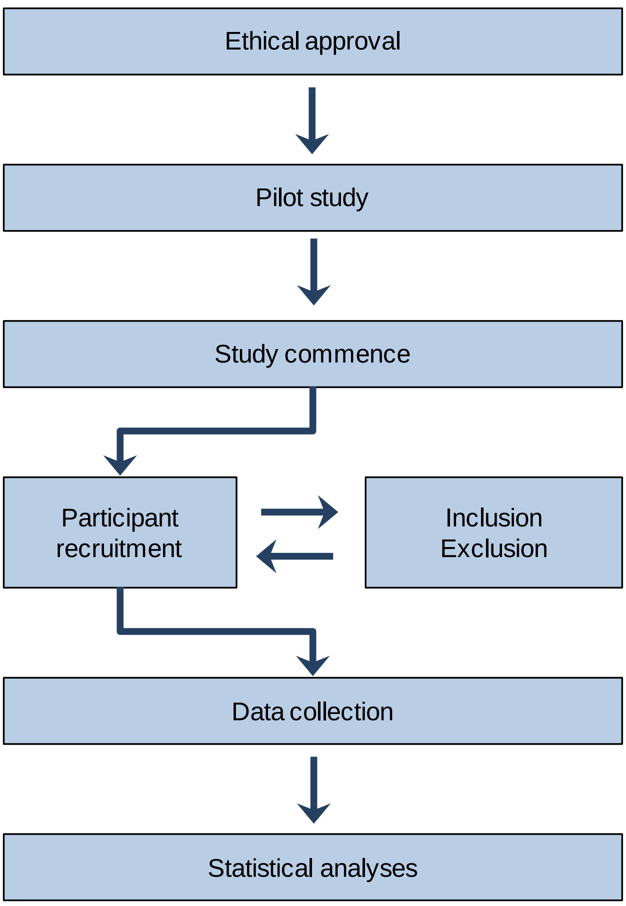

Figure 3.3.1: Flow diagram of the study procedure.

The data collection took place on the premises of Christy du Plessis Physiotherapists in Universitas Ridge, Bloemfontein, as permitted in writing

(Appendix E). Once ethical approval was obtained from the Faculty of Health Science's Ethical Committee of the University of the Free State (UFS), the pilot study commenced (Appendix F). The results and feedback gained from the pilot study was carefully reviewed by the researcher and no changes were necessary.

Potential participants were identified by using advertisements and word of mouth. Advertisements (Appendix A) were printed and put up in two gymnasiums and electronic copies were sent via e-mail to various running clubs in Bloemfontein, by the researcher. An appointment was made with potential participants according to the process described under sampling. Data collection took place from September to November 2015. Potential slots available during this time allowed for approximately twelve patients to be seen in a week, but far less participants were seen due to a lack of interest.

On arrival at the reception area of the practice rooms of Christy du Plessis Physiotherapy, each participant received an information document regarding the study (Appendix G) and a written informed consent form (Appendix H) which they had to sign before commencement of the study. Once consent was received, the participant was asked to complete a questionnaire (Appendix D) pertaining to their personal information, injury history and specific training habits. Thereafter the participant was taken to a private evaluation room which had a step for the warm-up, plinth to perform the necessary tests in supine and prone as well as enough space for the other tests to be conducted. While the patient warmed-up for five minutes, stepping up and down on the step in a rhythmic, comfortable speed demonstrated by the researcher, the researcher browsed through the completed questionnaire to double check that all relevant questions had been completed.

If consent was not given for the first test, the researcher then conducted the rest of the tests in the following order.

1. Surface EMG of the TrA muscle
2. PBU of the local stabilisers in prone
3. Sahrmann core stability test
4. ASLR

5. Sport specific plank
6. Single leg standing
7. Unilateral squat

There was a one minute rest between all tests during which time the researcher explained and demonstrated the following test. The participant had three trials for the surface EMG of the TrA, the PBU test and the Sahrmann test (Thompson et al. 2006a). The average was used for data analysis. The researcher documented the findings of each test on the data from.

If consent was given for the PFM tests then an appointment was made with the participant to see an experienced clinician, with post-graduate training in women's health, who performed the surface EMG of the PFM and the PERFECT test. Due to the invasion of privacy that may be experienced by the participant because of the invasive nature of the first test, the clinician explained to the participant that she could insert the intravaginal probe herself (instructions were given) if she chose to do so. The participant also had the option to have a chaperone present during the procedure. The clinician left the examination room to allow the participant to undress. The participant then placed a towel over her legs for privacy with the wires from the intravaginal probe visible and then the clinician connected the wires from the intravaginal probe to the EMG machine making the test as comfortable as possible for the participant. The participant had three trials for the surface EMG of the PFM and the average of the peak activation was then recorded. Once the test was completed the clinician left the room again for the participant to get dressed.

After completion of the tests the participant was able to schedule a date for the follow-up sport massage offered as an incentive to participate. Once this was complete the participant was thanked and allowed to leave the premises. The researcher then coded the questionnaires and data forms and added the data to EXCEL spreadsheets.

3.3.3. Data analysis

Statistical analyses were done by the Department of Biostatistics at the UFS.

Descriptive statistics including, means and standard deviations or medians and percentiles for continuous data and frequencies and percentages for categorical data, were calculated per group (nulligravid and parous). Groups were compared by means of 95% confidence intervals for the mean or median and percentage difference. Missing data were omitted from the data recorded in Chapter four.

3.3.3.1. Grouping of data

The data were grouped using the questionnaire that the participants completed. The 29 participants were divided into a parous group and nulligravid group. This was done based on their maternal history whether they had given birth to a child before or not. If they had given birth before, they were included in the parous group. If they had never been pregnant before they were included in the nulligravid group. The parous (case) group consisted of eight participants. To enable a case-control study design (Section 3.1) each parous participant was matched with a similar nulligravid participant, according to age, frequency and type of training as well as their injury profile and treatment received for injuries. The control group therefore consisted of eight matched nulligravid participants

The process of matching the participants was complicated as often one category matched well but then the rest of the data was not identical. Age proved to be a very limiting factor as the discrepancies were vast. Therefore frequency of running during the week and type of additional training were first considered. Then frequency of additional training, previous injuries and the type of treatment received for injuries were taken into account. Age was matched as accurately as possible but did not correlate to a difference of +- 2 years originally envisaged in the protocol. Matching was therefore limited and this is a limitation of the study discussed in Chapter six (Section 6.5).

3.3.3.2. Grouping of injury types

In the questionnaire (Appendix D) that the participants had to complete during the study they had to record all sport-related injuries that they had experienced. These injuries were then recorded and grouped together making the representation and interpretation of the results easier. The injuries were grouped into the following body regions and joints indicated on Figure 3.3.2 below.

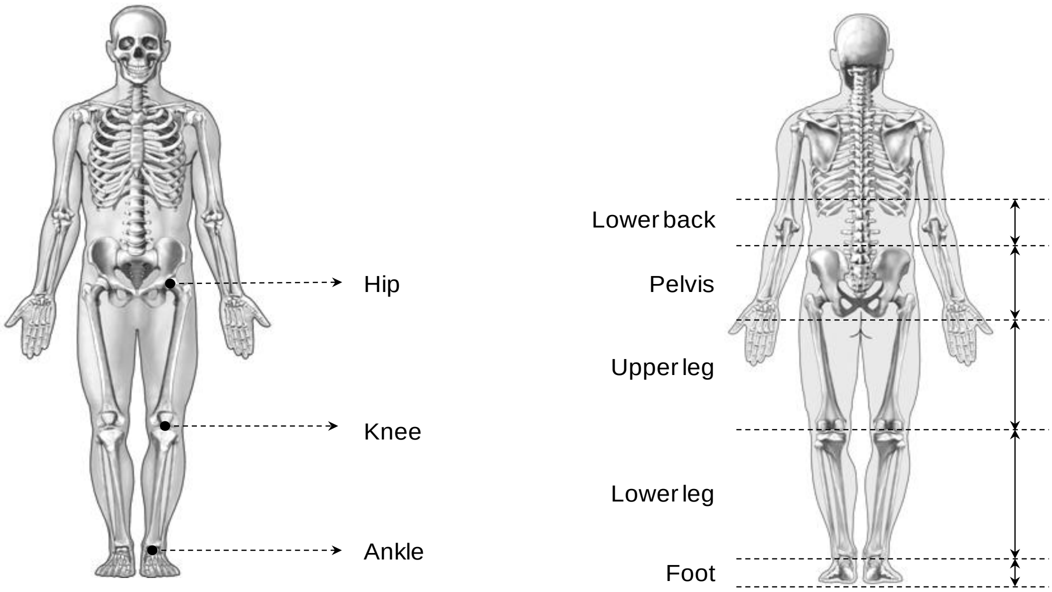

Figure 3.3.2 Body regions and joints for injuries.

3.3.4. Methodological and measurement errors

During the execution of the study certain methodological and measurement errors identified were addressed. To limit any bias in the sampling of the participants, potential participants contacted the researcher for further information or to make an appointment for data collection. This could however cause a lack of interest from participants, which was overcome by having an incentive to participate in the study. The incentive was a 30 minute sport massage and appointments were made after each participant was evaluated by the researcher.

Before the data collection started a pilot study (Section 3.4) was completed to ensure that the questionnaire was correctly understood and that all tests could be performed in the allotted time. Once the pilot study was complete, the data collection commenced. The tests included in the study all fell within the scope of normal practice of the researcher (a registered physiotherapist), according to the guidelines given by the Health Professions Council of South Africa (HPCSA). Reliability of the tests could be questioned as no standardised test was available for measuring core stability and strength and therefore a set of various tests was used to cover all aspects of trunk motor control (Section 2.6.1).

During the testing of participants, they were encouraged to give consent for the surface EMG test of the PFM as well as the PERFECT test, by letting them insert the intravaginal probe themselves due to the possible invasion of privacy. Once all participants had been assessed, matching criteria was used to compare the case and control groups to establish a similar baseline and ensure accuracy of results.

3.3.4.1. Reliability and validity of the measuring instruments

The reliability of a measurement instrument is the extent to which the instrument yields consistent results when the characteristics being measured have not changed (Leedy & Ormrod 2010). In this study reliability of the tests used during measurement, was ensured by all participants performing the same tests in the same order. The tests were rated by the researcher to ensure reliability in the data collection phase and participants were given the exact same time to perform the tests with standardised instructions.

To limit the influence of fatigue on results and to ensure validity of the findings, the order of the tests were structured in such a way that different muscle groups were tested and adequate rest periods given between tests. The validity of the measurement instrument is the extent to which the instrument accurately measures what it is actually intended to measure. Construct validity is the extent to which an instrument measures a characteristic that cannot be directly observed but is assumed to exist on patterns in people's behaviour (Leedy & Ormrod 2010). The participants performed a variety of tests to measure all aspects of trunk motor control and therefore it enhanced the validity of the derived findings across the wider spectrum of tests used in the measuring process.

The tests were also performed in the same venue for all participants for consistency and to control environmental factors. Each participant had to warm-up for five minutes before the tests were started by using a stepper, to prevent injury with maximum muscle contraction. These methods and testing procedures were also tested during a pilot study to identify any unforeseen errors.

3.4. PILOT STUDY

The aim of the pilot study was to determine if the questionnaire was clear and if the instructions for the trunk motor control tests were correctly understood. The time taken for the questionnaire and tests to be completed was also determined.

The pilot study included the first five female recreational runners to respond to the advertisement. Once these participants had completed the data collection process, they provided written feedback. In order to receive constructive feedback the researcher asked them if the information document was relevant and clear, if the tests were easily understood, if the environment was comfortable and if the questions in the questionnaire were easily understood and relative to the study. To ensure good ethical conduct, these participants were then given feedback regarding further inclusion/exclusion from the study. Considering that no adjustments to the questionnaire and data collection process were necessary following the pilot study, the data from the pilot study were included in the final analysis.

3.5. ETHICAL ASPECTS

Approval was obtained from the Ethics Committee of the Faculty of Health Sciences, UFS (Appendix F).

3.5.1. Informed consent

The necessary permission from authorities was gained by means of a signed consent form (Appendix E) once ethical approval was obtained. The participants received an information document (Appendix G) and had to sign an informed consent form (Appendix H) before the commencement of the data collection process.

3.5.2. Protection from harm

The researcher strived to be honest, respectful and sympathetic to all participants and provide a safe environment for the research to be conducted. The researcher did all that was possible to ensure that no harm occurred to any participant during the tests performed to measure trunk motor control and if the need arose for any help from a professional in another field, the necessary referral was made. The participant could withdraw from the study at any time without any consequences.

3.5.3. Privacy and confidentiality

Participants' information and responses shared during the study were kept confidential and personal details were not included in the study to ensure privacy and protect the identities of the participants. The participants were informed that the results of the study could be published but personal details would not be revealed.

3.5.4. Language preference

The study was conducted in English and Afrikaans and each participant had a choice as to which they preferred.

3.5.5. Remuneration

The participants benefited from a free sport massage after participating in the study as a follow-up appointment. There were no risks associated with the study.

3.6. SUMMARY

In this chapter a detailed account has been given of the study conducted. This allows transparency of the study and provides adequate reasoning for why certain decisions were made. This chapter provides a template for this study to be repeated in another location. Once the study was conducted, the data was processed and the results follow in Chapter four.

CHAPTER 4.

RESULTS

Chapter four will focus on the demographical profile, injury profile as well as trunk motor control of the participants described in Section 3.2.2.

4.1. INTRODUCTION

The 29 volunteer participants were assigned to three groups; a nulligravid group (n = 21) who had never been pregnant before, a parous group (n = 8) who had given birth before and the matched nulligravid group (n = 8) chosen from the nulligravid group to be paired with the participants from the parous group based on the criteria in Section 3.3.3.1. Differences and relationships were assessed using 95% confidence intervals (CI) and $p < 0.05$ as appropriate (Section 3.3.3). Data was presented in median (M), first and third quartile (Q_1, Q_3), minimum (min) and maximum (max) values.

4.2. DEMOGRAPHICS

4.2.1. Age profiles

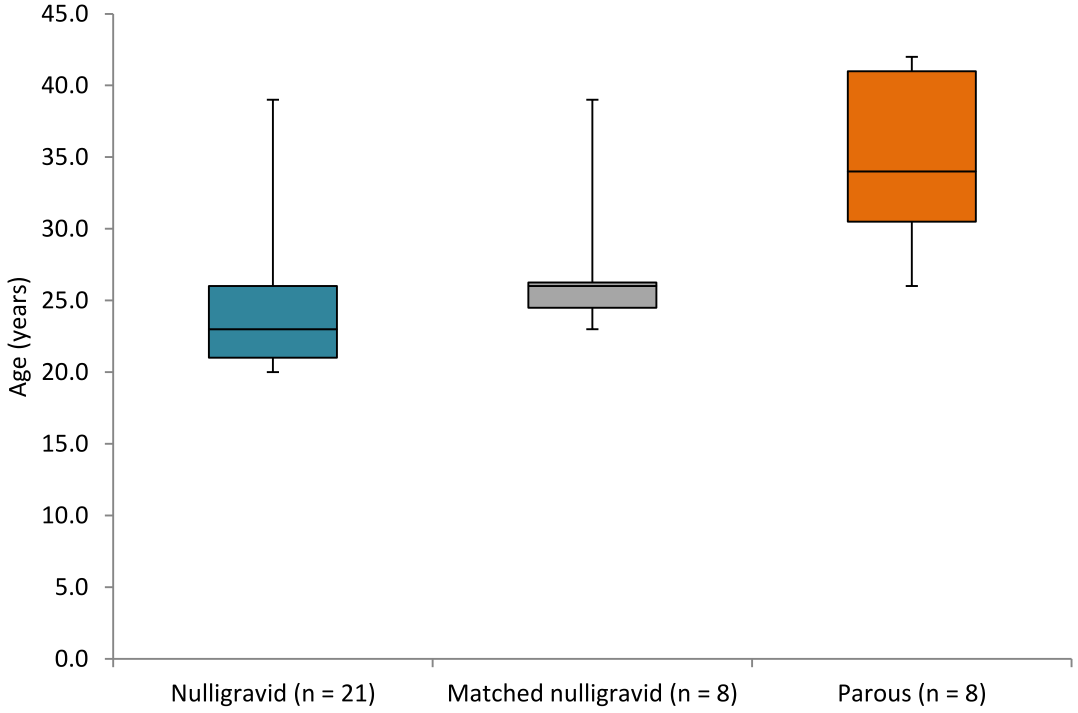

Figure 4.2.1: Age distribution of participants

From Figure 4.2.1 it is clear that the nulligravid group was younger with a median age of 23 years (Q_1: 21 ; Q_3: 26) compared to the matched group with a median age of 26 years (Q_1: 25 ; Q_3: 26) and the parous group with a median age of 34 years (Q_1: 31 ; Q_3: 41). The matched nulligravid participants were also significantly younger [95% CI: - 16 ; - 1] compared to the parous group, despite the maximum ages of these two groups only differing by three years (39 years for the matched nulligravid group and 42 years for the parous group).

