UNIVERSITY OF THE FREE STATE
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GESONDHEIDSWETENSKAPPE

# The effect of a core stability, m. gluteus medius and proprioceptive exercise program on dynamic postural control in netball players

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Submission date: 15 November 2014


A research report submitted in fulfilment of the requirements of the M.Sc. Physiotherapy with specialization in Clinical Sports Physiotherapy degree in the Faculty of Health Sciences, at the University of the Free State.

## Declarations

1. I, Marelise Wilson, declare that the master's research mini-dissertation or publishable, interrelated articles that I herewith submit at the University of the Free State, is my independent work and that I have not previously submitted it for a qualification at another institution of higher education.
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__________________________

Marelise Wilson

15th day of November 2014

## Acknowledgements

It would not have been possible to complete this research study without the help and support of kind people around me.

This script would not have been possible without the expert advice, encouragement and guidance of my research supervisor, Roline Barnes, who has been invaluable on both academic and personal level, for which I am extremely grateful.

I would like to acknowledge Dr. J. Raubenheimer for the statistical analysis of the study results.

I would also like to personally thank Burtha de Kock and all the Kovsie netball players who partook in the study, for their enthusiasm and commitment towards this study.

A special word of thanks to my sister, Izanne, for the technical assistance required for the completion of this study.

Lastly, to my husband, Keith and twin boys, Dylan and Kyle for their unwavering love and support.

## Abstract

**Introduction:** Maintaining dynamic postural control is essential for netball players as netball players frequently find themselves on one leg having to make an accurate pass. Evaluation of the physical profile of elite university netball players found poor balance in these netball players during pre-season. No literature could be found regarding studies investigating a programme that utilized the combination of core stability, m.gluteus medius (GMed) strengthening and proprioceptive balance exercises on dynamic postural control or studies investigating the effect of an exercise programme on dynamic postural control in netball players.

**Aim:** The research study was undertaken to determine if an exercise programme that incorporates core stability, m.GMed strengthening and proprioceptive balance exercises would lead to an improvement in dynamic postural control in a group of netball players.

**Methodology:** A cross-over randomised clinical trial was performed. Sixteen female university netball players participated in this study. Participants were randomly divided in two groups. Group A participated three times a week for six weeks in the exercise programme while group B was considered as the control group after which the roles were reversed. All participants were assessed at baseline, after six weeks and after 12 weeks using the Star Excursion Balance Test (SEBT). Data were analyzed by a biostatistician using student's and paired t-tests.

**Results:** Dynamic postural control as measured with the SEBT demonstrated a statistically significant improvement ($p<0.05$) across three reach directions (anterior, medial and posterior) in a group of netball players post participation in an exercise programme that incorporated core stability, m.GMed strengthening and proprioceptive balance exercises three times a week over a period of six weeks. The student's t-tests on difference in improvement in reach directions between groups were $p=0.0027$ (anterior), $p=0.0003$ (medial) and $p=0.0001$ (posterior) after group A participated in the exercise program. The student's t-tests were $p=0.0005$ (anterior), $p=0.0001$ (medial) and $p<.0001$ (posterior) after group B participated in the exercise program.

**Conclusion:** An exercise programme that incorporates core stability, m.GMed and proprioceptive balance exercises could be beneficial for improving dynamic postural control in a group of netball players.

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## Acronyms

CNS: - central nervous system

EMG: - electromyographic activity / electromyography

GMed: - gluteus medius

IFNA: - International Federation of Netball Associations

L: - left

LM: - lumbar multifidus

MVIC: - maximum voluntary contraction

NWB: - non-weight-bearing

Rep: - repetitions

R: - right

Sec: - seconds

SEBT: - Star Excursion Balance Test

TrA: - transversus abdominis

TFL: - tensor fascia lata

UFS: - University of the Free State

WB: - weight-bearing

Dynamic postural control: The ability to perform a functional task with purposeful movements that translates the body's centre of gravity without compromising a stable base of support. The functional task might involve jumping or hopping to a new location and immediately attempting to remain as still as possible or attempting to create movements such as reaching or throwing without compromising the base of support (Winter, Patla and Frank, 1990; Kahle and Gribble, 2009, Gribble, Hertel and Plisky, 2012). Dynamic postural control was also termed dynamic postural stability or dynamic balance in previous research studies (Madras and Barr, 2003; Kahle and Gribble, 2009). For this study the term dynamic postural control will be used as well as the operation definition as described above.

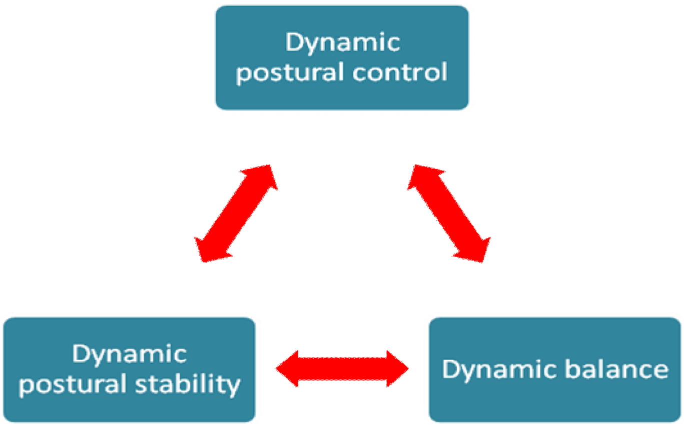



Figure 1: Synonyms for dynamic postural control

Core stability: The capacity to control intervertebral and global trunk movements which contributes to the control of distal segmental movements and loading forces via coordinated muscle recruitment (Smith, Nyland, Caudill, Brosky and Caborn, 2008: 703).

Proprioception: The awareness of body segment positions and orientations (Ashton-Miller, Wojtys, Huston and Fry-Welch, 2001: 128). Proprioception involves stimulus detection, processing of the stimulus and a reactive output from the neuromuscular system (Clark and Burden, 2005: 182).

# Chapter 1 Introduction

Maintaining dynamic postural control is essential for netball players as netball players frequently find themselves on one leg having to make an accurate pass, while still having to comply with the International Federation of Netball Associations (IFNA) footwork rule that once the landing foot is lifted, it may not be re-grounded until the ball is released. Research by Ferreira and Spamer (2010) evaluated the physical profile of elite university netball players and found poor balance in these netball players during pre-season computerised balance testing.

Numerous research studies (Kahle and Gribble, 2009; Fatma, Kaya, Baltact, Taskin, and Erkmen, 2010; Hosseinimehr and Norasteh, 2010; Amrinder, Deepender and Singh, 2012; Sandrey and Mitzel, 2013) have investigated the effect of exercise programmes consisting of core stability, m. gluteus medius (GMed) strengthening or proprioceptive balance programmes on dynamic postural control. On the other hand researchers (Aggarwal, Zutshi, Munjal, Kumar and Sharma, 2010; Filipa, Byrnes, Paterno, Myer and Hewett, 2010; Leavey, Sandrey and Dahmer, 2010) examined exercise programmes consisting of a combination of two components or compared the effect of different exercise programmes on dynamic postural control.

The reason for the inclusion of core stability in exercise programmes (Kahle and Gribble, 2009; Aggarwal *et al.*, 2010; Filipa *et al.*, 2010; Sandrey and Mitzel, 2013) for improving dynamic postural control is that core muscle recruitment and coordination occur during expected and unexpected perturbations so that dynamic balance during the intended movement can be maintained (Smith *et al.*, 2008). M.GMed exercises were also included in exercise programmes (Filipa *et al.*, 2010; Leavey *et al.*, 2010) due to the possibility that the m.GMed muscle contributes to dynamic postural control by stabilizing the hip to prevent the pelvis dropping on the unsupported side and controlling knee valgus (internal rotation and adduction of the femur) during single-limb support (Fujisawa, Masuda, Inaoka, Fukuoka, Ishida and Minamitanu, 2005; Distefano, Blackburn and Marshall, 2009; French, Dunleavy and Cusack, 2010; Boren, Conrey, Le Coguic, Paprocki, Voight and Robinson, 2011).

Another component considered by researchers for the improvement of dynamic postural control was proprioceptive balance exercises (Clark and Burden, 2005; Leavey *et al.*, 2010; Zech, Hübscher, Vogt, Banzer, Hänsel and Pfeifer, 2010). Improved proprioception increases the ability of mechanoreceptors to detect motion in the foot and make adjustments to restore balance and contributes to dynamic postural control (Clark and Burden, 2005; Leavey *et al.*, 2010). Although all these studies including core stability, m. gluteus medius (GMed) strengthening or proprioceptive balance programmes (Kahle and Gribble, 2009; Aggarwal *et al.,* 2010, Filipa *et al.,* 2010; Fatma *et al.,* 2010*;* Amrinder *et al.*, 2012; Sandrey and Mitzel, 2013) showed varying levels of benefit on dynamic postural control; Aggarwal *et al's* (2010) study found greater improvement in the core stability group when compared to the balance training group.

Research studies conducted by Filipa *et al.* (2010) and Leavey *et al.* (2010) investigated exercise programmes consisting of a combination of two of the above mentioned components with interesting results. Filipa *et al.* (2010) determined the effect of a neuromuscular training programme that focused on lower extremity strength and core stability in female soccer players. Dynamic postural control was improved in the neuromuscular training group while no change was found in the control group. Leavey *et al.* (2010) compared the effects of a six week balance, m.GMed strengthening, and a combination programme consisting of balance and m.GMed strengthening on dynamic postural control in healthy, active individuals. The combination programme consisting of two components demonstrated greater improvement when compared to only one component. It was hypothesised that an exercise programme consisting of a combination of these factors will lead to a greater improvement in dynamic postural control.

No literature could be found regarding studies investigating a programme that utilized the combination of core stability, m.GMed strengthening and proprioceptive balance exercises on dynamic postural control or studies investigating the effect of an exercise programme on dynamic postural control in netball players. As mentioned previously poor balance was found in netball players during pre-season (Ferreira and Spamer, 2010). Therefore research on the effect of a core stability, m.GMed strengthening and proprioceptive balance exercise programme might substantiate evidence that an exercise programme could possibly eliminate shortcomings in the physical profile of netball players, with regards to dynamic postural control.

Poor dynamic postural control has been theorized to decrease performance and increase the incidence of injury secondary to a lack of control of the centre of mass, especially in female athletes (Filipa *et al.*, 2010). During an epidemiology study of injuries in elite South African netball players (Langeveld, Coetzee and Holtzhausen, 2012), the injury rate was calculated at 500.7 injuries per 1000 playing hours and the direct probability that a player could sustain an injury was calculated at 0.15 per player. After the study was completed, Langeveld *et al.* (2012) recommended a structured programme to enhance core stability, neuromuscular control and proprioception to reduce the amount of lower extremity injuries in netball players. Previously conducted research studies (Emery, Casidy, Klassen, Rosychuk and Rowe, 2005; Elphinston and Hardman, 2006; Kibler, Press and Sciascia, 2006; McGuine and Keene, 2006) also suggested that improvement in core stability, neuromuscular control and proprioceptive exercise could limit sport injuries. The results of a research study by Saeterbakken, Roland and Seiler (2011) suggested that core stability training can significantly improve maximal throwing velocity in female handball players. Improved maximal throwing velocity could also lead to improved performance on the netball court.

Further research is warranted and therefore the aim of the study is to determine whether an exercise programme that incorporates core stability, m.GMed and proprioceptive balance exercises could lead to an improvement in dynamic postural control in a group of netball players and could contribute to improved performance and injury prevention.

The design of the research document is as follows:

In chapter two dynamic postural control is discussed, the influence of exercise programmes on dynamic postural control including core stability, m.GMed strengthening, proprioceptive balance as well as a combination of exercise programmes or the comparison of different exercise programmes. This discussion is followed by a review of the principles of a core stability, m.GMed strengthening and proprioceptive balance programme. The rules and requirements of netball as well as the physical profile and injury prevalence of netball players in South Africa are also reviewed. This chapter is concluded with a discussion of the reliability and validity as well as the execution of the Star Excursion Balance Test (SEBT).

In chapter three the aim of the study, the study design, the study population as well as the recruitment and randomization of the participants is discussed in detail. This discussion is followed by a step by step discussion of the measurement and procedures of the study. In conclusion the ethical aspects of the study are addressed.

In chapter four the results are discussed using charts and tables. The information obtained from the statistical analyses was divided into attendance of the participants, the participants' supporting leg used during the SEBT, the measurements during the first testing session as well as the improvement from one testing sessions to the next testing session. In chapter five reflective practice is used to link the findings of the study with the available literature. Critical reasoning skills were implemented to discuss the findings and to reach a conclusion.

In this chapter dynamic postural control is discussed as introductory. The influence of exercise programmes on dynamic postural control including core stability, m.GMed strengthening, proprioceptive balance as well as a combination of exercise programmes or comparison of different exercise programmes are discussed in full. An in-depth review of the principles of core stability, m.GMed strengthening and proprioceptive balance programmes are included. This discussion is followed with a review of the rules and requirements of netball as well as the physical profile and injury prevalence of netball players in South Africa. In conclusion the reliability and validity as well as the execution of the SEBT are discussed.

## 2.1 Dynamic postural control

Dynamic postural control requires afferent information from somatosensory, visual and vestibular systems regarding the body's position; processing and integration of this information by the central nervous system (CNS); coordination and selection of appropriate responses; and execution of these responses by the musculoskeletal system (Nakagawa and Hoffmann, 2004; Bressel, Yonker, Kras and Heath, 2007; Fatma *et al*., 2010). The visual system moves the head in relation to surrounding objects and provides information about the environment and the orientation and movement of the body (Winter *et al*., 1990; Hosseinimehr and Norasteh, 2010). Previous studies (Krishan and Aruin, 2011; Mohapatra and Aruin, 2013) suggested that adequate visual information is necessary for anticipatory activation of muscles prior to the disturbance of balance. This anticipatory activation of muscles increases postural stability and improves movement performance. The vestibular system detects acceleration of the head in relation to the body and the environment and allows independent control of head and eye positions (Winter *et al*.,1990; Bernier and Perrin, 1998), whilst the somatosensory system which includes muscle spindles, Golgi tendon organs, joint and subcutaneous receptors, relays information regarding the position and movement of muscles and joints as well as body movements in space to the CNS (Hosseinimehr and Norasteh, 2010; Hutt and Redding, 2014).

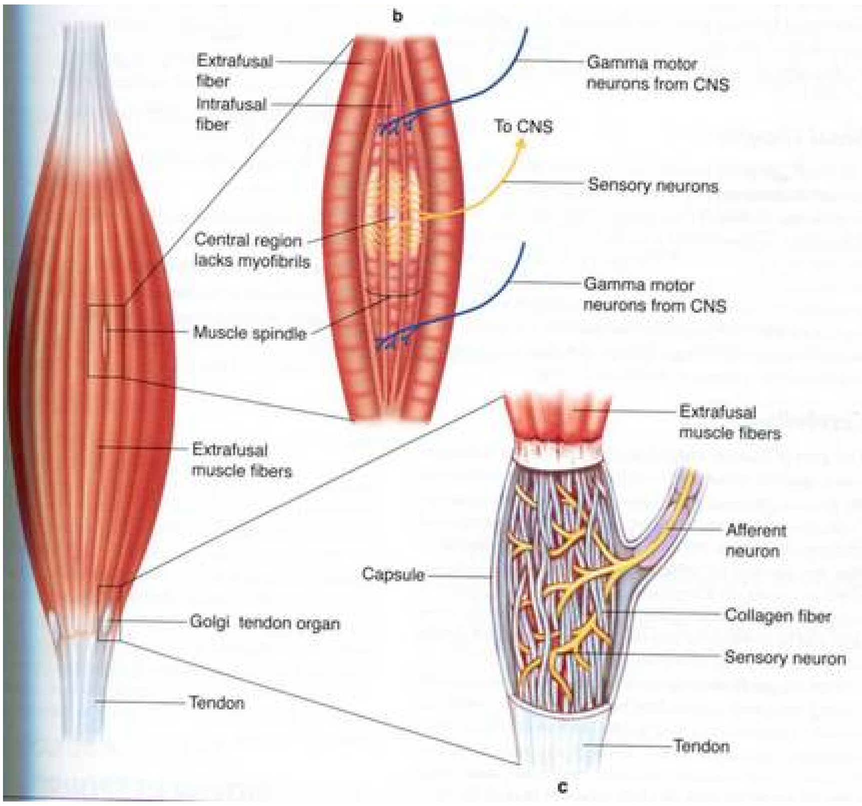



Figure 2: Somatosensory system

Online: Available from http://frankdag.com/wordpress/wp-content/uploads/2013/12/GTO.jpg [Accessed 8 June 2014]

Balter, Stokroos, Akkermans and Kingma (2004:75) suggested that improvement in dynamic postural control is largely the result of "*repetitive training of the motor system that influences motor responses and not greater sensitivity of the vestibular system*". Ashton-Miller *et al.* (2001:133) argued that improvement in dynamic postural control is the result of "*improved ability of the CNS to attend to relevant sensory and proprioceptive cues*". Although disagreement exists between Balter *et al.* (2004) and Ashton-Miller *et al.* (2001) regarding the influence of sensory and motor system training on dynamic postural control; most other authors suggest that both sensory and motor system training influence postural control (Bressel *et al.*, 2007; Gribble, Robinson, Hertel and Denegar, 2009).

From the above literature it can therefore be hypothesised that both sensory and motor system training influences dynamic postural control due to the fact that increased proprioceptive input from different sources could improve the ability of the CNS to integrate all the information and orchestrate an appropriate motor response. On the other hand, increased neural activation, coordination, strength and endurance of the motor system could lead to a more effective response and improve dynamic postural control.

Various studies investigating the effect of a variety of sensory and motor training exercise programmes, including core stability, m. GMed strength and proprioceptive balance, on dynamic postural control have been conducted. The findings and conclusions of these studies (Kahle and Gribble, 2009; Aggarwal *et al*., 2010; Fatma *et al*., 2010; Filipa *et al*., 2010; Hosseinimehr and Norasteh, 2010; Leavey *et al*., 2010; Amrinder *et al*., 2012; Sandrey and Mitzel, 2013) are summarized in paragraph 2.2 below.

## 2.2 Influence of exercise programmes on dynamic postural control

### 2.2.1 Core stability

All movements are initiated in the gravitational centre in the lumbo-pelvic region. The local and global core muscles surround the centre of gravity and during activity the centre of gravity constantly shifts and the core muscles play an important role by maintaining a stable base of support. The core muscles are constantly working to maintain posture, absorb loads, assist in changing postures and dynamic movements, and to transfer force between the upper and lower extremities (Kahle and Gribble, 2009; Aggarwal *et al*., 2010; Sandrey and Mitzel, 2013). Therefore, core stability forms an integral part of dynamic postural control.

A hypothesis was tested by Kahle and Gribble (2009) that training of the core muscles would lead to improving dynamic postural control in young physically active individuals. In the study dynamic postural control was measured using three reach directions of the SEBT. The core stability group demonstrated a significant increase in the three reach directions (Anteromedial direction: p=0.001, Medial direction: pÂ0.001 and Posteromedial direction: p=0.013) compared to a control group. The study results indicated that strengthening of the mm. transversus abdominis (TrA), internal and external obliques and rectus abdominis were beneficial for improving dynamic balance.

Sandrey and Mitzel (2013) examined the effect of a six-week core-stability training programme on dynamic balance in high school track and field athletes. The athletes performed exercises three times a week for 30 minutes. The programme focused on strengthening abdominal, low-back and pelvic muscles while maintaining neuromuscular control. The athletes were evaluated using the SEBT for posteromedial, medial and anteromedial directions and demonstrated significant improvement in the medial (p=0.002) and anteromedial (p=0.008) reach distances. The researchers concluded that the core-stability training programme resulted in improvements of dynamic postural control, but that further investigation is warranted due to the small sample size and absence of a control group.

### 2.2.2 Gluteus Medius muscle strengthening

The m.GMed is the largest hip abductor and it accounts for about 60% of the total abductor cross-sectional area (Neumann, 2010). The m.GMed is important in controlling the frontal plane motion of the pelvic hip complex (Ayotte, Stetts, Keenan and Greenway, 2007; French *et al.*, 2010). During single-limb support the m.GMed stabilises the hip to prevent the pelvis dropping on the unsupported side and controls internal rotation and adduction of the femur (French *et al.*, 2010; Boren *et al.*, 2011, Reiman, Bolgla and Loudon, 2012). Dynamic knee valgus, which results from coupled hip internal rotation and adduction, is an example of poor lower extremity control and the m.GMed resists hip internal rotation and adduction and contributes to dynamic postural control (Reiman *et al.*, 2012). It is evident from research that m.GMed strengthening is an important aspect that needs to be addressed during the rehabilitation of dynamic postural control (Fujisawa *et al.*, 2005; Distefano *et al.*, 2009). This finding was emphasized in a study conducted by Leavey *et al.* (2010) when the researchers found that the use of m.GMed exercises improved the dynamic postural control in healthy, active individuals. In the study college students were evaluated using the SEBT and significant improved distances ($p<0.001$) was found in all eight reach directions.

### 2.2.3 Proprioceptive balance

Proprioception is dependent on joint position sense, kinaesthesia, muscle spindles output and the strength of surrounding muscles (Madras and Barr, 2003; Kiers, Brumagne, van Dieen, van de Wees and Vanhees, 2012). According to Clark and Burden (2005) disruption of the proprioception system affects balance and dynamic postural control negatively due to the lack of joint position sense and a delay in protective muscle activity. Improved proprioception increases the ability of mechanoreceptors to detect motion in the foot and make adjustments to restore balance or postural control (Clark and Burden, 2005; Leavey *et al.*, 2010). Other researchers (Amrinder *et al.*, 2012; Kiers *et al.*, 2012) disagreed and claimed that joint mechanoreceptors are stimulated at end range of motion and that improved proprioception and balance are due to joint compression and increased muscle spindle sensitivity rather than increased sensitivity of joint mechanoreceptors.

Kiers *et al.* (2012) further suggested that different strategies are used to maintain balance on stable and unstable surfaces. Proprioceptive signals from muscles surrounding the ankle lead to maintaining balance on a stable surface whereas the CNS gives more priority to proprioceptive signals from muscles of the hip and lower back and the vestibular system when maintaining balance on an unstable surface. Kiers *et al.* (2012) postulated the reason for the difference being that when standing on a stable surface the proprioceptive information from the muscle spindles of the muscles surrounding the ankle and ankle joint correlate with the change in body orientation; whereas when standing on foam or a wobble board proprioceptive information from the muscle spindles of the muscles surrounding the ankle and ankle joint may or may not correlate with changes in body orientation. This inconsistency of proprioceptive information from the ankle causes the CNS to integrate proprioceptive signals from other body regions and the vestibular system to maintain balance.

Fatma *et al.* (2010) examined the effect of an eight week proprioception programme that included single-leg balance and wobble board exercises on dynamic postural control in taekwondo athletes and came to the conclusion that proprioceptive training significantly improved ($p<0.05$) the dynamic postural control performance of these athletes as measured with the Biodex postural control system. Twenty randomised controlled trials testing healthy and physically active participants aged up to 40 years of age were included in a systematic review by Zech *et al.* (2010). The review was performed by two independent reviewers and the results indicated that proprioceptive balance training was an effective intervention to improve dynamic balance in both athletes and non-athletes. Amrinder *et al.* (2012) also examined the effect of proprioceptive exercises on balance and centre of pressure in 80 athletes with self-reported functional ankle instability. The exercises included balancing on a wobble board, exercise mats, air squabs and an uneven walkway. The study results indicated that after a six week proprioceptive exercise programme there was a significant improvement ($p<0.05$) in the balance of athletes with functional ankle instability.

### 2.2.4 A combination of exercise programmes or comparison of different exercise programmes

Leavey *et al.* (2010) compared the effects of a six week balance, m.GMed strengthening, and a combination programme consisting of balance and m.GMed strengthening on dynamic postural control in healthy, active individuals.

Proprioceptive balance exercises included fixed-surface balancing with eyes open and closed, tilt-board and wobble-board exercises as well as functional hops. M.GMed exercises consisted of side-lying hip abduction, walking with a weight in the opposite hand, gorilla walking, single-leg squats and lateral step-downs. The participants performed three sets of ten repetitions increasing to three sets of twenty repetitions of side-lying hip abduction. In the "walking with a weight in the opposite hand" exercise the participants walked for three minutes around an 80 meter track, carrying a dumbbell in the hand opposite from the dominant leg. The weight of the dumbbell was 5% of their body weight progressing to 15% of their body weight. Three sets of 20 repetitions progressing to three sets of 40 repetitions of gorilla walking or lateral walking with Theraband wrapped around both legs just above the knees, was performed. Two sets of five increasing to four sets of five squats and lateral step-downs were also completed by the m.GMed strengthening group.

Dynamic postural control was measured with the SEBT and the difference between the pre-test and post-test reach distances of all three groups were significant at pÂ0.001. Although no significant differences were found between the groups as far as post-test reach improvement was concerned, the combination group demonstrated the most improvement. The results of the study indicated that the use of exercises for proprioception, or m.GMed strength, or a combination will improve dynamic postural control in healthy, active individuals.

