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EFFECT OF A CORE STABILITY, *M. GLUTEUS MEDIUS* AND PROPRIOCEPTIVE EXERCISE PROGRAMME ON DYNAMIC POSTURAL CONTROL IN NETBALL PLAYERS

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ABSTRACT

Maintaining dynamic postural control is essential for netball players as they frequently find themselves on one leg having to make a precise pass. Evaluation of the physical profile of elite university netball players found poor balance during pre-season. The research aimed to determine if a six-week exercise programme incorporating core stability, m. gluteus medius strengthening and proprioceptive balance exercises would lead to improvement in dynamic postural control in netball players. A crossover randomised clinical trial was performed on nineteen all-female university level netball players. The 19 participants were randomly divided into two groups. Group A (n=8) participated in the exercise programme three times a week for six weeks, while Group B (n=8) acted as the control group after which roles were reversed. Participants were assessed at baseline, after six and 12 weeks using the Star Excursion Balance Test. A statistically significant improvement (p<0.05) was found in dynamic postural control across three reach directions (anterior, medial and posterior) post participation in the exercise programme. A programme incorporating core stability, m. gluteus medius and proprioceptive balance exercises could be beneficial for improving dynamic postural control in all-female university level netball players.

Keywords: Core stability; Dynamic postural control; Effect; *M. gluteus medius*; Proprioceptive balance.

INTRODUCTION

Poor dynamic postural control has been theorised 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 *et al.,* 2012), the injury rate was calculated at 500.7 injuries. Seven injuries per 1000 playing hours, and the direct probability that a player could sustain an injury was calculated at 0.15 per player. Numerous research studies have recommended a structured programme to enhance core stability, neuromuscular control and proprioception to reduce the number of sports injuries (Emery *et al*., 2005; Elphinston & Hardman, 2006; Kibler *et al.,* 2006; McGuine & Keene, 2006; Langeveld *et al.,* 2012).

Maintaining dynamic postural control is essential for netball players as players frequently find themselves on one leg having to make a precise pass, while still having to comply with the International Federation of Netball Associations (IFNA) footwork rule that determines once the landing foot is lifted, it may not be re-grounded until the ball is released (IFNA, 2017). Ferreira and Spamer (2010) reported poor dynamic postural control of elite university netball players during pre-season with computerised balance testing.

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 *et al.*, 1990; Kahle & Gribble, 2009; Gribble *et al.*, 2012). The inclusion of core stability in exercise programmes (Kahle & Gribble, 2009; Aggarwal *et al.*, 2010; Filipa *et al.*, 2010; Sandrey & Mitzel, 2013) for improving dynamic postural control is based on the hypothesis 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. gluteus medius* exercises were also included in exercise programmes (Filipa *et al.*, 2010; Leavey *et al.*, 2010) due to the hypothesis that the gluteus muscle contributes to dynamic postural control by stabilising 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 *et al*., 2005; Distefano *et al*., 2009; French *et al*., 2010; Boren *et al*., 2011).

Another component considered by researchers for the improvement of dynamic postural control was proprioceptive balance exercises (Clark & Burden, 2005; Leavey *et al*., 2010; Zech *et al*., 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 & Burden, 2005; Leavey *et al*., 2010). The Star Excursion Balance Test (SEBT) has been used in numerous studies to assess dynamic postural control (Kahle & Gribble, 2009; Filipa *et al*., 2010; Leavey *et al*., 2010). The test is a valuable test for assessing dynamic balance as it has a high inter-rater and intra-rater reliability (Gribble *et al*., 2013). The SEBT is a useful clinical measure as it challenges the athlete's postural control system as the centre of mass of the body is moved in relation to its base of support (Kahle & Gribble, 2009) The test consists of determining the distance in four reach directions upon which improvement in the reach directions would indicate improvement in dynamic balance.

