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RELATIONSHIP BETWEEN FUNCTIONAL MOVEMENT SCREENING AND PERFORMANCE TESTS IN ELITE UNIVERSITY FEMALE NETBALL PLAYERS

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ABSTRACT

The use of Functional Movement Screening (FMS^{TM}) for elite university female netball players was investigated by evaluating the relationship between FMS^{TM} total score and various performance tests. Out of 20 netball players, 19 completed the FMS^{TM} screen consisting of deep overhead squat, hurdle step, in-line lunge, active straight leg raise, shoulder stability, trunk stability and rotary stability; and the performance tests consisting of maximum vertical and lateral jumps, 5m- and 10m-sprints, 5-0-5 agility tests and repeated sprints. Spearman's correlations ($p \leq 0.05$) examined the relationships between the FMS^{TM} and performance tests. Players with higher FMS^{TM} total scores were faster on the 5-0-5 agility test ($r=-0.52$, $p=0.02$) and covered more distance in the repeated sprints test ($r=0.51$, $p=0.03$). Agility 5-0-5 test was also significantly associated with repeated sprints ($r=-0.87$, $p=0.02$), while no significant relationships were found with 5m- or 10m-sprints. Due to specific demands of netball, female players develop physical performance characteristics that do not depict strong association with the FMS^{TM} assessment. Coaches and trainers should use both tools for comprehensive performance evaluation of their players.

***Key words*:** Functional movement screening; Netball; Agility; Speed.

INTRODUCTION

Physical performance of athletes may be monitored via a range of performance tests, which include assessment of strength, power, agility, flexibility, speed balance and proprioception. However, there is a reported increase in use of the FMS^{TM} (Lockie *et al*., 2015) to assess the locomotor, manipulative, and stabilizing actions and ability of athletes to control the specific movement (Cook *et al*., 2006a; Cook *et al*., 2006b). Netball, largely a female sport (Otago, 2004), is associated with traumatic and overuse injuries stemming from deficiencies in proper landing biomechanics, agility, balance and explosive power (Ferreira & Spamer, 2010). However, there is limited data on the use of functional screen tests in assessment of physical readiness of netball players.

FMS™ is designed to assess dynamic and functional abilities of an athlete (Schneiders *et al*., 2011) and is comprised of deep squat, hurdle step, in-line lunge, shoulder mobility, active straight-leg raise, trunk stability push-up and rotary stability test (Cook *et al.*, 2006a; Cook *et al.*, 2006b). Assessment of these movements identifies imbalances and abnormal movement patterns that may result in diminished athletic performance and possibly lead to injury (Cook *et al*., 2006a; Cook *et al*., 2006b; Chorba *et al*., 2010; Schneiders *et al*., 2011). Identifying limitations in the dynamic movements of an athlete may also help identify which intervention can be implemented for improvement in the performance of athletes (Onate *et al*., 2012).

Optimal performance in netball relies on the interaction of several underlying factors relating to the agility, balance and explosive power of players (Kiesel *et al*., 2011; Vanwanseele *et al*., 2013). Hence, a principal mechanism of intrinsic dysfunction in fundamental movement patterns could be addressed through targeted training interventions (Saunders *et al*., 2012). However, there are indications that the FMS^{TM} assessment may not be associated with the physical performance. Okada *et al*. (2011) found no relationships between the FMS^{TM} and core stability, and only a moderate relationship between FMS^{TM} scores and an overhead medicine ball throw and the T-test for agility. Furthermore, there are clear indications that females have a significantly different technique than males during movements, such as landing and cutting (Malinzak *et al.*, 2001), which are one of the essential movement patterns in netball. In addition, females rely on quadriceps eccentric work more during landing and cutting tasks (Malinzak *et al.*, 2001) considering that quadriceps flexibility has been found to decrease during the netball season (Ferreira & Spamer, 2010), decreased function may significantly affect performance and predispose players to various injuries of which the injury to the anterior cruciate ligament (ACL) is the most common in female athletes (Hewett *et al*., 2001). Therefore, predisposition of female athletes to different movement patterns may result in lower FMS^{TM} scores and, subsequently, the misinterpretation of the relationship between the functional movement, movement deficiencies and athletic performance.