A randomised controlled trial (Aggarwal *et al*., 2010) compared lumbar core stabilization training with balance training in recreationally active individuals. The core stabilization exercise programme focused on awareness and activation of mm. TrA and lumbar multifidus (LM) in various positions with progression to maintain the contraction of mm. TrA and LM while attempting various functional tasks. The balance training protocol included drills targeting the ankle muscles progressing to balance activities in more functional positions, consisting of one leg standing, one leg standing on a trampoline and doing ball catching activities whilst standing on one leg. Both the core stabilization training group and balance training group showed significant (pÂ0.05) improvement in dynamic balance compared to the control group. Dynamic postural control was measured with the SEBT and the core stabilization and balance training groups showed an improvement in the reach distance of seven of the eight directions of the SEBT. The group doing core stability training showed greater improvement in dynamic balance compared to the balance training group.

The objective of Filipa *et al's* (2010) study was to determine if a neuromuscular training programme that focused on lower extremity strengthening and core stability, would improve the lower extremity dynamic stability measured with the SEBT in female soccer players. Lower extremity strength exercises included barbell squats, walking lunges, lateral lunges and lateral step-downs. Core stability exercises included lateral crunches, double-crunches, pelvic bridges and Swiss ball back hyperextensions. Subjects in the neuromuscular training programme showed improved performance of the SEBT composite score on both limbs (p=0.03 for the right limb and p=0.04 for the left limb) after eight weeks of training, while no change was observed in the control group.

All the above mentioned studies showed improved dynamic postural control after the exercise programmes were completed as measured with the SEBT. It was interesting to note that when two components were combined during an exercise programme, greater improvement was found when compared to only one component (Filipa *et al.,* 2010; Leavey *et al.,* 2010). From the above literature it can therefore be hypothesised that a programme consisting of a combination of core stability, m.GMed strengthening and proprioceptive balance exercises could lead to further improvement in dynamic postural control due to the fact that all the sensory and motor systems are targeted (paragraph 2.1) (Bressel *et al.*, 2007; Gribble *et al.*, 2009).

After an extensive search of the available literature, no studies investigating a programme that utilised the combination of core stability, m.GMed strengthening and proprioceptive balance exercises on dynamic postural control could be found.

## 2.3 Principles of an exercise programme

### 2.3.1 Principles of a core stability exercise programme

Core stability exercises should be included in a rehabilitation programme to improve dynamic postural control as core stability forms an integral part of dynamic postural control (paragraph 2.2.1) (Smith *et al.,* 2008; Sandrey and Mitzel, 2013). A core stability programme begins with recognition of the neutral spine position as this is the position of power and balance for optimal athletic performance in many sports (Akuthota, Ferreiro, Moore and Fredericson, 2008: 41). Learning to co-activate the local muscle system (mm.TrA, LM, internal oblique and muscles of the pelvic floor) is the next step in a core stability programme as the intrinsic mechanism increases trunk stiffness by feed-forward neuromuscular pre-activation in anticipation of a perturbation

(Akuthota *et al.*, 2008; Smith *et al.*, 2008). The TrA contracts 30ms before movement of the shoulder and 110ms before movement in the leg in healthy people (Akuthota *et al.*, 2008). Once optimal local co-activation has been recruited, the interplay between local and global muscles is necessary for functional stability (Hodges and Moseley, 2003). The global muscle system is responsible for movement and includes the more superficial muscles e.g.mm. rectus abdominis, external oblique, erector spinae and gluteus maximus (Reiman, 2009). Local co-activation should then be progressed to endurance exercises in supine, crook-lying or quadruped positions e.g. curl-up, side-bridging and bird dog, while maintaining neutral spine position (Akuthota *et al.*, 2008; Smith *et al.*, 2008).

Phase two of the core stability programme should progress to higher velocity, more dynamic multiplanar endurance, strength, and coordination challenges incorporating upper and lower extremity movements e.g. physio ball exercises (Akuthota *et al.*, 2008; Smith *et al.*, 2008). Local muscles provide intrinsic spinal stability and activating a few local muscles is insufficient to achieve stability during high-velocity and high-load perturbations (Smith *et al.*, 2008; Reiman, 2009). Global muscles provide composite stability, large movements and torque production and are essential in providing dynamic stability (Smith *et al.*, 2008; Reiman, 2009). Isolated exercises do not represent the typical pattern and load demands of functional movement and is insufficient in providing dynamic stability (Smith *et al.*, 2008; Reiman, 2009). A comprehensive programme incorporating all the aspects of dynamic stability is therefore warranted.

Akuthota *et al.* (2008), Smith *et al.* (2008) and Reiman (2009) placed emphasis on functional sport-specific exercises in phase three of a core stability programme as non-weight bearing exercises might not provide a learning component and will not translate to improved athletic performance. The failure to train athletes in functional activities is one of the main reasons for poor results following exercise programmes (Reiman, 2009). Physiotherapists use sport-specific exercises during the final rehabilitation of patients according to the principles of specificity and learning. Specificity relates to the specific adaptation of the muscle to the imposed demands and rehabilitation needs to mirror the functional activity it aims to improve (Petty, 2004). Balance and coordination should be developed while performing a variety of movement patterns in the sagittal, frontal and transverse planes of movement (Akuthota *et al.*, 2008), because specific neuromuscular activation patterns differ depending on characteristics and spinal loads (Smith *et al.*, 2008). An advanced core stabilizing programme should include training of the reflexive control and postural regulation as the stability of the spine is not only dependent on muscle strength, but also sensory input. This sensory input alerts the central nervous system (CNS) regarding interaction between the body and the environment (Akuthota *et al*., 2008). Both sensory and motor system training is a requirement for dynamic postural control (paragraph 2.1). Research performed by Kahle and Gribble (2009) and Aggarwal *et al*. (2010) indicated that three sessions a week for six weeks of a core stability programme was sufficient for improving dynamic postural control.

### 2.3.2 Principles of a m. GMed exercise programme

Due to the importance of m.GMed in dynamic postural control (paragraph 2.2), several research studies (Bolgla and Uhl, 2005; Ayotte *et al*., 2007; Ekstrom, Donatelli and Carp, 2007; Distefano *et al*., 2009; Boren *et al*., 2011) analysed the electromyographic (EMG) activity of m.GMed during exercises used in the rehabilitation of m.GMed. Electromyography can be used to measure and compare muscle activity during different exercises (French *et al*., 2010). Greater EMG amplitude is related to an increase of motor units recruited and an increase in m.GMed activity during the exercise (Ekstrom *et al*., 2007; French *et al*., 2010). Researchers therefore postulate that exercises producing higher EMG amplitudes results in greater strengthening of the muscle (Ayotte *et al*., 2007). EMG amplitudes can also be used to determine the efficacy of the exercise and to make a decision during which stage of rehabilitation the exercises should be implemented (Ayotte *et al*., 2007). The exercises analysed and their m.GMed EMG activity expressed as a percentage of maximum voluntary contraction (MVIC) is indicated in Table 1 below.

Table 1: Comparison of exercises for recruitment of GMed using % MVIC

| Exercise | Boren, *et al.* 2011 | Distefano, *et al.* 2009 | Ayotte, *et al.* 2007 | Ekstrom, *et al.* 2007 | Bolgla and Uhl, 2005 |
|---|---|---|---|---|---|
| Side plank abduction | 103% | | | | |
| Side plank to neutral position | | | | 74% | |
| Single limb squat | 82% | 64% | | | |
| Single limb mini-squat | | | 36% | | |
| Single limb wall squat | | | 52% | | |
| Front plank with hip extension | 75% | | | | |
| Side-lying hip abduction | 63& | 81% | | 39% | 42% |
| Lateral step-up | 60% | | 38% | 43% | |
| Pelvic drop | 58% | | | | 57% |
| Single-limb dead lift | 56% | 58% | | | |
| Forward step-up | 55% | | 44% | | |
| Sideways hop | 57% | 57% | | | |
| Clamshell 1 (30° hip flexion) | 47% | 40% | | | |
| Clamshell 2 (60° hip flexion) | | 38% | | | |
| Clamshell 4 (hip extension) | 77% | | | | |
| Quadruped with contralateral arm and leg lift | | | | 42% | |
| Retro step-up | | | 37% | | |
| Lunge – neutral trunk position | | | | 29% | |
| Bridging on a stable surface | | | | 28% | |
| Unilateral bridge | | | | 47% | |
| Prone bridge plank | | | | 27% | |
| Sideways lunge | | 42% | | | |
| Transverse lunge | | 48% | | | |

Ayotte *et al.* (2007) indicated an expected strength gain when EMG activity is greater than 40% MVIC, but argued that exercises with lower EMG activity can be used to facilitate neuromuscular activation. A literature review of studies evaluating m.GMed activation during rehabilitation exercises (Reiman *et al.*, 2012) divided the exercises into four categories according to levels of activation. The categories include exercises with low-level activation (0-20% MVIC), moderate-level activation (21-40% MVIC), high-level activation (41-60% MVIC) and very high-level activation (higher than 60% MVIC).

None of the studies that met the inclusion criteria as stipulated (Bolgla and Uhl, 2005; Ayotte *et* al., 2007; Ekstrom *et al.*, 2007; Distefano *et al.*, 2009) in the literature review (Reiman *et al.*, 2012) included any exercises in the category of low-level activation. Exercises in the category of moderate-level activation (21-40% MVIC) included prone bridge plank, bridging on a stable surface, lunge with a neutral trunk position, single limb mini-squat, retro step-up, clamshell two with 60° hip flexion, sideways lunge and clamshell one with 30° hip flexion. Exercises in the category of high-level activation (41-60% MVIC) included lateral step-up, quadruped with contralateral arm and leg lift, forward step-up, unilateral bridge, transverse lunge, single limb wall squat, side-lying hip abduction, pelvic drop and single limb dead lift. Exercises in the category of very high-level activation (higher than 60% MVIC) included single limb squat and side plank to neutral position.

Greater EMG amplitudes of m.GMed were observed during exercises in which the base of support was minimal, e.g. side plank abduction, single-limb squat and lateral step-up, in comparison to exercises in which the base of support was greater, such as lunges (Boudreau, Dwyer, Mattacola, Lattermann, Uhl and McKeon, 2009). Lesser EMG amplitudes were noted during exercises with a larger base of support due to the fact that these exercises involved m.GMed stabilizing in the sagittal plane to keep the pelvis level (Reiman et al., 2012). The greater EMG amplitudes during exercises with a minimal base of support were due to the fact that such exercises directly involved the primary function of m.GMed as a stabiliser in the frontal plane (Distefano *et al.*, 2009).

Bolgla and Uhl (2005) further reported that weight-bearing (WB) exercises (pelvic drop, WB hip abduction) resulted in greater EMG amplitudes of m.GMed than non-weight-bearing (NWB) exercises (NWB standing hip abduction). The only exception was side-lying hip abduction and Distefano *et al.* (2009: 538) argued that the reason for the higher EMG amplitude in this NWB exercise was "*the large external moment arm created by the mass and the extended position of the lower extremity being lifted*."

Greater EMG amplitudes of m.GMed were also noted during exercises which involved a combination of hip abduction and lateral rotation e.g. clamshell; exercises controlling multiple planes of movement e.g. unilateral bridge; during exercises where the body's centre of mass is displaced away from the base of support e.g. single limb wall squat and single limb dead lift; and exercises which involved a combination of eccentric and concentric muscle contraction e.g. pelvic drop (Reiman *et al.*, 2012). Lee, Choi, Yoon and Jeong (2013) tested the effects of different hip rotations on mm.GMed and tensor fascia lata (TFL) muscle activity during isometric side-lying hip abduction. The study concluded that side-lying hip abduction when the hip is in medial rotation resulted in greater m.GMed activation and a higher mm.GMed:TFL ratio. The researchers hypothesised that during side-lying hip abduction, when the hip is in lateral rotation, the hip is pulled into extension which results in placing the m.TFL anterior to the hip joint causing m.TFL activity to increase and m.GMed activity to decrease. The contradiction between Reiman *et al.* (2012) and Lee *et al.* (2013) whether hip lateral or medial rotation are more beneficial for m.GMed activation in side-lying hip abduction could be explained due to the fact that only one set of electrodes over the middle m.GMed were used in Lee *et al's* (2013) study. The m.GMed is divided into an anterior, middle and posterior set of fibres and all these fibres contribute to hip abduction whilst the anterior fibres also assists with hip medial rotation and the posterior fibres with hip extension and lateral rotation (Neumann, 2010; Reiman *et al.,* 2012).

As a result of EMG activity, it is suggested that progression of exercises should be from exercises in a single plane to multi-planar exercises; from exercises with a larger base of support to exercises with a smaller base of support; and from exercises where the body's centre of mass fall within the base of support to exercises where the body's centre of mass is displaced away from the base of support (Distefano *et* al., 2009; Reiman et al., 2012).

It is important to consider "*functional demands on the muscle in athletes when selecting an exercise for muscle training and strengthening*" (Boren *et al.*, 2011: 213). "*For optimal transfer, training has to comprise of similar movement patterns and context to the goal task*" (Lederman in Aggarwal *et al*., 2010). Pelvic drop, single-limb squat, single-limb dead lift, and sideways hop are functional exercises that demand frontal-plane pelvic stability needed by netball players for pelvic stabilization in single limb stance (Distefano *et al*., 2009; Boren *et al*., 2011).

M.GMed is a "*global stabiliser which generates force to control movement through eccentric control*" (Petty, 2004:175). To improve endurance of a muscle, the muscle must be progressively overloaded through an increase in duration and frequency (Bruton, 2002). While aiming to improve muscle endurance a muscle must contract 30% to 50% of its maximum contraction, for 20-30 minutes three times a week and 25 to 35 repetitions need to occur at each session (Petty, 2004). A six week m.GMed programme showed an improvement in dynamic postural control in healthy, active individuals (Leavey *et al*., 2010). The participants performed six exercises three times a week. During the first two weeks three sets of ten repetitions were performed, increasing to three sets of 15 repetitions the third and fourth weeks and three sets of 20 repetitions the final two weeks. The exercise programme therefore followed the guidelines as discussed above, with the exception that slightly more repetitions were performed. No other study could be found to compare the effect that a certain or predetermined amount of repetitions would have on improvement of dynamic postural control.

### 2.3.3 Principles of a proprioceptive balance programme

Proprioceptive balance training is an effective intervention to improve dynamic balance (paragraph 2.2.3) (Fatma *et al*., 2010; Zech *et al*., 2010; Amrinder *et al*., 2012) and should be incorporated in a dynamic postural control programme. Proprioceptive training incorporates both static and dynamic balance exercises (Leavey *et al*., 2010). Static balance exercises aim to maintain the centre of pressure of the body within the base of support, while dynamic balance exercises aim to move the centre of pressure in a given direction within the limits of stability (Aggarwal *et al*., 2010). Single-leg balance on fixed and unstable surfaces, tilt board, wobble-board and functional hop exercises were effectively used in research studies to improve dynamic postural control (Paragraph 2.2.3; Paragraph 2.2.4.1) (Rasool and George, 2007). According to Aggarwal *et al.* (2010) weight bearing exercises are advised in proprioceptive balance training as it stimulates joint mechanoreceptors leading to increased proprioceptive input. Closed eyes training was effective in a randomised controlled pilot study conducted by Hutt and Redding (2014) in improving dynamic postural ability of dancers. The results of a systematic review on 20 randomised controlled trials (Paragraph 2.2.3) (Zech *et al*., 2010) showed more pronounced improvement in neuromuscular control with a training duration of at least six weeks. No consensus could be reached in the systematic review (Zech *et al*., 2010) regarding the duration of each session, which lasted between five and 90 minutes per day, and the training frequency from two to seven times a week.

## 2.4 Netball players

Maintaining dynamic postural control is essential in netball players due to the fact that netball players accelerate rapidly to break free from an opponent, change direction suddenly in combination with leaps to receive a pass, intercept a ball or rebound after attempting a goal (McGrath and Ozanne-Smith, 1998). Netball is an interval type game involving less than fifteen seconds work intervals of sprints, jumps and shuffling movements interspersed with rest-relief periods of slow jogging, goal shooting and passive defence (Ashfield, 1998). IFNA footwork rule states that a player can receive the ball with both feet grounded or jump to catch the ball and land on two feet simultaneously. The player may then take a step in any direction with one foot and pivot on the spot with the other foot. An alternative is to receive the ball with one foot grounded or jump to catch the ball and land on one foot. The landing foot cannot be moved, other than to pivot on the spot, whilst the other foot can be moved in any direction. Once the landing foot is lifted, it may not be re-grounded until the ball is released. It is evident that netball players frequently find themselves on one leg whilst still having to make an accurate pass and therefore require good balance and dynamic postural control. Research by Ferreira and Spamer (2010) evaluated the physical profile of elite university netball players and a computerised balance test was used to evaluate the balance of the netball players pre-season and post-season. The results of the study indicated that netball players demonstrated poor balance during pre-season testing.

Studies conducted in South Africa (Ferreira and Spamer,2010; Langeveld *et al*., 2012; Pillay and Frantz, 2012) which evaluated the injury prevalence of netball players reported the most common injured structures were the knee and ankle and the most common mechanism of injury to the lower limb was landing. Ferreira and Spamer (2010) reported an injury prevalence of 39% and 28% for the ankle and knee during one season among university netball players. Their findings are similar to the more recent studies conducted by Langeveld *et al*. (2012) and Pillay and Frantz (2012) who determined the epidemiology of injuries among elite South African netball players. Langeveld *et al*. (2012) reported an injury prevalence of 34% and 18% for the ankle and knee compared to Pillay and Frantz (2012) who reported an injury prevalence of 37.5% and 28.6% for the ankle and knee. According to Pillay and Frantz (2012) research is needed regarding measures to prevent lower limb injuries within South African netball players (Pillay and Frantz, 2012); whilst Langeveld *et al*. (2012) recommended an exercise programme consisting of core stability, neuromuscular control and proprioception in order to reduce lower limb injuries in netball players.

## 2.5 Netball Season

The duration of the pre-season in netball is from January to May of each calendar year, but this could vary depending on institutions and academic terms.

## 2.6 Star Excursion Balance Test

Dynamic postural control is assessed with the SEBT (Nakagawa and Hoffman, 2004; Gribble *et al.*, 2009; Kahle and Gribble, 2009; Filipa *et al.*, 2010; Leavey *et al.*, 2010), the Biodex postural control system (Filipa *et al.*, 2010) and with a force plate (Puls and Gribble, 2007). The SEBT is a valuable test for assessing dynamic balance as it has high inter-rater and intra-rater reliability (Gribble, 2003; Demura and Yamada, 2010; Gribble, Kelly, Refshauge and Hiller, 2013). A literature and systematic review (Gribble *et al.*, 2012) found that the SEBT is a valid and reliable test in predicting risk of musculoskeletal injury; to identify dynamic postural control deficits in individuals with lower extremity conditions; and has the ability to demonstrate improved performance from rehabilitative and preventive exercise programmes in healthy individuals and in those with lower extremity conditions. The SEBT is a simple, low cost alternative to more expensive instruments e.g. the Biodex and force plate (Leavey *et al.*, 2010) and the testing is not confined to a laboratory.

The SEBT is a useful clinical measure as it challenges the athletes' postural control system as the body's centre of mass is moved in relation to its base of support (Gribble, 2003; Kahle and Gribble, 02009). As a netball player's centre of mass is moved in relation to her base of support, the SEBT can therefore be used as a valuable measurement tool in the assessment of dynamic postural control in netball players.

Participants' leg length was measured in previous studies (Kahle and Gribble, 2009; Aggarwal *et al.*, 2010; Filipa *et al.*, 2010; Leavey *et al.*, 2010; Arminder *et al.*, 2012; Sandrey and Mitzel, 2013) and used to normalize reach distance data. Participants in this study were only compared to themselves and not to other participants and therefore leg length were not measured to avoid the possibility of unnecessary measurement errors.

## 2.7 Execution of the SEBT

Two marker lines are placed on a hard surface at an angle of 90< from each other to form four direction lines (Figure 2). A measuring tape is placed on each line to avoid the measuring point to differ between participants and to increase measurement accuracy (Demura and Yamada, 2010). The reach direction labels changes for right versus left stance or supporting leg (Figure 2) (Gribble, 2003).

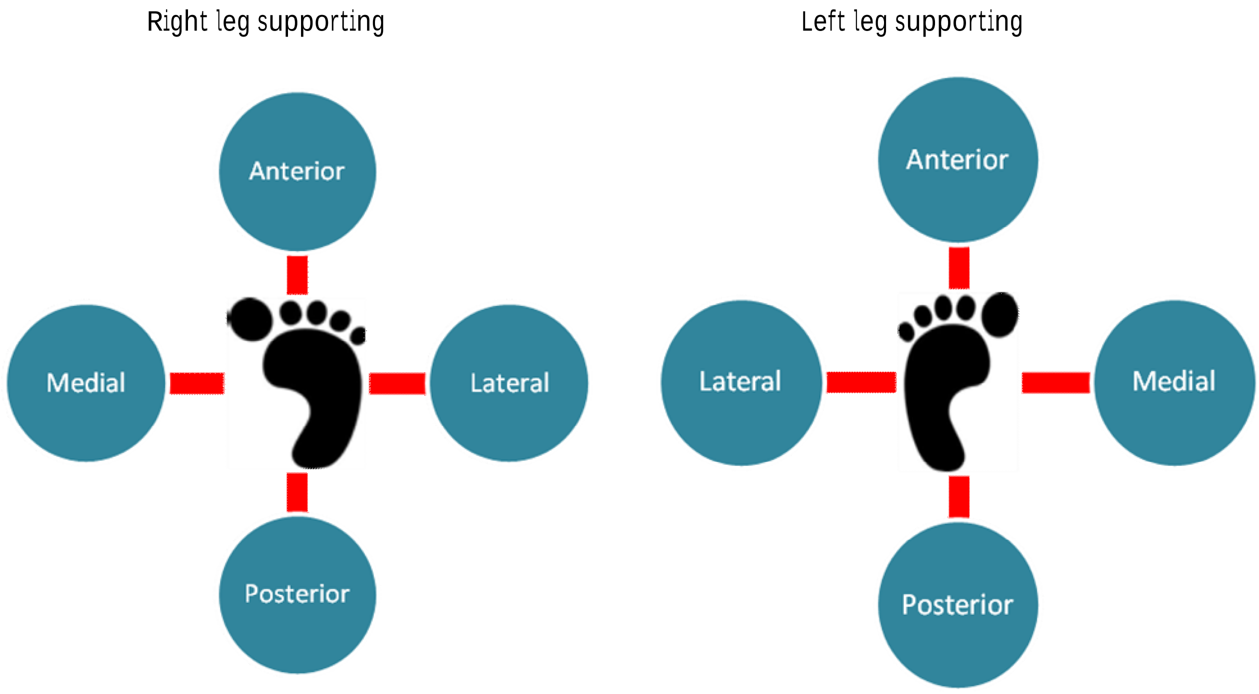



Figure 3: Reach direction lines for right and left stance

The participant maintains a base of support with one leg while reaching in the four directions with the opposite leg, without compromising the base of support on the stance leg (Gribble, 2003, Demura and Yamada, 2010). Participants are asked to stand with their supporting leg on the centre of the cross. Participants are then instructed to reach as far as possible along the four direction lines without lifting the supporting foot from the floor while holding their hands on their hips and facing forwards (Hosseinimehr and Norasteh, 2010). The beginning reach direction is anterior and a clockwise direction is followed for a participant with a left stance leg and a counter-clockwise direction for a participant with a right stance leg (Hosseinimehr and Norasteh, 2010). Participants perform a light touch with their big toe on the line as near as possible to their maximum reach, and then return to double-leg stance before attempting movement in the next direction (Hosseinimehr and Norasteh, 2010). If the participant cannot touch the line; or if the participant's weight is shifted to the reach leg; or if the support leg is lifted from the centre; or if the participant loses balance; or cannot return to the beginning position under control, the trial is then discarded and the participant is instructed to repeat all four reach directions of the trial they are currently engaged in (Gribble, 2003, Hosseinimehr and Norasteh, 2010).

Demura and Yamada (2010) also shows that testers can accurately point to and read the distance from the scale placed on the lines and this technique makes it possible to measure a large number of participants with the same four direction lines. To avoid a parallax fault, the data collector touches with a pencil on the measuring tape and reads the distance reached by the most distal part of the participant's big toe. The distance is recorded by an assistant on the participant's data sheet (see Appendix 4) and repeated back to the tester to evade measurement errors.

According to Kahle and Gribble (2009) and Demura and Yamada(2010) the same validity will be achieved measuring three trials and four directions (anterior, medial, posterior, lateral) as with the original test of ten trials and eight directions. The simple SEBT with three trials and four directions is more practical due to a reduction (about 85%) in measurement time and less physical burden on the subject (Demura and Yamada, 2010).