4.2.2. Physical activity profiles

4.2.2.1. The number of days participants went running per week

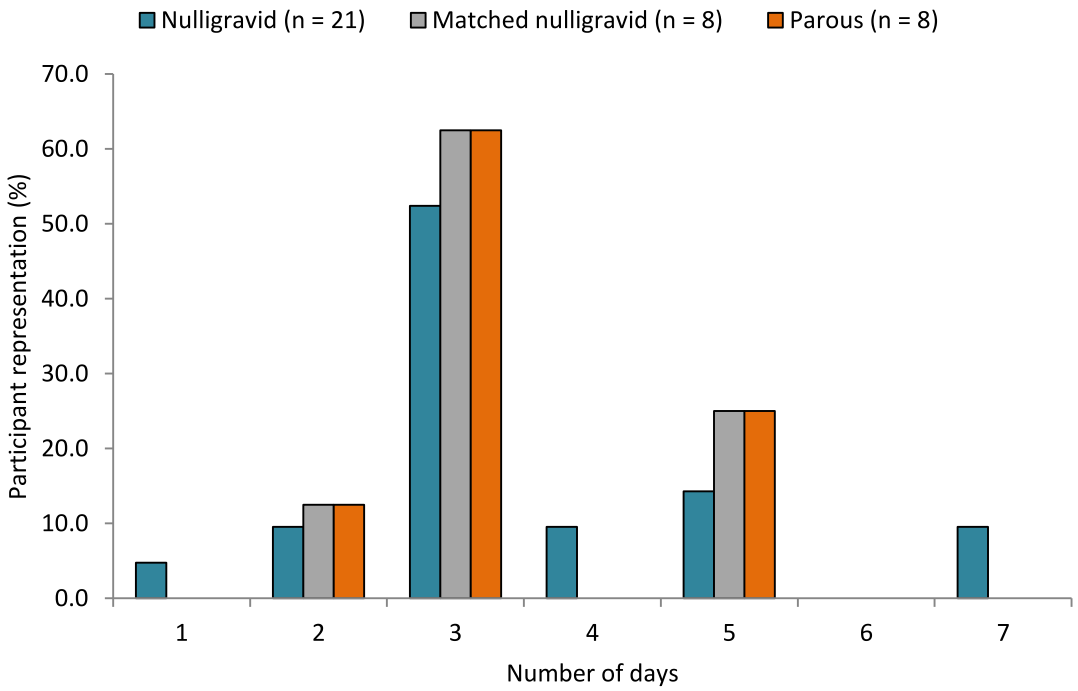

Figure 4.2.2: Number of days per week participants went running

Only two participants of the nulligravid group belonged to a running club at the time of the study. All the participants from this study were classified as recreational runners (see Glossary). In Figure 4.2.2 it can be seen that both the nulligravid and the parous group had the highest number of participants running three days a week with 62.5% (n = 5) of the parous group and 52.4% (n = 11) of the nulligravid group falling into this category. Participants running on average five days a week followed in second for both groups with 14.3% (n = 3) of the nulligravid group and 25% (n = 2) of the parous group. The parous group ran between two to five days per week while the nulligravid group included a more extreme representation with participants running between one to seven days a week. When the parous and the matched group were compared there was no difference between the groups [95% CI: - 2 ; 2] which was to be expected as their training was part of the criteria used to pair the participants of the groups (Section 3.3.3.1).

4.2.2.2. *The amount of time participants went running per week*

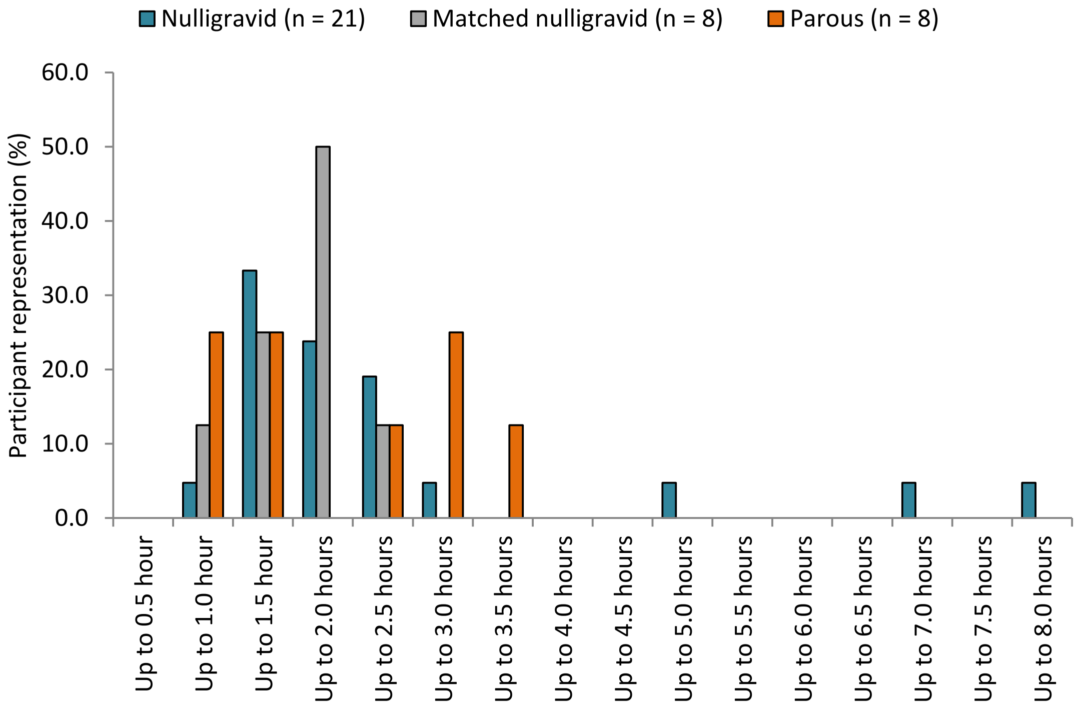

Figure 4.2.3: Average running time per week

To qualify for the study each participant had to run at least 0.5 hours a week (Section 3.2.3). Approximately a third of the nulligravid group 33.3% (n = 7) ran up to 1.5 hours per week with 23.8% (n = 5) running up to 2 hours and 19% (n = 4) running up to 2.5 hours. The nulligravid group again included extreme ranges with one participant running up to 8 hours a week. The parous group was more evenly distributed with 28.6% (n = 2) of the group each running up to 1 hour, 1.5 hours and 3 hours respectively. When the parous and matched groups were compared there again was no significant difference [95% CI: - 80 ; 75] as it fell under the training of the participants which was a criterion for pairing the nulligravid and parous participants (Section 3.3.3.1).

4.2.2.3. Additional types of training participants engaged in

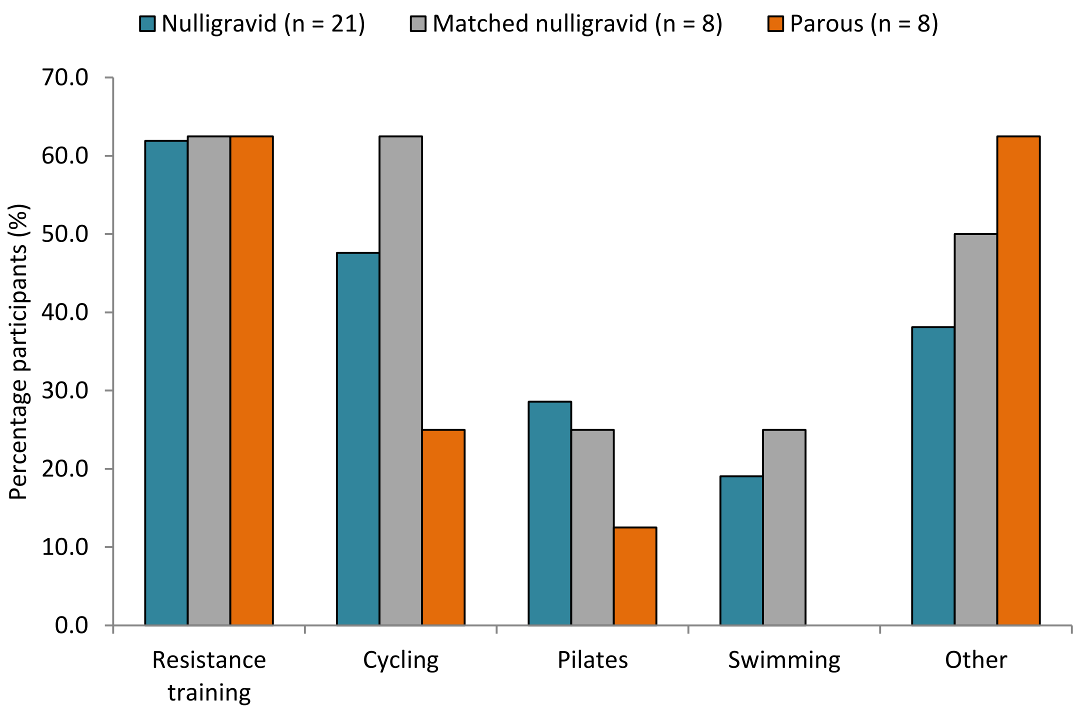

Figure 4.2.4: Types of additional training participants engaged in

Besides the amount of time participants spent running in a week (Figure 4.2.3), they also engaged in additional training. Resistance training was the most common type of cross training that the participants engaged in with 61.9% (n = 13) of the nulligravid group and 62.50% (n = 5) of both the parous and matched group participating. All three groups also considered cycling and Pilates as additional training. However, no parous participants indicated that they swam. The heading, “Other”, in Figure 4.2.4 included cross-fit training, squash, tennis, aerobics, spinning, cardio workouts in the gymnasium, high intensity interval training as well as maintenance rehabilitation under the supervision of a Biokineticist. No significant difference was noted for any category when the parous and matched group was compared (Appendix I).

4.2.2.4. The number of days participants engaged in additional training

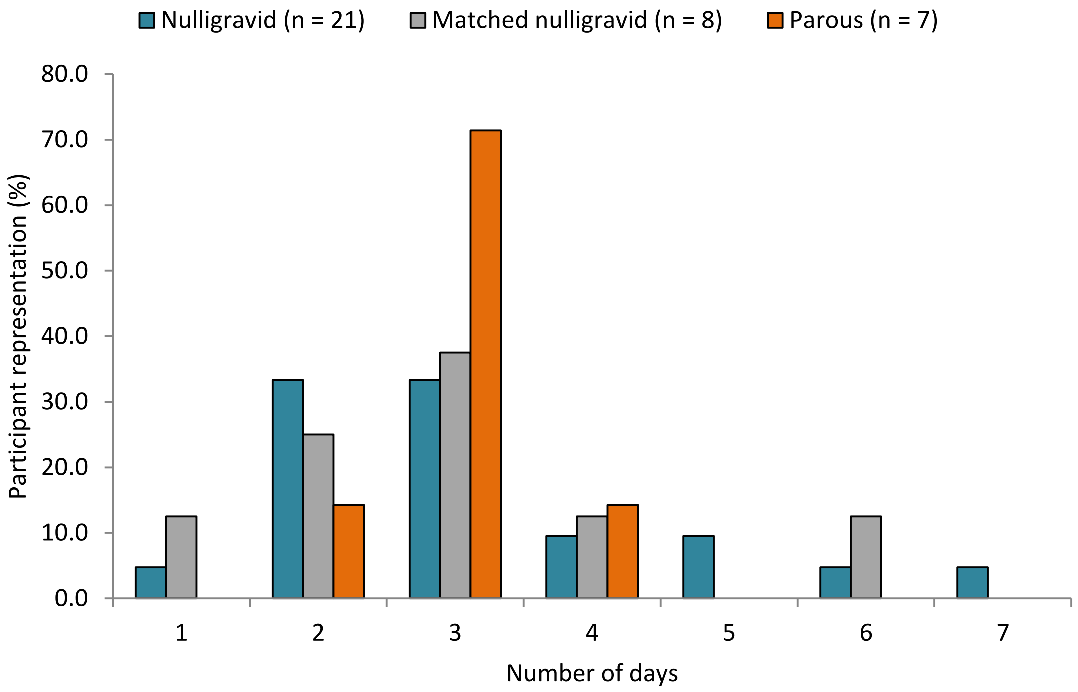

Figure 4.2.5: Number of days participants engaged in additional training

Most nulligravid participants (n = 7) partook in two to three days of additional training per week while the majority of both the parous (71.4% , n = 5) and matched (37.5% , n = 3) groups participated in additional training for three days a week. Only isolated cases of additional training below or above two to three days per week were reported across all three groups. No statistical significance [95% CI: - 2 ; 3] was seen for the median difference in additional training of the matched and parous group.

4.2.3. Parous profiles and histories

As previously mentioned eight participants had given birth before and were included in the parous group. The following information was obtained pertaining to the birth history of their children. The majority of the parous group (87.5% , n = 7), had given birth to two children while only 12.5% (n = 1) had given birth to three children. More than half of the parous group (75% , n = 6) had given natural birth to their child/children, while only 25% (n = 2) had undergone a caesarean section.

Table 4.2.1: Post-maternal history of parous participants (n = 8)

	Min	Q_1	Median	Q_3	Max
Time since last birth	6 months	9 months	3 years	9½ years	17 years
Return to run following birth	1 month	1½ month	5 months	1 year	1 year

The parous group was asked to state how long ago the birth of their last child was, as well as when they returned to running after the birth of their last child. The minimum and maximum number of years after the birth of their last child ranged between six months to 17 years respectively. All parous participants returned to running within one year of giving birth to their last child. The participant to return to running the soonest did so after one month following delivery. Only four parous participants reported to have engaged in abdominal exercises following their births. Two participants engaged in Pilates, while single participants engaged in cross-fit core strengthening exercises, Kegel exercises and sit-ups/crunches respectively.

4.3. INJURY PROFILES

4.3.1. Injury history of participants

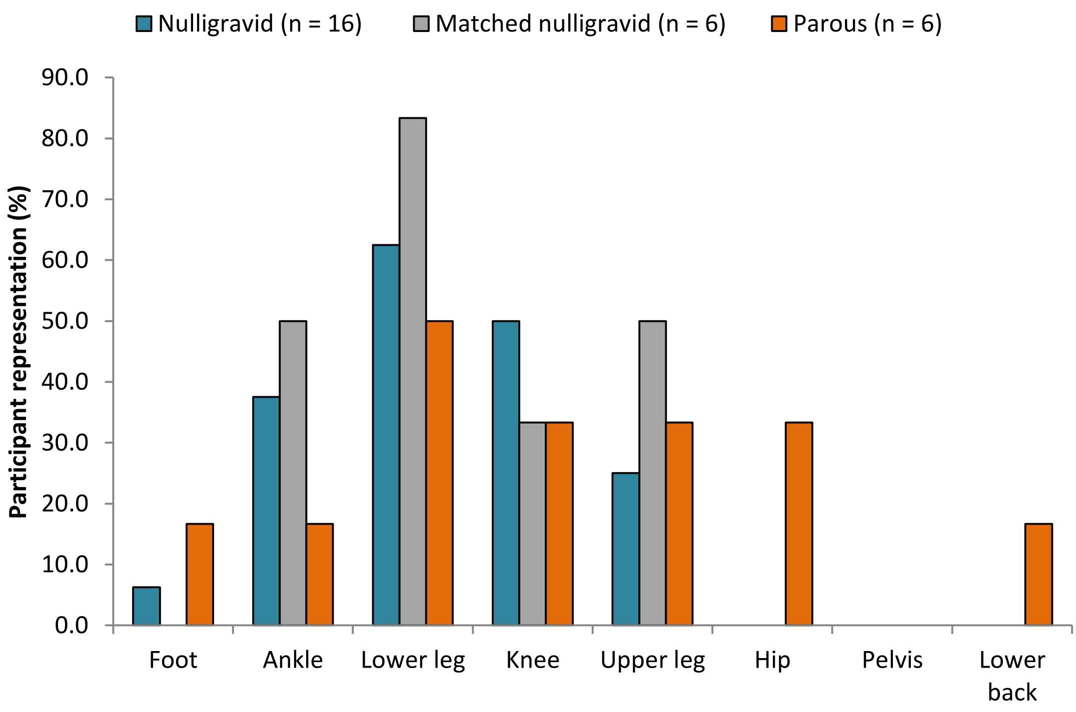

Figure 4.3.1: Reported previous sport-related injuries

All participants were asked to complete a few questions regarding sport-related injuries. However, only 16 participants from the nulligravid group, seven from the matched group and six from the parous group had experienced sport-related injuries. Although seven matched participants reported injuries only six matched participants could be paired with the six parous participants as seen in Figure 4.3.1. When the matched and parous group were compared as to the number of participants to experience sport-related injuries, no significant difference [95% CI: - 45.9% ; 22.8%] was seen. All the injuries described by the participants were grouped according to the body region where the injury was sustained (Section 3.3.3.2).