At the time of the current study, no literature could be found regarding studies investigating a programme that utilised the combination of core stability, *m. gluteus medius* 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 need for further research is warranted.

PURPOSE OF RESEARCH

The purpose of this study was to determine whether an exercise programme three times a week over six weeks that incorporates core stability, *m. gluteus medius* strengthening and proprioceptive balance exercises would lead to a significant improvement ($p<0.05$) in dynamic postural control in a group of university-level netball players.

METHODOLOGY

A crossover randomised clinical trial was performed on female netball players at a tertiary institution selected into the top junior netball group that consisted of 19 netball players. The guideline for junior netball players at university level is a first-year student under the age of 20. The null hypothesis for the study was that there would be no improvement in dynamic postural control in a group of university level netball players, while the alternative hypothesis was that there would be an improvement in dynamic postural control in a group of university level netball players.

The 19 participants were randomly divided into two groups. For the first six weeks, Group A (n=8) participated in the exercise programme while Group B (n=8) was the control group, after which the roles were reversed. Female university level netball players, selected into the top junior netball group who provided informed consent and voluntarily agreed to participate, were include in the study. The mean age of the participants was 19 years. Participants were excluded in the following instances: a history of lower extremity injuries during the past six months (any injury preventing the participant from partaking in physical activity for longer than two days) (Kahle & Gribble, 2009); lower extremity surgery during the past year (Leavey *et al.*, 2010), partaking in any balance, core stability or *m. gluteus medius* exercise programmes, not included in their standard exercise programme (Leavey *et al.*, 2010).

To ensure objectivity and reliability during the data collection phase, two qualified physiotherapists were recruited and trained to assist during the research study. The one physiotherapist acted as a data collector whose task was to measure the distances reached by the participant during the Star Excursion Balance Test (SEBT), and the other physiotherapist acted as an assistant who had to document the distances reached by participants during the SEBT on the relevant data sheet.

Ethical clearance was obtained from the Human Research Ethics Committee of the Faculty of Health Sciences, University of the Free State (189/2013), after which permission was obtained from all relevant stakeholders.

Players were specifically informed during an information session that non-participation would not influence team selection and during the same session informed consent was obtained from willing participants. The simple SEBT with three trials and four directions were used to measure dynamic postural control of the participants. In a previous study (Kahle & Gribble, 2009), determining 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 landing leg of the netball player was used as the supporting leg during assessment with the SEBT.

In order to limit inter-observer variation, the same data collector and assistant performed all the measuring and recording throughout the data collection process. The data collector gave each participant verbal instructions, as well as a physical demonstration on how to execute the SEBT. Despite some effect of practice by repeating trials, participants were allowed two practice trials before any data was recorded. This was done, because Demura and Yamada (2010) illustrated 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. All the participants were tested during three separate testing sessions.

To avoid diagnostic suspicion bias, blinding was applicable for both the data collector and assistant during the second and third testing sessions. All participants from both groups were tested simultaneously.

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.

The participants (first Group A and then after the second testing, Group B) trained under the supervision of the researcher at a sports centre. Each training session took approximately

60 minutes, three days a week for a period of six weeks. 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 data of the participants to be included in the results of the study (Leavey *et al.*, 2010).

The Department of Biostatistics, Faculty of Health Science at the UFS performed the statistical analysis. SEBT scores were presented as ranges with means and medians. Comparisons between each round of testing were presented as Pearson correlations and Fisher's r-to-z transformations determining differences between the correlations for the intervention/non-intervention groups. The change in SEBT scores for all participants between each successive round of testing were calculated by means of paired t-tests for the intervention/non-intervention groups separately. A difference at the $p<0.05$ level was interpreted as statistically significant. The meticulous way in which the study was conducted ensured that statistically significant results were obtained.

