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Research article

THE RELATIONSHIP BETWEEN FUNCTIONAL MOVEMENT SCREEN SCORES AND SPORTS PERFORMANCE IN ELITE WOMEN'S SOCCER PLAYERS

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Abstract. *The aim of this study was to analyze the relationship between functional movement screen (FMS) individual scores and sports performance variables in elite women's soccer players. Twenty elite women's soccer players (age: 22.01 ± 3.64) took part in the study. Players were screened using the FMS protocol with seven movement patterns: deep overhead squat (DS), hurdle step left (HS L) and right (HS R), in-line lunge left (ILL L) and right (ILL R), shoulder mobility left (SM L) and right (SM R), active straight leg raise left (ASLR L) and right (ASLR R), trunk stability push-up (TSPU) and rotary stability (RS) and three tests of vertical jumps: the squat jump, countermovement jump and countermovement jump with arms, speed on the 20m and slalom and zig zag test. The results showed negative correlations between the 10m sprint and HSL L ($p < 0.001$, $r = 0.587$), HS R ($p < 0.001$, $r = 0.566$) and ASLR R ($p < 0.001$, $r = 0.667$) and between the Slalom test and ILL R ($p < 0.005$, $r = 0.461$) and ASLR L ($p < 0.005$, $r = 0.454$). This study found little evidence of the relationship between FMS results and predictors of sports performance in elite women's soccer players. Strength and conditioning coaches may use these indicators as an assessment of the weakness of certain movements or muscle imbalance as one of the methods for correcting certain segments of sports performance which can later help them achieve better results on the field.*

Key words: *football, female, vertical jump, change of direction*

INTRODUCTION

Soccer is an intense multi-directional and intermittent field sport (Emmonds, Nicholson, Begg, Jones, & Bissas, 2019). At an elite level, women soccer requires high technical ability, tactical awareness, and an exceptionally high level of physical conditioning (Mohr, Krustrup, Andersson, Kirkendal, & Bangsbo, 2008). In sports performance aspects there are

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many explosive actions such as sprinting, jumping, tackling and change of direction (CoD) that appear to influence the outcome of games (Mujika, Santisteban, Impellizzeri, & Castagna, 2009). The assessment of performance is frequently used to monitor the fitness levels of athletes and the long-term effects of the training process (Turner et al., 2011). In the specific case of soccer assessment, batteries include tests to measure linear speed, change-of-direction speed, aerobic capacity, anaerobic power, lower-body power, isokinetic strength, flexibility, and technical skills (Brink, Nederhof, Visscher, Schmikli, & Lemmink, 2010; Svensson, & Drust, 2005). In addition to a biomechanical movement analysis there is a lack of tests that evaluate the movement pattern, a functional movement screen (FMS) has been proposed as a battery test to simplify the assessment of movement patterns in daily sports practice (Kraus, Schütz, Taylor, & Doyscher, 2014).

Functional movement can be defined as the ability to produce and maintain balance between mobility and stability along the kinetic chain while performing fundamental patterns with accuracy and efficiency (Mills, Taunton, & Mills, 2005). Functional movement is vital to performance and sports-related skills, and consists of the interplay between muscular strength, stability, flexibility, and motor control (Mills et al., 2005). Furthermore, the T-test used to study CoD performance and FMS found a moderate relationship in recreationally-active individuals ($r = -0.383$ to -0.462) (Okada, Huxel, & Nesser, 2011). Greater flexibility as measured by the hurdle step, in-line lunge, and the active straight leg raise, related to slower change-of-direction speed, and poorer unilateral jump performance in female team sports athletes (Lockie et al., 2015). Male youth soccer players showed the influence of FMS scores on the squat jump ($p< 0.001$; $r = 0.66$) and reactive agility ($p< 0.001$; $r = -0.54$) and significant correlations were found (Lloyd et. at., 2015). Finally, the squat jump and hurdle step showed a relationship ($p< 0.001$; $r = 0.369$) among youth elite soccer players (Silva, Clemente, Camões, & Bezerra, 2017). In contrast, FMS scores and sprinting tests at 5m, 10, and 20m were tested in nine female athletes, and sprinting tests had no significant correlations with the FMS tests (Lockie et al., 2015). Parchmann and McBride (2011) confirm these results where no relationship was found between speed tests and FMS scores.