Lower leg injuries constituted the highest percentage in all three groups with 62.5% (n = 10), 83.3% (n = 5) and 50% (n = 3) for the nulligravid, matched and parous groups respectively. Knee injuries (50% , n = 8) and ankle injuries (37.5% , n = 6) were also among the most common injured body regions in the nulligravid group. The parous group however had knee, upper leg and hip injuries all as the second highest at 33.3% (n = 2). No participants reported pelvis injuries. Two isolated injuries, one being an infraspinatus tear and the other described as “general joint stiffness” were not depicted in Figure 4.3.1, although it was included in the statistical analyses. Parous participants were then asked if they experienced sport-related injuries before or after the birth of their children. Only two participants reported that all their injuries were sustained after the birth of their children.

4.3.2. Treatment received for sport-related injuries

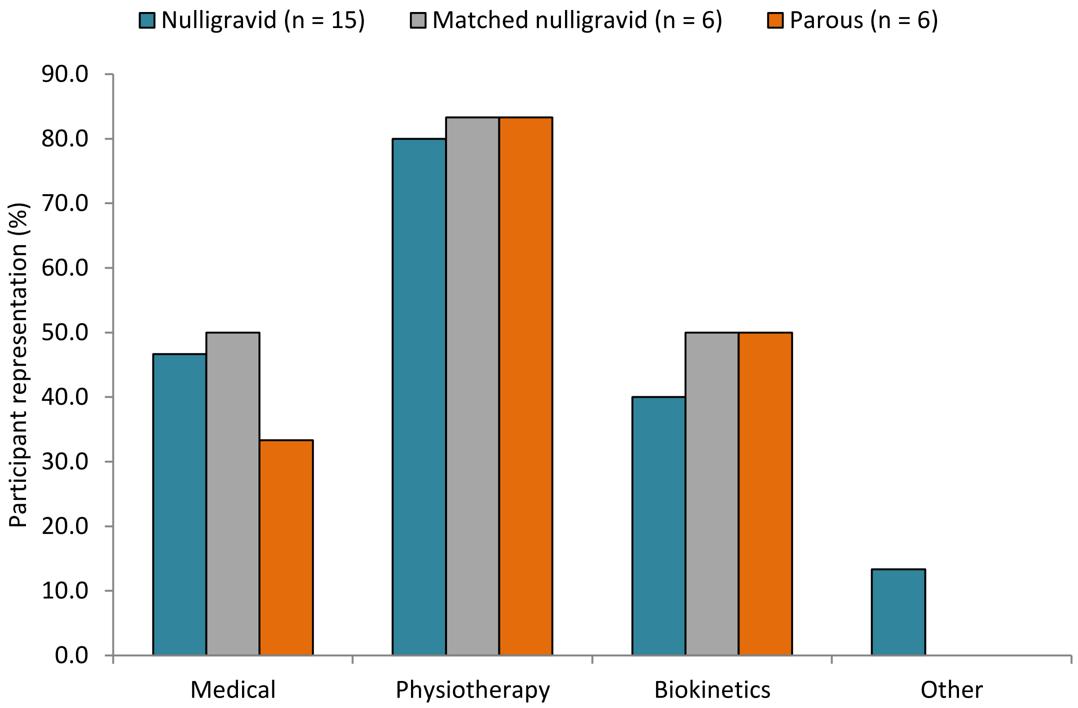

Figure 4.3.2: Sources of treatment for sport-related injuries sustained by participants

Physiotherapy treatment was the most popular treatment source by all participants who had experienced sport-related injuries. The nulligravid group indicated that 80% (n = 12) of the injured participants received physiotherapy treatment as well as 83.3 % (n = 5) of both the matched and parous group. Medical and biokinetic treatment seemed to be on a par between the various groups with two nulligravid participants having specified other treatment options which included the chiropractor and surgery.

4.4. TRUNK MOTOR CONTROL

4.4.1. Surface EMG of the PFM

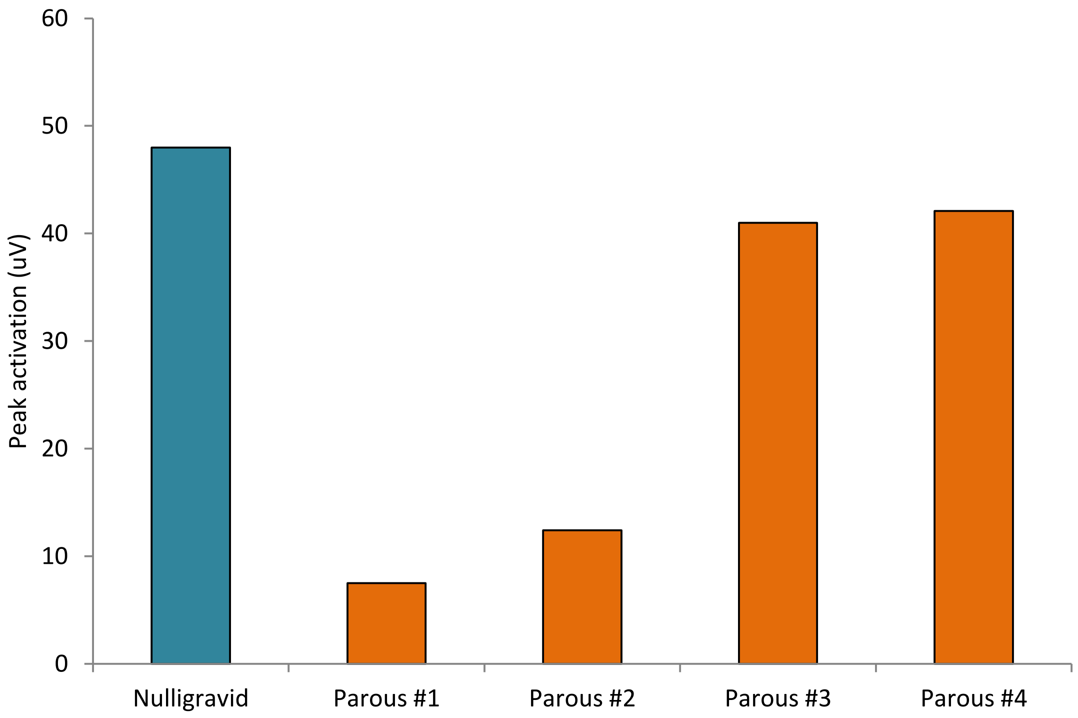

Figure 4.4.1: Peak activation of the pelvic floor muscles during a 10sec maximum voluntary contraction

A very small percentage of the study population (n = 5) gave consent for the pelvic floor muscle (PFM) surface electromyography (EMG) test. Only one nulligravid participant was tested along with four parous participants. Reasons for this finding are discussed in Section 6.5. The values depicted in Figure 4.4.1 are the averages taken from the peak activations within three trials (Section 3.3.1.1). The peak activation of the nulligravid participant (48uV) was higher than the value recorded by the Parous #4 (42uV) who had the highest value in the parous group. The minimum value of the parous group was 8uV while the median was 27uV (Q_1: 11uV ; Q_3: 41uV). As none of the matched nulligravid participants consented to this facet of the data collection procedure, statistical comparisons were not possible.

4.4.2. Endurance of the PFM measured by surface EMG

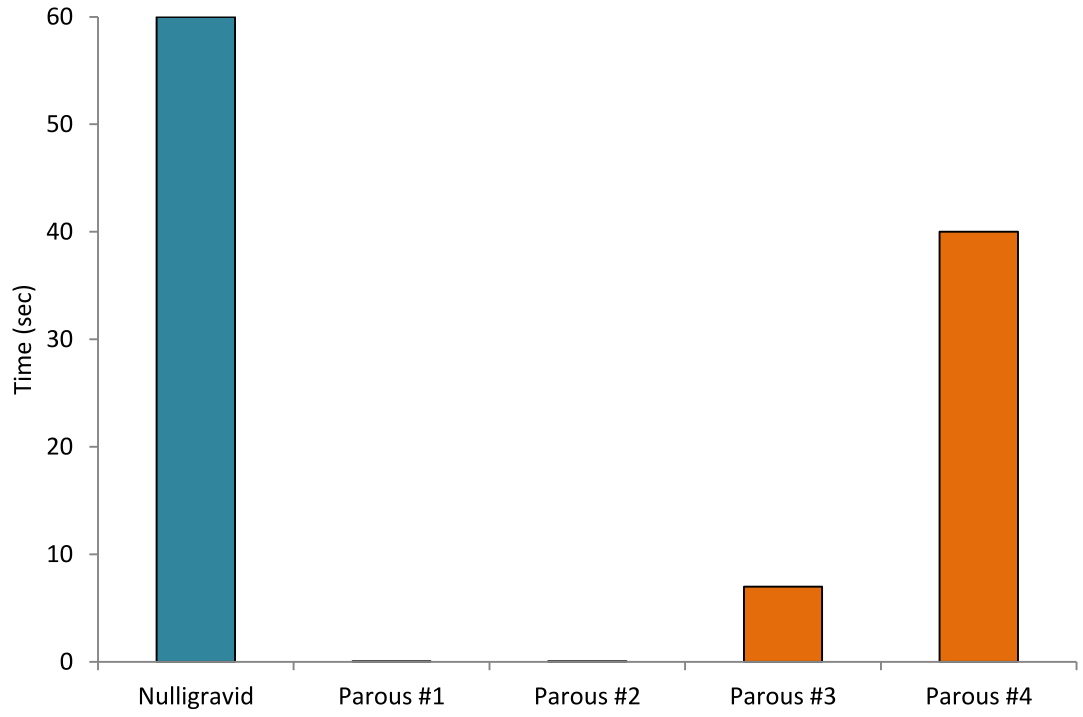

Figure 4.4.2: Endurance of the pelvic floor muscles to sustain 60% of the maximum voluntary contraction

Similarly to Figure 4.4.1 only five participants were measured, one nulligravid participant and four parous participants. The nulligravid participant held 60% of the maximal voluntary contraction (MVC) for the maximum required duration of 60 seconds (Section 3.3.1.1). Of the four parous participants, two scored 0 for the endurance test while the maximum for the parous group was 40 seconds. This was substantially lower than the 60 seconds achieved by the nulligravid participant.

4.4.3. PERFECT test for the PFM

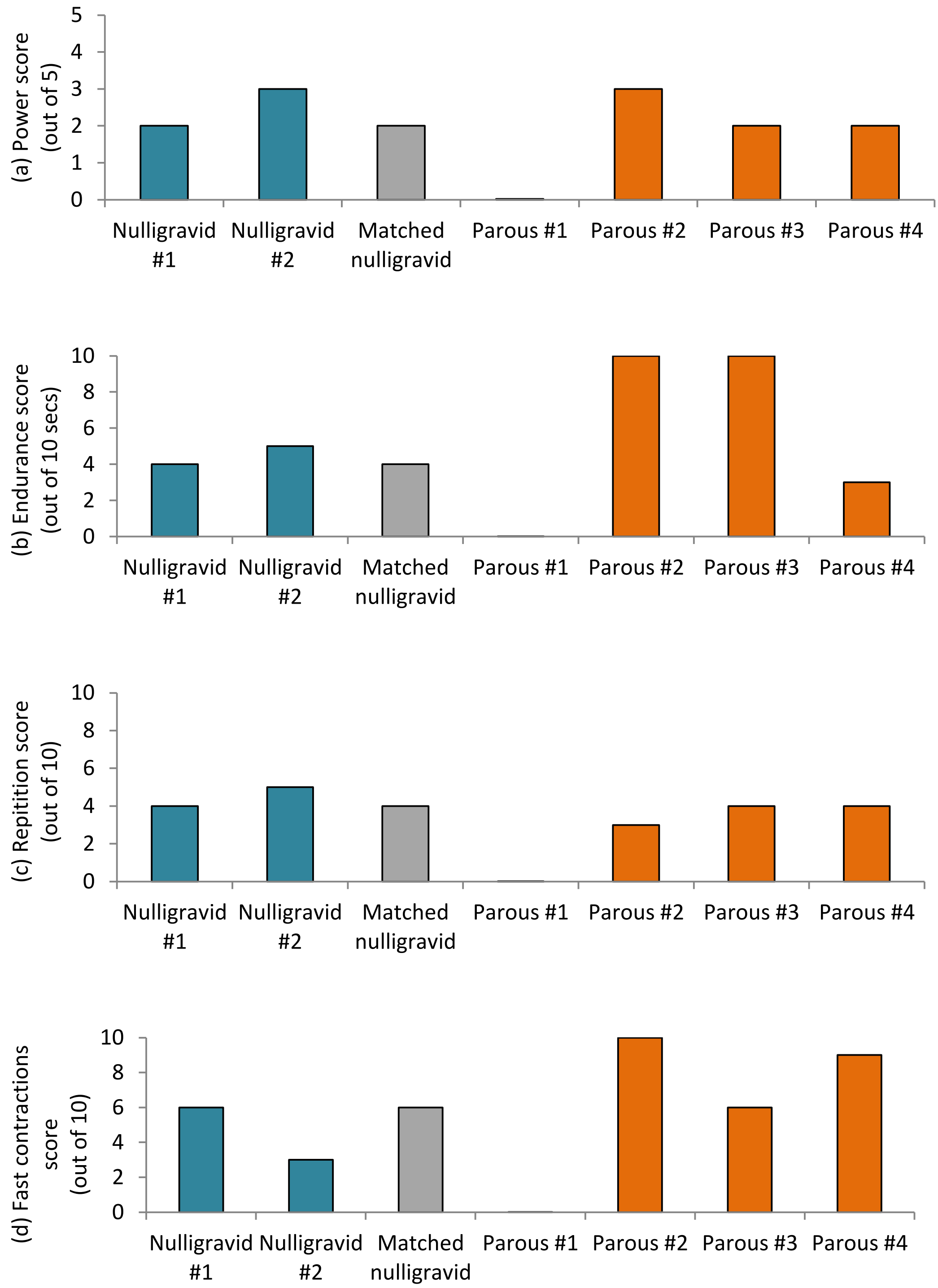

Figure 4.4.3 a-d: PERFECT test scores for pelvic floor power, endurance, repetition and fast contractions respectively

During the PERFECT (Power Endurance Repetitions Fast contractions Every Contraction Timed) test, two nulligravid and four parous participants were tested. One of the nulligravid participants was also the participant in the matched group. For the power test (Figure 4.4.3.a) the pelvic floor strength was rated out of 5. The maximum for both the nulligravid and parous group was 3/5, but the matched participant only obtained a 2/5 which was less than the maximum of the parous group. For the endurance test (Figure 4.4.3.b), the maximum for the nulligravid participants was 5 seconds while two parous participants scored the maximum of 10 seconds. The matched participant could only hold the MVC for 4 seconds. For the repetitions test (Figure 4.4.3.c), the nulligravid participant scored a maximum of 5/10 while the parous group and the matched participant were evenly matched with a maximum of 4/10. The last test, fast contractions (Figure 4.4.3.d), saw the parous group have a maximum of 10/10 while the minimum, 6/10 was equal to the maximum of both the nulligravid group and the matched participant. One of the parous participants scored a 0 in all four tests of the PERFECT scale. Due to the limited number of participants being matched for these tests, the 95% CI was not calculated.