PURPOSE OF RESEARCH

The purpose of this study was to analyse the relationship between the FMS^{TM} screening tests, and athletic performance in female netball players. The findings of this study may provide valuable information to coaches and trainers in monitoring functional, motor and performance deficiencies of the performance of their players.

METHODODOLOGY

Participants

Twenty elite female netball players (age: 19.95±1.76 years; height: 177.1±4.8cm; mass: 70.4±7.0kg) volunteered to participate in the study. Players were members of the top 20 university netball training squad who compete in the super league competition of the region, as well as the national universities competition. For participation, players had to be between ages of 18 and 25 years, medically cleared and injury free over the preceding 3 months. During recruitment, participants were given a general information sheet that explained the details of the study and were given an opportunity to ask any questions. Written informed consent was obtained from players before the start of testing. The study was approved by the ethics committee of the Department of Sport Science at Stellenbosch University.

Experimental procedure

Testing occurred at the start of the competitive season after the players completed an 8-week preparatory phase. Prior to data collection, participants completed the injury history questionnaire to determine if players were injured in the past 3 months. Additionally, the questionnaire collected injury related information over the preceding 6 years in the presence of a certified biokineticist to increase the face validity of the questionnaire. Three examiners, 2 primary researchers and the FMS™ subject expert conducted the testing. The average of the scores was used for the statistical analysis. All tests were performed in the indoor sport centre. Data was collected over 2 consecutive testing days. The first session incorporated the anthropometric assessment and FMS™ screening and the second session included the performance tests: maximal vertical jump, single leg lateral jump, 5m- and 10m-sprints, agility test, and a repeated short sprint test.

Functional movement screen (FMS™)

Prior to the testing, age, height and weight were recorded. Two video cameras (Sony HDR-XR100e, Sony Corp., Tokyo, Japan) were strategically placed to capture an anterior and a lateral view of the participant performing the tests. Tests were scored according to standards set in Cook *et al*. (2006a) and Cook *et al.* (2006b): a score of '3' indicates "performed without compensation"; '2' indicates "performed with compensation"; '1' indicates "could not perform"; and '0' represents "pain". Video footage was studied to review the discrepancies in scoring. The full description of the FMS™ tests was given in a study by Cook *et al*. (2006a) and Cook *et al.* (2006b), hence only a basic description of the following seven FMS™ tests is provided:

Deep squat: Participants performed deep squat with hands extended overhead holding a lightweight rod.

Hurdle step: Participants held a lightweight rod across the shoulders, and performed a step over a hurdle, touched the ground with the heel of the foot, and returned to the starting position.

In-line lunge: Participants stood with their feet apart equalling length of a tibia. A lightweight rod was held vertically behind the participant's back, so it touches the head, back and sacrum. With the feet aligned, the participants performed a split squat, with the back knee touching the ground, and returned to the starting position.

Trunk stability push-up: Participants performed a push-up with their hands shoulder width apart and the legs fully extended.

Rotary stability: Participants assumed a quadruped position and attempted to touch their knee and elbow, ipsi-laterally and contra-laterally.

Shoulder mobility: Participants attempted to touch their fists together behind their back.

Active straight-leg raise: Lying supine on the ground, the participants raised one leg as high as possible.

Performance tests

Standing maximum countermovement jump

Lower limb explosive power was assessed using a maximum countermovement jump. Participants stood against the wall with the dominant (hand) side against wall. First, the participants were instructed to reach as high as they can on the wall without the heels leaving the ground. This was marked as the maximum standing reach-height. Then, participants were asked to jump without taking the extra step, and reach as high as they can on the wall. Participants were given 2 attempts to jump. Standing reach-height was subtracted from the highest jump-height to obtain the vertical jump height.