## 2.8 Conclusion

Research was warranted to determine whether an exercise programme that incorporated scientifically grounded core stability, m.GMed strengthening and proprioceptive balance exercises three times a week over a period of six weeks (see principles of an exercise programme in paragraph 2.3.1, 2.3.2 and 2.3.3) could lead to an improvement in dynamic postural control as measured with the SEBT in a group of netball players. Poor core stability and decreased muscular synergy of the trunk and hip stabilisers have been theorized to decrease performance and increase the incidence of injury secondary to a lack of control of the centre of mass and dynamic posture, especially in female athletes (Filipa *et al*., 2010; Langeveld *et al*., 2012). Since poor balance was found in netball players pre-season (paragraph 2.4), research on the effect of a core stability, m.GMed strengthening and proprioceptive balance exercise programme in netball players could therefore substantiate evidence of the effectiveness of such an exercise programme to improve dynamic postural control. An exercise programme could contribute towards the elimination of shortcomings in the physical profile of netball players regarding dynamic postural control as well as contribute towards increased performance and injury prevention.

In the next chapter the methodology of the study will be described in detail including the pilot study, the recruitment of participants, the method of measurement, the exercise programme, procedures followed during the study as well as ethical aspects.

# Chapter 3 Methodology

In chapter three the aim of the study, the study design, the study population as well as the recruitment and randomization of the participants are discussed. Included in this chapter is a discussion of the training of the data collector and assistant as well as the pilot study. In conclusion the measurement, procedures and ethical aspects of the study are discussed step by step.

## 3.1 Research aim:

The aim of the study was to determine whether an exercise programme that incorporates core stability, m.GMed strengthening and proprioceptive balance exercises three times a week over a period of six weeks would lead to a statistically significant improvement (pÂ0.05) in dynamic postural control in a group of netball players.

## 3.2 Objectives

The objectives of the study were:

1) To compile an exercise programme that incorporated scientifically grounded core stability, m.GMed strengthening and proprioceptive balance exercises.

2) To assess the dynamic postural of the netball players using the SEBT to determine the efficacy of the exercise programme.

## 3.3 Research design

A cross-over randomised clinical trial was performed. The participants were randomly divided into two groups and for the first six weeks group A participated in the exercise programme while group B was considered as the control group after which the roles were reversed. The participants had been selected to one of the groups on a random basis to ensure that, on average, the two groups are quite similar and that any differences between them are due entirely to chance. A cross-over trial was performed to have a control group, but still allow all the participants to partake in the exercise programme. A control group was needed for the internal validity of the study to allow the researcher to draw accurate conclusions about the cause-and-effect within the data (Leedy and Ormrod, 2010).

## 3.4 Study participants

The study population was female netball players of the University of the Free State (UFS) selected into the top junior netball group consisting of 20 netball players. The following criteria were used to determine the inclusion, elimination and fall-out of eligible netball players.

### 3.4.1 Inclusion criteria

1) Voluntary agreement to participate.
2) Informed consent.

### 3.4.2 Exclusion criteria

1) A history of lower extremity injuries in the past six months (any injury preventing the participant from partaking in physical activity for longer than two days) (Kahle and Gribble, 2009).

2) Lower extremity surgery in the past year (Leavey *et al.*, 2010).

3) Currently partaking in any balance, core stability or m.GMed exercise programme, not included in their standard exercise programme (Leavey *et al.*, 2010).

Inaccurate history recall and information could be given regarding the exclusion criteria (history of lower extremity injuries in the past six months or lower extremity surgery in the past year). However a research study (Gabbe, Finch, Bennel and Wajswelner, 2003) assessed the accuracy of a 12 month injury history recall in a population of Australian football players and showed that 100% of participants could recall whether or not they were injured in the past year. Seventy-nine percent of participants reliably recalled the body region and number of injuries, but not the specific diagnosis (only 61% of participants). A 12 month sport injury history self-reported questionnaire in the study by Gabbe *et al.* (2003) showed good validity regarding recall for past injury status. An accurate diagnosis was not required in this research study, therefore an injury profile questionnaire which was attached to the informed consent form (Appendix 3) was used to determine whether a participant had a history of lower extremity injuries in the past six months or lower extremity surgery in the past year. The exclusion criteria were applied once the participants completed the injury profile questionnaire.

### 3.4.3 Fall out criteria

The participants needed to attend at least 14 of the 18 training sessions (approximately 77% attendance) and had to return for post testing in order for the data of the participants to be included in the study results (Leavey *et al.*, 2010). The participants' attendances were recorded on an attendance record sheet (Appendix 5).

### 3.5 Training of data collector and assistant

The simple SEBT was selected to measure dynamic postural control (paragraph 2.6). Two individuals, other than the researcher, were required to assist in the research study as a data collector and assistant to ensure objectivity and reliability during the data collection. The data collector's task was to measure the distances reached by the participant during the SEBT test. The assistant's task was to document the distances reached by participants during the SEBT test on the participant's data sheet (paragraph 2.7).

Two qualified physiotherapists were recruited to be the data collector and assistant. During a special session on the 11th of January 2014, before the pilot study the data collector and assistant underwent training by the researcher in order to execute the SEBT accurately.

### 3.6 Pilot study

Female hostel netball players of the UFS were approached and three netball players were recruited to participate in the pilot study. The data collector and assistant assessed the participants in the pilot study by means of the SEBT. The assessment during the pilot study was executed by the data collector and assistant in the exact same manner as the study. The three participants in the pilot study attended three exercise sessions in order to determine the accuracy and applicability of the exercise programme.

During the pilot study it was established that the data collector would be more accurate when touching with the edge of a small ruler instead of a pencil on the measuring tape as this made reading the distance reached by the most distal part of the participant's big toe easier. The participants were unsure if they should return to double-leg stance or single-leg stance before attempting movement in the next direction and the significance of clear instructions regarding return to double-leg stance were realized.

The data collector and assistant used the correct techniques and followed the stipulated procedures given by the researcher. The assistant was able to complete the data form as well as repeating the participant's reach distance back to the data collector with accuracy. The assistant confirmed the ease of use of the data sheet.

Although the participants in the pilot study could execute the exercise programme regarding difficulty, number and sets of exercises in a session, it was recognized that the co-activation of TrA and LM as well as the accuracy of the exercises needed to be checked regularly by the researcher. The results of the pilot study were excluded from the official study results, due to the fact that the pilot study participants participated in only three exercise sessions and not the full six weeks of exercise sessions as required in the main study.

## 3.7 Recruitment

After the top junior netball group of the UFS had been selected, the researcher held an information session on the 31st of January 2014 with the group and explained the reason and goal of the study, the requirements and commitment from participants as well as the possible benefits and risks involved. Once the information session had been completed, all twenty netball players indicated their interest in participating in the research study. Each participant was given an information leaflet as well as a consent form which had an injury profile questionnaire attached (Appendix 2 and 3). The injury profile questionnaire was completed and the consent form signed and returned to the researcher before commencement of the exercise programme.

One netball player was excluded due to a grade two hamstring injury during the past six months as diagnosed by a sport physician and this prevented her from partaking in physical activity for longer than two days (refer to paragraph 3.3.2 exclusion criteria). The netball player was allowed however to participate in the exercise programme as part of her rehabilitation, but none of her data was included in the study results.

## 3.8 Randomization

Consecutive numbers were given to each of the 20 participants that signed the consent form. Numbers were placed in a hat from which the two groups were drawn. The first 10 numbers drawn were allocated to group A while the remainder of the numbers was allocated to group B. Group A consisted of participants 2, 4, 5, 8, 11, 13, 15, 17 and 19. Group B consisted of participants 1, 3, 6, 7, 9, 10, 12, 14, 16, 18 and 20. For the first six weeks group A participated in the exercise programme while group B was considered as the control group after which the roles were reversed.

## 3.9 Measurement

The simple SEBT with three trials and four directions were used to measure dynamic postural control of the participants (paragraph 2.6 and 2.7). In a previous study (Kahle and Gribble, 2009) on dynamic balance in young, healthy adults; the leg the participant would use to stand on while kicking a ball was used as the supporting leg during assessment with the SEBT. In this study, the netball players' landing leg was used as the supporting leg during assessment with the SEBT.

The same trained physiotherapists (data collector and assistant) did all the measuring and recording to limit inter-observer variation. The data collector gave each participant verbal instructions as well as a physical demonstration on how to execute the SEBT. The data collector and assistant followed the procedure of the SEBT as stipulated in paragraph 2.7 with the exception that the data collector touched with the edge of a small ruler instead of a pencil on the measuring tape as this made reading the distance reached by the most distal part of the participant's big toe more accurate (refer to paragraph 3.5 pilot study).

In spite of some effect of practice by repeating trials, participants were allowed two practice trials before any data was recorded as Demura and Yamada (2010) showed that measured values became almost constant after the second trial. After the two practice trials participants were tested three times in four directions with a minute rest in between the three trials in the testing session.

All the participants were tested during three separate testing sessions. The first testing session of dynamic postural control took place on the 3rd of February 2014 prior to the commencement of the exercise programme of group A. The second testing session took place between the completion of group A's exercise programme and the start of group B's exercise programme on the 18th of March 2014. The third testing session took place after the completion of group B's exercise programme on the 2nd of June 2014. The second and third testing sessions were executed in the same venue at the UFS sport centre under similar conditions as the first testing session.

To avoid diagnostic suspicion bias the data collector and assistant were blinded during the second and third testing session after the completion of the exercise programme regarding the participants' reach distance values obtained during the previous testing sessions. All participants from both groups were tested simultaneously, and the data collector and assistant were blinded to which group the participants belonged.

### 3.10 Procedures

The participants (first group A and then after the second testing, group B) trained under the researcher's supervision at the UFS sport centre. Each training session took approximately 60 minutes, three days a week for a period of six weeks. Group A trained from the 4th of February 2014 to the 14th of March 2014 and group B from to 14th of April 2014 to the 30th of May 2014. Due to public and university holidays Group B had a break of one week from the 28th of April to the 4th of May.

Although the participants did not partake in any other balance, core stability or m.GMed exercise programme during this study, the participants were all first year female netball players selected in the top junior group and partook in pre-season netball training while participating in the exercise programme as well as during the time period of being in the control group. The pre-season netball training consisted of between four and eight hours of training per week.

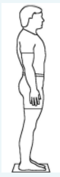
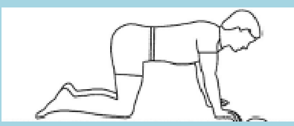
Participants' class schedules were taken into consideration and the training sessions did not interfere with class commitments. Observational notes were taken by the researcher at the training sessions to enhance the value of the study. If a participant failed to attend a training session, the participant was contacted the same or the following day on her cellular phone and the participant was motivated to continue participation. The failure to attend at least 14 of the 18 training sessions lead to the exclusion of the participant's data from the study results (paragraph 3.3.3).

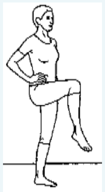
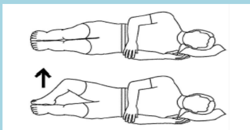
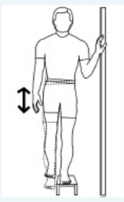
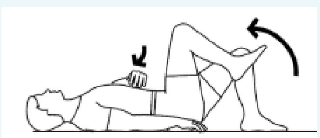
**Table 2: Timeframe of testing session**

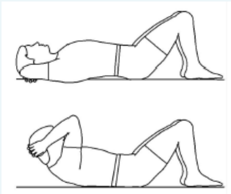
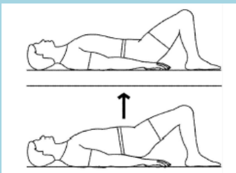
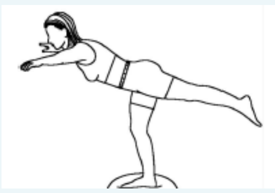
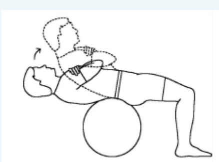
| 3 February 2014 | 4 February - 14 March 2014 | 18 March 2014 | 14 April – 30 May 2014 | 2 June 2014 |
|---|---|---|---|---|
| First testing session | **Group A - exercise programme** + netball training | Second testing session | Group A- control group + netball training | Third testing session |
| | Group B – control group + netball training | | **Group B - exercise programme** + netball training | |

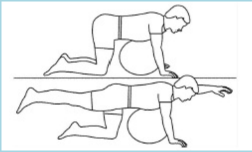
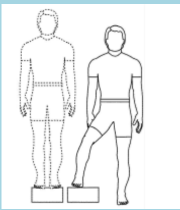
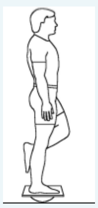
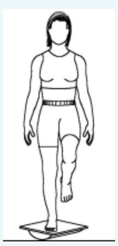
A short summary of the exercise programme followed during the study by participants is illustrated in Table 3 below. For a detailed description of the exercises, please refer to Appendix 6.

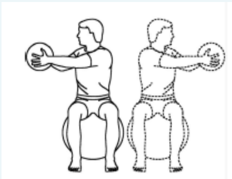
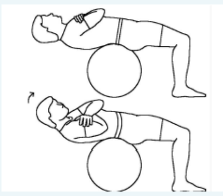
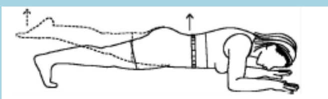
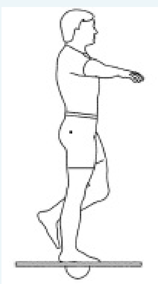
Table 3: Short summary of the exercise programme

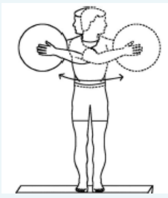
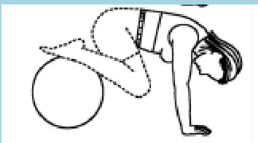
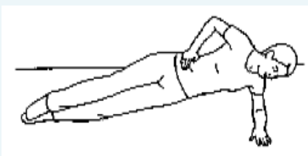
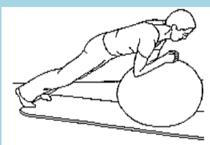
| Exercise | Dosage in sessions | Aim | Source |
|---|---|---|---|
| WEEK 1 | | | |
| 1.1 Recognition of neutral spine(centre of mass) in sitting and standing  | | Core stability | Akuthota *et al.*, 2008 |
| 1.2 Co-activation of TrA& LM in crook supine lying position (base position)  | 1: 10X10 sec. hold<br>2: 12X12 sec. hold<br>3: 15X15 sec. hold | Core stability | Aggarwal *et al.*, 2010 |
| 1.3 Co-activation of TrA& LM in prone lying position  | 1: 10X10 sec. hold<br>2: 12X12 sec. hold<br>3: 15X15 sec. hold | Core stability | *Aggarwal et al.*, 2010 |
| 1.4 Co-activation of TrA& LM in quadruped position (recognition of centre of mass)  | 1: 10X10 sec. hold<br>2: 12X12 sec. hold<br>3: 15X15 sec. hold | Core stability | Aggarwal *et al.*, 2010 |

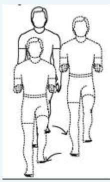
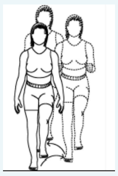
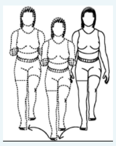
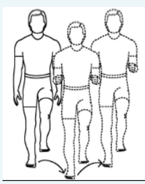
| | | | |
|---|---|---|---|
| 1.5 Co-activation of TrA& LM while standing on single limb (recognition of centre of mass)  | 1: 10X10 sec. hold<br>2: 12X12 sec. hold<br>3: 15X15 sec. hold | Core stability, m.GMed & balance | Aggarwal *et al.*, 2010 |
| 1.6 Clamshell 1  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m. GMed | Distefano *et al.*, 2009; Boren *et al.*, 2011 |
| 1.7 Pelvic drop  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability, m.GMed & balance | Bolga *et al.*, 2005; Boren *et al.*, 2011 |
| <u>WEEK 2</u> | | | |
| 2.1 Supine bent knee-raises  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability | Fredericson and Moore, 2005; Aggarwal *et al.*, 2010 |
| 2.2 Quadruped with alternate arm/leg raises (Superman exercise)  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Federicson *et al.*, 2005;<br>Aggarwal *et al.*, 2010 |

| | | | |
|---|---|---|---|
| 2.3 Abdominal crunches  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability | Kahle and Gribble, 2009 |
| 2.4 Bridging  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Fredericson *et al.*, 2005 |
| 2.5 Single limb dead lift  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | m.GMed, core stability & balance | Distefano *et al.*, 2009; Boren *et al.*, 2011 |
| 2.6 Co-activation of TrA & LM while standing on single limb with eyes closed  | 1: 10X10 sec. hold<br>2: 12X12 sec. hold<br>3: 15X15 sec. hold | Core stability, m.GMed & balance | Aggarwal *et al.*, 2010 & Leavey *et al.*, 2010 |
| WEEK 3 | | | |
| 3.1 Seated marching on physio ball  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability | Fredericson *et al.*, 2005 |
| 3.2 Abdominal crunches on a physio ball  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | | Fredericson *et al.*, 2005; Kahle and Gribble, 2009 |

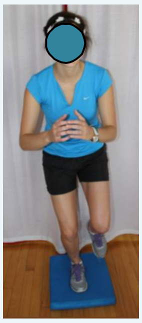
| | | | |
|---|---|---|---|
| 3.3 Superman exercise on a physio ball<br> | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Fredericson *et al.*, 2005 |
| 3.4 Bridging with alternate leg lifts<br> | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Fredericson *et al.*, 2005; Kahle and Gribble, 2009 |
| 3.5 Lateral step up<br> | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | m.GMed, core stability & balance | Ayotte *et al.*, 2007; Ekstrom *et al.*, 2007; Boren *et al.*, 2011 |
| 3.6 Tilt board exercises:<br>1) Balance in plantarflexion/ dorsiflexion<br><br>2) Balance in inversion / eversion<br><br>3) Balance in diagonal<br> | 1: Double leg with eyes open<br>3 sets X 30 sec of each of the 3 planes of motion. 30 sec rest in between<br>2: Double leg with eyes closed<br>3 sets X 30 sec of each of the 3 planes of motion. 30 sec rest in between<br>3: Single leg with eyes open<br>3 sets X 30 sec of each of the 3 planes of motion. 30 sec rest in between | Balance, Core stability & m.GMed | Fredericson *et al.*, 2005 |

| WEEK 4 | | | |
|---|---|---|---|
| 4.1 Trunk rotation with 2kg medicine ball while seated on physio ball  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Kahle and Gribble, 2009 |
| 4.2 Alternate leg bridge with shoulders on physio ball  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Fredericson *et al.*, 2005; Kahle and Gribble, 2009 |
| 4.3 Diagonal curls on physio ball  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Aggarwal *et al.*,2010 |
| 4.4 Front plank with alternate hip extension  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Fredericson *et al.*, 2005; Boren *et al.*, 2011 |
| 4.5 Wobbleboard - Unilateral balance  | 1: 3X20 sec. hold, 40 sec rest in between<br>2: 3X25 sec. hold, 35 sec rest in between<br>3: 3X30 sec hold, 30 sec rest in between | Balance & Core stability | Leavey *et al.*, 2010 |

| WEEK 5 | | | |
|---|---|---|---|
| 5.1 Standing 2kg medicine ball or pulley rotation  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability | Fredericson *et al.*, 2005 |
| 5.2 Lower trunk rotation with shins on physio ball  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Kahle and Gribble, 2009 |
| 5.3 Side plank with upper leg hip abduction  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Fredericson *et al.*, 2005; Ekstrom *et al.*, 2007; Boren *et al.*, 2011 |
| 5.4 Front plank on physio ball  | 1: 3 sets X 20 sec.<br>2: 3 sets X 30 sec.<br>3: 3 sets X 40 sec. | Core stability & m.GMed | Fredericson *et al.*,2005 |

| | | | |
|---|---|---|---|
| 5.5 Functional hop exercises:<br>1) Unilateral diagonal forward<br><br>2) Unilateral diagonal backward<br><br>3) Unilateral forward/backward same side 45˚<br><br>4) Unilateral forward/backward opposite side 45˚<br><br>5) Unilateral rotation 45˚<br> | 1: 1 set X 10 rep. of each of the 5 exercises<br>2: 1 set X 12 rep. of each of the 5 exercises<br>3: 1 set X 15 rep. of each of the 5 exercises | Balance & m.GMed | Leavey *et al.*, 2010 |

| WEEK 6 | | | |
|---|---|---|---|
| 6.1 Forward lunge with a 2kg medicine ball or weight with trunk rotation  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Fredericson *et al.*, 2005 |
| 6.2 Upper extremity-trunk supine overhead throw simulation using a physio ball and a netball  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Smith *et al.*, 2008<br>(Consent obtained for use of photo – Appendix 8) |
| 6.3 Upper extremity-trunk seated overhead throw simulation using a physio ball and a netball  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability & m.GMed | Smith *et al.*, 2008<br>(Consent obtained for use of photo – Appendix 8) |
| 6.4 Upper extremity-trunk-lower extremity standing passing simulation using a physio ball and a netball (Smith *et al.*, 2008)  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Core stability, m.GMed & balance | Smith *et al.*, 2008<br>(Consent obtained for use of photo – Appendix 8) |

| | | | |
|---|---|---|---|
| 6.5 Single-limb 90<Airex hop and hold  | 1: 3 sets X 10 rep.<br>2: 3 sets X 12 rep.<br>3: 3 sets X 15 rep. | Balance, Core stability & m.GMed | Filipa *et al.*, 2010<br>08<br>(Consent obtained for use of photo – Appendix 8) |

Acronyms: rep: - repetitions; sec: - seconds; TrA: - transversus abdominis; LM: - lumbar multifidus; GMed: - gluteus medius.

## 3.11 Contamination

Participants in the control group could have learnt about the exercise programme and adopted it for themselves. The participants taking part in the exercise programme were requested to keep the training programme confidential. Both groups were requested not to take part in any other exercise programme except pre-season netball training while involved in the study, therefore minimizing contamination.

## 3.12 Ethical aspects

The protocol was submitted to the Ethics committee of the Faculty of Health Sciences, UFS and the study was approved on the 29th of November 2013 (Approval number: 189/2013) after informed consent was obtained from the Vice-rector: Academics; the Dean of Student Affairs and the Assistant-Director of Kovsie Sport (see Appendix 1 and 7 for approval letters).

The researcher held an information session and each participant received an information letter informing them regarding the aim of the research study as well as requirements (see Appendix 2 for information letter). The netball players could have felt obligated to participate in the study as they were in the top junior netball group and the perception could have been created that non-participation might lead to discrimination during the team selection. Players were specifically informed during the information session that non-participation would not have an influence on team selection.

Informed consent was obtained from the participants once they read the information letter in their language of choice, Afrikaans or English (see Appendix 3 for consent form). The consent letter indicated that, should a player not wish to participate in the study, they were not required to complete the injury profile questionnaire.

Participants were guaranteed that all information collected during the study will be handled confidentially. The confidentiality of information was established by giving each participant (netball player) a unique, arbitrary code, which was documented on a master list. Only the researcher had access to the master list. Any written documents were labelled using the unique number to keep the nature of the participants' information strictly confidential (Leedy and Ormrod, 2010). All documents were locked in a secure cabinet, to which only the researcher had access and all information on the computer was password protected.

Participants' class schedules were taken into consideration and the training sessions did not interfere with class commitments. Participation in this study was voluntary and if at any time during the study the participant wished to withdraw, she was free to do so without any penalty or consequence. Participants received no remuneration for participation in this study and neither were there any costs involved by participants.

Although the study had a degree of risk involved due to the possibility that exercises might cause injury, the risk was no bigger than participating in a netball practice and great care was taken by the researcher to avoid injury. If the participant was injured as a result of partaking in the assessment or exercise programme of the research study, the researcher would have offered the injured participant physiotherapy treatment free of charge. No participant was injured as a result of partaking in the assessment or exercise programme.

The meticulous way in which the methodology was followed during the conducting of the study ensured that statistically significant results were obtained. In chapter four the results of the study will be illustrated with the use of tables and diagrams.