RESULTS

Of the nineteen participants recruited for the study, three participants were excluded due to non-compliance. Group A had an average attendance of 16 training sessions and Group B had an average attendance of 15 training sessions. There were no significant statistical differences between attendance of the two groups (Student's t-test: p=0.245). During assessment, using the SEBT the landing leg of the netball players was used as the supporting leg. Ten participants had a right leg-starting stance while six participants had a left leg-starting stance. The difference between the anterior, medial, posterior, and lateral reach direction distances between Group A and Group B during the first testing session were not statistically significant. The average measurements of the reach directions of participants during the first testing session is illustrated in Figure 1.

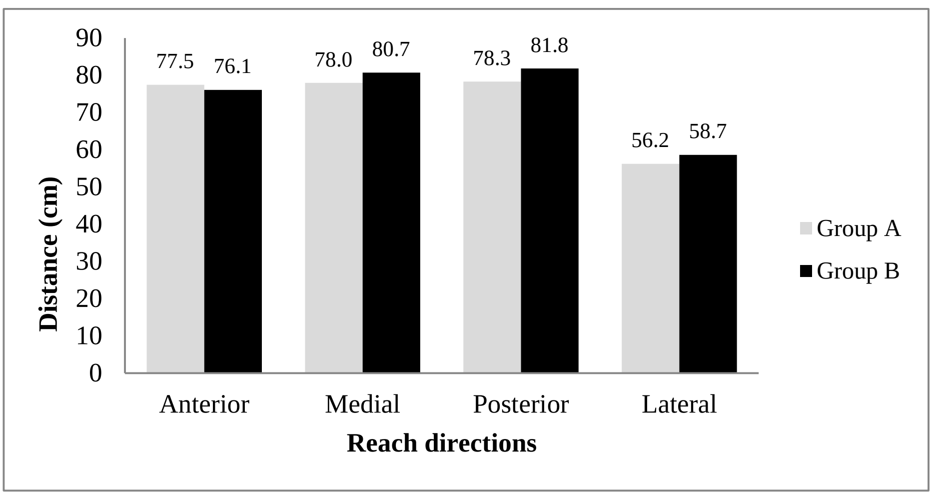

Figure 1. **AVERAGE REACH DIRECTIONS OF FIRST TESTING SESSION** (n=16)

Statistically significant improvement was found 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 not statistically significant. A summary of the average improvement in reach directions from the first to the third testing session is illustrated in Figure 2.

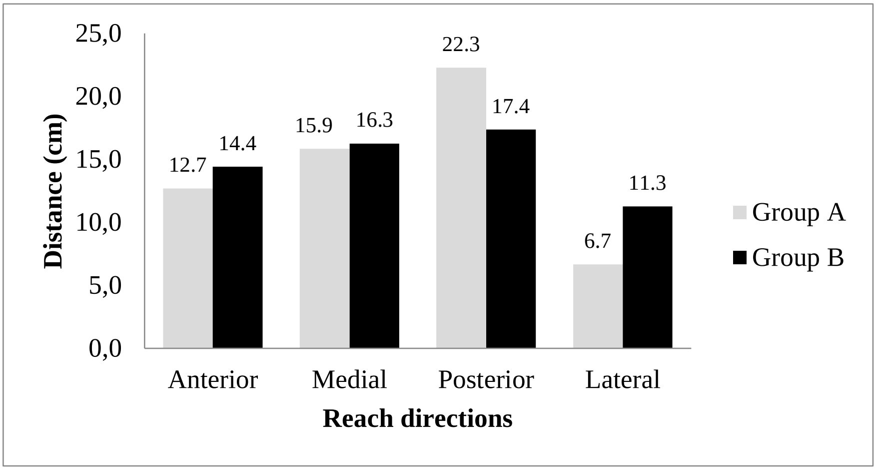

Figure 2. **AVERAGE IMPROVEMENT FROM FIRST TO THIRD TESTING SESSION** (n=16)

Interestingly, statistically significant improvement was found in three reach directions (anterior, medial and posterior) within Group B during the period when being the control group, while Group A participated in the training. However, this was not the case for Group A. Although improvement was found in three reach directions (anterior, medial and posterior) within Group A while Group B participated in the training, the improvement was not statistically significant.