Speed test

Running speed was evaluated with 5m- and 10m-sprint times. The time was measured with the dual electronic timing gates (Swift Speed Light-timing Systems, New South Wales, Australia). The participants were allowed 2 attempts to record the fastest time, with 2 minutes between each trial. The sprint times were recorded to the nearest 0.01 second. Reliability of this test has been reported at r=0.96 (TE=1.3%).

5-0-5 Agility test

The 5-0-5 is an agility test that isolates the change-of-direction ability for each leg (Cook *et al.*, 2014; Lockie *et al*., 2015) and assesses ability to accelerate and decelerate. The participants ran from the starting line past the 5m-mark where the timing gates were located. At the 10m-line participants were required to touch the line and turn back 180^0 and sprint back through the 5m-timing gates. The time was recorded to the nearest 0.01 second. The participants were allowed 2 attempts, with a rest period of 5 minutes. Gabbett *et al.* (2008) reported a validity of r=0.90, with TE=1.9%.

Repeated sprints

Six cones, 5m apart were placed along a straight line. Participants ran up to the first cone, turned 180^0 and ran back to the start line, and continued sprinting to the cone 2,3,4 and 5 with each subsequent sprint. Participants were given 30 seconds to cover as much distance as they could. If they completed the 5^{th} run before the time ran out, they would start from cone 1. If the time ran out before the participant reached the next cone, the distance to the preceding cone was used to measure distance. The purpose of the test was to run the furthest distance. Participants completed 6 trials with a 35 second rest. Distance covered in each 30-second interval was added together to determine total distance covered.

Data analyses

All statistical analyses were completed using the SPSS (Version 22.0, IBM Corporation, New York, USA). Descriptive data for each test were presented as means, standard deviations and the 95% confidence intervals. Due to the sample size, performance test data distribution was checked with Q-Q plots and the Shapiro-Wilk test. The intra-class correlation coefficient (ICC) was calculated to determine the interrater reliability, and the standard error of the mean (SEM) determined the error in the total FMS^{TM} score between the 2 examiners. An ICC of 0.7 or greater was considered acceptable (Gonzalo-Skok *et al*., 2015). Spearman's correlation was conducted to determine the relationship between the FMS^{TM} score and the performance tests, with the significance level α=0.05. The mean FMS^{TM} score from 2 examiners was used during data analysis.

RESULTS

Of the 20 players who volunteered for the study, 19 completed the FMS^{TM} screening. Table 1 displays the descriptive parameters for FMS^{TM} and performance tests.

Table 1. **MEANS AND CONFIDENCE INTERVALS FOR PERFORMANCE TESTS AND FMS™ TOTAL SCORE**

Tests	Mean±SD	95% CI
Vertical jump (m)	0.44±0.06	0.41–0.47
Lateral jump (m)	1.91±0.16	1.82–2.00
5m-sprint (s)	1.05±0.09	1.01–1.10
10m-sprint (s)	1.87±0.21	1.76–1.97
5-0-5 Agility test (s)	2.69±0.11	2.64–2.75
Repeated sprints (m)	635.80±26.86	622.50–649.20
Total FMS^{TM} score	14.50±3.80	12.7–16.30