4.4.4. Surface EMG of the TrA

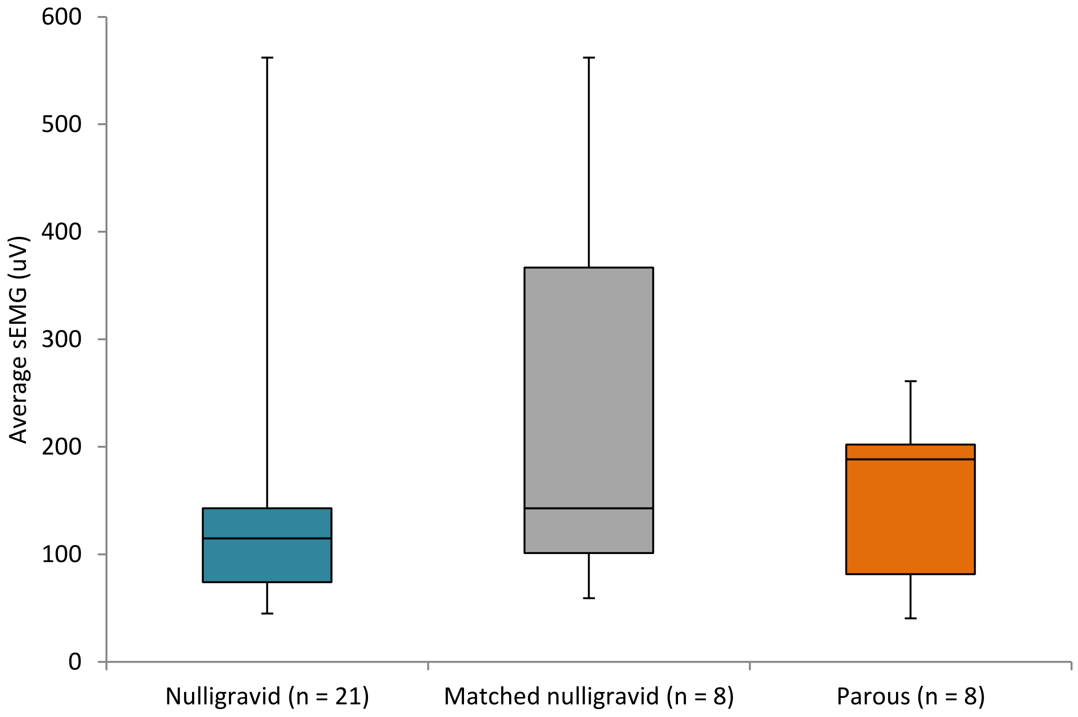

Figure 4.4.4: The average activation of the Transverse Abdominis

Interestingly for the surface EMG of the Transversus Abdominis (TrA), the nulligravid group had the lowest median of 115uV (Q_1: 74 ; Q_3: 143) while the parous group had the highest median of 189uV (Q_1: 82 ; Q_3: 202). The matched nulligravid group achieved a median activation of 143uV (Q_1: 101 ; Q_3: 367). The parous group however also had the lowest reading with 41uV but when looking at the data ranges of all the groups, the parous group had the least extreme ranges. No statistical significance was found when the median of the matched and parous groups were compared [95% CI: - 201.3 ; 504.5].

4.4.5. Prone PBU test

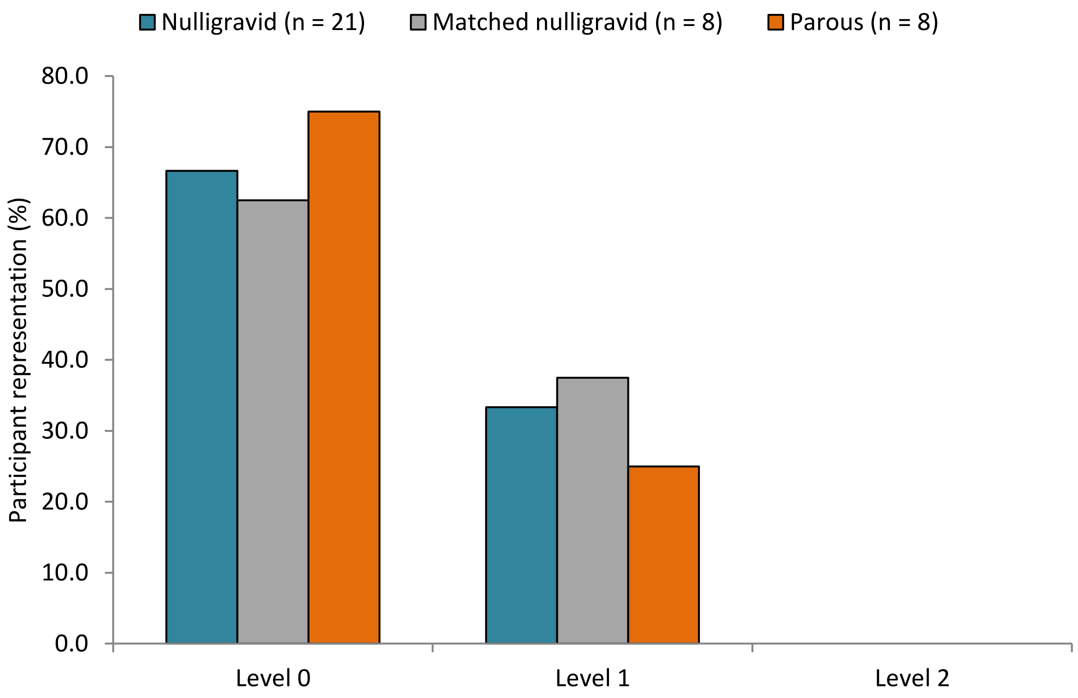

Figure 4.4.5: The average level reached during the prone pressure biofeedback unit test

While performing the pressure biofeedback unit (PBU) test, each participant had three trials and the average of these trials is depicted in the graph above (Figure 4.4.5). The highest level reached by any participant, when averaging three different attempts, was Level 1. The nulligravid group had 33.3% (n = 7) of its participants reach Level 1, while 66.7% (n = 14) remained on Level 0. The matched group had the highest percentage of participants reaching Level 1 with 37.5% (n = 3) and 62.5% (n = 5) remaining on Level 0.The parous group had the lowest percentage (25% , n = 2) of participants to reach Level 1 and the highest percentage (75% , n = 6) of participants at level 0. No significant difference [95% CI: - 1 ; 1] was found when comparing the matched and parous groups.

4.4.6. The Sahrmann core stability test

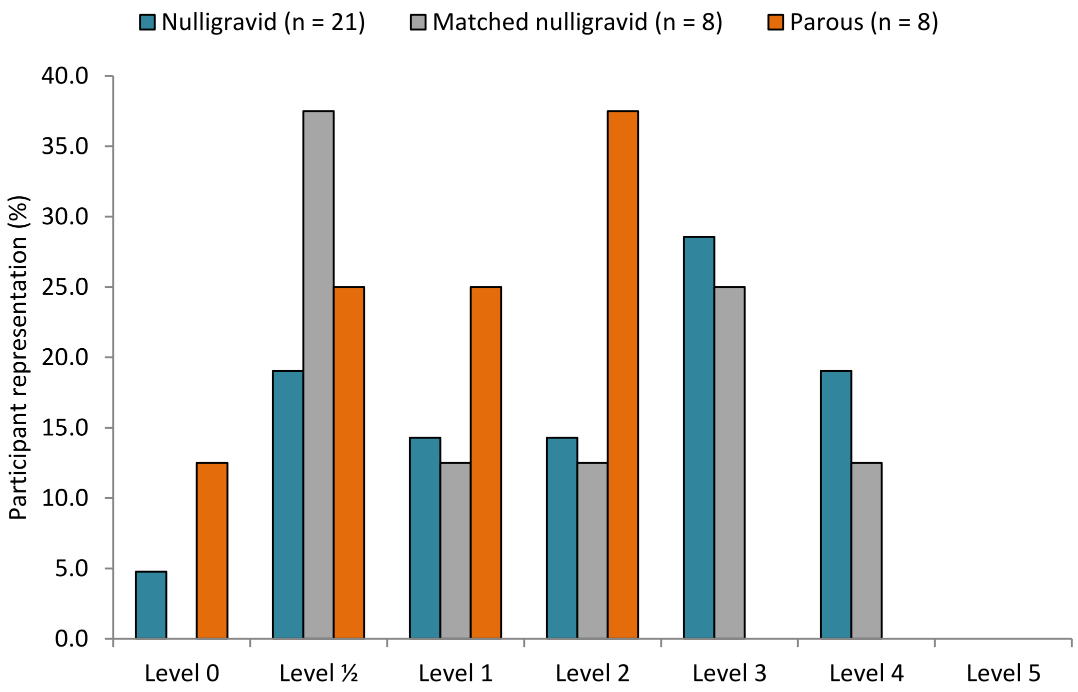

Figure 4.4.6: The average level reached in the Sahrmann core stability test

Each participant performed three trials of the Sahrmann test. The average from the three trials was calculated and reported in Figure 4.4.6. The highest level possible was Level 5 but no participant reached this level. Level 4 was the highest level reached by the nulligravid and matched group however, the parous group only reached Level 2. The level reached by the most number of participants in each group was Level 3 for the nulligravid group (28.6%, n = 6), Level 0.5 for the matched group (37.5%, n = 3) and Level 2 for the parous group (37.5% , n = 3). No statistical significance [95% CI: - 2.5 ; 2] was found when comparing the performance of the parous and matched groups to one another.

4.4.7. The ASLR

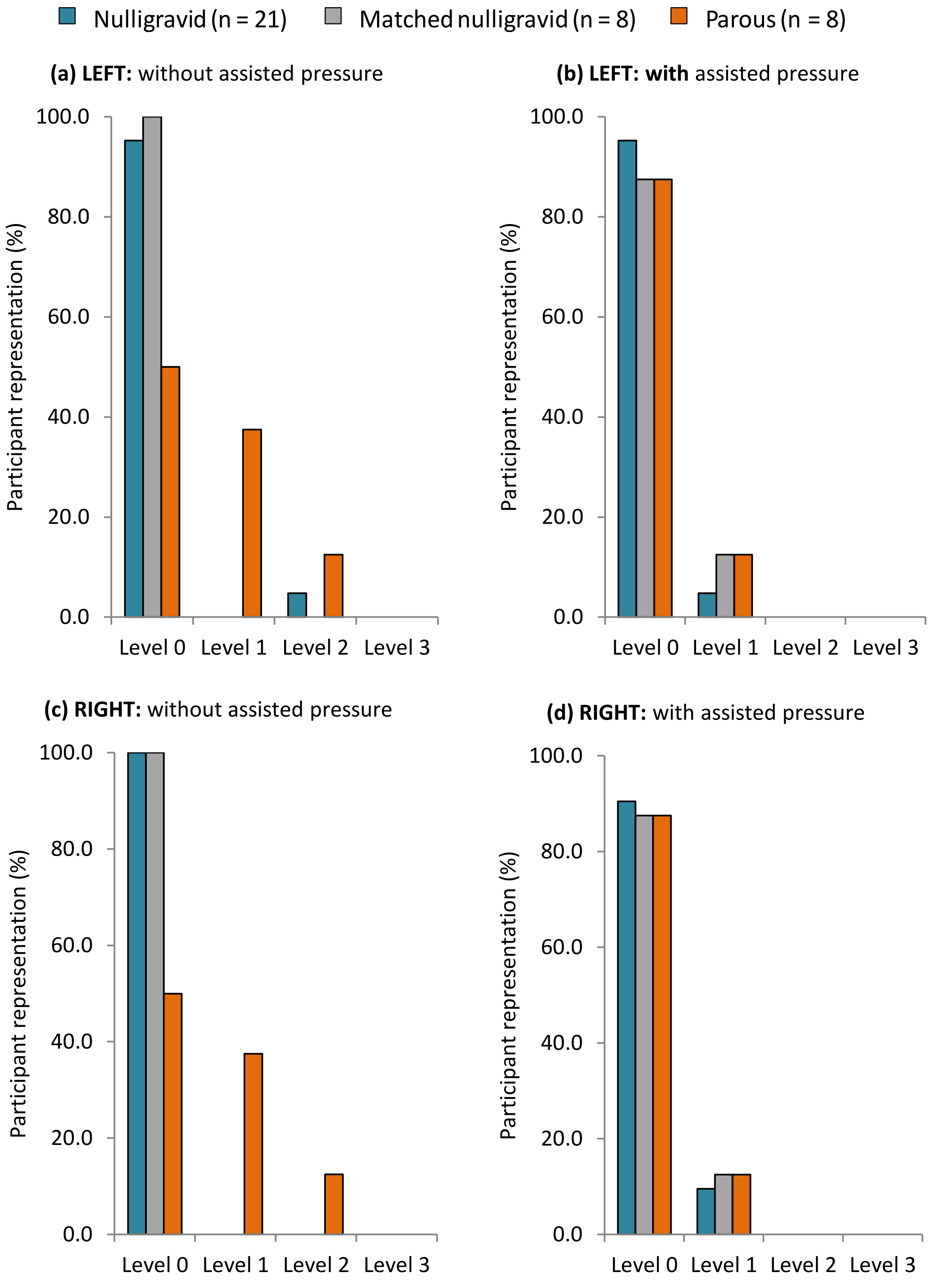

Figure 4.4.7 a-d: Levels reached during the active straight leg raise test for the left and right side, without and with assisted pressure

During the active straight leg raise (ASLR) test Level 0 indicated that no difficulty was experienced during the test, while Level 1-3 indicated some difficulty was experienced or impairment was observed (Section 3.3.1.1). When the left leg was tested without assisted pressure (Figure 4.4.7.a), 95.2% (n = 20) of the nulligravid group, 100% (n = 8) of the matched group and only 50% (n = 4) of the parous group attained a Level 0. When assisted pressure was applied on the left side (Figure 4.4.7.b), the same percentage of nulligravid participants (95.2% , n = 20) attained a Level 0 while an increased number of parous participants (87.5% , n = 7) attained a Level 0. The nulligravid participant that obtained a Level 2 in Figure 4.4.7.a however, moved up to Level 1 in Figure 4.4.7.b. In contrast the matched group attaining a Level 0 in Figure 4.4.7.a decreased from 100% (n = 8) to 87.5% (n = 7) in graph Figure 4.4.7.b.

When the right leg was tested without assisted pressure (Figure 4.4.7.c), 100% of participants from both the nulligravid (n = 21) and matched group (n = 8) attained a Level 0. Once again only 50% (n = 4) of the parous group obtained a Level 0. When the assisted pressure was added on the right side (Figure 4.4.7.d), the parous group increased from 50% (n = 4) to 87.5% (n = 7) at a Level 0. However both the nulligravid and matched group decreased slightly.

4.4.8. The sport specific plank test

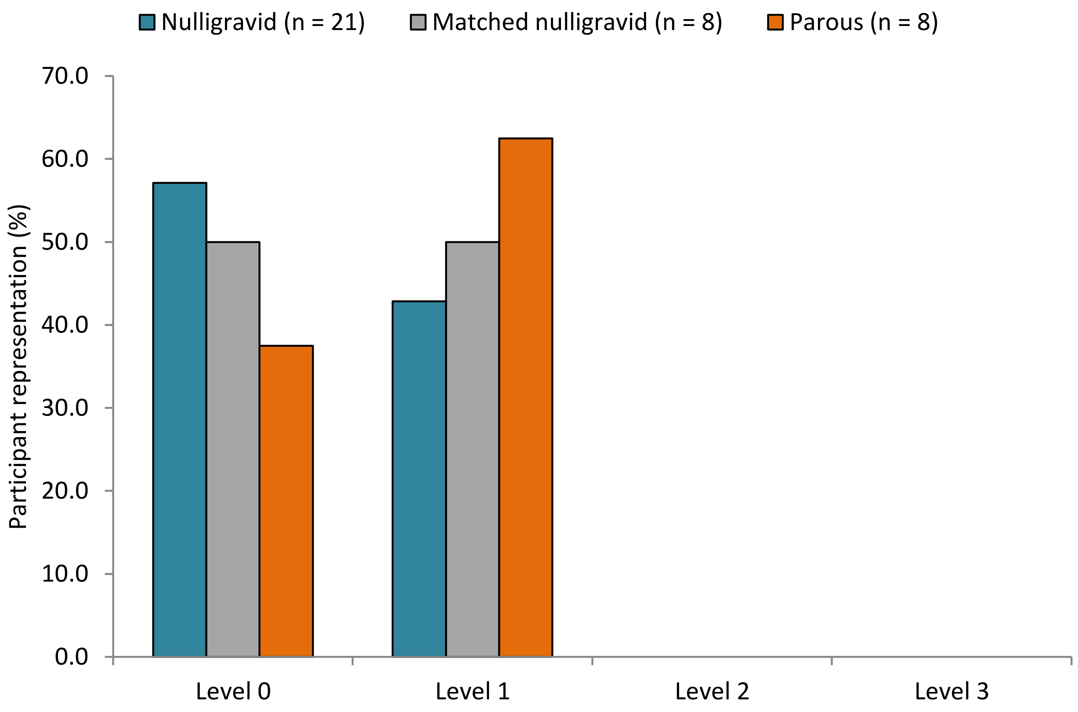

Figure 4.4.8: Level reached in the sport specific plank test

The highest level achieved by any participant in the sport specific plank was a Level 1. The parous group had the highest percentage of participants (62.5% , n = 5) reaching Level 1, followed by the matched group (50% , n = 4) and then the nulligravid group (42.9% , n = 9).