## 3.13 Data analysis

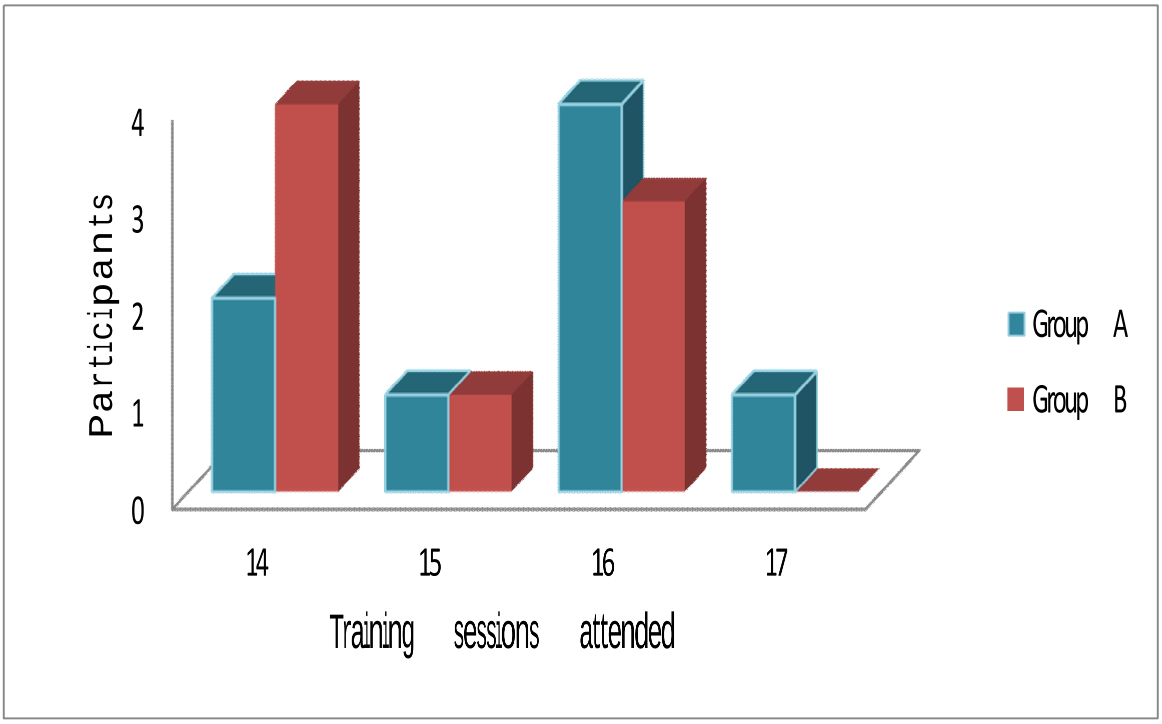
The Department of Biostatistics, Faculty of Health Science at the UFS performed the statistical analysis. The average of the three trials of each of the four reach directions of each participant for each of the three testing sessions were calculated to be used in the further analyses. In addition to this, improvement scores for the four average scores (for the four directions) were computed by subtracting the score for the first session from the second session, the second session from the third session, and the first session from the third session (the latter providing an overall improvement score). This allowed the improvement for the time frame during which the intervention was applied to be assessed directly. SEBT scores (being continuous) were presented as ranges with means and medians. The change in SEBT scores for all participants between each successive round of testing were computed by means of (parametric) paired t-tests for the intervention/non-intervention groups separately. Differences between the SEBT scores and the SEBT improvements for the two groups at each session were computed by means of (parametric) student's t-tests. A p-value of $p < 0.05$ was interpreted as statistically significant.

In this chapter the information obtained from the statistical analyses was divided into attendance of the participants, the participants' supporting leg used during the SEBT, the measurements during the first testing session, the improvement from the first to the second testing session, the improvement from the second to the third testing session as well as the improvement from the first to the third testing session. The results of the study are illustrated with the use of tables and diagrams.

## 4.2 Attendance

Nineteen participants were recruited for the study, but three participants were excluded due to non-compliance. The criteria for compliance were that participants attend at least 14 of the 18 training sessions (approximately 77% attendance) and had to return for post testing (paragraph 3.3). Both group A and B consisted of eight participants.

The attendance of Group A and B are illustrated in graph 1.




Graph 1: Group attendance (n=16)

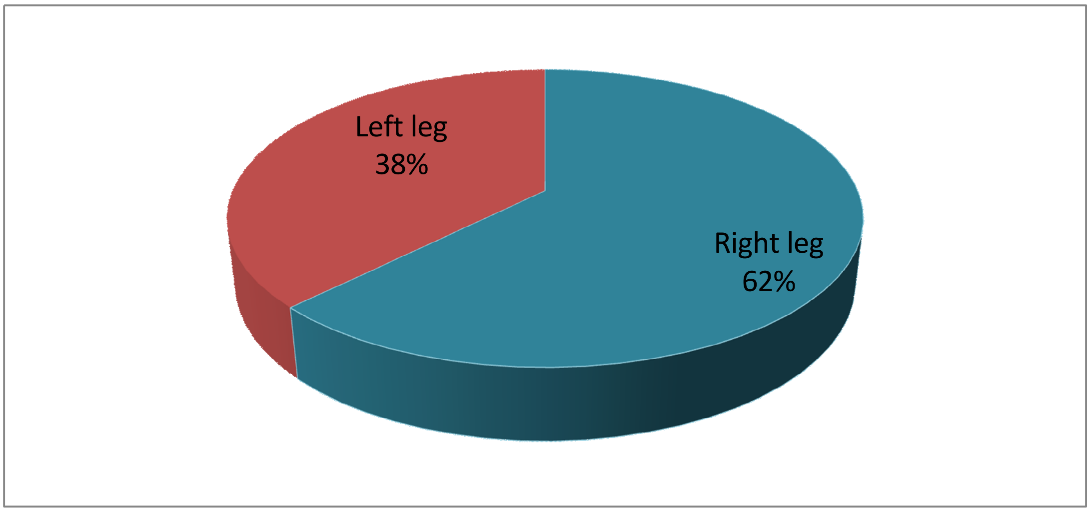
Group A had an average attendance of 16 training sessions and group B 15. The student's t-test was p=0.2453 which indicated that there was no significant statistical differences between attendance of the two groups (Table 4) (Graph 1).

**Table 4: Group attendance (n=16)**

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| **A** | 8 | 14 | 17 | 15.5000 | 1.0690 | | | |
| **B** | 8 | 14 | 16 | 14.8750 | 0.9910 | | | |
| **Diff (A-B) Pooled** | | 0 | 1 | 0.6250 | 1.0308 | 14 | 1.21 | 0.2453 |

## 4.3 Participants' supporting leg during SEBT

During assessment using the SEBT the netball players' landing leg was used as the supporting leg. Ten participants had a right leg starting stance while six participants had a left leg starting stance.




**Graph 2: Participants' supporting leg during SEBT (n=16)**

## 4.4 First testing session

The difference in the measurements of the four reach direction distances during the first testing session of the SEBT between group A and B were computed by means of the student's t-test. The reason for this calculation was to determine the starting point (baseline) between the two groups.

Table 5: Baseline SEBT anterior measurements between groups (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 63.7333 | 90.3333 | 77.5417 | 8.5683 | | | |
| B | 8 | 69.4000 | 92.2333 | 76.1125 | 7.5982 | | | |
| Diff (A-B) Pooled | | -5.6667 | -1.9000 | 1.4292 | 8.0978 | 14 | 0.35 | 0.7294 |

The average distance measured during the anterior reach direction for group A was 77.5 cm and for Group B 76.1 cm with a difference of 1.4 cm between the groups. The p-value was p=0.7294 (Table 5).

Table 6: Baseline SEBT medial measurements between groups (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 58.0667 | 86.9333 | 77.9500 | 9.2489 | | | |
| B | 8 | 66.1333 | 86.6667 | 80.7042 | 6.7596 | | | |
| Diff (A-B) Pooled | | -8.0666 | 0.2666 | -2.7542 | 8.1004 | 14 | -0.68 | 0.5076 |

The average distance measured during the medial reach direction for group A was 78 cm and for Group B 80.7 cm with a difference of 2.8 cm between the groups. The p-value was p=0.5076 (Table 6).

Table 7: Baseline SEBT posterior measurements between groups (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr >\|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 56.20 00 | 88.9000 | 78.3000 | 10.5118 | | | |
| B | 8 | 65.7000 | 93.3333 | 81.8417 | 8.8813 | | | |
| Diff (A-B) Pooled | | -9.5000 | -4.4333 | -3.5417 | 9.7308 | 14 | -0.73 | 0.4787 |

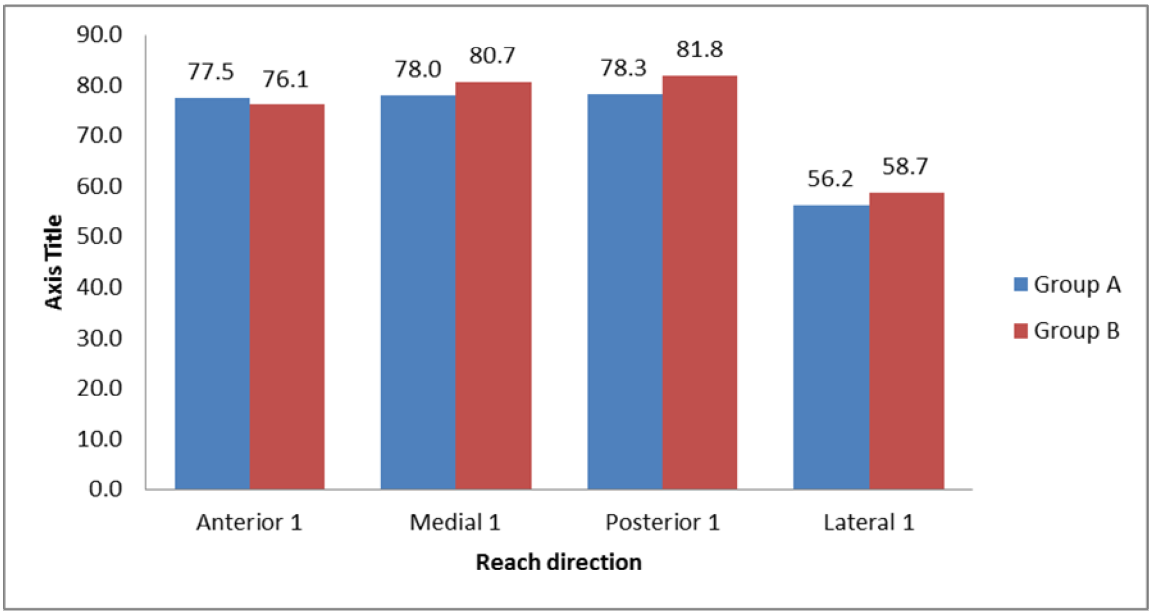
The average distance measured during the posterior reach direction for group A was 78.3 cm and for Group B 81.8 cm with a difference of 3.5 cm between the groups. The p-value was p=0.4787 (Table 7).

Table 8: Baseline SEBT lateral measurements between groups (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 45.8000 | 66.7667 | 56.2250 | 6.0922 | | | |
| B | 8 | 37.6000 | 71.7000 | 58.6833 | 10.4962 | | | |
| Diff (A-B) Pooled | | | | -2.4583 | 8.5815 | 14 | -0.57 | 0.5758 |

The average distance measured during the lateral reach direction for group A was 56.2 cm and for Group B 58.7 cm with a difference of 2.5 cm between the groups. The p-value was p=0.5758. The difference between the anterior, medial, posterior and lateral reach direction distances between group A and B during the first testing session were found statistically insignificant (Table 8).

The average measurements of the reach directions of participants during the first testing session are illustrated in graph 3.




Graph 3: Average measurements of reach direction during first testing session (n=16)

## 4.5 Improvement from first to second testing session

During the first six weeks group A participated in the exercise programme while group B was considered as the control group. The improvement in reach distances from the first testing session to the second testing session within each group was computed by means of the paired t-test. The difference in improvement in reach distances from the first testing session to the second testing session between group A and B was computed by means of the student's t-test.

Table 9: SEBT anterior measurements within and between groups comparing the 1st and 2nd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 0.6333 | 20.0333 | 12.4125 | 6.2163 | 7 | 5.65 | 0.0008 |
| B | 8 | 0.1000 | 8.2000 | 3.7500 | 2.6037 | 7 | 4.07 | 0.0047 |
| Diff (A-B) Pooled | | 0.5333 | 11.8333 | 8.6625 | 4.7655 | 14 | 3.64 | 0.0027 |

During the anterior reach direction the average distance of improvement for group A was 12.4 cm and for Group B 3.8 cm with a difference of 8.7 cm between the groups. The paired t-test was p=0.0008 for group A and p=0.0047 for group B. The improvement within both groups was statistically significant. The student's t-test on difference in improvement between the groups was p=0.0027 and therefore also statistically significant (Table 9).

Table 10: SEBT medial measurements within and between groups comparing the 1st and 2nd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 25.6000 | 14.6958 | 6.3924 | 7 | 6.5 | | 0.0003 |
| B | 8 | 7.4000 | 3.0833 | 2.6971 | 7 | 3.23 | | 0.0144 |
| Diff (A-B) Pooled | | 8.0667 | 18.2 | 11.6125 | 4.9060 | 14 | 4.73 | 0.0003 |

During the medial reach direction the average distance of improvement for group A was 14.7 cm and for Group B 3.1 cm with a difference of 11.6 cm between the groups. The paired t-test was p=0.0003 for group A and p=0.0144 for group B. The improvement within both groups was statistically significant. The student's t-test on difference in improvement between the groups was p=0.0003 and therefore also statistically significant (Table 10).

Table 11: SEBT posterior measurements within and between groups comparing the 1st and 2nd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 9.6000 | 37.9667 | 21.0833 | 8.9455 | 7 | 6.67 | 0.0003 |
| B | 8 | -0.8000 | 7.3000 | 3.5000 | 2.7524 | 7 | 3.6 | 0.0088 |
| Diff (A-B) Pooled | | 10.4000 | 30.6667 | 17.5833 | 6.6181 | 14 | 5.31 | 0.0001 |

During the posterior reach direction the average distance of improvement for group A was 21.1 cm and for Group B 3.5 cm with a difference of 17.6 cm between the groups. The paired t-test was p=0.0003 for group A and p=0.0088 for group B. The improvement within both groups was statistically significant. The student's t-test on difference in improvement between the groups was p=0.0001 and therefore also statistically significant (Table 11).

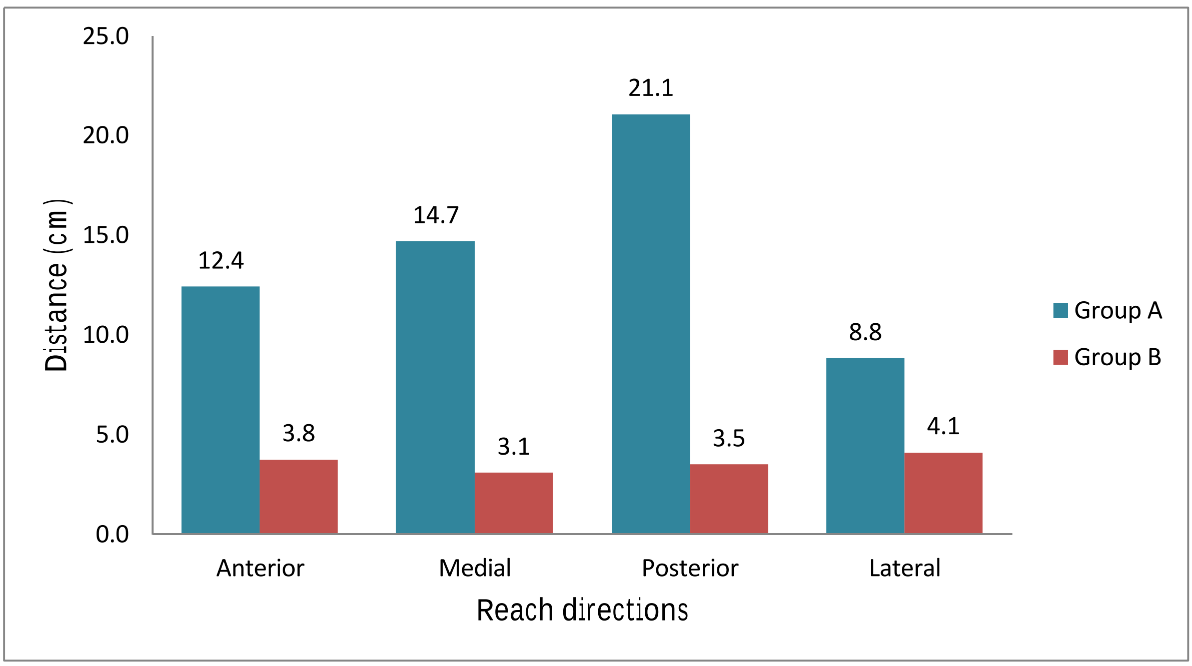
Table 12: SEBT lateral measurements within and between groups comparing the 1st and 2nd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 4.5667 | 18.1000 | 8.8292 | 4.8827 | 7 | 5.11 | 0.0014 |
| B | 8 | -4.1333 | 25.1000 | 4.1042 | 9.2256 | 7 | 1.26 | 0.2486 |
| Diff (A-B) Pooled | | | | 4.7250 | 3.6904 | 14 | 1.28 | 0.2212 |

During the lateral reach direction the average distance of improvement for group A was 8.8 cm and for Group B 4.1cm with a difference of 4.7 cm between the groups. The paired t-test was p=0.0014 for group A and p=0.2486 for group B. The improvement within group A was statistically significant, but the improvement within group B was statistically insignificant. The student's t-test on difference in improvement between the groups was p=0.2212 and was statistically insignificant (Table 12).

Although statistically significant improvement was calculated in the average distance in the anterior, medial and posterior reach directions within group A and B; the average distance of improvement in the anterior, medial and posterior reach directions of group A from the first testing session to the second testing session were found statistically significant when compared to group B. Contrary, although statistically significant improvement was calculated in the average distance in the lateral reach distance within group A; the average distance of improvement in the lateral reach direction of group A from the first testing session to the second testing session were found statistically insignificant when compared to group B.

A summary of the average improvement in reach directions from the first to the second testing session is illustrated in graph 4.




Graph 4: Average improvement from first to second testing session (n=16)

## 4.6 Improvement from second to third testing session

For the following six weeks (week seven to week 12) group B participated in the exercise programme while group A was considered as the control group. The improvement in reach distances from the second testing session to the third testing session within each group was computed by means of the paired t-test. The difference in improvement in reach distances from the second testing session to the third testing session between group A and B was computed by means of the student's t-test.

Table 13: SEBT anterior measurements within and between groups comparing the 2nd and 3rd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | -4.000 | 5.5333 | 0.2875 | 2.9003 | 7 | 0.28 | 0.7873 |
| B | 8 | 5.1000 | 24.0333 | 10.6792 | 5.8332 | 7 | 5.18 | 0.0013 |
| Diff (A-B) Pooled | | -9.1000 | -18.5000 | -10.3917 | 4.6064 | 14 | -4.51 | 0.0005 |

During the anterior reach direction the average distance of improvement for group A was 0.3 cm and for Group B 10.7 cm with a difference of 10.4 cm between the groups. The paired t-test was p=0.7873 for group A and p=0.0013 for group B. The improvement within group B was statistically significant, but the improvement within group A was statistically insignificant. The student's t-test on difference in improvement between the groups was p=0.0005 and therefore statistically significant (Table 13).

Table 14: SEBT medial measurements within and between groups comparing the 2nd and 3rd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | -1.6667 | 5.6333 | 1.1625 | 2.3938 | 7 | 1.37 | 0.2119 |
| B | 8 | 5.3667 | 22.9333 | 13.1750 | 6.1383 | 7 | 6.07 | 0.0005 |
| Diff (A-B) Pooled | | | | -12.0125 | 4.6588 | 14 | -5.16 | 0.0001 |

During the medial reach direction the average distance of improvement for group A was 1.2 cm and for Group B 13.2 cm with a difference of 12 cm between the groups. The paired t-test was p=0.2119 for group A and p=0.0005 for group B. The improvement within group B was statistically significant, but the improvement within group A was statistically insignificant. The student's t-test on difference in improvement between the groups was p=0.0001 and therefore statistically significant (Table 14).

Table 15: SEBT posterior measurements within and between groups comparing the2nd and 3rd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | -3.2000 | 8.8000 | 1.2083 | 4.2725 | 7 | 0.80 | 0.4500 |
| B | 8 | 8.6000 | 18.0667 | 13.8667 | 3.0654 | 7 | 12.79 | <.0001 |
| Diff (A-B) Pooled | | -11.8000 | -9.2667 | -12.6583 | 3.7182 | 14 | -6.81 | <.0001 |

During the posterior reach direction the average distance of improvement for group A was 1.2 cm and for Group B 13.9 cm with a difference of 12.7 cm between the groups. The paired t-test was p=0.4500 for group A and p<.0001 for group B. The improvement within group B was statistically significant, but the improvement within group A was statistically insignificant. The student's t-test on difference in improvement between the groups was p<.0001 and therefore statistically significant (Table 15).

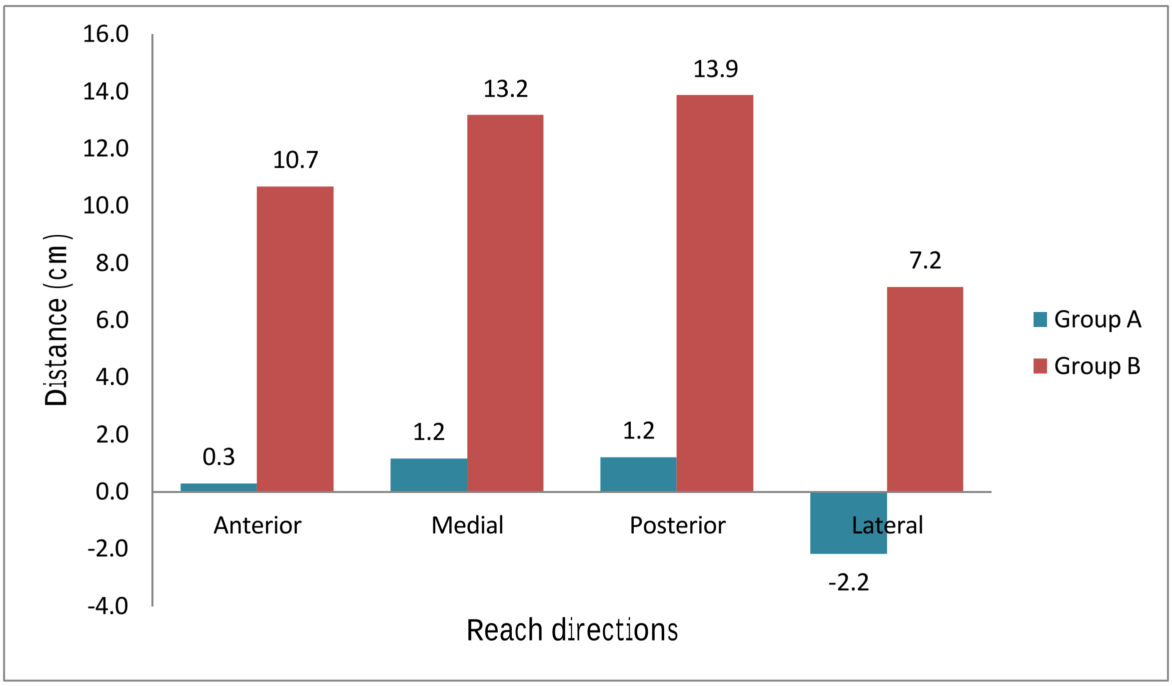
Table 16: SEBT lateral measurements within and between groups comparing the2nd and 3rd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | -11.3667 | 10.4667 | -2.1667 | 6.6967 | 7 | -0.92 | 0.3906 |
| B | 8 | -6.8333 | 30.6667 | 7.1708 | 10.8458 | 7 | 1.87 | 0.1037 |
| Diff (A-B) Pooled | | -4.5334 | -20.2 | -9.3375 | 9.0132 | 14 | -2.07 | 0.0572 |

During the lateral reach direction group A decreased with an average distance of 2.2 cm while Group B improved with an average distance of 7.2 cm with a difference of 9.3 cm between the groups. The paired t-test was p=0.3906 for group A and p=0.1037 for group B. The improvement within both groups was statistically insignificant. The student's t-test on difference in improvement between the groups was p=0.0572 and therefore statistically insignificant (Table 16).

Statistically significant improvement was calculated in the average distance in the anterior, medial and posterior reach directions within group B, but insignificant improvement within group A. The average distance of improvement in the anterior, medial and posterior reach directions of group B from the second testing session to the third testing session were found statistically significant when compared to group A. Contrary, statistically insignificant improvement was calculated in the average distance in the lateral reach distances within group A and B; and the average distance of improvement in the lateral reach direction of group B from the second testing session to the third testing session were found statistically insignificant when compared to group A.

A summary of the average improvement in reach directions from the second to the third testing session is illustrated in graph 5.




Graph 5: Average improvement from second to third testing session (n=16)

## 4.7 Improvement from first to third testing session

At the third testing session both group A and B have participated in the exercise programme. The improvement in reach distances from the first testing session to the third testing session within each group was computed by means of the paired t-test. The difference in improvement in reach distances from the first testing session to the third testing session between group A and B was computed by means of the student's t-test. The global improvement of both groups includes the improvement or deterioration (lateral reach direction for group A) during the six weeks in which the group was the control.

Table 17: SEBT anterior measurements between groups comparing the 1st and 3rd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 0.4000 | 21.3333 | 12.7000 | 6.8660 | 7 | 5.23 | 0.0012 |
| B | 8 | 5.2000 | 26.2333 | 14.4292 | 5.9522 | 7 | 6.86 | 0.0002 |
| Diff (A-B) Pooled | | -4.8000 | -4.9000 | -1.7292 | 6.4253 | 14 | -0.54 | 0.5989 |

During the anterior reach direction the average distance of improvement for group A was 12.7 cm and for Group B 14.4 cm. Group B had an average improvement of 1.7 cm more than group A. The paired t-test was p=0.0012 for group A and p=0.0002 for group B. The improvement within both groups was statistically significant. The student's t-test was p=0.5989 and therefore statistically insignificant (Table 17).