Statistically non-significant improvement was found in the lateral reach direction within Group A and Group B during the period of being the control group, as well as within Group B after having participated in the training. However, statistically significant improvement was found in general within both groups.

A summary of the t-tests on improvement in all four reach directions within and between groups is shown in Table 1. Statistically significant improvement ($p<0.05$) after participation in training was found in the average distance in the anterior, medial and posterior reach directions within Group A and Group B. Although improvement was found within Group A and Group B during the period of being the control group, the average distance of improvement in the anterior, medial and posterior reach directions of both groups after having participated in the training, were found statistically significant ($p<0.05$) when compared to the group being the control group.

***Table 1*. SUMMARY OF IMPROVEMENT WITHIN AND BETWEEN GROUPS**

Testing session	**Group A (paired t-test)**	**Group B (paired t-test)**	**Diff. (A-B) pooled (Student's t-test)**
First vs. second testing	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 vs. third testing	Pr > |t|	Pr > |t|	Pr > |t|
Anterior	0.7873	0.0013	0.0005
Medial	0.2119	0.0005	0.0001
Posterior	0.4500	<0.0001	<0.0001
Lateral	0.3906	0.1037	0.0572
First vs. third testing	Pr > |t|	Pr > |t|	Pr > |t|
Anterior	0.0012	0.0002	0.5989
Medial	0.0006	0.0005	0.9170
Posterior	0.0009	<0.0001	0.2724
Lateral	0.0204	0.0042	0.2098

n=16

DISCUSSION

The measurements of the four reach direction distances during the first testing session of the SEBT between Group A and Group B was calculated by means of the Student's t-test. The average of the three trials of each of the four reach directions of each participant were calculated followed by the average of each of the reach directions for Group A and Group B separately, to determine baseline status between the two groups.

During baseline measurements, all the participants measured the least distance in the lateral reach direction. The same finding was made by Leavey *et al*. (2010) and therefore the researchers 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.

After each group received six weeks of training, the final testing session took place. The improvement in reach distances from the first testing session to the third testing session within each group was calculated 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 Group B was calculated by means of the Student's t-test.

Statistically significant improvement in the average distance in the anterior, medial, posterior and lateral reach directions within Group A was found after the first six weeks of training. Whilst being the control group, participants of Group B showed improvement in the average distance in the anterior, medial and posterior reach directions. However, when comparing the two groups, the average distance of improvement in the anterior, medial and posterior reach directions of Group A 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, which could translate 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 hip adduction passing the midline as measured with the lateral reach direction. This action is not frequently used in netball training and therefore no learning component was provided during normal netball training.

The improvement within Group A could be partially contributed to participation in netball training, but the Student's t-test measuring the difference in improvement between Group A and Group 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 $p=0.0037$, for the medial reach direction $p=0.0003$ and for the posterior reach direction $p=0.0001$. This strong statistical difference consequently 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.

After the six weeks during which Group B participated in the exercise programme while group A acted 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 attributed 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 best improvement was found in the posterior reach direction distances and the least in the lateral reach direction distances. These findings correlate with those of a previous study by Leavey *et al.* (2010) where the same phenomena were noticed during assessment with the SEBT after a balance, *Gluteus Medius* muscle strength and combination programme. Aggarwal *et al.* (2010) hypothesised 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 stabilising 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. gluteus medius* 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.