4.4.9. Time recorded for the single leg stand test

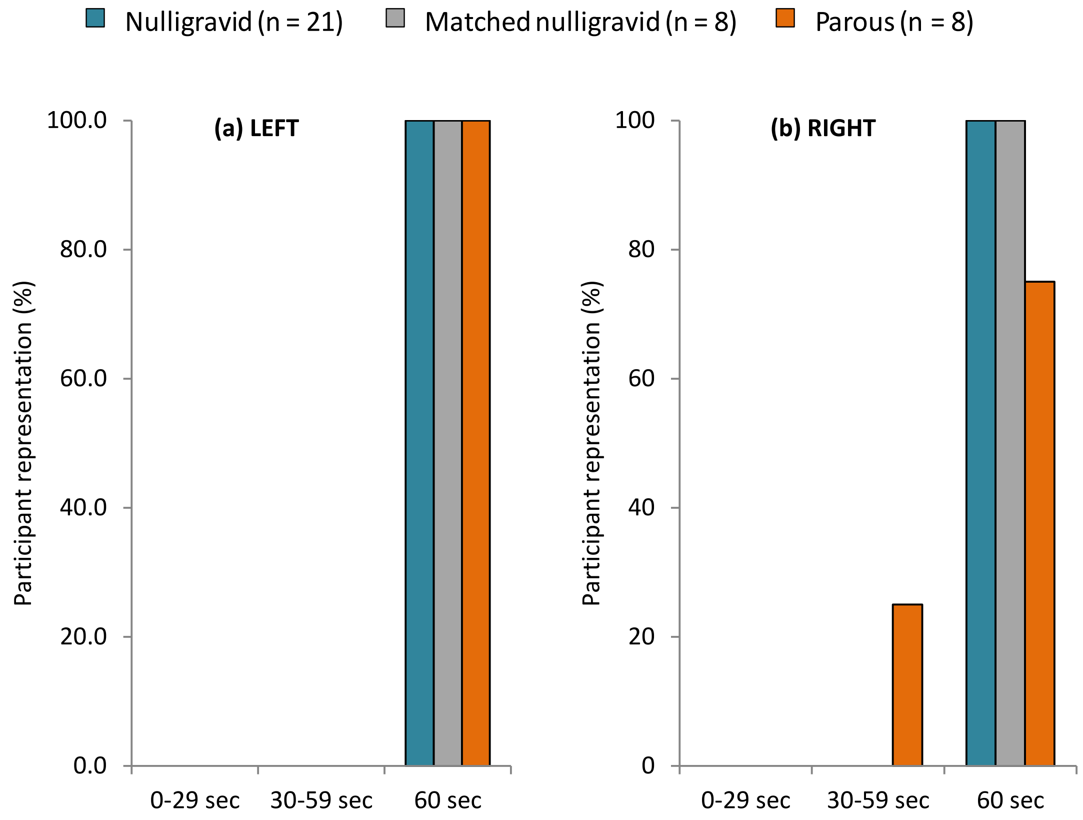

Figure 4.4.9 a-b: Durations achieved during the single leg stand test for the left and right sides respectively

All participants were able to hold their balance on their left leg for 60 seconds (Figure 4.4.9.a), but two participants from the parous group could not complete the full 60 seconds on the right leg (Figure 4.4.9.b). Even though the matched nulligravid group showed a tendency to reach longer durations on the right side which neared significance [95% CI: 0 ; 30], a statistical difference could not be established.

4.4.10. Grading of the single leg stand test

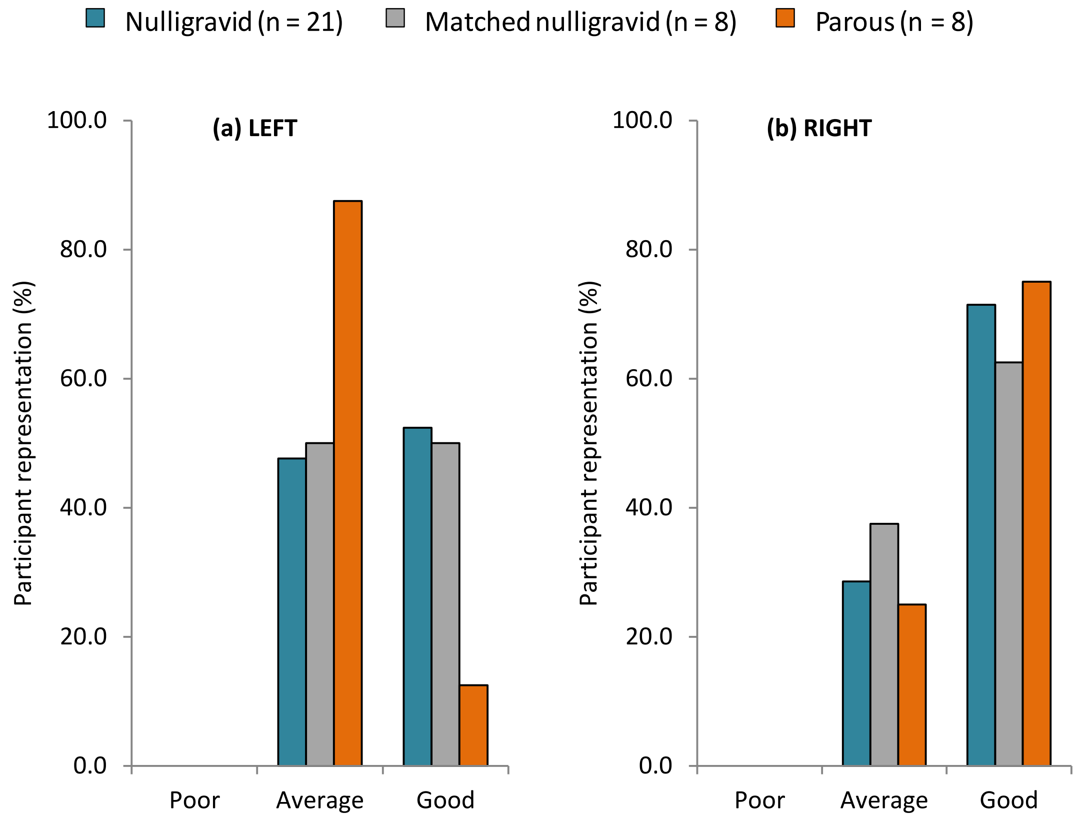

Figure 4.4.10 a-b: Subjective performance grading of the single leg stand test for the left and right sides respectively

When participants performed the single leg stand, they were graded on a scale of poor, average or good (Section 3.3.1.1). The nulligravid group had the highest percentage (52.4% , n = 11) of participants with a good rating in single leg standing on the left leg (Figure 4.4.10.a). The matched group followed with 50% (n = 4) and the parous group with only 12.5% (n = 1). The majority of the parous participants (87.5% , n = 7) scored an average rating for single leg standing on the left leg (Figure 4.4.10.a). However the parous group fared the best in the grading of single leg standing on the right leg (Figure 4.4.10.b), with 75% (n = 6) of the participants obtaining a good rating, followed by the nulligravid group with 71.4% (n = 15) and the matched group with 62.5% (n = 5). All three groups fared better on the right leg than on the left leg. No participant in all three groups was rated as poor during the single leg stand test. No statistical significance was seen when the parous and matched groups were compared for the grading of the single leg stand test on the left side [95% CI: - 15% ; 71.2%] or on the right side [95% CI: - 29.1% ; 49.1%] (Figure 4.4.10.a-b).

4.4.11. Deviations observed during the single leg stand test

Table 4.4.1: Observed deviations during the single leg stand test

Deviation	Nulligravid (n = 21)		Matched nulligravid (n = 8)		Parous (n = 8)	
	Left	Right	Left	Right	Left	Right
Leg internal rotation	57.1	42.9	37.5	37.5	37.5	50.0
Lateral trunk flexion	23.8	0.0	25.0	0.0	87.5	12.5
Ipsilateral hip hiking	9.5	4.8	0.0	0.0	12.5	0.0
Contralateral pelvic drop	38.1	23.8	50.0	25.0	25.0	12.5
Foot supination/pronation	4.8	4.8	12.5	12.5	0.0	0.0
Knee hyperextension	0.0	0.0	0.0	0.0	0.0	12.5
Balance with arms	0.0	0.0	0.0	0.0	12.5	12.5

The deviation seen in most nulligravid participants when standing on the left leg was leg internal rotation (57.1% , n = 12), while contralateral pelvic drop (50% , n = 4) and lateral trunk flexion (87.5% , n = 7) had the highest percentage in the matched group and parous group respectively. On the right leg all the groups had a majority in the same deviation, leg internal rotation, with the nulligravid group at 42.9% (n = 9), 37.5% (n = 3) and 50% (n = 4) for the matched and parous group respectively. Throughout all three groups on both the left and right leg, internal leg rotation was the most common deviation noted.

4.4.12. Grading of the unilateral squat test

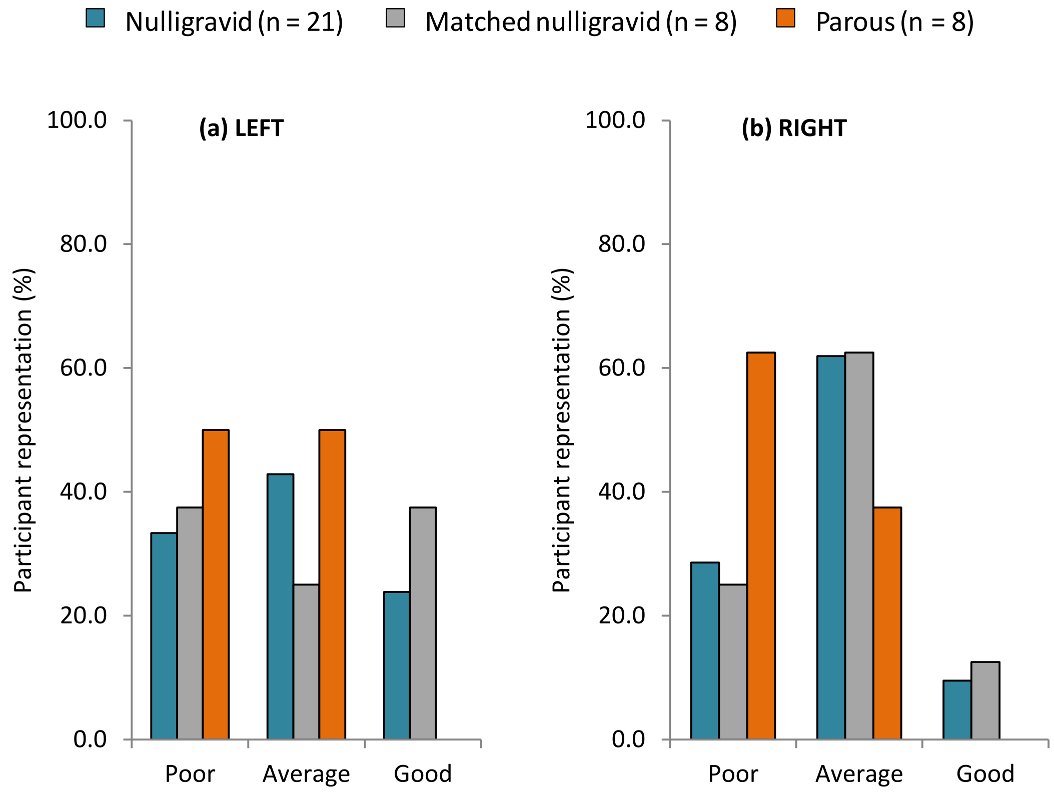

Figure 4.4.11 a-b: Subjective grading of the unilateral squat performance for the left and right sides respectively

When participants performed a unilateral squat, they were graded on a scale of poor, average or good (Section 3.3.1.1). When performing the squat on the left leg (Figure 4.4.11.a) 23.8% (n = 5) of the nulligravid group's unilateral squat performance was graded as good, with most participants 42.9% (n = 9) rated as average and 33.3% (n = 7) were rated as poor. The matched group had the highest percentage of participants to reach a good rating with 37.5% (n = 3) on the left side. The parous group was split in half with 50% (n = 4) reaching an average rating while the other 50% (n = 4) could only manage a poor rating on the left side. When the 95% CI was calculated between the parous and matched group, the good and average rated percentages were grouped together. A statistically significant difference [95% CI: - 1.5% ; - 7.45] was found between the performances of the matched group and the parous group. However, to compare the groups more accurately, the ratings were not grouped and the Bhapkar's test (Bhapkar 1966) was used to determine a p-value of 0.3, which indicated no significance in contrast to the 95% CI.

When performing the same test on the right leg (Figure 4.4.11.b) the matched group once again had the highest percentage of participants reaching a good rating with 12.5% (n = 1) although the percentage did decrease from the left side 37.5% (n = 3) (Figure 4.4.11.a). The nulligravid group had a higher percentage of their participants reach an average rating on the right side (61.9% , n = 13) but only 9.5% (n = 2) achieved a good rating which decreased from 23.8% (n = 5) on the left side (Figure 4.4.11.a). In the nulligravid group 28.6% (n = 6) were rated as poor. The majority of the parous group only attained a poor rating 62.5% (n = 5) while the rest reached an average rating 37.5% (n = 3). Once again for the 95% CI, the good and average ratings were grouped together and it was found that the matched group performed statistically significantly better than the parous group with the ratings of a right leg squat, [95% CI: - 4.5% ; - 11.9%]. Once again the Bhapkar's test indicated no significant difference (p = 0.45) when the ratings were not grouped together.

4.4.13. Deviations observed during the unilateral squat test

Table 4.4.2: Observed deviations during the unilateral squat test

Deviation	Nulligravid (n = 21)		Matched nulligravid (n = 8)		Parous (n = 8)	
	Left	Right	Left	Right	Left	Right
Knee valgus	4.8	4.8	0.0	0.0	0.0	0.0
Corkscrewing	38.1	33.3	37.5	25.0	50.0	62.5
Knee tremor	19.0	38.1	12.5	50.0	37.5	25.0
Upper limb stabilisation	4.8	0.0	0.0	0.0	0.0	0.0
Decreased hip control	9.5	4.8	25.0	12.5	0.0	0.0

During the unilateral squat on the left and right leg certain deviations were noted which are seen in Table 4.4.2. For the left unilateral squat it was seen that most participants in all three groups had a corkscrewing deviation with 38.1% (n = 8) for the nulligravid group, 37.5% (n = 3) for the matched group and 50% (n = 4) for the parous group.

During the right unilateral squat most participants in the nulligravid group had a knee tremor (38.1% , n = 8), followed closely by the corkscrewing deviation at 33.3% (n = 7). The matched group had the same pattern as the nulligravid group with the majority having a knee tremor (50% , n = 4), followed by the corkscrewing deviation (25% , n = 2). The parous group had a majority recorded with a corkscrewing deviation (62.5% , n = 5) which increased from 50% (n = 4) on the left side, followed by 25% (n = 2) displaying a knee tremor which was the only other deviation noted in this group.

4.5. SUMMARY

The results of the questionnaire, as well as the tests performed by all the participants in the study, have been laid out in Chapter four. In the next chapter the relevance of these results are discussed in relation to the aims of the study.

CHAPTER 5.

DISCUSSION

The results captured in Chapter four have highlighted a few points of interest.

5.1. DEMOGRAPHICS

The 29 participants who volunteered for this study included 21 nulligravid participants and eight parous participants. Eight nulligravid participants were selected and paired with the eight parous participants by using certain criteria (Section 3.3.3) to make the comparison of results more accurate. The criteria included the age of participants, frequency and type of training and their injury profile. The parous group constituted less than a third (27.5%) of the total study sample. Possible explanations for this could include that parents are usually less active than non-parents (Bellows-riecken & Rhodes 2008), mothers possibly ran less and did not qualify for the study (Section 3.2.3), or the public places where the advertisements were displayed (Section 3.3.2) did not attract the attention of mothers. It is therefore advised that the future studies involving mothers should carefully consider the most appropriate venues to place participant recruitment advertisements or consider other ways of recruitment.

As seen in Figure 4.2.1 the nulligravid group was significantly younger than the parous group with a median age of 26 years and 34 years respectively. This could be expected as child bearing years are generally associated with being older in age although, females between the age of 20 to 24 years in South Africa had the highest birth rate in 2011 (Statistics 2011). However, the age difference did not have a big impact on the number of days that participants ran during the week. The nulligravid and parous groups were fairly evenly matched on their activity status as the majority of participants in both groups ran three days a week (Figure 4.2.2). The nulligravid group did however indicate a few extreme participants running between five to eight hours a week. A possible explanation for this could be that the nulligravid participants had more time on their hands to run and be active (Bellows-riecken & Rhodes 2008) compared to mothers with children. Most participants in all three groups also indicated that they participated in additional training three times per week with the nulligravid and matched groups both showing a few isolated cases of more extreme training between six to seven days a week (Figure 4.2.5). This can once again indicate that these two groups of participants had more time to engage in additional training as well as their running programme. Resistance training was the most common adjunct to the participants' weekly running programme (Figure 4.2.4).