Table 18: SEBT medial measurements between groups comparing the 1st and 3rd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 7.3667 | 28.6667 | 15.8583 | 7.6247 | 7 | 5.88 | 0.0006 |
| B | 8 | 4.1667 | 26.0333 | 16.2583 | 7.4453 | 7 | 6.18 | 0.0005 |
| Diff (A-B) Pooled | | 3.2000 | 2.6337 | -0.4000 | 7.5355 | 14 | -0.11 | 0.9170 |

During the medial reach direction the average distance of improvement for group A was 15.9 cm and for Group B 16.3 cm. Group B had an average improvement of 0.4 cm more than group A. The paired t-test was p=0.0006 for group A and p=0.0005 for group B. The improvement within both groups was statistically significant. The student's t-test was p=0.9170 and therefore statistically insignificant (Table 18).

Table 19: SEBT posterior measurements between groups comparing the 1st and 3rd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | 10.1000 | 40.2667 | 22.2917 | 11.4265 | 7 | 5.52 | 0.0009 |
| B | 8 | 12.9667 | 24.5667 | 17.3667 | 4.2522 | 7 | 11.55 | <.0001 |
| Diff (A-B) Pooled | | -2.8667 | 15.7000 | 4.9250 | 8.6211 | 14 | 1.14 | 0.2724 |

During the posterior reach direction the average distance of improvement for group A was 22.3 cm and for Group B 17.4 cm. Group A had an average improvement of 4.9 cm more than group B. The paired t-test was p=0.0009 for group A and p<0.0001 for group B. The improvement within both groups was statistically significant. The student's t-test was p=0.2724 and therefore statistically insignificant (Table 19).

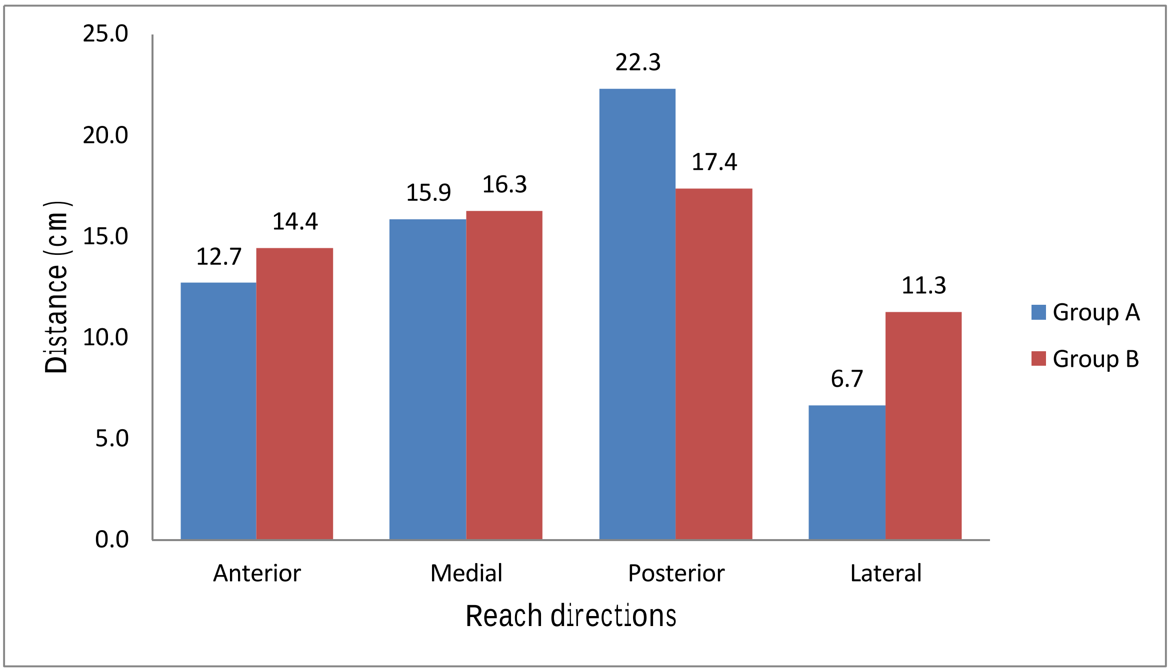
Table 20: SEBT lateral measurements between groups comparing the 1st and 3rd testing sessions (n=16)

| Group | N | Minimum | Maximum | Mean | Std Dev | DF | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|---|---|
| A | 8 | -2.3333 | 17.8000 | 6.6625 | 6.3129 | 7 | 2.99 | 0.0204 |
| B | 8 | 3.4000 | 26.6333 | 11.2750 | 7.6590 | 7 | 4.16 | 0.0042 |
| Diff (A-B) Pooled | | -5.7333 | -8.8333 | -4.6125 | 7.0183 | 14 | -1.31 | 0.2098 |

During the lateral reach direction the average distance of improvement for group A was 6.7 cm and for Group B 11.3 cm. Group B had an average improvement of 4.6 cm more than group A. The paired t-test was p=0.0204 for group A and p=0.0042 for group B. The improvement within both groups was statistically significant. The student's t-test was p=0.2098 and therefore statistically insignificant (Table 20).

Statistically significant improvement was calculated in the average distance in the anterior, medial, posterior and lateral reach directions within both groups. When comparing the two groups, the average distance of improvement in the anterior, medial, posterior and lateral reach directions were found statistically insignificant.

A summary of the average improvement in reach directions from the first to the third testing session is illustrated in graph 6




Graph 6: Average improvement from first to third testing session (n=16)

Interestingly enough, statistically significant improvement was found in three reach directions (anterior, medial and posterior) within group B during the period of being considered the control group while group A participated in the exercise programme. This was not the case for group A. Although improvement was found in three reach directions (anterior, medial and posterior) within group A during the period of being considered the control group, the improvement was statistically insignificant.

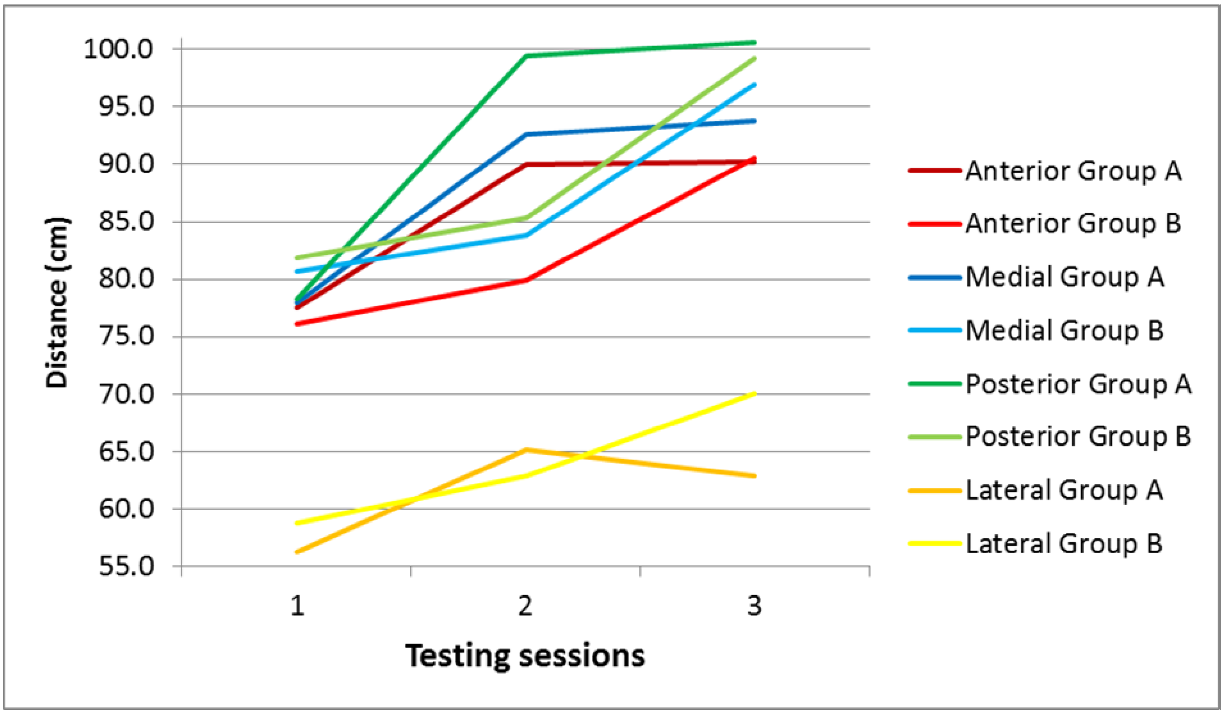
Statistically insignificant improvement was found in the lateral reach direction within group A and B during the period of being considered the control group as well as within group B after having participated in the exercise programme, but statistically significant improvement was found globally within both groups.

A summary of the t-tests on improvement in all four reach directions within and between groups are illustrated in Table 21 below.

**Table 21: Summary of t-tests on improvement within and between groups (n=16)**

| | Group A (paired t-test) | Group B (paired t-test) | Diff (A-B) Pooled (Student's t-test) |
|---|---|---|---|
| First to second testing session | Pr > \|t\| | Pr > \|t\| | Pr > \|t\| |
| Anterior | 0.0008 | 0.0047 | 0.0027 |
| Medial | 0.0003 | 0.0144 | 0.0003 |
| Posterior | 0.0003 | 0.0088 | 0.0001 |
| Lateral | 0.0014 | 0.2486 | 0.2212 |
| Second to third testing session | Pr > \|t\| | Pr > \|t\| | Pr > \|t\| |
| Anterior | 0.7873 | 0.0013 | 0.0005 |
| Medial | 0.2119 | 0.0005 | 0.0001 |
| Posterior | 0.4500 | <.0001 | <.0001 |
| Lateral | 0.3906 | 0.1037 | 0.0572 |
| First to third testing session | Pr > \|t\| | Pr > \|t\| | Pr > \|t\| |
| Anterior | 0.0012 | 0.0002 | 0.5989 |
| Medial | 0.0006 | 0.0005 | 0.9170 |
| Posterior | 0.0009 | <.0001 | 0.2724 |
| Lateral | 0.0204 | 0.0042 | 0.2098 |

The average improvement in all four reach directions from the first to the second to the third testing session is illustrated in graph 7.




Graph 7: Improvement from first to second to third testing session (n=16)

The data reflects statistically significant improvement ($p<0.05$) in the average distance in the anterior, medial and posterior reach directions within group A and B after having participated in the exercise programme. Although improvement was found in the average distance in the anterior, medial and posterior reach directions within group A and B during the period of being considered the control group, the improvement within group A was statistically insignificant. However, the average distance of improvement in the anterior, medial and posterior reach directions of both groups after having participated in the exercise programme, were found statistically significant ($p<0.05$) when compared to the group considered as the control group.

A discussion will follow in chapter five using reflective practice to link the findings of the statistical analyses with the available literature. Critical reasoning skills were implemented to discuss the findings and to reach a conclusion.

# Chapter 5 Discussion, Conclusion and Recommendations

In this chapter a brief summary of the conducted research is given, followed by a comprehensive discussion of the data found. The chapter will be completed with the conclusion reached by the study as well as the value of the study.

## 5.1 Brief summary

A cross-over randomised clinical trial was performed. The participants were randomly divided into two groups and for the first six weeks group A participated in the exercise programme while group B was considered as the control group after which the roles were reversed. Although the participants did not partake in any other balance, core stability or m.GMed exercise programme during this study, the participants were all first year female netball players selected in the top junior group and partook in pre-season netball training while participating in the exercise programme as well as during the time period of being in the control group. The pre-season netball training consisted of between four and eight hours of training per week.

The simple SEBT with three trials and four directions were used to measure dynamic postural control of the participants (paragraph 2.6 and 2.7). All the participants were tested during three separate testing sessions. The first testing session took place prior to the commencement of the exercise programme of group A. The second testing session took place between the completion of group A's exercise programme and the start of group B's exercise programme. The third testing session took place after the completion of group B's exercise programme (Table 22).

**Table 22: Timeframe of testing sessions**

| 3 February 2014 | 4 February - 14 March 2014 | 18 March 2014 | 14 April – 30 May 2014 | 2 June 2014 |
|---|---|---|---|---|
| First testing session | **Group A - exercise programme** + netball training | Second testing session | Group A- control group + netball training | Third testing session |
| | Group B – control group + netball training | | **Group B - exercise programme** + netball training | |

## 5.2 First testing session

The average of the four reach direction distances during the first testing session of the SEBT was used to compare the starting point between group A and B. The difference between the four reach direction distances between group A and B during the first testing session were found statistically insignificant. Therefore group A and B started at an equal baseline which made comparison between the two groups statistically more reliable. All the participants measured the least distance in the lateral reach direction. The same finding was made by Leavey *et al.* (2010) and the researcher hypothesised that a shorter reach distance in the lateral direction could imply that it is more difficult to perform the lateral direction or that there is a lack of dynamic postural control from participants in the lateral direction.

## 5.3 Improvement from first to second testing session

After the first six weeks during which group A participated in the exercise programme and group B was considered as the control group, there was a statistically significant improvement in the average distance in the anterior, medial, posterior and lateral reach directions within group A as well as in the average distance in the anterior, medial and posterior reach directions within group B. However, the average distance of improvement in the anterior, medial and posterior reach directions of group A after having participated in the exercise programme were found statistically significant when compared to group B.

The seemingly spontaneous improvement in three reach directions within group B whilst being the control group could possibly be attributed to participation in usual netball training. Netball training provides a learning component and could be translated to improved balance according to the principle of specificity (Petty, 2004). Specificity relates to the specific adaptation of the muscle to the imposed demands and netball training mirrors dynamic balance as measured with the SEBT. The lack of statistically significant improvement in the lateral reach direction within group B could be due to the fact that crossing one's legs as measured with the lateral reach direction is not frequently used in netball training and therefore a learning component was not provided during normal netball training.

The improvement within group A could partially be contributed to participation in netball training, but the student's t-test measuring the difference in improvement between group A and B indicated a strong statistical difference in three reach directions between the two groups. The student's t-test for the anterior reach direction was p=0.0027, for the medial reach direction P=0.0003 and for the posterior reach direction p=0.0001. This strong statistical difference therefore indicated that the exercise programme made a significant contribution to the improvement within group A in the anterior, medial and posterior reach direction distances as measured with the SEBT.

## 5.4 Improvement from second to third testing session

After the following six weeks (week seven to week 12) during which group B participated in the exercise programme while group A was considered as the control group, there was a statistically significant improvement in the average distance in the anterior, medial and posterior reach directions within group B, but insignificant improvement within group A. Statistically insignificant improvement was found in the lateral reach distance within group B and deterioration within group A.

Although improvement was found in three reach directions (anterior, medial and posterior) between week six and twelve within group A whilst considered as the control group, the improvement was statistically insignificant despite their netball training. This lack of statistically significant improvement could be due to the principle of diminishing returns (Petty, 2004). According to this principle an exercise programme will result in greater improvement in people in poor physical condition than in those in a good physical condition. Group A was already in a good physical condition at the second testing session due to the combination of netball training and participating in the exercise programme. The participants were all first year students that for the first time participated in pre-season netball training. Group B was in a weaker physical condition at the first testing session at the beginning of the year compared to group A at the second testing session. Therefore less improvement was found within group A compared to group B during the period when each group was considered as the control group and when the groups were only participating in netball training.

After the six weeks during which group B participated in the exercise programme while group A was considered as the control group, the average distance of improvement in the anterior, medial and posterior reach directions of group B were found statistically significant when compared to group A. The improvement within group B could partly be contributed to participation in netball training, but the student's t-test measuring the difference in improvement between group B and group A again indicated a strong statistical difference in three reach directions. The student's t-test for the anterior reach direction was $p=0.0005$, for the medial reach direction $P=0.0001$ and for the posterior reach direction $p<0.0001$. This strong statistical difference indicates that the exercise programme also significantly contributed to the improvement within group B in the anterior, medial and posterior reach direction distances as measured with the SEBT.

The most improvement was found in the posterior reach direction distances and the least in the lateral reach direction distances. These findings correlate with a previous study (Leavey *et al.*, 2010) where the same phenomena were noticed during assessment with the SEBT after a balance, m.GMed and combination programme. Aggarwal *et al.* (2010) postulated that during the posterior reach direction, the leg extends backwards with trunk and hip flexion to maintain balance. Core stability is required to stabilise the trunk against gravity. Improved core stability provides more effective control of the spinal segments and co-contraction of the deep stabilizing muscles resulting in better lumbo-pelvic control so that the reaching leg can extend further backwards. Filipa *et al.* (2010) suggested that improvements in the SEBT are due to increased hip and knee flexion of the stance leg. From the literature review it can be hypothesised that enhanced core stability, m.GMed strength and proprioception would result in better lumbo-pelvic control as well as control of the hip and knee, therefore improved posterior reach direction could be due to either one of the postulations or a combination of both

## 5.5 Lateral reach direction

The insignificant improvement in the lateral reach direction within group B and deterioration within group A at the third testing session could be attributed to one or more of the following reasons. During the first six weeks of an exercise programme improved performance is due to motor learning, increased neural activation to the muscle and improved coordination. According to research (Petty, 2004) it is anticipated that at about 10 to 12 weeks of participation in an exercise programme muscle hypertrophy takes place where the muscle increases in the cross-sectional area. If taken into consideration that the control group participated in netball training during the first six weeks, both groups were exposed to twelve weeks of training. During assessment of the lateral reach direction, the reaching leg has to cross the supporting leg and the movement is obstructed by the mm.adductor mass of the supporting leg. If there was hypertrophy of mm.adductor, the movement could be obstructed earlier in range of movement and reduce the lateral reach direction distance. The same scenario could have occurred if participants gained weight which is a possibility, as they were all first year female students. To determine the influence of mm.adductor mass in measuring lateral reach direction distances, a suggestion would be to measure the circumference of the widest part of the supporting leg of participants in future studies and compare these measurements pre- and post-exercise programme.

Another possible explanation for insignificant improvement in the lateral reach direction could be attributed to the following: During the third testing session the data collector noticed that while reaching in the lateral direction some of the participants were indecisive as to whether they should cross the reaching leg anteriorly or posteriorly to the supporting leg. When the reaching leg crosses anteriorly to the supporting leg, the supporting leg's hip rotates medially in relation to the pelvis. The opposite occurs when the reaching leg crosses posteriorly to the supporting leg. The supporting leg's hip then rotates laterally in relation to the pelvis. Normal range of motion of lateral rotation of the hip joint is 45° and medial rotation is 35° (Quinn, 2010). When the reaching leg crosses posteriorly, there is also less of an obstruction of the m.adductor mass of the supporting leg. The increased lateral rotation range of motion of the hip as well as the lesser obstruction of the m.adductor mass when a participant's reaching leg crosses posteriorly to the supporting leg, would lead to increased lateral reach direction distances when compared to the reaching leg crossing anteriorly to the supporting leg. A measurement error could have occurred during assessment of the SEBT lateral reach direction if the participants were not consistent between the different testing sessions possibly affecting the results of the lateral reach direction in this study. Other studies (Gribble, 2003; Demura and Yamada, 2010; Gribble *et al.*, 2013) investigating reliability found high inter-rater and intra-rater reliability in the lateral reach direction. The literature describing the SEBT test did not indicate whether the reaching leg of participants has to cross anteriorly or posteriorly to the supporting leg while reaching in the lateral reach direction. To avoid measurement errors in future studies, a decision should be made regarding a standard test before the commencement of the study and communicated accurately to the participants.

## 5.6 Comparison with previous studies on dynamic postural control

Results of previous studies (Kahle and Gribble, 2009; Aggarwal *et al*., 2010; Filipa *et al*., 2010; Leavey *et al*, 2010; Sandrey and Mitzel, 2013) evaluating different exercise programmes on dynamic postural control using the SEBT are summarized in Table 22 and 23 below.

Table 23: Summary of t-tests on improvement within groups of different studies

| | Group A | Group B | Sandrey and Mitzel, 2013 | Leavey *et al*, 2010 | Aggarwal *et al*., 2010 | Aggarwal *et al*., 2010 | Filipa *et al*., 2010 |
|---|---|---|---|---|---|---|---|
| | Pr > \|t\| | Pr > \|t\| | Pr > \|t\| | Pr > \|t\| | Pr > \|t\| | Pr > \|t\| | Pr > \|t\| |
| Type of exercises | CoreS, GMed & PB | CoreS, GMed & PB | CoreS | GMed / PB/ GMed & PB | CoreS | PB | CoreS & GMed |
| Ant | 0.0008 | 0.0013 | | <.001 | <.001 | 0.005 | L leg: 0.193<br>R leg: 0.321 |
| AM | | | 0.008 | | <.001 | 0.24 | |
| Med | 0.0003 | 0.0005 | 0.002 | <.001 | 0.001 | 0.002 | |
| PM | | | | | 0.280 | 0.004 | L leg: 0.028<br>R leg: 0.226 |
| Post | 0.0003 | <.0001 | | <.001 | 0.032 | 0.009 | |
| PL | | | | | 0.032 | 0.017 | L leg: 0.040<br>R leg: 0.008 |
| Lat | 0.0014 | 0.1037 | | <.001 | 0.01 | 0.05 | |
| AL | | | | | 0.005 | 0.049 | |

Acronyms: CoreS: - core stability GMed: - gluteus medius; PB: - proprioceptive balance; Ant: - anterior; AM: - anteromedial; Med: - medial; PM: - posteromedial; Post: - posterior; PL: - posterolateral; Lat: - lateral; AL: - anterolateral; L: - left; R: - right

Table 24: Summary of t-tests on improvement between groups of different studies

| | Group A after having participated in CoreS, m.GMed and PB exercise programme vs Group B | Group B after having participated in CoreS, m.GMed and PB exercise programme vs Group A | Kahle & Gribble, 2009 CoreS programme vs control group |
|---|---|---|---|
| Diff (A-B) | Pr > \|t\| | Pr > \|t\| | Pr > \|t\| |
| Anterior | 0.0027 | 0.0005 | |
| AM | | | 0.001 |
| Medial | 0.0003 | 0.0001 | <0.001 |
| PM | | | 0.013 |
| Posterior | 0.0001 | <0.0001 | |
| Lateral | 0.2212 | 0.0572 | |

Acronyms: CoreS: - core stability GMed: - gluteus medius; PB: - proprioceptive balance; Ant: - anterior; AM: - anteromedial; Med: - medial; PM: - posteromedial; Post: - posterior; Lat: - lateral

The studies mentioned in Tables 22 and 23 (Kahle and Gribble, 2009; Aggarwal *et al.*, 2010; Filipa *et al.*, 2010; Leavey *et al*, 2010; Sandrey and Mitzel, 2013) have all been performed on young, active people. The participants in the studies were as follow: young, physically active university students (Kahle and Gribble, 2009), high school track and field athletes (Sandrey and Mitzel, 2013), healthy college students (Leavey *et al.*, 2010), recreationally active university students (Aggarwal *et al.*, 2010) and young female soccer players (Filipa *et al.*, 2010). Although men and women were included in most of the studies, Kahle and Gribble (2009) reported no significant influence of gender on their results. Therefore the above-mentioned studies are all well-matched and comparable to the present study results.

The present study evaluated the effect of core stability, m.GMed strengthening and proprioceptive balance exercises on dynamic postural control. When comparing this present study's results to studies (Kahle and Gribble, 2009; Aggarwal *et al.*, 2010; Sandrey and Mitzel, 2013) evaluating the effect of only core stability training on dynamic postural control, the following was noticed. Only one reach direction was compatible in all the studies, namely the medial reach direction. In the present study, the improvement in the medial reach direction was p=0.0003 within group A and p=0.0005 within group B. In comparison the improvement in the medial reach direction was p=0.002 in Sandrey and Mitzel's (2013) study and p=0.001 in Aggarwal *et al.'s* (2009) study. The student's t-test on difference in improvement in medial reach direction between the groups in the present study was p=0.0003 after group A participated in the exercise programme and p=0.0001 after group B participated in the exercise programme. The difference in improvement in the medial reach direction between the core stability training group and a control group in Kahle and Gribble's (2009) study was p<.001.

In the present study, the improvement in the anterior reach direction was p=0.0008 within group A and p=0.0013 within group B compared to the improvement within the core stability training group (Aggarwal *et al*., 2010) which was p<.001. The improvement in the posterior reach direction within group A was p=0.0003 within group A and p<.0001 within group B compared to the improvement within the core stability training group (Aggarwal *et al*., 2010) which was p=0.032. The improvement in the lateral reach direction was p=0.0014 within group A and p=0.1037 within group B compared to the improvement within the core stability training group (Aggarwal *et al*., 2010) which was p=0.05.