A review of the existing evidence relationship between FMS and sports performance reveals inconsistent findings (Mills et al., 2005; Okada et al., 2011; Parchmann, & McBride 2011; Lockie et al., 2015; Lloyd et at., 2015; Silva et al., 2017). Specifically, some research has documented significant relationships between FMS and CoD tests and FMS and vertical jumps tests (Mills et al., 2005; Okada et al., 2011; Lloyd et. at., 2015; Silva et al., 2017). In contrast, studies have reported no significant relationships between FMS and sprint tests (Parchmann, & McBride 2011; Lockie et al., 2015). Although there are studies involving both female athletes (Mills et al., 2005) and male young soccer players (Lloyd et. at., 2015), there is a lack of data documenting how and whether there is a relationship between FMS and sports performance in elite women's soccer players. Due to the need for effective movement patterns during sports performance in soccer, it was hypothesized that higher scores on the FMS would relate to better performance on the sport-specific tests. The aim of this study was to analyze the relationship between functional movement screen individual scores and sports performance variables in elite women's soccer players. This study will provide a preliminary investigation of whether there is value for coaches to use the FMS to monitor functional deficiencies in women's soccer players with a view to enhancing sports performance.

METHODS

Participants

Twenty elite women's soccer players (age: 22.01 ± 3.64; height: 166.52±5.64 cm; body weight: 58.42±9.59 kg; body mass index: 21.02±2.89) took part in the cross sectional study. Procedure and testing were at the start of the preparatory phase. Players who were recruited had at least 3 years of experience in playing in the highest rank of the competition; had a general training history (more than four times per week) in the previous 12 months. Players who were in the recovery phase from some form of acute or chronic injuries and players in the process of rehabilitation were excluded.

All of the football players were first informed about the study. The purpose and aim of the study were explained to them, along with any possible consequences. In addition, the players were also informed about the procedure and course of the testing itself. All the players and their guardians gave written consent for voluntary participation in the testing.

Procedures

Before testing, all players were familiarized with the testing procedures. Familiarization involved a verbal explanation and demonstration of each test by the same member of the research team. Height was measured using an anthropometer (Seca 220; Seca Corporation, Hamburg, Germany) to the nearest 0.1 cm, while body composition was measured using a digital Inbody 770 (Brewer et al., 2021) scale to the nearest 0.1 kg (InBody 770; Biospace Co. Ltd, Seoul, Korea). Body composition, the functional movement screen, and vertical jump tests were estimated in the morning hours (8 a.m.-11 a.m.). One day prior to body composition testing, the players had to adhere to a protocol which included a minimum of eight hours of not consuming food, caffeine, or alcohol until testing the following morning (Brewer et al., 2021). After body composition testing, the players did a standardized 10-minute warm-up which consisted of jogging and multi-way dynamic stretching was used for all players before testing. The players completed 3 trials of each vertical jump test, each separated by 3 minutes of passive standing rest. The best performance was recorded as the outcome measure. Speed and change of direction tests were done on the club's courts in the afternoon. Also, the same warm-up was done as for the explosive power tests.

Measurement

Anthropometry

Height and body weight were measured to the nearest 0.1cm using a Martin anthropometer (GPM in Switzerland), and to the nearest 0.1kg using a calibrated balance beam (Avery Ltd, Model 3306 ABV).

Body composition

The evaluation of body composition was carried out in an indoor facility using multifrequency bioelectrical impedance (Inbody 770; Biospace Co. Ltd, Seoul, Korea) as per Brewer et al. (2021), at frequencies of 1, 5, 50, 250, 500 and 1000 kHz under controlled temperature conditions of 23-28°C. The measuring instrument used a tetrapolar system of tactile electrodes with eight points (four are attached to the palm and thumb, and the remaining four to the feet), which independently measure the impedance of the arms, torso, and legs. Body composition measures that were measured include: body weight and the body mass index.