Table 2. **SPEARMAN'S CORRELATIONS BETWEEN FMS™ TESTS AND PERFORMANCE TESTS**

Perf. tests	FMS^{TM} total	Deep Squat	Hurdle step	In-line lunge	AS leg raise	Shoulder stability	Trunk stability	Rotary stability
Vertical jump	0.10 p=0.73	0.36 p=0.19	-0.73 p=0.80	-0.14 p=0.62	-0.35 p=0.20	0.16 p=0.58	0.04 p=0.89	**-0.54 p=0.04**
Lateral jump	0.09 p=0.75	0.25 p=0.37	0.25 p=0.37	0.25 p=0.31	0.32 p=0.24	-0.51 p=0.05*	0.17 p=0.54	0.08 p=0.78
5-0-5	**-0.56 p=0.02**	-0.36 p=0.16	0.05 p=0.86	-0.24 p=0.36	-0.17 p=0.52	-0.22 p=0.39	**-0.52 p=0.03**	-0.06 p=0.82
5m-sprint	-0.27 p=0.35	-0.03 p=0.92	-0.28 p=0.27	-0.25 p=0.34	0.34 p=0.19	0.05 p=0.84	-0.24 p=0.36	0.25 p=0.34
10m-sprint	-0.38 p=0.12	-0.12 p=0.64	-0.30 p=0.25	-0.20 p=0.44	0.34 p=0.18	-0.07 p=0.79	-0.20 p=0.44	0.12 p=0.64
Repeat sprints	**0.51 p=0.03**	0.28 p=0.27	0.01 p=0.96	0.18 p=0.48	0.05 p=0.86	0.10 p=0.69	**0.50 p=0.04**	0.07 p =0.78

* = 0.054 Perf. Tests=Performance tests AS leg raise=Active straight leg raise **Bold**=Significant

Average total FMS^{TM} score was 14.5±3.8 with 5 players scoring less than 14. The lowest FMS^{TM} score was 11, and the highest was 18. The Q-Q plots and Shapiro-Wilks test indicated that FMS^{TM} total score and the performance tests were normally distributed. The ICC (Intraclass Correlation Coefficient) for inter rater reliability between the 2 examiners for the total FMS^{TM} score was ICC=0.764.