Comparison of the improvement in the anterior, medial, posterior and lateral reach directions within group A and B of the present study to the core stability training group in other studies (Aggarwal *et al*., 2010; Sandrey and Mitzel, 2013), indicated more improvement within group A and B of the present study than studies evaluating core stability (Aggarwal *et al*., 2010; Sandrey and Mitzel, 2013). The only exception is the improvement in the lateral reach direction where lesser improvement was found within group B when compared to the core stability training group of studies conducted by Aggarwal *et al.* ( 2010); Sandrey and Mitzel (2013) (see Table 22). These findings therefore indicate that an exercise programme that incorporates core stability, m.GMed strengthening and proprioceptive balance exercises leads to additional improvement in dynamic postural control when compared to an exercise programme consisting of only core stability training.

Leavey *et al.* (2010) compared the effects of a balance, m.GMed strengthening, and a combination programme consisting of balance and m.GMed strengthening on dynamic postural control. Comparison to the present study was difficult due to the fact that Leavey *et al.'s* study results were described as improvement of reach distance divided by leg length. No p values for separate reach distances were calculated, but the difference between the pre-test and post-test reach distances of all three groups were significant at pÂ0.001. Although insignificant differences were found between the groups as far as post-test reach improvement was concerned, the combination group demonstrated the most improvement.

The effect of balance training on dynamic postural control was assessed in a randomised controlled trial (Aggarwal *et al*., 2010). A comparison between improvements within group A and B in the present study and within the balance training group within Aggarwal *et al.'s* (2010) study the following was noticed. The improvement in the anterior reach direction was p=0.0008 within group A and p=0.0013 within group B compared to the improvement within the balance training group (Aggarwal *et al*., 2010) which was p=0.005. The improvement in the medial reach direction was p=0.0003 within group A and p=0.0005 within group B compared to the improvement within the balance training group (Aggarwal *et al*., 2010) which was p=0.002. The improvement in the posterior reach direction within group A was p=0.0003 within group A and p<.0001 within group B compared to the improvement within the balance training group (Aggarwal *et al*., 2010) which was p=0.009. The improvement in the lateral reach direction was p=0.0014 within group A and p=0.1037 within group B compared to the improvement within the balance training group (Aggarwal *et al*., 2010) which was p=0.05. The findings indicated that more improvement was found in all four reach directions within group A and B in the present study which incorporated all three components of core stability, m.GMed strengthening and proprioceptive balance training in comparison to Aggarwal *et al.'s* (2010) study which incorporated only balance training (see Table 22).

A combination programme consisting of lower extremity strengthening and core stability was implemented by Filipa *et al.,* 2010 to determine the effect on dynamic postural control. Only three reach directions were measured and significant statistical improvement was found within the posteromedial reach direction for the left leg and the anteromedial reach direction for both legs. Improvement in the anterior reach direction was p=0.193 within the group for the left leg and p=0.321 for the right leg. In comparison, greater improvement in the anterior reach direction was found within group A (p=0.0008) and group B (p=0.0013) in the present study (see Table 22). The anteromedial and posteromedial reach directions were not measured in the netball players in the present study and therefore no comparison could be made in these reach directions between the two studies.

The added improvement in the present study could possibly be attributed to more than one component. Components considered by researchers for the improvement of dynamic postural control are core stability, m.GMed strength and proprioceptive balance. Previous studies (Kahle and Gribble, 2009; Aggarwal *et al*., 2010; Filipa *et al*., 2010; Leavey *et al*, 2010; Sandrey and Mitzel, 2013) utilized one or two of the components. The combination of m.Gmed strength and balance training resulted in greater improvement in dynamic postural control compared to only m.GMed strength or balance training (Leavey *et al*., 2010). The above mentioned findings when comparing the combination of all three components in an exercise programme as utilized in the present study to only one or two components in other studies (Kahle and Gribble, 2009; Aggarwal *et al*., 2010; Filipa *et al*., 2010; Leavey *et al*, 2010; Sandrey and Mitzel, 2013) also indicated that the combination of all three components resulted in additional benefits.

Another contribution to the better improvement in the present study could be the participation in the netball training. As mentioned previously, netball training provides a learning component and has the benefit of sport-specific exercises that forms an integral part of rehabilitation (Akuthota *et al*., 2008; Smith *et al*.; 2008 and Reiman, 2009). Additionally, the participants were all motivated to follow the exercise programme as they were all first year students striving to play for the university's first team. Training was done under the researcher's supervision and the execution of the exercises was checked and corrected if deemed necessary.

## 5.7 Contribution of different components

No conclusion can be made in the present study regarding the contribution of each of the components of the exercise programme to the improvement of dynamic postural control due to the fact that each component was not individually measured. The core stability exercises improve both the muscle activation patterns as well as strength of the local and global core muscles. The anticipatory activation of TrA before perturbation increases the intra-abdominal pressure and tenses the thoracolumbar fascia creating a stable base of support for lower extremity movement. The internal and external obliques and rectus abdominis contracts in specific patterns depending on the lower extremity movement and add to the postural support as well as the transfer of force between the upper and lower extremities. Therefore, core stability could lead to improved dynamic postural control (Akuthota *et al*., 2008; Kahle and Gribble, 2009; Aggarwal *et al*., 2010; Sandrey and Mitzel, 2013).

M.GMed. stabilises the hip to prevent the pelvis dropping on the unsupported side. M.GMed strengthening improves lumbo-pelvic and lower extremity control and is important in dynamic postural control (French *et al*., 2010; Boren *et al*., 2011, Reiman *et al*., 2012). Furthermore proprioceptive balance training improves the ability of the CNS and the neuromuscular system to integrate information from different peripheral receptors and orchestrate an appropriate motor response (Fatma *et al*., 2010; Kiers *et al*., 2012).

In a randomised controlled trial (Aggarwal *et al*., 2010) both the core stabilization training group and balance training group showed significant (pÂ0.05) improvement in dynamic balance compared to the control group. The group doing core stability training showed greater improvement in dynamic balance compared to the balance training group. Comparing the effects of a balance, m.GMed strengthening, and a combination programme consisting of balance and m.GMed strengthening on dynamic postural control (Leavey *et al*., 2010), the combination group demonstrated the most improvement in four of the reach distances, followed by the m.GMed strength group for three reach distances and the proprioception group with only one. No studies could be found that compared the influence of core stability versus m.GMed strength on dynamic postural control. The researcher recommends that future studies includes measuring instruments such as EMG, dynamometer and force plates etc. to measure core stability, m.GMed strength and proprioceptive balance as individual components before and after the exercise programme to determine the level of improvement and contribution of each component.

## 5.8 Injury profile of netball players

An interesting observation made was that none of the participants in this study had any lower extremity injuries pre-season or during the netball season while playing matches. This observation was made as the researcher was still involved with the team, travelled with the team as the team physiotherapist and therefore was familiar with the injury profile of the netball players. Studies conducted in South Africa (Ferreira and Spamer, 2010; Langeveld *et al*., 2012; Pillay and Frantz, 2012) which evaluated the injury prevalence of netball players reported the most common injured structures were the ankle (34 to 39%) and knee (18 to 28,6%) and the most common mechanism of injury to the lower limb was landing (19 to 29%). Dynamic postural control is essential during landing due to the fact that netball players immediately attempt to remain as still as possible or attempt to create movements such as reaching or throwing without compromising the base of support (Winter, Patla and Frank, 1990; Kahle and Gribble, 2009, Gribble, Hertel and Plisky, 2012), as required by the IFNA footwork rule.

Poor core stability and decreased muscular synergy of the trunk and hip stabilisers have been theorized to decrease performance and increase the incidence of injury secondary to a lack of control of the centre of mass and dynamic posture, especially in female athletes (Filipa *et al.*, 2010; Langeveld *et al.*, 2012). Previously conducted research studies (Emery, Casidy, Klassen, Rosychuk and Rowe, 2005; Elphinston and Hardman, 2006; Kibler, Press and Sciascia, 2006; Langeveld *et al.*, 2012) suggested that improvement in core stability, neuromuscular control and proprioceptive exercise could limit sport injuries. A study by McGuine and Keene (2006) indicated that balance training reduced the rate of ankle sprains by 38% in high school basketball and soccer players. The findings of McGuine and Keene (2006) were substantiated by Clark and Burden (2005) who also found that a four week wobble board programme reduced the risk of recurrent ankle sprains in functionally unstable ankles. Both studies (Clark and Burden, 2005; McGuine and Keene, 2006) used only one component, namely balance, and this already reduced the risk of injuries. Therefore, although not specifically investigated, participation of the netball players in the exercise programme that incorporated core stability, m.GMed strengthening and balance training in the present study could have led to injury prevention due to improved dynamic postural control.

## 5.9 Limitations

There are mixed results in the literature regarding the influence of core stability on performance. The results of a research study by Saeterbakken, Roland and Seiler (2011) suggested that core stability training can significantly improve maximal throwing velocity in female handball players. Contradictory, a previous study (Stanton, Reaburn and Humphries, 2004) found that six weeks of Swiss ball training had significant effects on core stability, but did not improve running performance in young adolescent male athletes.

Yet a third study by Aggarwal *et al.* (2010) found that although dynamic postural control as measured with the SEBT improved after core stability training and balance training, functional balance as measured with the multiple single leg hopping stabilization test did not improve. The researchers (Aggarwal *et al.* 2010) suggested that core stability should be combined with some other neuromuscular training to investigate the effect on hopping performance. Netball players frequently jump horizontally and vertically. As this study combined core stability, m.GMed strengthening and proprioceptive balance, it would have been interesting to investigate the influence of the exercise programme on the netball players' explosive power as measured with e.g. a standing vertical jump test.

The present study indicated that an exercise programme that incorporates core stability, m.GMed strengthening and proprioceptive balance exercises contributed to dynamic postural control in netball players, but future research is warranted to investigate if such an exercise programme would contribute to improved performance and injury prevention in netball players.

## 5.10 Conclusion

The aim of the study was to determine whether an exercise programme that incorporates core stability, m.GMed strengthening and proprioceptive balance exercises three times a week over a period of six weeks would lead to a significant improvement (pÂ0.05) in dynamic postural control in a group of netball players. The results of the study indicated that dynamic postural control as measured with the SEBT demonstrated a statistically significant improvement ($p<0.05$) across three reach directions (anterior, medial and posterior) in a group of netball players post participation in an exercise programme that incorporated core stability, m.GMed strengthening and proprioceptive balance exercises three times a week over a period of six weeks. This study proposes that an exercise programme that incorporates core stability, m.GMed strengthening and proprioceptive balance exercises could be beneficial for improving dynamic postural control in a group of netball players.

## 5.11 Clinical recommendations

- Physiotherapists: The results of the study provided substantial evidence for the use of a combination of core stability, m.GMed strengthening and proprioceptive balance exercises in programmes rehabilitating netball players with poor dynamic postural control. Ankle and knee injuries are a risk in netball players as investigated in previous epidemiology studies of injuries in elite South African netball players (Ferreira and Spamer, 2010; Langeveld et al., 2012; Pillay and Frantz, 2012). Previously conducted research studies (Clark and Burden, 2005; McGuine and Keene, 2006) found that a proprioceptive balance programme alone, already reduced the risk of recurrent ankle sprains. Even though the present study was conducted on healthy, active netball players, physiotherapists can use the results of the present study as motivation in considering including all three components (core stability, m.GMed strengthening and proprioceptive balance) in exercise programmes following lower extremity injuries in netball players.

- Netball players: Netball players can confidently use the developed exercise programme in the present study to eliminate shortcomings in their physical profile, with regards to dynamic postural control.
- Further research: The present study provides a baseline for further research whether an exercise programme that incorporated core stability, m.GMed strengthening and proprioceptive balance exercises would contribute towards improved performance and injury prevention in netball players. The effectiveness of the exercise programme described in the present study could be implemented and investigated in other sporting codes requiring dynamic postural control. A systematic review and meta-analysis can be done on the effectiveness of interventions on the improvement of the SEBT.

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## Appendix 1 Permission letters from authorities

Letter asking permission from Vice-rector: Academics

Dear Prof Hay

Re: Permission for research study in netball players at the UFS

Study title: The effect of a core stability, m. gluteus medius and proprioceptive exercise programme on dynamic postural control in netball players

I am a M.Sc. student in sport physiotherapy at the University of the Free State (UFS). Part of the requirements of my degree is a research study. My field of interest is netball and I would like to perform a research study to determine the effect of an exercise programme on dynamic postural control in netball players.

Dynamic postural control is the ability to perform a functional task with purposeful movements that translates the body's centre of gravity without compromising a stable base of support (Winter, Patla and Frank, 1990; Kahle and Gribble, 2009). Research by Ferreira and Spamer (2010) measured poor dynamic postural control or balance in elite university netball players during pre-season testing. No literature could be found regarding studies investigating a programme that utilised the combination of core stability, m.GMed strengthening and proprioceptive balance exercises on dynamic postural control or studies investigating an exercise programme on dynamic postural control in netball players. My aim is to investigate the effectiveness of such a programme on dynamic postural control in netball players.

This research study is a baseline study and an exercise programme compiled from scientific literature will be followed. It will incorporate m.GMed (hip) strength, core stability and proprioceptive balance exercises. Participation in this study will take approximately 60 minutes three days a week for a period of six weeks. A Star Excursion Balance Test will be executed the week before, the week after the exercise programme as well as six weeks before the commencement or alternatively after the completion of the exercise programme to evaluate the dynamic postural control of the participants.

My hypothesis is that a core stability, m.GMed and proprioceptive balance exercise programme might lead to an improvement in dynamic postural control. It might benefit the players' balance abilities if the exercise programme leads to an improved outcome. More potential benefits are improvement in their m.GMed (hip) strength and core stability. Improved dynamic postural control might also lead to improve performance and help prevent injuries in the netball players. The exercise programme will be made available to the UFS netball academy and the participants after the completion of the study. Participants will be female netball players selected into the top junior netball group of the UFS.

Participation in this study is voluntary and if at any time during the study the netball player wishes to withdraw, she will be free to do so without any consequence. The netball player will only be included if she reports no history of lower extremity injuries in the past 6 months (any injury requiring not taking part in physical activity for longer than two days) or lower extremity surgery in the past year.

The training programme will take place during February to May 2014. They will train under the researchers' supervision at the university's sport centre. The participants' class schedule will be taken into consideration and the training sessions will not interfere with class commitments.

Although this study has a degree of risk due to the possibility that any exercise may cause injury, the risk is no bigger than participating in a netball practice and great care will be taken to avoid injury. If the participant is injured as a result of partaking in the assessment or exercise programme of the research study, the researcher will offer the injured participant physiotherapy treatment free of charge.

The information of the participants and the results of their individual tests will be strictly confidential. Each participant (netball player) will receive a unique, arbitrary code and any written documents will be labelled with that number to keep the nature and quality of the participants' information strictly confidential. Each participant will have access to their own test results. The group result of the study will be communicated to the UFS netball academy after the completion of the study and may be published in an accredited journal and presented at a meeting or a congress.

This letter is to ask permission to recruit netball players from the UFS to participate in my study.

The protocol for this study will be submitted to the Ethics committee of the University of Free State's Faculty of Health Science for approval. The protocol of the research is available from the secretariat of the Ethics committee of the University of Free State's Faculty of Health Science on request.

For any questions regarding the study, you can contact me at 0835576381 or e-mail me at marelisew@telkomsa.net or contact my study leader, Roline Barnes at 0827401069 or contact the secretariat of the Ethics committee of the University of Free State's Faculty of Health Science at 051-4052812.

If permission is granted for recruitment of netball players from the UFS, please sign the attached slip.

Yours faithfully

Marelise Wilson

(Researcher)(Physiotherapist)

Signature_______________________________ Date_______________________________

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To: Marelise Wilson

I, ______________________, Vice-rector: Academics at the UFS have read the information document and understand the nature of the study as well as the benefits and risks involved. I give my permission for the recruitment of netball players from the UFS to participate in the research study. The research study is to evaluate the effect of an exercise programme on the dynamic postural control in netball players. I wish to be kept informed of any changes to the research study as well as the results of the study.

Name: ________________________________________

Signature: ______________________________________

Date: _________________

Letter asking permission from Student dean

Dear Mr Buys

Re: Permission for research study in netball players at the UFS

Study title: The effect of a core stability, m. gluteus medius and proprioceptive exercise programme on dynamic postural control in netball players

I am a M.Sc. student in sport physiotherapy at the University of the Free State (UFS). Part of the requirements of my degree is a research study. My field of interest is netball and I would like to perform a research study to determine the effect of an exercise programme on dynamic postural control in netball players.

Dynamic postural control is the ability to perform a functional task with purposeful movements that translates the body's centre of gravity without compromising a stable base of support (Winter, Patla and Frank, 1990; Kahle and Gribble, 2009). Research by Ferreira and Spamer (2010) measured poor dynamic postural control or balance in elite university netball players during pre-season testing. No literature could be found regarding studies investigating a programme that utilised the combination of core stability, m.GMed strengthening and proprioceptive balance exercises on dynamic postural control or studies investigating an exercise programme on dynamic postural control in netball players. My aim is to investigate the effectiveness of such a programme on dynamic postural control in netball players.

This research study is a baseline study and an exercise programme compiled from scientific literature will be followed. It will incorporate m.GMed (hip) strength, core stability and proprioceptive balance exercises. Participation in this study will take approximately 60 minutes three days a week for a period of six weeks. A Star Excursion Balance Test will be executed the week before, the week after the exercise programme as well as six weeks before the commencement or alternatively after the completion of the exercise programme to evaluate the dynamic postural control of the participants.

My hypothesis is that a core stability, m.GMed and proprioceptive balance exercise programme might lead to an improvement in dynamic postural control. It might benefit the players' balance abilities if the exercise programme leads to an improved outcome. More potential benefits are improvement in their m.GMed (hip) strength and core stability. Improved dynamic postural control might also lead to improve performance and help prevent injuries in the netball players.

The exercise programme will be made available to the UFS netball academy and the participants after the completion of the study. Participants will be female netball players selected into the top junior netball group of the UFS.

Participation in this study is voluntary and if at any time during the study the netball player wishes to withdraw, she will be free to do so without any consequence. The netball player will only be included if she reports no history of lower extremity injuries in the past 6 months (any injury requiring not taking part in physical activity for longer than two days) or lower extremity surgery in the past year.

The training programme will take place during February to May 2014. They will train under the researchers' supervision at the university's sport centre. The participants' class schedule will be taken into consideration and the training sessions will not interfere with class commitments.

Although this study has a degree of risk due to the possibility that any exercise may cause injury, the risk is no bigger than participating in a netball practice and great care will be taken to avoid injury. If the participant is injured as a result of partaking in the assessment or exercise programme of the research study, the researcher will offer the injured participant physiotherapy treatment free of charge.

The information of the participants and the results of their individual tests will be strictly confidential. Each participant (netball player) will receive a unique, arbitrary code and any written documents will be labelled with that number to keep the nature and quality of the participants' information strictly confidential. Each participant will have access to their own test results. The group result of the study will be communicated to the UFS netball academy after the completion of the study and may be published in an accredited journal and presented at a meeting or a congress.

This letter is to ask permission to recruit netball players from the UFS to participate in my study.

The protocol for this study will be submitted to the Ethics committee of the University of Free State's Faculty of Health Science for approval. The protocol of the research is available from the secretariat of the Ethics committee of the University of Free State's Faculty of Health Science on request.

For any questions regarding the study, you can contact me at 0835576381 or e-mail me at marelisew@telkomsa.net or contact my study leader, Roline Barnes at 0827401069 or contact the secretariat of the Ethics committee of the University of Free State's Faculty of Health Science at 051-4052812.

If permission is granted for recruitment of netball players from the UFS, please sign the attached slip.

Yours faithfully

Marelise Wilson

(Researcher)(Physiotherapist)

Signature_______________________________ Date_______________________________

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To: Marelise Wilson

I, ______________________, student dean at the UFS have read the information document and understand the nature of the study as well as the benefits and risks involved. I give my permission for the recruitment of netball players from the UFS to participate in the research study. The research study is to evaluate the effect of an exercise programme on the dynamic postural control in netball players. I wish to be kept informed of any changes to the research study as well as the results of the study.

Name: ________________________________________

Signature: ______________________________________

Date: _________________

Letter asking permission from Assistant Director of Kovsie Sport

Dear Mrs de Kock

Re: Permission for research study in netball players at the UFS

Study title: The effect of a core stability, m. gluteus medius and proprioceptive exercise programme on dynamic postural control in netball players

I am a M.Sc. student in sport physiotherapy at the University of the Free State (UFS). Part of the requirements of my degree is a research study. My field of interest is netball and I would like to perform a research study to determine the effect of an exercise programme on dynamic postural control in netball players.

Dynamic postural control is the ability to perform a functional task with purposeful movements that translates the body's centre of gravity without compromising a stable base of support (Winter, Patla and Frank, 1990; Kahle and Gribble, 2009). Research by Ferreira and Spamer (2010) measured poor dynamic postural control or balance in elite university netball players during pre-season testing. No literature could be found regarding studies investigating a programme that utilised the combination of core stability, m.GMed strengthening and proprioceptive balance exercises on dynamic postural control or studies investigating an exercise programme on dynamic postural control in netball players. My aim is to investigate the effectiveness of such a programme on dynamic postural control in netball players.

This research study is a baseline study and an exercise programme compiled from scientific literature will be followed. It will incorporate m.GMed (hip) strength, core stability and proprioceptive balance exercises. Participation in this study will take approximately 60 minutes three days a week for a period of six weeks. A Star Excursion Balance Test will be executed the week before, the week after the exercise programme as well as six weeks before the commencement or alternatively after the completion of the exercise programme to evaluate the dynamic postural control of the participants.

My hypothesis is that a core stability, m.GMed and proprioceptive balance exercise programme might lead to an improvement in dynamic postural control. It might benefit the players' balance abilities if the exercise programme leads to an improved outcome. More potential benefits are improvement in their m.GMed (hip) strength and core stability. Improved dynamic postural control might also lead to improve performance and help prevent injuries in the netball players.

The exercise programme will be made available to the UFS netball academy and the participants after the completion of the study. Participants will be female netball players selected into the top junior netball group of the UFS.

Participation in this study is voluntary and if at any time during the study the netball player wishes to withdraw, she will be free to do so without any consequence. The netball player will only be included if she reports no history of lower extremity injuries in the past 6 months (any injury requiring not taking part in physical activity for longer than two days) or lower extremity surgery in the past year.

The training programme will take place during February to May 2014. They will train under the researchers' supervision at the university's sport centre. The participants' class schedule will be taken into consideration and the training sessions will not interfere with class commitments.

Although this study has a degree of risk due to the possibility that any exercise may cause injury, the risk is no bigger than participating in a netball practice and great care will be taken to avoid injury. If the participant is injured as a result of partaking in the assessment or exercise programme of the research study, the researcher will offer the injured participant physiotherapy treatment free of charge.

The information of the participants and the results of their individual tests will be strictly confidential. Each participant (netball player) will receive a unique, arbitrary code and any written documents will be labelled with that number to keep the nature and quality of the participants' information strictly confidential. Each participant will have access to their own test results. The group result of the study will be communicated to the UFS netball academy after the completion of the study and may be published in an accredited journal and presented at a meeting or a congress.

This letter is to ask permission to recruit netball players from the UFS to participate in my study.

The protocol for this study will be submitted to the Ethics committee of the University of Free State's Faculty of Health Science for approval. The protocol of the research is available from the secretariat of the Ethics committee of the University of Free State's Faculty of Health Science on request.

For any questions regarding the study, you can contact me at 0835576381 or e-mail me at marelisew@telkomsa.net or contact my study leader, Roline Barnes at 0827401069 or contact the secretariat of the Ethics committee of the University of Free State's Faculty of Health Science at 051-4052812.

If permission is granted for recruitment of netball players from the UFS, please sign the attached slip.

Yours faithfully

Marelise Wilson

(Researcher)(Physiotherapist)

Signature______________________________ Date______________________________

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To: Marelise Wilson

I, ______________________, assistant director Kovsie sport at the UFS have read the information document and understand the nature of the study as well as the benefits and risks involved. I give my permission for the recruitment of netball players from the UFS to participate in the research study. The research study is to evaluate the effect of an exercise programme on the dynamic postural control in netball players. I wish to be kept informed of any changes to the research study as well as the results of the study.

Name: ________________________________________

Signature: ______________________________________

Date: _________________

Dear netball player

<u>Information on the study regarding the effect of an exerciseprogramme on dynamic postural control in netball players.</u>

You have indicated after the information session to be interested to participate in a study investigating the effect of an exercise programme on dynamic postural control in netball players. I am a M.Sc. student in sport physiotherapy at the University of the Free State (UFS). Part of the requirement of my degree is a research study. I am interested in determining if certain exercises will improve movement balance in netball players. Dynamic postural control is balance while moving and an important skill in netball players. It is indicated that the results of this study would be useful in improving exercise programmes for netball players.