Functional movement screen

Players were screened using the functional movement screen protocol that comprised the following seven movement patterns: the deep overhead squat (DS), hurdle step left (HS L) and right (HS R), in-line lunge left (ILL L) and right (ILL R), shoulder mobility left (SM L) and right (SM R), active straight leg raise left (ASLR L) and right (ASLR R), trunk stability push-up (TSPU), and rotary stability (RS). Players were given three trials of each movement pattern, with each trial being scored by an experienced rater in real time on a 4-point scale according to the functional movement screen rater manual and previous research (Cook, et al., 2006). The total FMS score was used for comparisons, and could range from 0 to 21.

Vertical jumps (SJ, CMJ, CMJA)

Vertical jumps were assessed by using the squat and countermovement jumps. The squat jump (SJ) consisted of a standing position with knees flexed at 90°, hands on the waist. With no help from the upper limbs, the player should jump and extend the legs, falling in the same place. The players waited 3s in the squat position before each jump. The countermovement jump (CMJ) started in a standing position with hands on the waist, was realized with flexion of the legs and simultaneously with the jump, the legs would be extended and fall in the same place. While the CMJA jump procedure was the same as for the previous jump, only the hands were free during all the phases of the maximum jump. For each movement, three trials were executed, with a rest period of 30s between them. The SJ, CMJ, and CMJA were tested with an optical measurement system consisting of a transmitting and receiving bar (Optojump, Microgate, Bolzano, Italy). The outcome extracted in each trial was jump height (cm). For each measure, the highest jump was taken into consideration for data analysis. The validity and reliability of these tests have been confirmed in previous studies (Glatthorn, et al., 2011).

Speed (running 0-20m)

The running speed of the players was determined based on time at 10m and 20m using infrared timing gates, the 20m sprint effort with photocell gates (Microgate, Polifemo Radio Light, Bolzano, Italy) placed 0.4m above the ground, with an accuracy of 0.001s. The timer was automatically activated as the participants crossed the first gate at the starting line with split times at 10m. The players were instructed to run the 20m distance as quickly as possible from a standing start (crouched start position 0.5m behind the timing lights). Acceleration was evaluated using the time to cover the first 5m of the 20m test. The participants performed two trials with at least 3 minutes of rest between them. The best performance of the two tests was used for further analysis. The 20m sprint was previously used to estimate linear speed in a study by Mirkov, Nedeljkovic, Kukolj, Ugarkovic, & Jaric (2008).

The slalom test

The participants all started with both feet behind the starting line. Six cones were set up 2 m apart, the first cone 1 m away from the starting line. Every player stood still facing the starting line, feet apart and the cone between his legs. He started after the signal and ran from the first to second cones. The player at the second cone had to be passed on his right-hand side. The player continued to run as fast as possible constantly changing direction from right to left, until he reached the player standing by the last cone. After the last cone, the player made a 180° turn and went on running the slalom to the starting line (Sporis, Jukic, Milanovic, & Vucetic, 2010).

The zig-zag test

The zig-zag test consisted of four 5-m sections set out at 100° angles. All players started with both feet behind the starting line. Every player stood still facing the starting line, feet apart and the cone between his legs. He started after the signal and ran from the first cone. The player continued to run as fast as possible constantly changing direction from right to left, until he reached the player standing by the last cone and finish line (Little, & Williams, 2005).

Statistical analysis

The data were processed by the Statistical Package for Social Sciences SPSS (v26.0, SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test confirmed normality in all the measures for use of parametric analyses ($p \geq 0.05$). Descriptive statistics (mean ± standard deviation; 95% confidence intervals) provided a profile for each parameter. Spearman's correlation analysis computed relationships between the FMS and performance tests ($p \leq 0.05$). The correlation coefficient strength was designated as per Hopkins (Hopkins, W. G. (2014). A rho (ρ) value between 0 to 0.3, or 0 to -0.3, was small; 0.31 to 0.49, or -0.31 to -0.49, moderate; 0.5 to 0.69, or -0.5 to -0.69, large; 0.7 to 0.89, or -0.7 to -0.89, very large; and 0.9 to 1, or -0.9 to -1, near perfect for predicting relationships. Stepwise multiple regression analyses ($p \leq 0.05$) were conducted to determine which could best predict performance in a particular test.

RESULTS

The performance test data is shown in Table 1. The Shapiro-Wilk test ($p = 0.077$ - 0.200) indicated that this data was normally distributed, even with the different athletic backgrounds of the participants.