The non-significant improvement in the lateral reach direction could be ascribed to improved performance during the first six weeks of an exercise programme that is due to motor learning, increased neural activation to the muscle, and improved coordination. According to 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 dimension. Considering that the control group participated in netball training during the first six weeks, both groups were in fact 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 muscles of the 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 present study evaluated the effects of core stability, *m. gluteus medius* strengthening, and proprioceptive balance exercises on dynamic postural control. When comparing the results of the present study to those of other research studies assessing the effect of only core stability training (Kahle & Gribble, 2009; Aggarwal *et al*., 2010; Sandrey & Mitzel, 2013); or only proprioceptive balance (Aggarwal *et al*., 2010); or only *m. gluteus medius* strengthening (Leavey *et al.*, 2010) on dynamic postural control, the findings indicated statistically significant results in all the studies. However, a training programme incorporating core stability, *m gluteus medius* strengthening and proprioceptive balance exercises, lead to additional improvement in dynamic postural control, when compared to an exercise programme consisting of only one component as indicated above. Additional improvements were also found when compared to studies combining only two components. Leavey *et al.* (2010) investigated the effects of *m. gluteus medius* strengthening and proprioceptive balance and Filipa *et al.* (2010) lower extremity strengthening and core stability on dynamic postural control.

A further contribution to the level of improvement in the present study could be the participation in 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; Reiman, 2009). Additionally, the participants were motivated to follow the training programme, as they were all first year students striving to play ultimately for the University's first team. Training was done under the supervision of the researcher who checked the execution of the exercises and corrected performance as deemed necessary.

Due to the fact that each component of the exercise programme was not individually measured, no conclusion could be made regarding the contribution of each of the components towards the improvement of dynamic postural control. In summary, the core stability exercises improved both the muscle activation patterns, as well as strength of the local and global core muscles. The anticipatory activation of *transverses abdominus* 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 & Gribble, 2009; Aggarwal *et al.*, 2010; Sandrey & Mitzel, 2013).

M. gluteus medius stabilises the hip to prevent the pelvis dropping on the unsupported side. *M. gluteus medius* strengthening improves lumbo-pelvic and lower extremity control and is important in dynamic postural control (Reiman, 2009; French *et al.*, 2010; Boren *et al.*, 2011). Furthermore, proprioceptive balance training improves the ability of the central nervous system 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).

Poor core stability and decreased muscular synergy of the trunk and hip stabilisers have been theorised 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 *et al*., 2005; Elphinston & Hardman, 2006; Kibler *et al*., 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 latter findings are substantiated by results of a study by Clark and Burden (2005), who found that a four-week wobble board programme reduced the risk of recurrent ankle sprains in functionally unstable ankles. Both studies (Clark & Burden, 2005; McGuine & 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. gluteus medius* strengthening and balance training in the present study, could have led to injury prevention due to improved dynamic postural control.

Mixed results are found in the literature regarding the influence of core stability on performance. Results of a study by Saeterbakken *et al.* (2011) suggested that core stability training could significantly improve maximal throwing velocity in female handball players, while Stanton *et al.* (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.

PRACTICAL APPLICATION

A training programme that incorporates core stability, *m. gluteus medius* strengthening and proprioceptive balance exercises contribute to dynamic postural control in university-level netball players.

CONCLUSION

Results of the current study indicated that dynamic postural control demonstrated a statistically significant improvement ($p<0.05$) across three reach directions (anterior, medial and posterior) in a group of University level netball players as measured with the SEBT. This study proposed that a training programme that incorporates core stability, *m. gluteus medius* strengthening, and proprioceptive balance exercises, could be beneficial for improving dynamic postural control in a group of netball players. This was achieved post-participation in a training programme that incorporated core stability, *m. gluteus medius* strengthening and proprioceptive balance exercises, three times a week over a period of six weeks.

Although the results of the study are a clear indication that a training programme that incorporates core stability, *m. gluteus medius* strengthening and proprioceptive balance exercises contribute to dynamic postural control in university-level netball players, it is justified to investigate if such a training programme would contribute to improved performance and injury prevention in the broader community of netball players in future research. A limitation of the study to be noted is that the findings of the study is not generalisable to the broader community of netball players based on the study alone due to the relatively small sample size consisting of only 16 female university-level netball players.

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