The study involves an exercise programme of hip (m.gluteus medius) strength, core stability and balance exercises. Participation in this study will take approximately 60 minutes three days a week for a period of six weeks. A Star Excursion Balance Test will be executed the week before, the week after the exercise programme as well as six weeks before the commencement or alternatively after the completion of the exercise programme to evaluate your dynamic postural control. Your class schedule will be taken into consideration and the training sessions will not interfere with class commitments.

Potential benefits are improvement in your strength, core stability, proprioception and balance. My hypothesis is that the training programme would also lead to an improvement in your dynamic postural control. Improved dynamic postural control would also lead to improve performance and help to prevent injuries.

To participate you need to be selected in the top junior netball group and over the age of 18 years. To participate in this study, you need to be injury free before the commencement of the study and have no history of lower extremity injuries in the past 6 months (any injury requiring not taking part in physical activity for longer than two days), or had lower extremity surgery in the past year. You should also not be currently partaking in a balance, core stability or m. gluteus medius exercise programme that is not included in your standard netball exercise programme.

The training programme will take place during February to May 2014. You will train under the researcher’s supervision at the university’s sport centre.

Although this study has a degree of risk due to the possibility that any exercise may cause injury, the risk is no bigger than participating in a netball practice and great care will be taken to avoid injury. If you are injured as a result of partaking in the assessment or exercise programme of the research study, the researcher will offer you physiotherapy treatment free of charge. Discomfort and muscle soreness experienced after a training session is quite normal and should disappear after a day or two.

Your participation in this study is voluntary; you are under no obligation to participate. If at any time during the study you wish to withdraw, you are free to do so without any penalty or consequence. You will receive no remuneration for participation in this study; neither will there be any costs involved.

Your information and the results of your tests will be strictly confidential. You will receive a unique, arbitrary code and any written documents will be labelled with that code to keep the nature and quality of your information strictly confidential. If requested, you will have access to your own test results. Only group results will be reported. The group results of the study will be communicated to the UFS netball academy after the completion of the study and may be published in an accredited journal and presented at a meeting or a congress.

Permission has being asked from the Vice-rector, the Student Dean and the Assistant-Director of Kovsie Sport (Burta de Kock) and the study will be submitted to the Ethics committee of the University of Free State's Faculty of Health Science for approval.

If you have any questions prior to your participation in the study, please do not hesitate to contact the researcher, Marelise Wilson, at 0835576381.

Yours faithfully

Marelise Wilson

Inligting aan deelnemers

Geagte netbalspeler

Inligting in verband met 'n studie oor die effek van 'n oefeningprogramme op dinamiese posturele beheer van netbalspelers.

Na die inligtingsessie het u aangedui dat u belangstel om deel te neem in 'n studie wat die effek van 'n oefeningprogramme op die dinamiese posturele beheer van netbalspelers ondersoek. Ek is 'n M.Sc. student in sport fisioterapie aan die Universiteit van die Vrystaat (UVS). 'n Navorsingstudie is `n vereiste om my graad te behaal. Ek stel daarin belang om vas te stel of sekere oefeninge dinamiese posturele beheer of bewegingsbalans van netbalspelers sal verbeter. Dit is aangedui dat die resultate van so 'n studie sal help om oefeningprogrammeme vir netbalspelers te verbeter.

Die studie behels 'n oefeningprogramme bestaande uit heup- (gluteus medius spier), kernstabiliteit- en balansoefeninge. Deelname aan hierdie studies sal plus-minus 60 minute, drie dae 'n week vir 'n periode van ses weke van u tyd in beslag neem. 'n "Star Excursion" balans toets sal die week voor die aanvang van die oefeningsprogramme, die week na die oefeningsprogramme en weer ses weke daarna of alternatiewelik ses weke voor die aanvangs van die oefeningsprogramme op u uitgevoer word. U klas skedule sal in ag geneem word en die oefentye sal nie inmeng met u klas verpligtinge nie.

Potensiële voordele is die verbetering van u spiersterkte, kernstabiliteit, propriosepsie en balans. My hipotese is dat die oefeningprogramme sal lei tot 'n verbetering van u posturele dinamiese beheer. Verbeterde posturele dinamiese beheer mag ook moontlik daartoe lei dat u beter presteer en help om beserings te voorkom.

Om deel te neem aan die studie, moet u gekies wees om deel te wees van die top junior netbalgroep en moet u ook ouer as 18 jaar wees. U moet beseringsvry voor die aanvang van die studie wees, geen geskiedenis hê van enige onderste ledemaat beserings in die laaste ses maande nie (enige beserings wat u meer as 2 dae weerhou het van enige fisiese aktiwiteit) en geen onderste ledemaat chirurgie in die laaste jaar ondergaan het nie. U mag ook nie huidiglik deelneemaan enige ander balans-, kernstabiliteit- of heup (gluteus medius) oefeningprogramme behalwe u standaard netbal oefenprogramme nie.

Die oefenprogramme sal gedurende Februarie tot Mei 2014 plaasvind. U sal onder die navorser se toesig by die universiteit se sport sentrum oefen.

Alhoewel die studie ‘n mate van risiko inhou as gevolg van die moontlikheid dat enige oefening ‘n besering kan veroorsaak, is die risiko nie groter as wat u aan ‘n netbaloefening deelneem nie en sorg sal aan die dag gelê word om beserings te voorkom. As u beseer word as gevolg van u deelname aan die evaluering of oefenprogramme van die navorsingstudie, sal die navorser gratis fisioterapie behandeling aan u verskaf. Ongemak en spierpyn wat u na ‘n oefensessie kan ondervind is normaal en behoort na ‘n dag of twee te verdwyn.

U deelname aan hierdie studie is vrywillig; u is onder geen verpligting om deel te neem nie. U kan ter enige tyd gedurende die studie onttrek, sonder enige straf ofnagevolge. U sal geen vergoeding vir u deelname aan die studie ontvang nie, maar daar sal ook geen koste daaraan verbonde wees nie.

U inligting en die resultate van die studie sal streng vertroulik hanteer word. U sal ‘n unieke, arbitrêre kode ontvang en slegs die kode sal op alle geskrewe dokumente gebruik word om die aard en stand van jou inligting streng vertroulik te hou. Op versoek, sal u toegang tot u eie toetsresultate verkry. Daar sal slegs oor groepresultate verslag gedoen word. Die groepresultate sal nadie voltooiing van die studie aan die netbalakademie van die UVS beskikbaar gestel word en mag in `n geakkrediteerde joernaal gepubliseer word en op ‘n vergadering of kongres voorgedra word.

Toestemming is van die Vise-rektor, die Studente Dekaan en van die Assistant-direkteur van Kovsie Sport (Burta de Kock) verkry en die studies sal aan die Etiek komitee van die Fakulteit Gesondheidswetenskappe van die UVS vir goedkeuring voorgelê word.

As u enige vrae het oor u deelname aan die studie, kontak gerus die navorser, Marelise Wilson, by 0835576381.

Die uwe

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Marelise Wilson

## Appendix 3 An informed consent letter to get permission from the participant

Dear participant

Study title: The effect of a core stability, m. gluteus medius and proprioceptive exercise programme on dynamic postural control in netball players

Researcher: Marelise Wilson

You have being asked to participate in a research study investigating the effect of an exercise programme on dynamic postural control in netball players. I am interested in determining if certain exercises will improve movement balance in netball players.

The study and its procedures have been approved by the Ethics committee of the University of Free State's Faculty of Health Science, the student Dean and the Director of Kovsie Sport of the University of the Free State. The study involves an exercise programme of hip (m.gluteus medius) strength, core stability and balance exercises. Participation in this study will take approximately 60 minutes three days a week for the six weeks. The training programme will take place during February to May 2014 under the supervision of the researcher at the university's sport centre. Potential advantages might include improved strength, core stability, proprioception and balance. My hypothesis is that the training programme might also lead to an improvement in your dynamic postural control. Improved dynamic postural control might also lead to improve performance and help to prevent injuries.

Although this study has a degree of risk due to the possibility that any exercise may cause injury, the risk is no bigger than participating in a netball practice and great care will be taken to avoid injury. If you are injured as a result of partaking in the assessment or exercise programme of the research study, the researcher will offer you physiotherapy treatment free of charge. Discomfort and muscle soreness experienced after a training session is quite normal and should disappear after a day or two.

Your participation in this study is voluntary; you are under no obligation to participate. If at any time during this study you wish to withdraw, you are free to do so without any penalty or consequence. You will receive no remuneration for participation in this study; neither will there be any costs involved.

If you have any questions prior or during your participation in the study, please do not hesitate to contact the researcher, Marelise Wilson at 0835576381 or the study leader, Roline Barnes at 0827401069. You may also contact the secretariat of the Ethics committee of the University of Free State's Faculty of Health Science at 051-4052812 if any questions arises as to your rights as a participant in the research.

The study data will be coded so that they will not be linked to your name. Your identity will not be revealed while the study is being conducted or when the study is reported or published. Only group results will be reported. All your study data will be stored in a secure place and not shared with any other person without your permission.

The group results of the study may be published in an accredited journal and presented at a meeting or congress. The training programme will be available to the UFS netball academy and participants after the completion of the study.

If you wish to participate in the study, please complete the injury profile questionnaire and sign this information sheet as well as the consent form. You will receive a signed copy of the information sheet as well as the informed consent form.

If you do not wish to participate in the study, you are not required to complete the injury profile questionnaire or to sign the consent form.

________________________ ____________________

Signature of participant Date

Informed consent:

I have read this consent form and understand the nature of this study as well as the possible benefits and risks involved. I understand that by agreeing to participate in this study I have not waived any legal or human right and that I may contact the researcher (Marelise Wilson, 0835576381) at any time. I understand what my involvement in the study means and I voluntarily agree to participate in this study. I understand that I may refuse to participate or I may withdraw from the study at any time without penalty or consequence. I declare that information I have given is correct at this time.

Name of Participant: ____________________________________

___________________ ___________________

Participant's signature Date

Cell nr: _____________

I have explained this study verbally to the above subject and have sought her understanding.

___________________ ___________________

Researcher's signature Date

Study title: The effect of a core stability, m. gluteus medius and proprioceptive exercise programme on dynamic postural control in netball players

Researcher: Marelise Wilson

Name of participant:___________________________________

Injury profile questionnaire:

Have you had any lower extremity injuries in the past six months that may have prevented you from participating in any physical activity for longer than two days? Yes_____ No_____

Have you had any lower extremity surgery in the past year? Yes_____ No______

Are you currently partaking in any balance, core stability or gluteus medius muscle exercise programme?

Yes_____ No_____

___________________________ ______________________

Participant's signature Date

**'n Ingeligte toestemmingsbrief om toestemming van deelnemer te verkry**

Geagte deelnemer

**Studie titel: Die effek van 'n kernstabiliteit, m.gluteus medius en propriosepsie oefenprogramme op dinamiese posturele beheer van netbalspelers**

**Navorser: Marelise Wilson**

U is genader om deel te neem aan 'n studie wat die effek van 'n oefenprogramme op dinamiese posturele beheer van netbalspelers ondersoek. nteresseerd om te bepaal of sekere oefeninge die bewegingsbalans van netbalspelers gaan verbeter.

Die studie en die prosedures is deur die Etiek komitee van die Fakulteit Gesondheidswetenskappe van die Universiteit van die Vrystaat (UVS), die Studente Dekaan en die Direkteur van Kovsie sport goedgekeur. Die studie behels 'n oefenprogramme bestaande uit heup (gluteus medius), kernstabiliteit en balansoefeninge. Deelname aan hierdie studie sal plus-minus 60 minute, drie dae 'n week vir 'n periode van ses weke van u tyd in beslag neem. Die oefenprogramme sal gedurende Februarie tot Mei 2014 plaasvind. U sal onder die navorser se toesig by die universiteit se sport sentrum oefen. Potensiële voordele is die verbetering van u spiersterkte, kernstabiliteit, propriosepsie en balans. My hipotese is dat die oefeningprogramme mag lei tot 'n verbetering van u posturele dinamiese beheer. Verbeterde posturele dinamiese beheer mag ook daartoe lei dat u beter presteer en help om beserings te voorkom.

Alhoewel die studie 'n mate van risiko inhou as gevolg van die moontlikheid dat enige oefening 'n besering kan veroorsaak, is die risiko nie groter as wat u aan 'n netbaloefening deelneem nie en sorg sal aan die dag gelê word om beserings te voorkom. As u beseer word as gevolg van u deelname aan die evaluering of oefenprogramme van die navorsingstudie, sal die navorser gratis fisioterapie behandeling aan u verskaf. Ongemak en spierpyn wat u kan ondervind na 'n oefensessie is normaal en behoort na 'n dag of twee te verdwyn.

U deelname aan hierdie studie is vrywillig; u is onder geen verpligting om deel te neem nie. U kan ter enige tyd gedurende die studie onttrek, sonder enige straf of nagevolge. U sal geen vergoeding vir u deelname aan die studie ontvang nie, maar daar sal ook geen koste daaraan verbonde wees nie.

As u enige vrae het voor of tydens u deelname aan die studie, kontak gerus die navorser, Marelise Wilson by 0835576381 of die studieleier, Roline Barnes by 0827401069. U mag ook die sekretariaat van die Etiek komitee van die Fakulteit Gesondheidswetenskappe van die UVS by 051-4052812 kontak as daar enige vrae ontstaan oor u regte as ‘n deelnemer aan hierdie studie.

Die studie data sal gekodeer word sodat daar nie ‘n verbinding met u naam is nie. U identiteit sal nie tydens die studie bekend gemaak word nie en ook nie as daar oor die studie verslag gelewer word of as die studie gepubliseer word nie. Al u studie data sal in ‘n veilige plek bewaar word en sal nie aan enige iemand bekend gemaak word sonder u toestemming nie.

Die groepresultate van die studie mag in ‘n geakkrediteerde joernaal gepubliseer word en op ‘n vergadering of kongres voorgedra word. Die oefenprogramme sal na die voltooiing van die studie aan die netbalakademie van die UVS en die deelnemers beskikbaar gestel word.

As u aan die studie wil deelneem, voltooi asseblief die aangehegte beseringsprofiel vraelys en teken die inligtingstuk sowel as die ingeligte toestemmingsbrief. U sal ‘n ondertekende afskrif van die inligtingstuk sowel as die ingeligte toestemmingsbrief ontvang.

As u nie aan die studie wil deelneem nie, hoef u nie die beseringsprofiel te voltooi of die ingeligte toestemmingsbrief te onderteken nie.

_______________________________          _______________________

Handtekening van deelnemer          Datum

Ingeligte toestemming

Ek het die ingeligte toestemmingsvorm deurgelees en verstaan die aard van die studie sowel as die moontlike voordele en risiko`s verbonde van deelname aan die studie. Ek verstaan dat deur in te stem om deel te neem aan hierdie studie het ek nie afstand gedoen van enige wetlike of menseregte nie. Ek kan die navorser (Marelise Wilson, 0835576381) enige tyd kontak. Ek verstaan wat my betrokkenheid by die studie beteken en ek stem vrywilliglik in om deel te neem aan die studie. Ek verstaan dat ek mag weier om deel te neem of kan onttrek aan die studie sonder enige straf of nagevolge. Ek verklaar die inligting wat ek verskaf het, as huidiglik korrek.

Naam van deelnemer: ________________________________________

________________________________ ________________

Handtekening van deelnemer Datum

Selfoonnr:______________________

Ek het die studie verbaal aan die deelnemer verduidelik en seker gemaak dat sy verstaan.

________________________________ ________________

Handtekening van navorser Datum

**Studie titel: Die effek van 'n kernstabiliteit, m.gluteus medius en propriosepsie oefenprogramme op dinamiese posturele beheer van netbalspelers**

**Navorser: Marelise Wilson**

**Naam van deelnemer:______________________________**

| **Beseringsprofiel vraelys** | |
| --- | --- |
| Het u enige onderste ledemaat beserings in die laaste ses maande gehad wat u langer as twee dae verhoed het om aan fisiese aktiwiteite deel te neem? Ja____ Nee_____ | |
| Het u enige onderste ledemaat chirurgie gehad in die laaste jaar? Ja____ Nee____ | |
| Neem u huidiglik deel aan enige balans, kernstabiliteit of gluteus medius oefenprogramme? Ja_____ Nee_____ | |
| _________________________ | _____________ |
| Handtekening van deelnemer | Datum |

Appendix 4 Data sheet

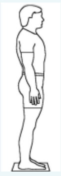
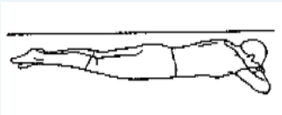
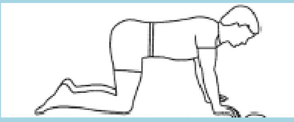
| | | | For Office Use | |
|---|---|---|---|---|
| Participant no | | ______ | ☐☐ | 1-2 |
| Date | | ______ | ☐☐☐☐☐☐ | 3-8 |
| Testing session | 1 | ☐ | ☐ | 9 |
| | 2 | ☐ | | |
| | 3 | ☐ | | |
| Stance | Right | ☐ | ☐ | 10 |
| | Left | ☐ | | |
| Trial 1 | Anterior | ______ | ☐☐☐.☐ | 11-15 |
| | Medial | ______ | ☐☐☐.☐ | 16-20 |
| | Posterior | ______ | ☐☐☐.☐ | 21-25 |
| | Lateral | ______ | ☐☐☐.☐ | 26-30 |
| Trial 2 | Anterior | ______ | ☐☐☐.☐ | 31-35 |
| | Medial | ______ | ☐☐☐.☐ | 36-40 |
| | Posterior | ______ | ☐☐☐.☐ | 41-45 |
| | Lateral | ______ | ☐☐☐.☐ | 46-50 |
| Trial 3 | Anterior | ______ | ☐☐☐.☐ | 51-55 |
| | Medial | ______ | ☐☐☐.☐ | 56-60 |
| | Posterior | ______ | ☐☐☐.☐ | 61-65 |
| | Lateral | ______ | ☐☐☐.☐ | 66-70 |

## Appendix 5 Attendance record sheet

For Office use

| | Present | Absent | For Office use | |
|---|---|---|---|---|
| Participant no | | | | 1-2 |
| **Week 1** | | | | |
| Session 1 | | | | 3 |
| Session 2 | | | | 4 |
| Session 3 | | | | 5 |
| **Week 2** | | | | |
| Session 1 | | | | 6 |
| Session 2 | | | | 7 |
| Session 3 | | | | 8 |
| **Week 3** | | | | |
| Session 1 | | | | 9 |
| Session 2 | | | | 10 |
| Session 3 | | | | 11 |
| **Week 4** | | | | |
| Session 1 | | | | 12 |
| Session 2 | | | | 13 |
| Session 3 | | | | 14 |
| **Week 5** | | | | |
| Session 1 | | | | 15 |
| Session 2 | | | | 16 |
| Session 3 | | | | 17 |
| **Week 6** | | | | |
| Session 1 | | | | 18 |
| Session 2 | | | | 19 |
| Session 3 | | | | 20 |

## Appendix 6 Description of exercise programme

| Exercise | Description |
| --- | --- |
| Week 1 | |
| 1.1 Recognition of neutral spine (centre of mass) in sitting and standing (Akuthota *et al.*, 2008 )  | Recognition of the midrange between lumbar flexion (posterior pelvic tilt) and extension (anterior pelvic tilt) in sitting and standing. |
| 1.2 Co-activation of TrA& LM in crook supine lying position (base position) (Aggarwal *et al.*, 2010)  | The participant voluntary activates TrA by pulling the umbilicus inwards towards the spine, and the LM by causing the muscles on either side of the lumbar spine to swell, while in crook supine lying position. A pressure biofeedback unit (PBU) is used to ensure recruitment of TrA and LM. Compensatory movements such as pelvic tilting and rectus abdominis and gluteal contraction are discouraged. |
| 1.3 Co-activation of TrA& LM in prone lying position (Aggarwal *et al.*, 2010)  | The participant voluntary activates TrA by pulling the umbilicus inwards towards the spine, and the LM by causing the muscles on either side of the lumbar spine to swell, while in prone lying position. A pressure biofeedback unit (PBU) is used to ensure recruitment of TrA and LM. Compensatory movements such as pelvic tilting and rectus abdominis and gluteal contraction are discouraged |
| 1.4 Co-activation of TrA& LM in quadruped position (recognition of centre of mass) (Aggarwal *et al.*, 2010)  | The participant voluntary activates TrA by pulling the umbilicus inwards towards the spine, and the LM by causing the muscles on either side of the lumbar spine to swell, while in quadruped position. Compensatory movements such as pelvic tilting and rectus abdominis and gluteal contraction are discouraged. |

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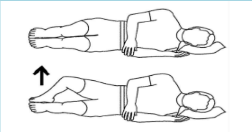
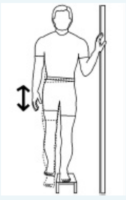
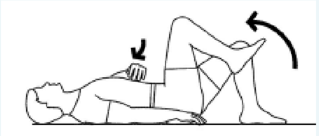
| 1.5 Co-activation of TrA& LM while standing on single limb (recognition of centre of mass) (Aggarwal *et al.*, 2010)  | The participant voluntary activates TrA by pulling the umbilicus inwards towards the spine, and the LM by causing the muscles on either side of the lumbar spine to swell, while standing on a single limb with eyes closed. Compensatory movements such as pelvic tilting are discouraged. |
| 1.6 Clamshell 1 (Distefano *et al.*, 2009; Boren *et al.*, 2011)  | The participant is in R side-lying on the floor; with the knees flexed 90° and hips flexed 45°. The participant activates TrA and LM and maintains the lumbar spine in a neutral position. The participant abducts and externally rotates the L knee off the bottom knee while keeping the heels together and the anterior superior iliac spines facing forward, and then return to the starting position. After completing a set in R side-lying, the exercise is repeated in L side-lying. |
| 1.7 Pelvic drop (Bolga *et al.*, 2005; Boren *et al.*, 2011)  | The participant stands with the R leg on the edge of a 5cm step. The participant activates TrA and LM and maintains the lumbar spine in a neutral position while lowering the heel of the L leg to touch the ground without weight bearing. The participant returns foot to the height of the box. After completing a set with the R leg, the exercise is repeated with the L leg on the edge of the step. |
| Week 2 | |
| 2.1 Supine bent knee-raises (Fredericson *et al.*, 2005; Aggarwal *et al.*, 2010)  | The participant is in hook-lying position with knees bent and feet flat on the floor. The participant activates TrA and LM and maintains the lumbar spine in a neutral position while she slowly raises one foot 15 to 30 cm off the ground with alternate legs. Compensatory movements such as rocking the pelvis, abdominal protrusion and an inability to maintain a neutral lumbar spine are discouraged. |

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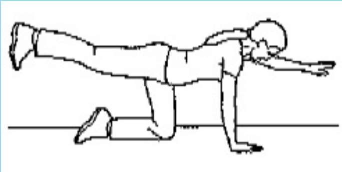
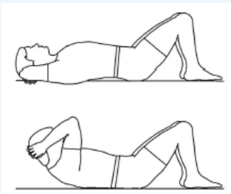
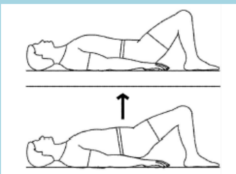
| 2.2 Quadruped with alternate arm/leg raises (Superman exercise) (Fredericson *et al.*, 2005; Aggarwal *et al.*, 2010)  | The participant is in the quadruped position and activates TrA and LM and maintains the lumbar spine in a neutral position. The participant raises the R arm and the L leg into a line with the trunk while preventing any rocking of the pelvis or spine (excessive transverse or coronal plane motion). A wooden dowel is placed along the spine to add tactile feedback and help the participant to maintain alignment. The leg is only raise to the height at which the participant can control excessive motion of the pelvis. The exercise is repeated by raising the L arm and R leg. |
| 2.3 Abdominal crunches (Kahle and Gribble, 2009)  | The participant is in hook-lying position with both hands behind the neck, knees bent and feet flat on the floor. The participant activates TrA and LM and tucks her chin in a little as if holding a tennis ball between chin and chest. The participant curls up, only until the shoulder blades are off the ground. The participant holds the position for five seconds and lowers the head and shoulders returning to the starting position. |
| 2.4 Bridging (Fredericson *et al.*, 2005)  | The participant is in hook-lying position with her arms resting at her side. The participant activates TrA and LM and squeezes the gluteal muscles before initiating movement. The participant lifts the pelvis and hips off the ground by keeping the feet on the floor while maintaining neutral lumbar spine alignment. The hips should be aligned with the knees and shoulders in a straight line and there should be no rotation of the pelvis. The participant holds the position for ten seconds and lowers the body back onto the ground. |
| 2.5 Single limb dead lift (Distefano *et al.*, 2009; Boren *et al.*, 2011)  | The participant balances on the R leg, with the knee and hip flexed approximately 30° and their hands on their hips. Participant activates TrA and LM, slowly flexes at the hip, and touches their L middle finger to the floor beside their R foot. Participant returns to the starting position. After completing a set on the R leg, the exercise is repeated on the L leg. Participants are instructed to maintain neutral alignment, and to keep their knees over their toes. |