Table 1 Descriptive data (mean ± standard deviation; 90% confidence intervals [CI]) for sports performance tests

Tests	Mean±SD	95% CI
SJ	22.65 ± 3.51	21.01 - 24.29
CMJ	23.34 ± 3.32	21.78 - 24.89
CMJA	27.31 ± 4.04	25.41 - 29.2
Sprint 10m	2.09 ± 0.9	2.05 - 2.13
Sprint 20m	3.59 ± 0.19	3.05 - 3.68
Slalom	6.30 ± 0.26	6.18 - 6.42
Zig-zag	5.85 ± 0.28	5.72 - 5.98

Note: SJ: squat jump; CMJ: countermovement jump; CMJA: countermovement jump with arm.

Figure 1 displays the mean individual FMS scores. There were no differences in the rotary stability for either side of the body, so one score is shown.

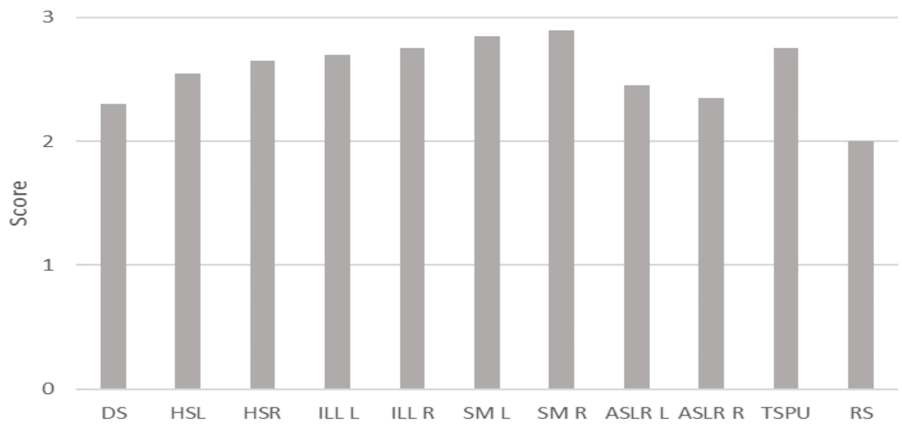

Fig. 1 Scores (mean ± standard deviation) for the Functional Movement Screen assessments (DS = deep squat, HS = hurdle step, ILL = in-line lung, SM = shoulder mobility, ASLR = active straight-leg rise, TSPU = trunk stability push-up, RS = rotary stability) for the left and right of the body in elite women's soccer players (n= 20).

Table 2 displays Spearman's correlations between the FMS and the sports performance tests. For the vertical jump test, the correlation is visible only on the CMJ test. The statistical correlation showed a positive value on the tests SM L ($p < 0.005$, $r = 0.535$) and TSPU ($p < 0.005$, $r = 0.491$). For the sprint tests, there were negative correlations between the 10m sprint and HSL L ($p < 0.001$, $r = 0.587$), HS R ($p < 0.001$, $r = 0.566$), and ASLR R ($p < 0.001$, $r = 0.667$). The Slalom test had a negative correlation with ILL R ($p < 0.005$, $r = 0.461$) and ASLR L ($p < 0.005$, $r = 0.454$).

Table 2 Spearman's correlations between Functional Movement Screen assessments for the left (L) and right (R) sides of the body, and sports performance tests in elite women's soccer players (n= 20).

	DS	HSL	HSR	ILL L	ILL R	SM L	SM R	ASLRL	ASLRR	TSPU	RS
SJ	0.350	0.209	0.164	-0.009	0.140	0.365	0.174	0.323	0.209	0.391	0.340
CMJ	0.303	0.105	0.036	-0.047	0.230	**0.535***	0.390	0.262	0.146	**0.491***	0.316
CMJA	0.294	0.288	0.327	-0.019	0.301	0.413	0.289	0.227	0.191	0.210	0.352
Sprint 10m	-0.342	**-0.587****	**-0.566****	-0.276	-0.050	0.098	0.073	-0.429	**-0.667****	-0.111	-0.024
Sprint 20m	-0.114	0.113	0.082	-0.114	-0.170	-0.061	-0.173	-0.375	-0.336	-0.250	-0.109
Slalom	-0.227	0.262	0.309	-0.341	**-0.461***	-0.316	-0.159	**-0.454***	0.009	-0.281	-0.243
Zig-zag	-0.312	0.270	0.155	-0.275	-0.090	-0.097	-0.159	-0.401	-0.036	0.090	-0.231

Note: SJ = squat jump; CMJ: countermovement jump; CMJA: countermovement jump with arm; DS = deep squat; HS = hurdle step; ILL = in-line lunge; SM = shoulder mobility; ASLR = active straight-leg raise; TSPU = trunk stability push-up; RS = rotary stability.