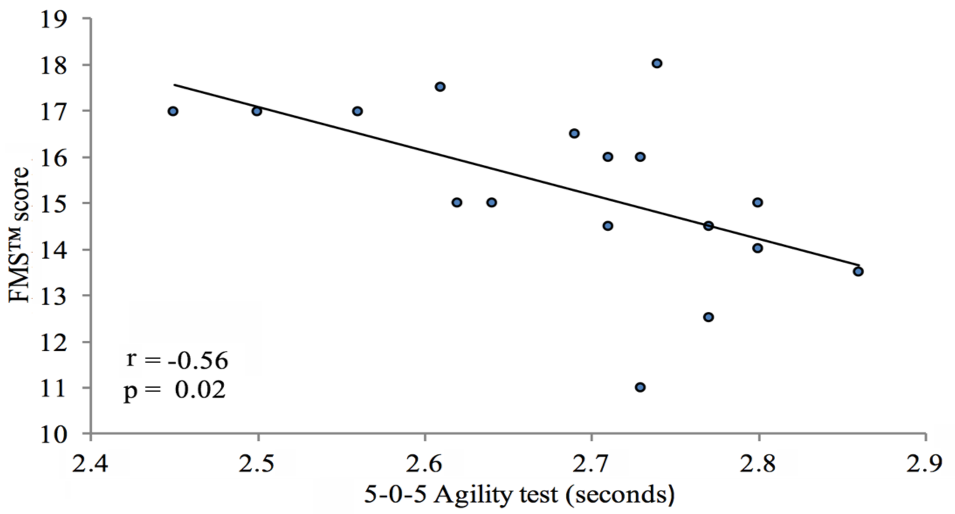

Figure 1. **SPEARMAN CORRELATION BETWEEN MEAN TOTAL FMS™ SCORE AND 5-0-5 AGILITY TEST**

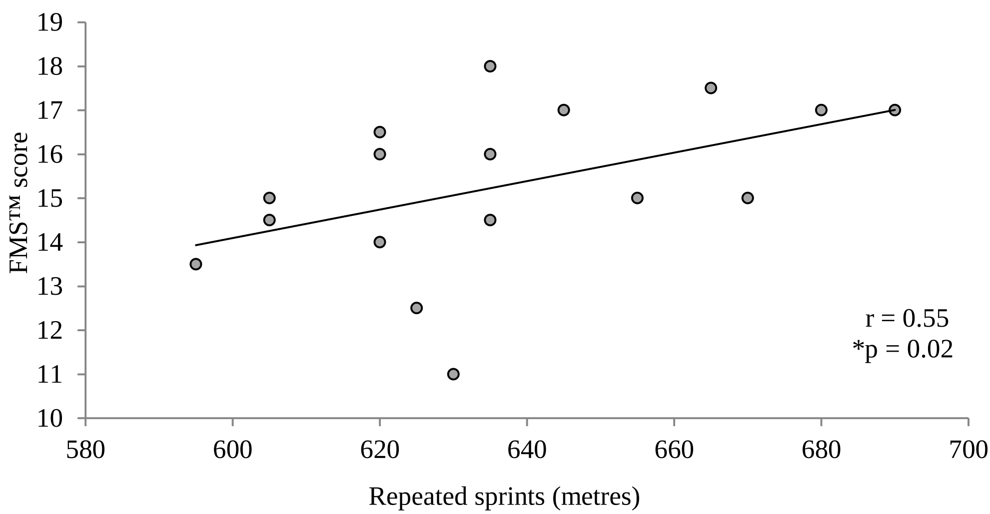

Figure 2. **SPEARMAN'S CORRELATION BETWEEN MEAN TOTAL FMS™**

Spearman's correlations depicted in Table 2, revealed that there was a significant inverse correlation between the FMS™ total score and the 5-0-5 agility test (r=-0.56, p=0.02) as shown in Figure 1. In addition, the FMS™ total score was significantly associated with the repeated sprints distance (r=0.51, p=0.03) depicted in Figure 2. No other significant correlation is noted between the total FMS™ score and the performance tests, however, trunk stability tests showed significant negative correlation with the 5-0-5 agility test (r=-0.52, p=0.03), and significant positive correlation with the distance covered in the repeated sprints (r=0.50, p=0.04). Additional analyses demonstrated that 5-0-5 agility test had strong negative correlation with the repeated sprints (r=-0.87, p≤0.001) (Figure 3).

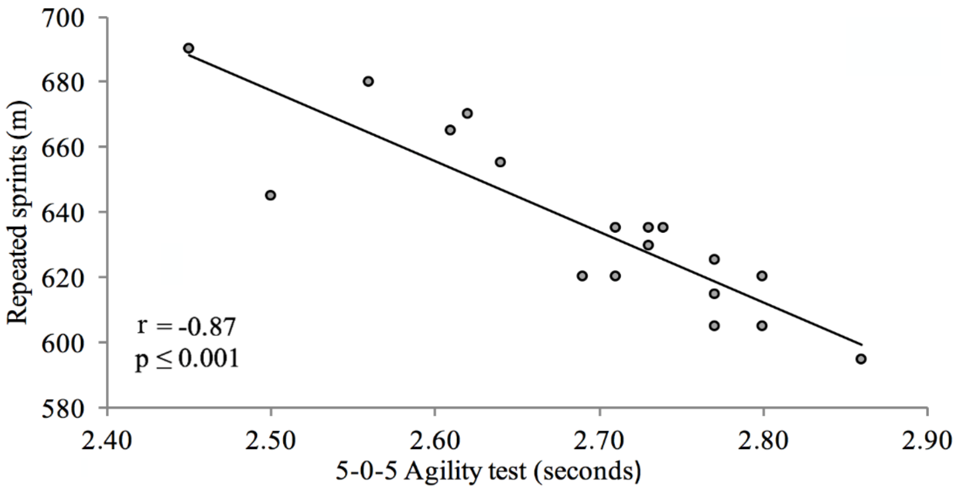

Figure 3. **SPEARMAN'S CORRELATION BETWEEN 5-0-5 AGILITY TEST**

DISCUSSION

The primary aim of this study was to evaluate the relationship between FMS^{TM} screening and the performance tests in female netball players. The findings indicate that total FMS^{TM} score was associated with agility based performances, 5-0-5 agility test and the repeated sprints, while speed and power tests did not have significant correlation with the FMS^{TM} screen.