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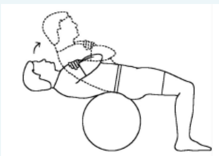
| 2.6 Co-activation of TrA& LM while standing on single limb with eyes closed (Aggarwal *et al.*, *2010*; Leavey *et al.*, 2010)<br> | The participant activates TrA by pulling the umbilicus inwards towards the spine, and the LM by causing the muscles on either side of the lumbar spine to swell, while standing on single limb with eyes closed. Compensatory movements such as pelvic tilting are discouraged. |
| Week 3 | |
| 3.1 Seated marching on physio ball (Fredericson *et al.*, 2005)<br> | The participant sits upright on a physio ball, with the lumbar spine in neutral position. The participant's feet are placed hip-width apart. While activating TrA and LM, she lifts one leg and foot slightly off the ground while maintaining lumbo-pelvic stability. |
| 3.2 Abdominal crunches on a physio ball (Fredericson *et al.*, 2005; Kahle and Gribble, 2009)<br> | The participant positions herself on the physio ball so that her spine contours the ball and is well supported. The position should allow the head to almost touch the ball when it drops into full extension and the buttocks should remain on the ball. The participant activates TrA and LM and tucks her chin in a little as if holding a tennis ball between chin and chest. The participant curls up, until the shoulder blades are off the physio ball. The participant holds the position for five seconds and returns to the starting position. |

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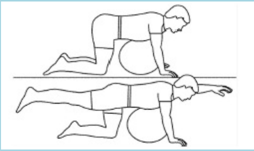
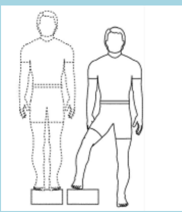
| 3.3 Superman exercise on a physio ball (Fredericson *et al.*, 2005)<br> | The participant is in the quadruped position with a physio ball underneath the trunk. The participant activates TrA and LM and maintains the lumbar spine in a neutral position. The participant raises the R arm and the L leg into a line with the trunk while preventing any rocking of the pelvis or spine (excessive transverse or coronal plane motion). A wooden dowel is placed along the spine to add tactile feedback and help the participant to maintain alignment. The leg is only raise to the height at which the participant can control excessive motion of the pelvis. The exercise is repeated by raising the L arm and R leg. |
| 3.4 Bridging with alternate leg lifts (Fredericson *et al.*, 2005; Kahle and Gribble, 2009)<br> | The participant is in hook-lying position with her arms resting at her side. The participant activates TrA and LM and squeezes the gluteal muscles before initiating movement. The participant lifts the pelvis and hips off the ground by keeping the feet on the floor while maintaining neutral lumbar spine alignment. The hips should be aligned with the knees and shoulders in a straight line and there should be no rotation of the pelvis. In the lifted-bridge position, while maintain neutral lumbar spine alignment, the participant lifts one foot off the ground. The participant holds the position for five seconds and first lowers the foot and then lowers the body back to the ground. The exercise is repeated with the alternate leg. |
| 3.5 Lateral step up (Ayotte *et al.*, 2007; Ekstrom *et al.*, 2007; Boren *et al.*, 2011)<br> | Participant stands on the edge of a 15cm step on the R leg and activates TrA and LM and maintains the lumbar spine in a neutral position. The participant squats slowly to lower the heel of the L leg toward the floor and then returns to the start position. After a set, the exercise is repeated with the participant standing on the edge on the L leg. |

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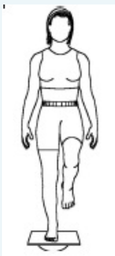
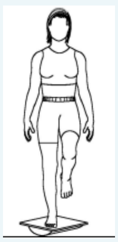
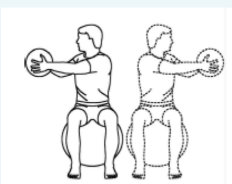
| 3.6 Tilt board exercises: (Fredericson *et al.*, 2005)<br>1) Balance in plantarflexion/ dorsiflexion<br><br>2) Balance in inversion / eversion<br><br>3) Balance in diagonal<br> | The participant stands on a tilt board, activates TrA and LM and maintains static stability. The participant keeps lumbo-pelvic alignment and balance while controlling aberrant motion. The participant's feet are placed in various planes of motion on the tilt board. These planes include plantarflexion/dorsiflexion, inversion/eversion and diagonal. Progression is made from double leg stance with eyes open to double leg stance with eyes closed to single leg stance with eyes open. |
| Week 4 | |
| 4.1 Trunk rotation with 2kg medicine ball while seated on physio ball (Kahle and Gribble, 2009)<br> | The participant sits upright on a physio ball, with the lumbar spine in neutral position. The participant's feet are placed hip-width apart. A 2kg medicine ball is held in front of the chest with the arms extended. While activating TrA and LM, she rotates to one side while maintaining lumbo-pelvic alignment and stability. The trunk rotation is repeated to the other side. |

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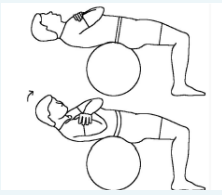
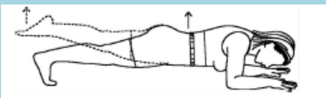
| 4.2 Alternate leg bridge with shoulders on physio ball (Fredericson *et al.*, 2005; Kahle and Gribble, 2009)  | The participant sits on the physio ball and walks forward with her feet on the ground, leaning back until her head, neck and shoulder blades are supported on the ball. Knees are bent 90° with the feet flat on the ground. The participant contracts TrA and LM and raises one foot off the ground while maintaining lumbar alignment and avoiding pelvic rotation. The participant holds the position for five seconds and lowers the foot to the ground. The exercise is repeated with the alternate leg. |
| 4.3 Diagonal curls on physio ball (Aggarwal *et al.*, 2010)  | The participant position herself on the physio ball so that her spine contours the ball and is well supported. The position should allow the head to almost touch the ball when it drops into full extension and the buttocks should be on the ball. The participant activates TrA and LM and tucks her chin in a little as if holding a tennis ball between chin and chest. The participant curls up, bringing her shoulder across toward the opposite knee while keeping both elbows wide and chest open. The participant holds the position for five seconds and returns to the starting position. The exercise is repeated to the alternate side. |
| 4.4 Front plank with alternate hip extension (Fredericson *et al.*, 2005; Boren *et al.*, 2011)  | The participant supports herself with her forearms, elbows bent 90°, and the toes resting on the ground. The spine, hips, and knees are in neutral alignment. The participant activates TrA and LM, recruits the gluteal muscles and keeps the head level with the ground. The participant lifts the R leg off the ground, flexes the knee of the R leg, and extends the hip past neutral hip alignment by bringing the heel toward the ceiling and then returns to parallel. Neutral lumbar alignment should be maintained and increased lumbar lordosis avoided. After completing a set with the R leg, the exercise is repeated with the L leg. |

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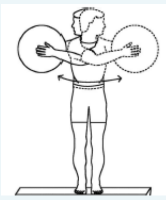
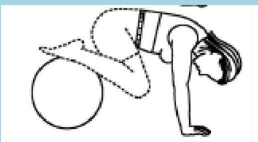
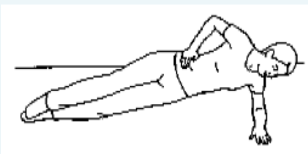
| 4.5 Wobbleboard - Unilateral balance(Leavey *et al.*, 2010)<br> | The participant stands on wobble board, activates TrA and LM and maintains static stability. The participant keeps lumbo-pelvic alignment and balance while controlling aberrant motion. |
| Week 5 | |
| 5.1 Standing 2kg medicine ball or pulley rotation (Fredericson *et al.*, 2005)<br> | The participant stands with her feet shoulder-width apart and knees slightly bent. The participant activates TrA and LM and maintains neutral spinal alignment throughout the movement. The participant holds a straight-arm position (elbows extended) and grasps the pulley handle or medicine ball with both hands. The athlete rotates the trunk by activating the abdominal obliques and spinal rotators while maintaining a stable pelvis. The exercise is repeated to the alternate side. |
| 5.2 Lower trunk rotation with shins on physio ball (Kahle and Gribble, 2009)<br> | The participant begins the exercise by placing her shins on the physio ball and her hands directly below her shoulders. The participant activates TrA and LM and maintains neutral lumbar spine throughout the movement. The athlete rotates the trunk by activating the abdominal obliques and spinal rotators while allowing the physio ball to roll. The participant returns to the starting position and the exercise is repeated to the alternate side. |
| 5.3 Side plank with upper leg hip abduction (Fredericson *et al.*, 2005; Ekstrom *et al.*, 2007; Boren *et al.*, 2011)<br> | The participant lies on her R side with the R arm extended in a straight line up from the shoulder, with the forearm resting on the mat. Participant activates TrA and LM and is instructed to keep shoulders, hips, knees and ankles in line bilaterally throughout the movement. The participant then raises the hips from the ground to achieve neutral alignment of trunk, hips, and knees (side plank position). While balancing on elbow and foot, the participant abducts the L leg. Participant maintains plank position throughout all repetitions. The exercise is repeated on the alternate side. |

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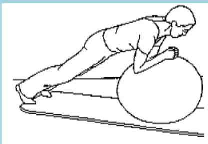
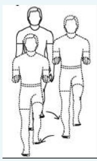
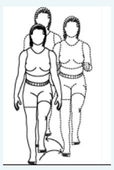
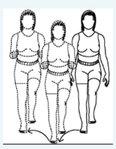
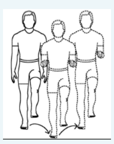
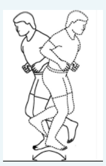
| 5.4 Front plank on physio ball (Fredericson *et al*., 2005)<br> | The participant kneels behind the physio ball, with both forearms on the ball. Keeping TrA and LM activated and the lumbar spine in a neutral position, the participant rolls the physio ball away from her body until there is a straight line from the shoulders to hips. While maintaining neutral alignment, the participant holds the position for 20 seconds, working up to 40 seconds. If the participant is able to maintain neutral alignment throughout a set of repetitions, the body is gradually straightened until up to the toes. |
| 5.5 Functional hop exercises: (Leavey *et al*., 2010)<br>1) Unilateral diagonal forward<br><br>2) Unilateral diagonal backward<br><br>3) Unilateral forward/backward same side 45˚<br><br>4) Unilateral forward/backward opposite side 45˚<br><br>5) Unilateral rotation 45˚<br> | 1) Participant stands on her R leg and hops forward in a zig-zag pattern. The exercise is repeated on the L leg.<br>2) Participant stands on her R leg and hops backward in a zig-zag pattern. The exercise is repeated on the L leg.<br>3) Participant stands on her R leg and hops forward and backward to her R in a zig-zag pattern. The exercise is repeated on the L leg.<br>4) Participant stands on her R leg and hops forward and backward to her L in a zig-zag pattern. The exercise is repeated on the L leg.<br>5) Participant stands on her R leg , hop and rotates alternately 45° to her L and R. |

| WEEK 6 | |
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| 6.1 Forward lunge with a 2kg medicine ball or weight with trunk rotation (Fredericson *et al.*, 2005)<br> | The participant stands upright, holding a 2kg medicine ball, with arms outstretched, perpendicular to the body. The participant steps forward with the medicine ball in front of the chest with the arms extended. The participant lunges and after the lunge is completed, the participant rotates the trunk by bringing the ball across the body toward the same side as the front leg and then returns the ball to the midline as the next step is made. The knee joint of the front limb should not come pass the vertical angle relative to the ankle joint and the second toe should be aligned perpendicular with the patella. |
| 6.2 Upper extremity-trunk supine overhead throw simulation using a physio ball and a netball (Smith *et al.*, 2008)<br>(Consent obtained for use of photo – Appendix 8)<br> | The participant positions herself on the physio ball that her spine contours the ball and is well supported. The participant activates TrA and LM and tucks her chin in a little as if holding a tennis ball between chin and chest. The participant curls up and simulates an overhead throw. |
| 6.3 Upper extremity-trunk seated overhead throw simulation using a physio ball and a netball (Smith *et al.*, 2008)<br>(Consent obtained for use of photo – Appendix 8)<br> | The participant sits upright on a physio ball, with the lumbar spine in neutral position. The participant's L foot is on the floor while the R foot is placed on the L knee with the R shin parallel to the floor. The participant activates TrA and LM and while maintaining lumbo-pelvic stability simulates a netball throw. |

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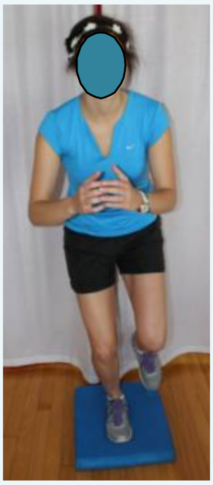
| 6.4 Upper extremity-trunk-lower extremity standing passing simulation using a physio ball and a netball (Smith *et al*., 2008)<br><br>(Consent obtained for use of photo – Appendix 8)<br><br> | The participant stands on her L leg with het R foot on a small physio ball. The participant activates TrA and LM and while maintaining lumbo-pelvic stability and balance simulates a netball throw. |
| 6.5 Single-limb 90<Airex hop and hold (Filipa *et al*., 2010)<br><br>(Consent obtained for use of photo – Appendix 8)<br><br> | The participant stands with her R leg on an Airex mat. The participant activates TrA and LM and while maintaining lumbo-pelvic stability, the participant hops on one leg and keeps balance for five seconds prior to the next attempt. |

Acronyms: R: - right; L: - left; TrA: - transversus abdominis; LM: - lumbar multifidus; GMed: - gluteus medius.

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2013-11-29

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C/O MS R BARNES
DEPARTMENT OF PHYSIOTHERAPY
CR DE WET BUILDING
UFS

Dear Ms Wilson

**ECUFS NR 189/2013**
**MS M WILSON** **DEPARTMENT OF PHYSIOTHERAPY**
**PROJECT TITLE: THE EFFECT OF A CORE STABILITY, M. GLUTEUS MEDIUS AND PROPRIOCEPTIVE EXERCISE PROGRAM ON DYNAMIC POSTURAL CONTROL IN NETBALL PLAYERS.**

- You are hereby kindly informed that at the meeting on 26 November 2013 the Ethics Committee condoned the approval of the study after all conditions have been met when the following were submitted:
    - ***Signed permission letters received from the following:***
        - ***Prof GJ van Zyl, Dean of the Faculty of Health Sciences***
        - ***Prof HR Hay, Vice-rector: Academic***
        - ***Mr Rudi Buys, Dean: Student Services***
        - ***Ms de Kock, Assistant Director of Kovsie Sport***
        - ***Dr S van Vuuren, School of Allied Health Professions***
- Committee guidance documents: Declaration of Helsinki, ICH, GCP and MRC Guidelines on Bio Medical Research. Clinical Trial Guidelines 2000 Department of Health RSA; Ethics in Health Research: Principles Structure and Processes Department of Health RSA 2004; Guidelines for Good Practice in the Conduct of Clinical Trials with Human Participants in South Africa, Second Edition (2006); the Constitution of the Ethics Committee of the Faculty of Health Sciences and the Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines.
- Any amendment, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.
- The Committee must be informed of any serious adverse event and/or termination of the study.
- All relevant documents e.g. signed permission letters from the authorities, institutions, changes to the protocol, questionnaires etc. have to be submitted to the Ethics Committee before the study may be conducted (if applicable).
- 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.

University of the Free State | Universiteit van die Vrystaat, 205 Nelson Mandela Drive/Rylaan, Park West/Parkwes, Bloemfontein 9301, South Africa/Suid-Afrika
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- Kindly refer to the ETOVS/ECUFS reference number in correspondence to the Ethics Committee secretariat.

Yours faithfully

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**FOR CHAIR: ETHICS COMMITTEE**

cc **Ms R Barnes**

ECUFS 189/2013

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07 -11- 2013

# APPROVAL FORM: UFS AUTHORITIES / GOEDKEURINGSVORM: UV OWERHEDE

FOR PARTICIPATION OF STUDENTS/STAFF OF THIS FACULTY IN RESEARCH PROJECTS

*VIR DEELNAME VAN STUDENTE/PERSONEEL VAN HIERDIE FAKULTEIT AAN NAVORSINGSPROJEKTE*

Name & student/ staff number
*Naam & studente-/personeelnr* MARELISE WILSON 1991015783.

Department
*Departement* FISIOTERAPIE

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*Tel nr & e-pos* 0135576381 marelisew@telkomsa.net

Study leader(s)
*Studieleier(s)* Mev. R. Barnes Tel: 082 740 1069

Title of project / *Titel van projek*

The effect of a core stability, m gluteus medius and proprioceptive exercise program on dynamic postural control in netball players.

Who will be involved in the study? Please tick (✓) in appropriate box. /
*Wie sal by die studie betrek word? Merk (✓) asseblief in die gepaste blokkie.*

| | YES / JA | NO / NEE | | YES / JA | NO / NEE |
|---|---|---|---|---|---|
| Personnel / *Personeel* | | | Students / *Studente* | X | |

**Please attach the protocol for the study and the Ethics Committee application form.**

***Kindly note that it is the responsibility of the researcher(s) to ensure that all relevant signatures are obtained before this signed form is returned to the Ethics Committee Administration Division (D115) Francois Retief Building, Faculty of Health Sciences, UFS. The protocol may, however, be submitted for Ethics Committee approval while signatures are being obtained. /***

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Appendix 8 Consent form for the use of photographs

I, Margot Venter, the undersigned, do hereby consent and agree that Marelise Wilson has the right to take photographs and to use these in any script or publication. I do hereby release Marelise Wilson all rights to exhibit this work in print and electronic form publicly or privately. I understand that there will be no financial or other remuneration. My identity will remain anonymous. I hold the right to withdraw at any stage if I wish to do so.

Signature: [illegible] Date: 29 October 2014

Witness: [illegible] Date: 29 October 2014

## A summary of the mini-script

Dynamic postural control is the ability to perform a functional task with purposeful movements that translates the body's centre of gravity without compromising a stable base of support. The functional task might involve jumping or hopping to a new location and immediately attempting to remain as still as possible or attempting to create movements such as reaching or throwing without compromising the base of support (Winter, Patla and Frank, 1990; Kahle and Gribble, 2009, Gribble, Hertel and Plisky, 2012).

Maintaining dynamic postural control is essential for netball players as netball players frequently find themselves on one leg having to make an accurate pass. Research by Ferreira and Spamer (2010) evaluated the physical profile of elite university netball players and found poor balance in these netball players during pre-season.

No literature could be found regarding studies investigating a programme that utilized the combination of core stability, m.gluteus medius (GMed) strengthening and proprioceptive balance exercises on dynamic postural control or studies investigating the effect of an exercise programme on dynamic postural control in netball players. The research study was undertaken to determine if an exercise programme that incorporates core stability, m.GMed strengthening and proprioceptive balance exercises would lead to a significant improvement (pÂ0.05) in dynamic postural control in a group of netball players.

A cross-over randomised clinical trial was performed. Sixteen female university netball players selected in the top junior group participated in this study. Participants were randomly divided in two groups. Group A participated three times a week for six weeks in the exercise programme while group B was considered as the control group after which the roles were reversed.

The simple Star Excursion Balance Test (SEBT) with three trials and four directions were used to measure dynamic postural control of the participants. All participants were assessed at baseline, after six weeks and after 12 weeks. Participants from both groups were tested simultaneously, and the data collector and assistant were blinded to which group the participants belonged. Data were analyzed by a biostatistician using student's and paired t-tests.

Dynamic postural control as measured with the SEBT demonstrated a statistically significant improvement ($p<0.05$) across three reach directions (anterior, medial and posterior) in a group of netball players post participation in an exercise programme that incorporated core stability, m.GMed strengthening and proprioceptive balance exercises. The study proposes that an exercise programme that incorporates core stability, m.GMed and proprioceptive balance exercises could be beneficial for improving dynamic postural control in a group of netball players.

The results of the study provided substantial evidence for the use of a combination of core stability, m.GMed strengthening and proprioceptive balance exercises in programmes rehabilitating netball players with poor dynamic postural control. The present study also provides a baseline for further research whether an exercise programme that incorporated core stability, m.GMed strengthening and proprioceptive balance exercises would contribute towards improved performance and injury prevention in netball players. The effectiveness of the exercise programme described in the present study could be implemented and investigated in other sporting codes requiring dynamic postural control. Netball players can also confidently use the developed exercise programme in the present study to eliminate shortcomings in their physical profile, with regards to dynamic postural control.

Key terms: *dynamic postural control; dynamic balance, dynamic postural stability; core stability; gluteus medius strengthening; proprioception; Star Excursion Balance Test; netball players; transversus abdominis; neuromuscular control; centre of mass*

**'n Opsomming van die mini-verhandeling**

Dinamiese posturele beheer is die vermoë om 'n funksionele aktiwiteit met doelgerigte bewegings uit te voer wat die liggaam se swaartepunt verplaas, sonder om 'n stabiele ondersteuningsbasis prys te gee. Die funksionele aktiwiteit mag spring na 'n ander area insluit terwyl daar onmiddellik daarna gepoog word om so stil te staan of om 'n beweging soos uitreik of gooi uit te voer sonder om die stabiele basis prys te gee (Winter, Patla and Frank, 1990; Kahle and Gribble, 2009, Gribble, Hertel and Plisky, 2012).

Die handhawing van dinamiese posturele beheer is essensieel vir netbalspelers aangesien netbalspelers hulself dikwels op een been bevind terwyl hulle nog steeds akkuraat moet gooi. Navorsing deur Ferreira and Spamer (2010) het die fisiese profiel van elite universiteitsvlak netbalspelers pre-seisoen geëvalueer en hulle bevinding was dat netbalspelers swak balans gehad het.

Geen literatuur kon gevind word rakende navorsingstudies wat die invloed van 'n kombinasie oefenprogramme bestaande uit kernstabiliteit, m. gluteus medius (GMed) versterking en proprioseptiewe balansoefeninge insluit, op dinamiese posturele beheer ondersoek nie of enige studie wat die effek van 'n oefenproram op dinamiese posturele beheer in netbalspelers ondersoek nie. Die navorsingstudie is onderneem om te bepaal of 'n oefenprogramme wat kernstabiliteit, m.GMed versterking en proprioseptiewe balansoefeninge insluit sal lei tot 'n beduidende verbetering (pÂ0.05) in die dinamiese posturele beheer van 'n groep netbalspelers.

'n Gerandomiseerde gekruisde kliniese proef is uitgevoer. Sestien vroulike universiteits netbalspelers wat verkies is as die top junior groep, het aan die studie deelgeneem. Deelnemers is ewekansig verdeel in twee groepe. Groep A het drie maal 'n week vir ses weke aan die oefenprogramme deelgeneem terwyl groep B as die kontrole groep beskou is, daarna is die rolle omgekeer.

Die eenvoudige "Star Excursion Balance Test" (SEBT) met drie proefslae en vier rigtings is gebruik om die dinamiese posturele beheer van die deelnemers te bepaal. Al die deelnemers is evalueer voor die aanvang van die oefenprogramme, na ses weke en na 12 weke. Beide groepe se deelnemers is gelyktydig evalueer en die dataversamelaar sowel as die assistant was blind ten opsigte van die groep waaraan die deelnemer behoort het. Data is deur 'n biostatistikus analiseer met studente en gepaarde t-toetse.

Dinamiese posturele beheer soos bepaal met die SEBT het 'n beduidende verbetering (pÂ0.05) getoon in drie rigtings (anterior, mediaal and posterior) in 'n groep netbalspelers na deelname in 'n oefenprogramme wat kernstabiliteit, m.GMed versterking en proprioseptiewe balansoefeninge ingesluit het. Die huidige studie stel voor dat 'n oefenprogramme wat kernstabiliteit, m.GMed versterking en proprioseptiewe balansoefeninge insluit, voordelig kan wees vir die verbetering van dinamiese posturele beheer van 'n groep netbalspelers.

Die resultate van die studie verskaf beduidende bewyse vir die gebruik van 'n kombinasie van kernstabiliteit, m.GMed versterking en proprioseptiewe balansoefeninge in rehabilitasie programmeme van netbalspelers met swak posturele beheer. Die huidige studie verskaf ook 'n grondslag vir verdere navorsingstudies om te bepaal of 'n oefenprogramme wat kernstabiliteit, m.GMed versterking en proprioseptiewe balansoefeninge insluit tot verbeterde spel en voorkoming van beserings in netbalspelers kan lei. Die effektiwiteit van die oefenprogramme wat in die huidige studie ontwikkel is, kan ook geimplementeer en ondersoek word in ander sportsoorte wat dinamiese posturele beheer benodig. Netbalspelers kan die ontwikkelde oefenprogramme van die huidige studie met vertroue gebruik om tekortkominge in hulle fisiese profiel rakende dinamiese posturele beheer uit te skakel.

Sleutelterme: *dinamiese posturele beheer; dinamiese balans; dinamiese posturele stabiliteit; kernstabiliteit; gluteus medius versterking; propriosepsie; Star Excursion Balance Test; netbalspelers; transversus abdominis; neuromuskulêre beheer; swaartepunt.*