Interestingly, natural birth was the most common form of delivery found amongst the parous group, which is in contrast to the general trend of extremely high caesarean births in South Africa (James et al. 2012). The time that had passed since the birth of the parous participants' last child varied from six months to 17 years ago. This could be paralleled to the minimum and maximum age of the sample group (Figure 4.2.1) which was 26 to 42 years old, since the difference was 16 years on both accounts. After child birth only four parous participants reported to have engaged in specific abdominal exercises, although all returned to running within the guidelines of Artal & O'Toole (2003) (Section 2.5.2).

5.2. INJURY PROFILES

5.2.1. Injuries and parity

Pregnancy has been found to affect the abdominal muscles (Gilleard & Brown 1996), the pelvic floor muscles (Van Veelen et al. 2014) and the anterior abdominal fascia (Lee et al. 2008). Together with the weight gained during pregnancy, a combination of these aspects could possibly negatively affect weight bearing joints (Artal & O'Toole 2003) (Section 2.5.1). These structural changes that occur during pregnancy are associated with decreased functional abilities up to eight weeks postpartum which contribute to a reduction in the ability to stabilise the pelvis (Gilleard & Brown 1996). The stability of the spine, during forceful or high velocity movements of the trunk and limbs, is believed to play a vital role in preventing injuries (Brown 2006). Therefore as female athletes have been found to have decreased core stability when compared to their male counterparts (Leetun et al. 2004, Sharrock et al. 2011), pregnancy which further compromises pelvic stability was considered to increase the risk of injury. However, no literature was found directly linking parity as a risk factor for injuries in female recreational runners.

In this study not all participants reported to have experienced sport-related injuries. In the respective groups, 76.2% (n = 16) of the nulligravid group, 87.5% (n = 7) of the matched group and 75% (n = 6) of the parous group reported sport-related injuries. From this it is clear that the matched nulligravid group had the highest proportion of sports injuries compared to the nulligravid group as a whole, as well as the parous group. Considering that female athletes are generally more prone to sustain sports injuries (Taunton et al. 2002, Zazulak et al. 2007 & Leetun et al. 2004) and that parity could increase this risk, it was interesting that the findings from this study indicated that the parous group had the lowest percentage of injuries. This could possibly be attributed to the small sample group, that certain participants did not understand what sport-related injuries entailed or that the nulligravid group, who had a tendency for more extreme ranges regarding the number of days and amount of time that participants exercised (Figure 4.2.2, Figure 4.2.3), was more prone to injuries.

5.2.2. Injuries of specific body regions

Once the injuries were classified into different body regions (Section 3.3.3.2), the lower leg injuries were found to be the most common injury site amongst all three groups of participants. The injuries included in this category were recorded by participants as shin splints, compartment syndrome, calf strain, stress fractures and Achilles tendon injury which can therefore mostly be classified as overuse type of injuries. Knee injuries, classified as a separate anatomical site, was the second most common type of injuries in both the nulligravid and parous groups. In the study by Junior et al. (2013) muscular related injuries were found to be the most common in recreational runners with the knee as the most affected anatomical site (Section 2.4.1). In this study the injuries were not classified into the structure it affected (muscular), but as seen above the majority of lower leg injuries included a muscular component. The knee as the most affected anatomical site was congruent with what was found by Junior et al. (2013).

The parous population was the only group to report hip and lower back injuries. Only one case of each was recorded in the parous group. The parous participant to complain of a lower back injury indicated she sustained it before child birth. It could be expected that parous participants would have reported having lower back pain postpartum (Wu et al. 2004) but it is unclear whether the participants really did not have any lower back injuries or possibly did not consider it to be a sport-related injury. It is suggested that a clear definition of what constitutes as a sport injury be included in future questionnaires.

Two parous participants reported that they sustained sport-related injuries after child birth. These injuries included bilateral knee injuries, a left hip injury, left foot injury, a right Achilles tendon injury and bilateral calf pain. Both of them indicated that they experienced no injuries before child birth. An increase in injuries postpartum could possibly indicate that their core stability was not returned to optimal functioning and strength after pregnancy and child birth (Gilleard & Brown 1996), which could increase their risk of injury (Leetun et al. 2004). Both the participants delivered their children naturally which could have led to decreased pelvic floor muscle (PFM) strength and endurance postpartum (Hilde et al. 2013), influencing trunk motor control. Only one of the two participants who experienced sport-related injuries after child birth gave consent for the PFM tests. She scored 40uV for the surface electromyography (EMG) and 41 seconds on the endurance test, which was the second best and best score respectively amongst the parous participants. However, the sample group was very small for the PFM tests therefore no conclusion could be made.

Six of the eight parous participants had given birth naturally, indicating that four of the six parous participants reportedly did not sustain injuries after child birth. Therefore, in addition to the small sample size, no conclusions regarding the link between natural delivery and postpartum injuries in female recreational runners could be made. One of the participants sustaining sport-related injuries postpartum performed specific abdominal strengthening exercises (Pilates) after child birth. It is inconclusive whether postpartum injuries were obtained due to changes that occurred during pregnancy and labour, regarding aspects of motor control. However, the differences/lack thereof regarding motor control between parous and nulligravid participants will be further discussed in Section 5.3.

5.2.3. Treatment received for injuries

Only one nulligravid participant who had sustained a sport-related injury did not receive any treatment for it. Physiotherapy was the most popular treatment option for all participants who sustained sport-related injuries. This could be attributed to the association physiotherapy often has to sport.

5.3. TRUNK MOTOR CONTROL

The majority of participants were unwilling to give consent for the PFM tests which included the surface EMG test for peak activation and endurance, as well as the PERFECT (Power Endurance Repetitions Fast contractions Every Contraction Timed) test. Due to the invasive nature of the tests, this was expected and addressed in Section 3.3.4. However, only two nulligravid participants and four parous participants gave consent. One nulligravid participant found it too painful to perform the surface EMG test for peak activation and endurance. Taking all these factors into account it was difficult to make accurate comparisons between the nulligravid, matched and parous groups for these tests.

5.3.1. Surface EMG of the PFM

During the surface EMG test of the PFM, the nulligravid participant had a higher average peak activation (48uV) than the best performing parous participant (42uV) (Figure 4.4.1). Both these values are however higher than the average activity recorded (22.2uV) during a study of 17 healthy nulliparous females between the ages of 20 - 35 (Grape et al. 2009) (Section 3.3.1.1). Although it seemed that the nulligravid participant performed better, higher values recorded by the EMG indicate higher electrical activity in the muscle and not necessarily strength. The nulligravid participant also performed better in the endurance test. The participant could hold 60% of their maximum voluntary contraction (MVC) for the full 60 seconds while the best performing parous participant could only hold it for 40 seconds (Figure 4.4.2). Taking into account the factors mentioned above, it could be considered that parity may possibly have a negative influence on the peak activation and endurance of the PFM and should be investigated further in future research.

5.3.2. PERFECT test for PFM

During the PERFECT test, the groups seemed to be more evenly matched. The nulligravid and parous group both scored a maximum of 3/5 for the power test (Figure 4.4.3.a.), while the parous group scored higher for endurance than both the nulligravid and matched participant (Figure 4.4.3.b.). For the repetitions test the nulligravid participant scored 5/10 while both the matched and parous group scored a maximum of 4/10 (Figure 4.4.3.c.). The parous group once again performed better during the fast contractions test with a maximum of 10/10 while both the nulligravid and matched participant scored 6/10. One parous participant scored a 0 for the whole PERFECT test however, the rest of the parous group had the best performance in certain sections of the test. Although the PERFECT test was not used in a study by Slieker-ten Hove et al. (2009), similar observation and palpation techniques were used to measure PFM strength and endurance. They found that no significant difference in PFM strength and endurance between parous and nulliparous women. Similarly, in other studies where PFM function was measured in the general female population, using perineometry and digital vaginal palpation, pregnancy and child birth did not significantly reduce PFM strength (Caroci et al. 2010). Elenskaia et al. (2011) found that the PFM weaken temporarily, measured by a perineometer and the Oxford scale, after child birth but recovers by one year postpartum. The different measurement tools and different population used in these studies can contribute to the variation of results. In the current study the results of the PERFECT test were also inconclusive as to which group performed better.

5.3.3. Surface EMG of the TrA

The results of the surface EMG for the Transverse Abdominis (TrA) showed an interesting finding as the nulligravid group had the lowest median for average MVC (115uV). The parous group had the highest median for average MVC (189uV) while the matched group fell in between with 143uV. In a study conducted on nulliparous female physical therapists, an average of 35.3uV was found (Stupp et al. 2011) (Section 3.3.1.1), which is considerably lower than the medians for all three groups in this study. A reason for this finding could include that participants of the Stupp et al. (2011) study were well acquainted with the drawing-in technique. When the drawing-in technique was performed under a magnetic resonance imaging (MRI), results showed that there was a significant increase in thickness of the TrA as well as the internal oblique muscles (Hides et al. 2006), therefore activation of the internal obliques can influence the measurements when testing the average MVC of the TrA via surface EMG. When performing the drawing-in technique for the first time, increased activation of the internal obliques could influence the accuracy of the results. These muscles would be expected to be more active during dysfunction of the deeper stabiliser muscles such as the TrA.

Although the median of the parous group was higher than the nulligravid and matched group, the nulligravid and matched group had the highest maximum score (562uV) and the parous group had the lowest minimum score (41uV). No significant difference was found between the parous and matched group with reference to the 95% confidence interval. Therefore no concrete conclusion could be made pertaining to the effect of pregnancy on TrA activation potentials.

5.3.4. Prone PBU test

The matched group performed the best during the prone pressure biofeedback unit (PBU) test. It had the highest number of participants to reach an average of Level 1, while the parous group had the lowest number of participants to reach Level 1 (Figure 4.4.5). The majority of the parous group (75%) remained at a Level 0. Although the matched group seemed to perform better, no statistical difference was found when the two groups were compared.

An average decrease in pressure of 4.6 – 5.3mmHg, indicating a Level 2 - 3, was found during the prone PBU test described by Storheim et al. (2002). This seems to indicate that all participants from this study underperformed. However, the sample in the Storheim et al. (2002) study included male and female participants who were all physiotherapy students (drawing-in technique is known to them), and they had two practise sessions where participants were excluded if the pressure during the test was reduced by less than 3mmHg. It is considered that the novice patient performing the drawing-in technique is more likely to contract wide groups of abdominal muscles leading to inaccurate assessment and poor noted performance (De Paula Lima et al. 2012). It is therefore advised that future research should consider a familiarisation period with supervised instruction regarding the drawing-in technique if it doesn't interfere with the aims and possible outcomes of the studies.

5.3.5. Sahrmann core stability test

The Sahrmann test has also been found to be reliable in testing global mobility (Stanton et al. 2004), with the PBU placed under the lumbar spine and the participant performing different movements with their legs, increasing in difficulty as the levels progress. The nulligravid and matched group reached a maximum of Level 4 during the test, while the parous group only managed to reach a Level 2. However, most parous participants (37.5%) reached a Level 2, while most of the matched group (37.5%) could only attain a Level 0.5. No significance difference was seen when the parous and matched groups were compared and therefore parity seemingly had no definite influence on global core stability according to this study. No literature can be found to confirm or contradict this finding.

5.3.6. ASLR

When the active straight leg raise (ASLR) test was performed on the left leg, the addition of pressure had a positive effect on the parous group. In the parous group an increased number of participants had no difficulty lifting the leg when pressure was applied to the pelvis (Figure 4.4.7.a-d). The addition of pressure also had a positive effect on one nulligravid participant that improved form a Level 2 to a Level 1. In contrast, the addition of pressure had a negative effect on one participant from the matched group that declined from Level 0 to Level 1.

When the ASLR was performed on the right side, all participants from both the nulligravid and matched group attained a Level 0 without the pressure. The parous group had the exact same results when compared to the left side. Initially only four participants attained a Level 0 but when the pressure was added to the pelvis, the number of participants rose to seven that attained a

Level 0. The results for the nulligravid and matched groups for the ASLR are inconclusive, but for the parous group it showed significant improvement on both sides when the assisted pressure was applied. This could indicate that the presence of external stability around the pelvis increased the performance of the parous participants in the ASLR test. This is confirmed by Gilleard & Brown (1996), that found that pelvic stability decreased postpartum. Similarly, when parous females, who were suffering from pregnancy related pelvic girdle pain postpartum, wore a pelvic belt (at the level of the ASIS) a decrease in sacro-iliac joint (SIJ) laxity was found as well as an improved score of the ASLR test (Mens et al. 2006).

5.3.7. Sport specific plank test

The sport specific plank test was found to be valid and reliable for testing global core muscle stability and endurance (Tong et al. 2014). The highest level reached by any participant during this test was Level 1 (Figure 4.4.8), which entailed holding the plank position described in Section 3.3.1.1 for 60 seconds. The parous group had the highest percentage of participants reaching Level 1, which could indicate that parity does not have a major effect on global core muscle function postpartum. However, conclusions are limited due to the small sample size.

5.3.8. Single leg standing

All participants were able to perform a single leg stand for 60 seconds on both the right and left leg except two parous participants who could not complete the 60 seconds on the right leg (Figure 4.4.9). The participants were graded as good, average or poor while performing the single leg stand test. All three groups performed the best on the right leg. No statistical difference was found when the parous and matched groups were compared for the single leg stand test. Internal leg rotation was the deviation seen in most participants during the left and right single leg stand test. According to Kibler et al. (2006) deviations such as internal rotation of the weight bearing limb during the single leg stand test, indicates inability to control the posture which suggests proximal core weakness.

5.3.9. Unilateral squat

When performing the single leg squat, the participants were once again rated as poor, average or good. When performing the squat on the left leg, the matched group performed the best while the parous group had no participants that were rated as good (Figure 4.4.11.a). On the right leg the matched group once again had the highest percentage of participants to reach a good rating while again no parous participant attained a good rating (Figure 4.4.11.b). However no statistical significance was found when the parous and matched groups were compared for the unilateral squat on both sides. The corkscrewing deviation was the most prevalent during the left leg squat amongst all three groups. On the right side a knee tremor was most prevalent in the nulligravid and matched group but the parous group had a majority displaying the corkscrew deviation. The corkscrewing deviation (exaggerated flexed and rotated posture) that was most prevalent in the parous group on both sides may be an indication of a compensation of weak muscles around the hip and pelvis, often involving the gluteal muscles (Kibler et al. 2006).

Figure 5.3.1: Corkscrewing deviation (Kibler et al. 2006)

5.4. SUMMARY

In general the parous and nulligravid groups had very similar training programmes with regards to the number of days that they ran or participated in additional training. The nulligravid group however had more extreme cases of participants training five to seven days a week. No tendency was observed between parity and increased injuries, although two parous female recreational runners experienced sport-related injuries for the first time after the birth of their children. This can also be associated with age as the parous group was significantly older than the nulligravid group.

Parity had a negative effect on the performance of the PFM during the surface EMG test, focussing mainly on local stability. However, when global stability was tested during the sport specific plank test, the parous group performed the best, indicating a positive effect on global stability which could also be interpreted as a compensation mechanism for lack of local stability. When functionality was tested using the ASLR test, the parous group needed more external support at the pelvis than the nulligravid group, indicating a negative effect on pelvic stability in the parous group.

Therefore the importance is highlighted that strengthening of the local stabilisers is needed postpartum to improve pelvic stability and motor control.

CHAPTER 6.

CONCLUSION

6.1. INTRODUCTION

The study set out to explore the relationship between parity, trunk motor control and injury profiles in female recreational runners. From literature it was found that parity can have an effect on trunk motor control (Gilleard & Brown 1996) and that in general, female runners were found to be more susceptible to injuries (Taunton et al. 2002). Therefore parity and decreased trunk motor control were investigated in female recreational runners with an added objective of determining their injury profiles. To achieve this, a case-control study design was used to determine the level of trunk motor control and the injury profiles in parous and nullligravid female recreational runners. These results were compared to establish our findings.

6.2. MAIN FINDINGS

When comparing the injury profiles of the parous and nulligravid group it was found that the parous group had the lowest percentage of injuries reported. Lower leg injuries were the most common injuries in the parous and nulligravid group. Knee and ankle injuries were the second most common injuries in the nulligravid group, whereas knee injuries and more proximal injuries including upper leg and hip injuries were the second most common in the parous group. Therefore, from these findings there seemed to be a tendency towards equal injury prevalence in parous and nulligravid female recreational runners, although parous runners seemed to have a tendency to more proximal injuries.