Only the TSPU, ASLL L and R, DS, and SM R produced significant predictive relationships on the performance tests (Table 3).

Table 3 Stepwise linear regression between Functional Movement Screen assessments for the left (L) and right (R) sides of the body, and sports performance tests

Best Predictors of the Tests	r	r^2	p
CMJ			
TSPU	0.499	0.249	0.025
Sprint 10m			
ASLR R	0.637	0.406	0.003
ASLR R - DS	0.786	0.618	0.000
Slalom			
ASLR L	0.457	0.208	0.043
Zig-zag			
SM R	0.467	0.218	0.038

Note: CMJ = countermovement jump; DS = deep squat; SM = shoulder mobility; ASLR = active straight-leg raise; TSPU = trunk stability push-up

DISCUSSION

The aim of this study was to analyze the relationship between functional movement screen individual scores and sports performance variables in elite women's soccer players. The present results revealed that there is an association between individual parameters of the FMS test and sports performance assessment tests. For the sports performance evaluation tests, it was shown that the muscular stability as well as the mobility of certain joints is very significant and related to the achieved results on the tests. Specifically, the trunk stability push-up is the strongest predictor of performance for the vertical jump tests, while the active straight-leg raise test was the strongest predictor for the 10m sprint test and the slalom test. The performance of vertical jumps, CoD, and sprints can be influenced by factors such as strength and technique and thus may not easily predict deficiencies. Nevertheless, the range of motion required within the FMS actions does bear resemblance to those required in team sports movements (Minick, et al., 2010) and this study provides a preliminary analysis of whether FMS could identify deficiencies that may affect sports performance in elite women's soccer players.

The results showed the existence of a relationship between trunk stability push-up and CMJ ($p < 0.005$; $r = 0.491$). Lockie et al. (2015) obtained similar results for the vertical jump and trunk stability push-up in female athletes where the relationship was ($p < 0.005$ $r = 0.846$), while no relationship with the standing broad long jump was determined. In contrast, Parchmann and McBride (2011) indicated that no relationship was determined between the FMS score and vertical jump in golfer players. The trunk stability push-up involves the maintenance of a stable trunk, which should allow for force transition through the body into the upper extremities (Cook et al., 2006). A vertical jump requires a strong core, to allow the force generated by the legs to travel into the upper body (Butcher, et al., 2007), which is important for team sport athletes who need to use their arms when airborne (Walsh, Boehm, Butterfield, & Santhosam, 2007). The trunk stability push-up may provide an indication of core stability that could assist with between-leg balance in vertical jumping for females. The strongest predictor of vertical jump height in the CMJ test was the trunk stability push-up ($p < 0.025$; $r = 0.499$; $r^2 = 0.249$).

The 10m sprint showed a relationship between the hurdle step left ($p < 0.001$, $r = -0.587$) and right ($p < 0.001$, $r = -0.566$) and active straight-leg raise ($p < 0.001$, $r = -0.667$), while the strongest predictors of the 10m sprint were the deep squat ($p < 0.000$; $r = 0.786$; $r^2 = 0.618$) active straight-leg raise ($p < 0.003$; $r = 0.637$; $r^2 = 0.406$). Lockie et al. (2015) determined no relationship between FMS tests and the 5m, 10m and 20m sprint. Parchmann and McBride (2011) also determined that there was no relationship between the FMS score and the 10m sprint. The hurdle step is a movement that requires proper coordination and stability between the hips and torso during the stepping motion as well as single leg stance stability (Cook et al., 2006). A good score on the hurdle step test requires stance-leg stability of the ankle, knee, and hip as well as maximal closed-kinetic chain extension of the hip (Cook et al., 2006). The active straight leg raise test assesses active hamstring and gastroc-soleus flexibility while maintaining a stable pelvis and active extension of the opposite leg (Cook et al., 2006). The active straight leg raise test requires functional hamstring flexibility. However, each of these screens is performed slowly, from positions atypical to team sports (Lockie et al., 2015). In contrast Lockie et al. (2015) determined that greater flexibility, and by extension greater musculotendinous compliance, may compromise power-based activities such as sprinting. As an example, greater musculotendinous compliance has been linked to increased 20-m sprint time in track sprinters (Nelson, Driscoll, Landin, Young, & Schexnayder, 2005).