Firstly, the inter rater reliability between the two scorers in the current study, ICC=0.775 and SEM=0.921, is comparable to previous research. A study by Anstee *et al*. (2003) between 11 examiners for 10 participants showed the ICC=0.66 and SEM=1.23, and a study by Onate *et al*. (2012) examining differences between experienced and inexperienced scorer for 16 participants reported inter rater reliability as ICC=0.98 and SEM=0.25.

The seven movements in the FMS™ attempt to challenge the body's ability to facilitate efficient movement by identifying deficits in mobility, stability and neuromuscular control of motion (Cook *et al.*, 2014). Correct execution of these tests should provide an indication of athletic performance. However, total FMS^{TM} score was not significantly related to determinants of power (vertical and lateral jump) or speed (sprints). Vertical and lateral jumps were also not related to the deep squat component of the FMS^{TM}, which is required for most power movements (Cook *et al.*, 2014).

These results are in agreement with that of Lockie *et al*. (2015), who also investigated female netball players and found no significant correlation of FMS^{TM} total score or deep squat with vertical or lateral jumps, or any of the sprints. However, both of these findings contradict those for male soccer players. A study by Lloyd *et al.* (2015) showed that male soccer players of different ages, all demonstrated significant correlation of total FMS^{TM} score, and deep squat with squat jump, although sprint times were not compared in this study. Considering that female athletes display greater knee valgus and flexion during cutting movements when compared to males (Malinzak *et al*., 2001), this may affect the screening score since knee valgus during FMS^{TM} is considered a compensation mechanism (Lloyd *et al.*, 2015) and is scored lower. Lockie *et al.* (2015) identified that potential gender discrepancies in movement mechanics may lead to the miscorrelation between physical performance variables and FMS^{TM}. Yet, there is a lack of research to substantiate this theory.

Additional correlations demonstrated that the agility and speed were independent for the participants in this study, as 5-0-5 agility test did not show significant correlation with the 5m-sprint (r=0.44, p=0.07), or the 10m-sprint (r=0.45, p=0.06), but there was a significant negative correlation between the repeated sprints and the 5-0-5 test (r=-0.87, p≤0.001). These results may reflect on the physical demands of netball. Due to the strategic nature of netball, players are never required to reach the full sprinting speed, but are rather required to create an open position to receive the ball by evading the defending player after which a complete stop is required. This is attained via efficient change of direction and speed, which are characteristics of agility. Hence, while the total FMS^{TM} score is not significantly correlated with sprint time, agility results showed a different relationship.

Netball players with higher scores FMS^{TM} had faster times on the 5-0-5 test (r=-0.52, p=0.02) (Figure 1), and covered more distance in the repeated sprints test (r=0.51, p=0.03) (Figure 2). Agility performance depends on the athlete′s ability to explosively brake, change direction and accelerate, and is often more important than simply achieving and maintaining high velocity. This is particularly true for netball players as discussed earlier. The primary method for developing agility and speed is the execution of proper technique which stems from already developed levels of endurance, mobility and strength (Beachle & Earl, 2009). Considering that participants in this study were elite netball players in the competitive phase, it is a safe assumption that their conditioning was close to the optimal. These results are in agreement with those of Lockie *et al*. (2015), who also found a significant relationship between the overall FMS^{TM} score and the 5-0-5 agility test.

CONCLUSION

Based on the findings, it can be concluded that the total or individual FMS^{TM} scores may not be a good indicator of the physical readiness or performance of female netball players. However, this study did not evaluate upper body strength and performance of the players, hence the correlation of the upper body specific tests with speed, may not provide valid association. While total FMS^{TM} does associate highly with the agility tests, the current data demonstrates that both assessments should be used congruently to provide the coaches and trainers with a more comprehensive evaluation of physical conditioning and readiness of their players.

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