A battery of tests was compiled to assess trunk motor control as accurately and comprehensively as possible. When testing the pelvic floor muscles (PFM), the nulligravid group performed better during the surface electromyography (EMG) peak activation and endurance test. No difference was found during the PERFECT (Power, Endurance, Repetitions, Fast contractions, Every Contraction Timed) test, although the findings of all the PFM tests were based on very small samples who gave consent for the tests. No statistical significance was found between groups during the surface EMG test for the Transverse Abdominis (TrA), the pressure biofeedback unit (PBU) test as well as the Sahrmann test. The parous group tended to perform better during the sport specific plank test, but in contrast performed weaker in the active straight leg raise (ASLR) test. During the single leg stand test as well as the unilateral squat no significant difference was found between the nulligravid and parous groups. However, no parous participant received a good rating during the unilateral squat test and the parous group had the highest prevalence of the corkscrewing deviation. No conclusion can be drawn regarding trunk motor control although, some individual tests did show a slight decrease in performance in the parous group.

6.3. IMPLICATIONS OF THE STUDY

As seen in the results, parous women did not seem more prone to injuries when compared to the nulligravid female recreational runners. Therefore, it could be speculated that parous female runners do not have added risks for injuries when returning to running in the postpartum period. However, many women experience pregnancy related lower back pain (PRLBP) in the postpartum period (Wu et al. 2004) which has an effect on trunk motor control and co-ordination during gait (Lamoth et al. 2006). This may emphasise the individual needs of patients which need to be addressed during assessment and management. Physiotherapy plays a vital role in helping patients postpartum as Vleeming et al. (2008) prescribed guidelines for PRLBP which included physiotherapy for individualised treatment and exercise programmes. Education is important for any female recreational runner postpartum as she gradually returns to sport (Artal & O'Toole 2003) or needs help addressing certain changes in her body.

As definite changes occur in the female body during pregnancy and the postpartum period, it is important for female athletes to be aware that it could influence their trunk motor control. Decreased PFM peak activation and endurance were lower in the parous group as well as a decreased ability to perform the ASLR in supine. This indicates that parity may have an effect on the local as well as global muscle functions of the core influencing trunk motor control as a whole. Only four parous participants had performed abdominal strengthening exercises postpartum, indicating a need for more awareness amongst female recreational runners in the importance of motor control pre- and postpartum.

6.4. RECOMMENDATIONS

Trunk motor control in athletes has many facets and the relationship to injury is still being thoroughly researched, therefore not all aspects could be covered in this study. No associations were made using specific trunk motor control tests and specific injuries (with regards to anatomy or side). Knee injuries were common in both the nulligravid and parous group which is confirmed by Junior et al. (2013) who found the knee joint to be the most common anatomical site for injuries in recreational runners. Focussing on whether parity would further increase the injury risk of female recreational runners already predisposed to knee injuries attributed to decreased trunk motor control (Zazulak et al. 2007), can definitely be investigated in the future to eliminate as many risks to injuries as possible. Although statistically insignificant, parous participants did have a tendency to perform worse during the unilateral squat subjective grading indicating possible muscle weakness around the hip and pelvis that needs to be addressed postpartum. This can be investigated in more detail by assessing specific muscles' strengths in the future. The findings of the study can be the basis for further research into the physiotherapy field of women's health and sport.

6.5. LIMITATIONS OF THE STUDY

The choice of study design allowed for increased validity by controlling the confounding effect that certain variables could have on the results of the comparison of the two groups. Although the study design addressed certain aspects of validity, limited resources and funds during the study potentially led to a decrease of validity in specific measurement tools. Fine wire EMG and ultrasound imaging have been found to be the most accurate when measuring TrA muscle activity while specific tests performed on a stability platform were recommended for measuring core strength and stability which could not be used in this study. During the collection of data, neither the assessors nor participants were blinded as to which group the participants were in, which could have led to potential bias. Certain participants were also recruited by word of mouth as participants who already had done the data collection referred them to the study. This could have also introduced an element of bias. As indicated by the above discussion, limited significant differences were found when comparing the parous and matched nulligravid groups, mostly due to the small group sizes being compared. Only during the analysis of the data the participants were grouped into two groups namely parous and nulligravid. The amount of participants in each group could therefore not be anticipated initially. Comparison of data required the parous group to be matched to the same size nulligravid group. This was done by each parous participant being matched to a similar nulligravid participant using the criteria of age, type and frequency of training and injury profiles with type of treatment received. This process deemed to be very difficult as to find a match that suited all three categories was scarce. Often one category fit perfectly, for example age, but then the other categories had no or little resemblance. As the case group was small, the comparison to the whole sample group was considered, but this would decrease the quality of the findings and design due to the introduction of the confounding factors.

6.6. CONCLUSION

Female runners have been found to be twice as likely to sustain injuries as their male counterparts. Weak core stability has been identified as a risk factor for injuries in female athletes and pregnancy directly affects the core musculature. However, a dearth in literature exists, identifying parity as a risk factor for injuries. If risk factors for injuries can be identified in female recreational runners and managed accordingly, their performance can potentially be improved (Palmer-Green et al. 2013). Therefore, this study set out to determine whether there was a difference in the injury profiles and trunk motor control of parous and nulligravid female athletes. No significant difference was found between the parous and nulligravid group regarding injuries and only a few tests of trunk motor control were influenced by parity, although not enough to make conclusive recommendations.

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APPENDIX A: ADVERTISEMENT

ATTENTION ALL FEMALE ATHLETES

A study is being conducted to assess the core stability and injury profiles of female recreational runners and whether there is an association between the two.

Requirements:

- **Females between the ages of 18-45**
- **Female athletes currently exercising 150min per week including at least 30min of running once a week for the past month.**
- **Understand English or Afrikaans**

You will be required to complete a questionnaire pertaining to your injuries and then complete a set of tests to determine your core stability. The whole assessment will take an hour of your time.

Participants will benefit from a free core stability evaluation and a 30 min sport massage as a FOLLOW-UP SESSION.

Participation is voluntary and the participant may withdraw at any time.

THANK YOU

EVERY PARTICIPANT WILL BE APPRECIATED

Please feel free to contact the researcher, Rochelle Moles 076 0919102 for more information.

The study has been approved by the Ethics Committee of the Faculty of Health Sciences, UFS.

AANDAG ALLE VROULIKE ATLETE

'n Studie word gedoen om die kernstabiliteit en besering profiele van vroulike ontspanningsgeriewe hardlopers te evalueer en te bepaal of daar 'n verband tussen die twee is.

Vereistes:

- **Vroue tussen die ouderdomme van 18-45**
- **Vroulike atlete wat tans 150min per week oefen, insluitend ten minste 30min se draf een keer 'n week vir die afgelope maand.**
- **Kan Engels of Afrikaans verstaan**

U sal verwag word om 'n vraelys in te vul, met betrekking tot jou beserings en dan 'n stel van toetse voltooi om jou kernstabiliteit te bepaal. Die hele assessering sal 'n uur van jou tyd neem.

Deelnemers sal voordeel trek uit 'n vrye kernstabiliteit evaluering en 'n 30 min sport massering as 'n OPVOLG SESSIE.

Deelname is vrywillig en die deelnemer mag enige tyd onttrek.

DANKIE

ELKE DEELNEMER SAL WAARDEER WORD

Voel asseblief vry om die navorser te kontak, Rochelle Moles 076 0919102 vir meer inligting.

Die studie is goedgekeur deur die Etiekkomitee van die Fakulteit Gesondheidswetenskappe, UV.

APPENDIX B: PBU TEST (GARNIER ET AL. 2009)

A pressure biofeedback unit (Stabilizer Pressure Biofeedback Unit, Chattanooga GroupInc.) was used for the PRONE test. The participant lay in a prone position on a plinth, arms to each side, head fully relaxed in the designated mould so that the neck was straight and relaxed with the head in the midline. The pressure biofeedback unit was placed under the lower abdomen with its distal end in line with the anterior superior iliac spine. According to Richardson and Jull, this tool was designed to monitor movement of the abdominal wall by measuring a change in pressure during abdominal hollowing. At first, the bulb was inflated to a pressure of 70mmHg. Participants were instructed to relax their whole body fully, especially the abdomen, before each contraction. The aim was to measure the ability of each subject to perform abdominal hollowing, holding the contraction for 4 seconds within a 10-second period, monitored using a digital watch. The participants were not given any feedback about their performance until all parts of the test had been completed.

The observers used the following observation and palpation criteria to check if the participants were performing the abdominal hollowing technique correctly. Firstly, the participant had to perform the abdominal hollowing action without substitution manoeuvres such as contraction of the global abdominal musculature or any evasive movements of the spine, hips, pelvis or shoulder girdle. Secondly, the participant had to continue normal, regular breathing. The total change in pressure shown on the gauge was recorded in mmHg. The observer placed both hands in the recommended position to detect appropriate muscle contraction, medially and inferiorly to the anterior superior iliac spines and lateral to the rectus abdominis muscle. For each 2mmHg the participant can decrease the pressure, it is graded as a level 1-5 up to 10mmHg. Level 5 being the highest. After each contraction, there was an interval of 20 seconds for the participant to rest. To avoid between-device differences, the same set of pressure biofeedback units was used throughout the study. According to the manufacturer's operating instructions, the accuracy of the device is ±3mmHg.

APPENDIX C: SAHRMANN TEST (STANTON ET AL. 2004)

A clinical measure of core stability was obtained using the Sahrmann core stability test. The inflatable pad of a Stabilizer Pressure Biofeedback Unit (PBU) (Chattanoo- ga Group, Inc., Hixson, TN) is placed in the natural lordotic curve, while the subject is lying supine, and is inflated to 40 mm Hg. The test consists of 5 levels, with each level increasing in difficulty as follows: Level 1. From a crook lying position, abdominal pre-setting is performed. This entails the participant activating the abdominal musculature to brace the trunk in an isometric fashion without movement being produced (1). Once this is achieved, the subject slowly raises one leg to a position of 100 degrees of hip flexion with comfortable knee flexion. The opposite leg is then brought to the same position in the same manner with a change of not more than 10 mm Hg in pressure on the PBU. This position was employed as the start position for subsequent levels of the test protocol. The pressure on the PBU was noted and a reading greater or less than 10 mm Hg above or below this baseline indicated lumbopelvic stability was lost at this level. If the subject could maintain control on the initial, but not the final movement, the subject was graded at 0.5 for that test level. Level 2. From the start position, the subject slowly lowers one leg such that the heel contacts the ground. Then the leg is slid out to fully extend the knee, and then returned to the start position. Level 3. From the start position, the subject slowly lowers one leg such that the heel reaches 12 cm above the ground. Then the leg is slid out to fully extend the knee and then returned to the start position. Level 4. From the start position, the subject slowly lowers both legs such that the heels contact the ground. Then the legs are slid out to fully extend the knees and then returned to the start position. Level 5. From the start position, the subject slowly lowers both legs such that the heels reach 12 cm above the ground. The legs are then slid out to fully extend the knees and then returned to the start position. For the purpose of this study, in order to attain each new level of the Sahrmann test, the lumbar spine position had to be maintained as indicated by a change of no more than 10 mm Hg in pressure on the analogue dial of the PBU.

APPENDIX D: QUESTIONNAIRE

Physiotherapy Department
Parity and motor control in female recreational runners
Questionnaire

Mark the appropriate block (x) or fill in the information in the space provided. | **For office use only**

Participant number | [ ][ ][ ] 1-3

Section A: Demographics

1 How old are you? ________ yrs | [ ][ ] 4-5

2 Are you currently a member of a running club?

YES	NO

[ ] 6

Section B: Training

1 How many days of a week do you run?

________ days | [ ] 7

2 How much time do you spend running on average in a week?

________ min | [ ][ ][ ] 8-10

3 What other training do you do?
(You may select more than one)

- [ ] resistance training (weights) | [ ] 11
- [ ] cycling | [ ] 12
- [ ] pilates | [ ] 13
- [ ] yoga | [ ] 14
- [ ] other | [ ] 15

4 If other, please specify.

____ | [ ][ ] 16-17
____ | [ ][ ] 18-19
____ | [ ][ ] 20-21
____ | [ ][ ] 22-23
____ | [ ][ ] 24-25

Section C: Child Birth history

1 Have you been pregnant before?

YES	NO

[ ] 26

If no, please move directly to section D. If your answer is yes, please complete the questions to follow.

2 How many children have you given birth to? | 27-28

____

3 Which method of delivery was used during your child/childrens birth? | 29

- [ ] Natural birth
- [ ] Ceasarian section
- [ ] Both

4 When was the birth of your last child? | 30-31

__________ years ago

5 How many months after your last child's birth did you return to running? | 32-33

__________ months

6 Did you do any specific abdominal strengthening exercises after the birth of your last child? | 34

YES	NO

7 If yes, please specify the exercises. | 35-36 | 37-38 | 39-40 | 41-42 | 43-44

____
____
____
____

<u>Section D: Injury profile</u>

1 Have you ever had any sport-related injuries? | 45

YES	NO

If no, thank you for your time. If yes, please complete the following questions.

2 If yes, please list your injuries with specific refernence to the side, muscle/joint.

____
____
____
____
____

46-47
48-49
50-51
52-53
54-55

3 Have you experienced any sport-related injuries after child birth? **(If you have not been pregnant before continue to question 5)**

YES	NO

56

4 If yes, please list all sport related injuries you have experienced after giving birth with specific reference to the side, muscle/joint.

____
____
____
____
____

57-58
59-60
61-62
63-64
65-66

5 Are you currently or have you previously received any of the following treatments for your injury?
(more than one is allowed)

☐ Medical
☐ Physiotherapy
☐ Biokinetics
☐ Other

67
68
69
70

6 If other, please specify.

____
____
____
____
____

71-72
73-74
75-76
77-78
79-80

Thank you for completing the questionnaire, please bring it along to the treatment room.

Data form
For office use only

Motor control tests

1 Surface EMG of the pelvic floor

Average of three trials [ ] uV — [| | | |] 1-5

2 Surface EMG of the TrA

Average of three trials [ ] uV — [| | | |] 6-10

3 PBU of the local stabilsers

First trial	**Level**	[ ]	[ ]	11
Second trial	**Level**	[ ]	[ ]	12
Third trial	**Level**	[ ]	[ ]	13

4 Sahrmann test

First trial	**Level**	[ ]	[ ]	14
Second trial	**Level**	[ ]	[ ]	15
Third trial	**Level**	[ ]	[ ]	16

5 ASLR

Left

Without assited pressure
level [ ] — [ ] 17

With assited pressure
level [ ] — [ ] 18

Right

Without assited pressure
level [ ] — [ ] 19

With assited pressure
level [ ] — [ ] 20

6 Sport specific plank

Only trial   level [ ]   [ ] 21

7 One leg standing

Time [ ] secs   [ ][ ][ ] 22-24

Left

Good	Average	Poor

[ ] 25

Deviations:

[ ][ ] 26-27
[ ][ ] 28-29
[ ][ ] 30-31
[ ][ ] 32-33
[ ][ ] 34-35

Time [ ] secs   [ ][ ][ ] 36-38

Right

Good	Average	Poor

[ ] 39

Deviations:

[ ][ ] 40-41
[ ][ ] 42-43
[ ][ ] 44-45
[ ][ ] 46-47
[ ][ ] 48-49

8 One leg squat

Left

Good	Average	Poor

[ ] 50

Deviations:

[ ][ ] 51-52
[ ][ ] 53-54
[ ][ ] 55-56
[ ][ ] 57-58
[ ][ ] 59-60

Right

Good	Average	Poor

[ ] 61

Deviations:

[ ][ ] 62-63
[ ][ ] 64-65
[ ][ ] 66-67
[ ][ ] 68-69
[ ][ ] 70-71

Fisioterapie Departement

Parity and motor control in female recreational runners

Vraelys

Merk die toepaslike blokkie (X) of vul die informasie in die gegewe spasie.

Slegs vir kantoor gebruik

Deelnemer nommer ☐☐☐ 1-3

Afdeling A: Demografie

1 Hoe oud is u? ___________ jaar ☐☐ 4-5

2 Is u tans 'n lid van 'n draf klub?

JA	NEE

☐ 6

Afdeling B: Oefening

1 Hoeveel dae van die week draf u?

___________ dae ☐ 7

2 Wat is die gemiddelde tyd wat u in 'n week draf?

___________ min ☐☐☐ 8-10

3 Watter ander oefening doen u?
(Meer as een mag gekies word)

- ☐ weerstand oefening (gewigte) ☐ 11
- ☐ fietsry ☐ 12
- ☐ pilates ☐ 13
- ☐ yoga ☐ 14
- ☐ ander ☐ 15

4 Indien ander, spesifiseer asseblief.

___________________________________ ☐☐ 16-17
___________________________________ ☐☐ 18-19
___________________________________ ☐☐ 20-21
___________________________________ ☐☐ 22-23
___________________________________ ☐☐ 24-25

Afdeling C: Geboorte geskiedenis

1 Was u al swanger?

JA	NEE

☐ 26

Indien Nee, gaan asseblief na afdeling D. Indien Ja, voltooi asseblief die vrae wat volg.