In the CoD tests, in addition to the importance of the active straight leg raise test results ($p < 0.005$, $r = -0.454$), a relationship with the results of the in-line lunge test ($p < 0.005$, $r = -0.461$) was also determined. Also, Lloyd et al. (2015) determined that there was a relationship between active straight leg raise test and in-line lunge gain statistical significance. In contrast to these results, Parchmann and McBride (2011) showed that there was no association between FMS scores and t-test agility. Our results are in contrast with the results of Lockie et al. (2015) who showed a positive a relationship between the in-line lunge and the active straight-leg raise test. For both the 505 and modified T-test, higher scores on the hurdle step, in-line lunge, active straight-leg raise, and rotary stability were related to slower change-of-direction speed test times (Lockie et al., 2015).

CONCLUSION

The results of the study found little evidence of a relationship between FMS results and sports performance in elite women's soccer players. However, certain significant relationships and predictors were found. The results are partially in line with previous research that determined a small relationships between FMS results and sports performance. A characteristic of the FMS is that it is performed slowly, from positions atypical to soccer, and may lead us to believe that the movement patterns evaluated by the FMS are not important in sports performance. Although functional movement and functional performance are related, the FMS should not be considered as a test of performance or to predict sports performance. Strength and conditioning coaches may use these indicators as an assessment of the weakness of certain movements or muscle imbalance as one of the methods for correcting certain segments of sports performance which can later help them achieve better results on the field. Future studies should use the FMS score as an additional indicator of the athlete's condition. Existing studies look at young athletes and injury prediction using the FMS test, while more studies are needed that deal with professional athletes and their abilities.

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ODNOS IZMEĐU REZULTATA TESTA FUNKCIONALNOG KRETANJA I SPORTSKIH PERFORMANSI ELITNIH FUDBALERKI

Cilj ove studije je bio da se analizira odnos između individualnih rezultata funkcionalne pokretljivosti (FMS) i varijabli sportskih performansi kod elitnih fudbalerki. U istraživanju je učestvovalo dvadeset elitnih fudbalerki (starost: 22.01 ± 3.64). Sportistkinje su ispitivane FMS protokolom sa sedam obrazaca pokreta: duboki čučanj sa potiskom (DS), skip preko prepone levom (HS L) i desnom nogom (HS R), iskorak u liniji desnom (ILL L) i levom nogom (ILL R), pokretljivost ramenog zgloba leve (SM L) i desne ruke (SM R), aktivno podizanje opružene level noge (ASLR L) i desne (ASLR R), sklek - stabilnost trupa (TSPU) i rotirajuća stabilnost (RS) i tri testa vertikalnih skokova: skok iz čučnja (SJ), skok u kontra pokretu (CMJ) i skok u kontra pokretu sa rukama (CMJa), sprint na 20m, brzina na slalom i cik-cak testu. Rezultati su pokazali negativne korelacije između sprinta na 10 m i HSL L ($p \leq 0,001$, $r = 0,587$), HS R ($p \leq 0,001$, $r = 0,566$) i ASLR R ($p \leq 0,001$, $r = 0,667$) i između slalom testa i ILL R ($p \leq 0,005$, $r = 0,461$) i ASLR L ($p \leq 0,005$, $r = 0,454$). Ova studija je pokazala malu povezanost između rezultata FMS-a i prediktora sportskih performansi kod elitnih fudbalerki. Treneri snage i kondicije mogu koristiti ove indikatore kao procenu slabosti određenih pokreta ili mišićne neravnoteže kao jednu od metoda za korigovanje pojedinih segmenata sportskog učinka koji im kasnije mogu pomoći da ostvare bolje rezultate na terenu.

Ključne reči: *fudbal, žene, vertikalni skok, promena pravca*