2 Aan hoeveel kinders het u al vir geboorte gegee?

______________________________ 27-28

3 Watter metode of tipe kraam was dit?

- [ ] Natuurlike kraam
- [ ] Keisersnit
- [ ] Albei

29

4 Hoe lank terug was die geboorte van u laaste kind?

__________ jaar/jare geleede 30-31

5 Hoeveel maande na u laaste kind se geboorte het u begin om weer te draf?

__________ maande 32-33

6 Het u engie abdominale versterkings oefeninge gedoen na u laaste kind se geboorte?

JA	NEE

34

7 Indien ja, spesifiseer die oefeninge asseblief.

35-36
37-38
39-40
41-42
43-44

Afdeling D: Besering profiel

1 Het u al enige sport verwante beserings gehad?

JA	NEE

45

Indien Nee, dankie vir u tyd. Indien Ja, voltooi asseblief die volgende vrae.

2 Indien ja, lys asb jou beserings en spesifiseer die kant, spier/gewrig.

____

		46-47
		48-49
		50-51
		52-53
		54-55

3 Het u al enige sport verwante beserings opgedoen na die geboorte van u kind/kinders?
(As u nog nie swnager was nie, gaan asb na vraag 5)

JA	NEE

☐ 56

4 Indien ja, maak asseblief 'n lys van al u beserings wat u opgedoen het na die geboorte van u kind/kinders en spesifiseer asseblief die kant, spier/gewrig.

		57-58
		59-60
		61-62
		63-64
		65-66

5 Is u tans besig of het u in die verlede enige van die volgende behandelings vir 'n besering ontvang?
(Meer as een opsie mag gekies word)

☐ Mediese behandeling ☐ 67
☐ Fisioterapie ☐ 68
☐ Biokinetika ☐ 69
☐ Ander ☐ 70

6 Indien ander, spesifiseer asseblief.

		71-72
		73-74
		75-76
		77-78
		79-80

Dankie dat U die vraelys beantwoord het, bring dit asseblief saam na die behandelings kamer.

APPENDIX E: PERMISSION LETTERS

UFS·UV HEALTH SCIENCES

Dear Christy du Plessis Physiotherapy

A research study is being conducted to assess the motor control and injury profiles of female recreational runners who have given birth to a child/children and of female recreational runners who have not been pregnant, and determine if an association exists. This information could be valuable in the treating of female athletes postpartum and in the future for potential development of an individualised exercise programme postpartum. Approval has been obtained from the Faculty of Health Science's Ethics committee, UFS. The research study involves performing a set of core stability tests on the participant and they will be asked to complete a questionnaire capturing their injury profile.
The researcher therefore requests permission to evaluate the participants of the study in your practise rooms after hours.

The researcher kindly requests your consent.

Yours sincerely
The researcher
Rochelle Moles (076 0919102)

[signature]

Research supervisor: Corlia Brandt 0822023366
Ethics committee of the faculty of Health Sciences, UFS: (051) 401 7794

I...Christy du Plessis.................grant permission for the researcher to use my premises during the execution of the study. I have read the above form and I fully understand what is to happen in the study.

Signed: ....[signature]........................ Date: ..1/9/15..................

205 Nelson Mandela Drive/Rylaan
Park West/Parkwes
Bloemfontein 9301
South Africa/Suid-Afrika

P.O. Box/Posbus 339
Bloemfontein 9300
South Africa/Suid-Afrika
T: +27(0)51 401 9111
www.ufs.ac.za

UFS·UV

To whom it may concern

A research study is being conducted to assess the motor control and injury profiles of female recreational runners who have given birth to a child/children and of female recreational runners who have not been pregnant, and determine if an association exists. This information could be valuable in the treating of female athletes postpartum and in the future for potential development of an individualised exercise programme postpartum. Approval has been obtained from the Faculty of Health Science's Ethics committee, UFS. The research study involves performing a set of core stability tests on the participant and they will be asked to complete a questionnaire capturing their injury profile.

The researcher therefore requests permission to advertise the study on the premises.

The researcher kindly requests your consent.

Yours sincerely

The researcher

Rochelle Moles (076 0919102)

Research supervisor: Corlia Brandt 0822023366

Ethics committee of the faculty of Health Sciences, UFS: (051) 401 7794

I Prof FF Coetzee grant permission for the researcher to advertise the study on our premises. I have read the above form and I fully understand what is to happen in the study.

Signed:

PROF F.F. COETZEE (DPhil, MPA)

Date: 08/09/2015

www.ufs.ac.za

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

To whom it may concern

A research study is being conducted to assess the motor control and injury profiles of female recreational runners who have given birth to a child/children and of female recreational runners who have not been pregnant, and determine if an association exists. This information could be valuable in the treating of female athletes postpartum and in the future for potential development of an individualised exercise programme postpartum. Approval has been obtained from the Faculty of Health Science's Ethics committee, UFS. The research study involves performing a set of core stability tests on the participant and they will be asked to complete a questionnaire capturing their injury profile.
The researcher therefore requests permission to advertise the study on the premises.

The researcher kindly requests your consent.

Yours sincerely
The researcher
Rochelle Moles (076 0919102)

Research supervisor: Corlia Brandt 0822023366
Ethics committee of the faculty of Health Sciences, UFS: (051) 401 7794

I ...Ricam Roux...grant permission for the researcher to advertise the study on our premises. I have read the above form and I fully understand what is to happen in the study.

Signed: .... Date: 10/09/2015

205 Nelson Mandela Drive/Rylaan
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Bloemfontein 9301
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UNIVERSITY OF THE FREE STATE
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YUNIVESITHI YA FREISTATA

APPENDIX F: ETHICAL APPROVAL

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

IRB nr 00006240
REC Reference nr 230408-011
IORG0005187
FWA00012784

20 October 2015

MS RT MOLES
C/O MS C BRANDT
DEPARTMENT OF PHYSIOTHERAPY
CR DE WET BUILDING
UFS

Dear Ms Moles

ECUFS NR 119/2015
MS RT MOLES
DEPARTMENT OF PHYSIOTHERAPY
PROJECT TITLE: PARITY AND MOTOR CONTROL IN FEMALE RECREATIONAL RUNNERS

1. You are hereby kindly informed that, at the meeting held on 15 October 2015, the Ethics Committee approved the above project after all conditions were met.

2. Any amendment, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

3. A progress report should be submitted within one year of approval of long term studies and a final report at completion of both short term and long term studies.

4. Kindly use the ECUFS NR as reference in correspondence to the Ethics Committee Secretariat.

5. The Ethics Committee functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the Ethics Committee of the Faculty of Health Sciences.

Yours faithfully

....
DR SM LE GRANGE
CHAIR: ETHICS COMMITTEE

Cc: Ms C Brandt

Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | F: +27 (0)51 444 4359 | E: ethicsfhs@ufs.ac.za
Block D, Dean's Division, Room D104 | P.O. Box/Posbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa
www.ufs.ac.za

APPENDIX G: INFORMATION DOCUMENT

INFORMATION DOCUMENT

Title: Parity and motor control in female recreational runners.

Introduction: Rochelle Moles, a qualified physiotherapist doing her M.Sc, is conducting research to determine the core stability and injury profile of female recreational runners. The study will evaluate female athletes who have given birth to a child/children and those who have not been pregnant to determine if any associations exist.

Invitation to participate: You are invited to participate in the research study. There is no cost involved for you as the participant.

What does the study entail: The study is a descriptive, case-control study. The researcher requests an hour of your time, which will be scheduled by appointment. Eight tests will be performed by the researcher to determine the functioning of your core stability. The first test can be invasive of nature. For the intravaginal EMG a probe will be inserted intravaginal, which can be done by the participant herself, to test the strength of the pelvic floor muscles. To test the strength of the transverse abdominis, surface EMG will be used which requires electrodes to be placed on the participant's abdomen while lying on her back. The local stabiliser (PBU) test in performed in stomach lying with an inflatable pouch placed under the stomach and the participant is required to perform the drawing in technique which will be explained. The plank is performed to assess the global stability of the core and the Sahrmann's test is performed in lying with the inflatable pouch placed under the small of her back. Different movements will be requested as she keeps the abdominal contraction, to determine the level of strength of her global mobility. The active straight leg raise (ASLR) test will be performed in lying and the participant will be required to lift her leg up with and without assistance. The last two tests are performed in a functional position (standing) with verbal cues given by the researcher and the responses of the participant will be assessed. You will also be required to complete a questionnaire with regards to previous injuries.

Advantages: By participating in the study you can contribute to possible advancements in the treatment of female athletes and future education of women after giving birth, facilitating a safe return to running.

The participant will be given pertinent information on the study while involved in the project and after the results are available.

Participation is voluntary, and refusal to participate will involve no penalty or loss of benefits to which the participant is otherwise entitled; the participant may discontinue participation at any time without penalty or loss of benefits to which the participant is otherwise entitled.

Compensation/Incentive: The researcher will provide a follow-up sports massage of 30min to the participant free of charge. This will be scheduled after participation in the study.

Confidentiality: Efforts will be made to keep personal information confidential. Absolute confidentiality cannot be guaranteed. Personal information may be disclosed if required by law. If results are published, this may lead to individual/cohort identification.

Contact details of researcher: Rochelle Moles 0760919102

Contact details of Secretariat and Chair: Ethics Committee of the Faculty of Health Sciences, University of the Free State – for reporting of complaints/problems.

Telephone number (051) 401 7794

INFORMASIE DOKUMENT

Titel: Parity and motor control in female recreational runners.

Inleiding: Rochelle Moles, 'n gekwalifiseerde fisioterapeut wat haar M.Sc doen, is besig met navorsing om die motoriese beheer en besering profiel van vroulike atlete te bepaal. Die studie sal vroulike ontspanningsgeriewe hardlopers evalueer wat al geboorte gegee het aan 'n kind / kinders as ook die wat nie al swanger was nie, om te bepaal of enige verenigings bestaan.

Uitnodiging om deel te neem: U word uitgenooi om deel te neem aan die studie. Daar is geen koste verbonde vir jou as deelnemer nie.

Wat behels die studie: Die studie is 'n beskrywende, geval-kontrole studie. Die navorser versoek 'n uur van jou tyd, wat ‘n geskeduleerde afspraak is. Agt toetse sal uitgevoer word deur die navorser om die funksionering van U kern stabiliteit te bepaal. Die eerste toets kan indringende van natuur wees. Vir die intravaginaal EMG sal ‘n elektrode intravaginaal ingesit word, wat die deelnemer self kan doen, om die krag van die pelviese vloer spiere te toets. Om die sterkte van die transvers abdominis te toets sal oppervlak EMG gebruik word wat vereis dat elektrodes op die deelnemer se maag geplaas word terwyl sy op haar rug lê. Die plaaslike stabiliseerder (PBU) toets word in maaglê getoets, met 'n opblaas sak onder die maag, en die deelnemer voer dan die “drawing in” tegniek wat verduidelik sal word. Die plank is uitgevoer om die globale stabiliteit van die kern te bepaal en die Sahrmann toets is uitgevoer met die opblaas sak onder haar laer rug. Verskillende bewegings sal getoets word terwyl sy die abdominale kontraksie hou, om die krag vlak van haar globale mobiliteit te bepaal. Die aktiewe reguit been oplig (ASLR) toets sal uitgevoer word in ruglê en die deelnemer sal verwag word om haar been optelig met en sonder hulp. Die laaste twee toetse word uitgevoer in 'n funksionele posisie (staan) met verbale aanwysings wat deur die navorser gegee word en die reaksie van die deelnemer sal beoordeel word. Jy sal ook verwag word om 'n vraelys te voltooi met betrekking tot vorige beserings.

Voordele: Deur deel te neem in die studie kan U bydra tot moontlike vooruitgang in die behandeling van vroulike atlete en toekomstige opvoeding van vroue na geboorte om 'n veilige terugkeer na hardloop te fasiliteer.

Die deelnemer sal relevante inligting ontvang oor die studie terwyl sy betrokke is in die projek en na die uitslae beskikbaar is.

Deelname is vrywillig. Die weiering om deel te neem sal geen straf of verlies van voordele waarop die deelnemer anders geregtig betrek; die deelnemer mag deelname op enige tyd staak sonder straf of verlies van voordele waarop die deelnemer anders geregtig is.

Vergoeding: Die navorser sal 'n opvolg sport massering van 30min aan die deelnemer gee, gratis. Dit sal geskeduleer word na deelname aan die studie.

Vertroulikheid: Pogings sal aangewend word om persoonlike inligting vertroulik te hou. Absolute vertroulikheid kan nie gewaarborg word nie. Persoonlike inligting kan bekend gemaak word as dit deur die wet vereis word. As resultate gepubliseer is, kan dit lei tot individu / groep identifikasie.

Kontakbesonderhede van navorser: Rochelle Moles 0760919102
Kontakbesonderhede van Sekretariaat en Voorsitter: Etiekkomitee van die Fakulteit Gesondheidswetenskappe, Universiteit van die Vrystaat - vir verslagdoening van klagtes/ probleme.

Telefoonnommer (051) 401 7794

APPENDIX H: INFORMED CONSENT

<u>CONSENT TO PARTICIPATE IN RESEARCH</u>

PARITY AND MOTOR CONTROL IN FEMALE RECREATIONAL RUNNERS

You have been asked to participate in a research study. You have been informed about the study by Rochelle Moles. You have been informed about any available compensation or medical treatment if injury occurs as a result of study-related procedures.

You may contact Rochelle Moles at 0760919102 any time if you have questions about the research or if you are injured as a result of the research. You may contact the Secretariat of the Ethics Committee of the Faculty of Health Sciences, UFS at telephone number (051) 401 7794 if you have questions about your rights as a research participant.

Your participation in this research is voluntary, and you will not be penalised or lose benefits if you refuse to participate or decide to terminate participation.

If you agree to participate, you will be given a signed copy of this document as well as the participant information sheet, which is a written summary of the research.

The research study, including the above information has been verbally described to me. I understand what my involvement in the study means and I voluntarily agree to participate in the following tests,

☐	Intravaginal EMG
☐	Surface EMG of the transverse abdominis
☐	PBU of the local stabilisers in prone
☐	Sport specific plank
☐	Sahrmann core stability test
☐	Single leg standing, unilateral squat and ASLR

________________________ ____________________

Signature of Participant Date

TOESTEMMING VIR DEELNAME AAN NAVORSING

PARITY AND MOTOR CONTROL IN FEMALE RECREATIONAL RUNNERS

U is gevra om deel te neem aan 'n navorsingstudie. U was ingelig oor die studie deur Rochelle Moles. U is ingelig oor enige beskikbare vergoeding of mediese behandeling indien besering voorkom as gevolg van studie-verwante prosedures.

U kan Rochelle Moles enige tyd kontak by 0760919102 as jy vrae oor die navorsing het, of as jy beseer is as gevolg van die navorsing. U kan die sekretariaat van die Etiekkomitee van die Fakulteit Gesondheidswetenskappe, UV by telefoonnommer (051) 401 7794 kontak indien jy vrae oor jou regte as 'n onderwerp het.

Jou deelname aan hierdie navorsing is vrywillig, en jy sal nie gestraf word of voordele verloor as of jy besluit om deelname te beëindig of weier om deel te neem nie.

Indien jy instem om deel te neem, sal jy 'n getekende afskrif van hierdie dokument sowel as die deelnemer inligtingsblad gegee word, wat 'n skriftelike opsomming van die navorsing is.

Die navorsingstudie, insluitend die bogenoemde inligting is mondelings vir my beskryf. Ek verstaan wat my betrokkenheid in die studie beteken en ek stem vrywillig in om deel te neem aan die volgende toetse.

	Intravaginaal EMG
	Oppervlak EMG van die transvers abdominis
	PBU van die lokale stabiliseerders in prone
	Sport spesifieke plank
	Sahrmann kernstabiliteit toets
	Een been staan, eensydige squat en ASLR

______________________ ____________________

Handtekening van Deelnemer Datum

APPENDIX I: 95% CI FOR ADDITIONAL TRAINING

Type of training	95% CI
Resistance training	[- 35.8% ; 35.8%]
Cycling	[- 69.3% ; 12.5%]
Pilates	[- 50.2% ; 29.7%]
Yoga	0
Other	[- 49.1% ; 29.1%]