Submitted: 10 August, 2024 Accepted: 19 November, 2024 Published: 30 December, 2024 DOI:10.22514/jomh.2024.208

JOMH Journal of Men's Health

ORIGINAL RESEARCH

Relationship between functional movement screening (FMS) scores and balance and strength performance in young male athletes

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Abstract

Functional movement screening (FMS) is a test developed to evaluate the fundamental movement patterns underlying both sports performance and injury risk. This study aims at evaluating the relationships between FMS test scores and strength and balance performance in young male athletes. Male athletes (n = 41, mean age 13.5 $\pm$ 1.7 years) interested in team sports participated in the study voluntarily. FMS scores, dynamic balance, static balance and strength values of the participants were determined. Shapiro-Wilk test was applied to determine if the data were normally distributed, Pearson's correlation coefficient analysis was used measure linear correlation, and Spearman's rank correlation coefficient (ρ) was determined to measure the strength and direction of correlation between variables. Significant differences ranged between p = 0.01 and p = 0.05. As a result of the analyses, a positive low-level relationship for the balance measures was found between the total. FMS score and the right postero-medial (p = 0.042), and right leg composite (p = 0.30), left leg composite (p = 0.026) of the Y balance subtests while no relationships were identified in other parameters ($p > 0.05$). For the strength masures, a positive low-level relationship was detected between the FMS score and back strength (p = 0.016), while no relationship was found between the other strength parameters ($p > 0.05$). For balance and strength parameters, a moderate negative relationship was found between the FMS score and the left leg flamingo test (p = 0.009). Also according to regression analysis that the predictive power of independent variables on FMS scores is quite low. In general, it is seen that the autocorrelation between the dependent variable and predictor variables is at an acceptable level (1.768 < Durbin-Watson < 2.196). As a result, FMS scores in this athlete sample were associated with dynamic balance, static balance and strength performance.

Keywords

Functional movement screening; Strength; Balance; Young male athletes

1. Introduction

Improving the basic movement patterns of athletes determined by strength, power, balance, speed and agility specific to their sports disciplines is key to athletic performance and injury prevention [1]. There is no single gold standard test for evaluating the ability of athletes to perform a range of movements to their full capacity [2]. Functional movement screening (FMS) is designed to evaluate seven fundamental movement patterns that require the interaction of cognitive, perceptual, proprioceptive and motor functions, including muscle strength/endurance, flexibility, mobility, coordination and balance [3].

Understanding the movement competency of athletes and the dynamic stability components associated with their sports discipline-specific performance through periodic functional movement screening can improve sport-specific performance, help prevent injuries and, if necessary, assist in rehabilitation [4, 5]. Muscular strength is strongly associated with the force-time characteristics that determine an athlete's overall performance. An array of investigations support the concept that greater muscular strength increases general performance and athletic skills such as jumping, sprinting, and change of direction movements [6]. Balance is the ability to respond to changes in body position while maintaining overall stability and controlled equilibrium. Proper balance allows a person to perform activities and movements effectively and efficiently with minimal risk of losing control and falling [7]. Plenty of studies have reported on the relationship between FMS scores and athletic performance in athletes of different age groups and disciplines [8–10].

The results indicate that FMS-based training programs can reduce functional imbalances and improve general motor control skills not only in professional and recreational sports, but also in other occupations that rely on peak physical performance including firefighters and the military [11]. Similarly, it has been documented that functional movement training programs strengthen the athlete's core stability and enhance overall power management and transmission efficiency [12]. Notably, it has been reported that children and adolescents with high FMS scores show superior performance in measures of agility, running speed, power and cardiovascular endurance compared to individuals with lower FMS scores [9]. An independent study found that FMS scores in young male football players moderately correlated with their athletic performance test results [13]. In contrast, other reports indicate that FMS lacks validation as a composite score of multiple subtests to accurately and precisely measure posture and balance deficits [14] and serve as an injury prediction tool [15, 16].

To address these inconsistencies, this study aimed at evaluating relationships between FMS test scores and strength and balance performance in young male athletes who regularly participate in training programs of their specific sports disciplines and have at least two years of sports experience.

2. Materials and methods

2.1 Participants

The study included male athletes between the ages of 13–17 who play football (n = 18), basketball (n = 11) and volleyball (n = 12) in clubs affiliated with the Zonguldak Youth and Sports Provincial Directorate.

2.2 Study design

Athletes who had not had any injuries in the last 6 months and had participated in regular training for at least two years were included in the study. The tests were conducted on the same day that the athletes did not have training during the preparation period (December 2024). Athletes were warned not to do any exercise for 24 hours before the measurements were taken.

2.3 Height and body weight measurement

The athletes' heights were measured using a height scale with a sensitivity of 0.01 cm, and their body weights were registered with bare feet and with light clothing, using an electronic scale with a sensitivity of 0.1 kg.

2.4 Functional movement screening (FMS) measurement

Before the screening began, all athletes participating in the study were given clear information by the expert who applied the test of the FMS, explaining the components that included deep squat, hurdle step, in-line lunge, shoulder mobility, active straight-leg raise, trunk stability push-ups and rotary stability movements that were performed without any warm-up. At the test, participants began the movements with their right limbs. Each movement was repeated three times, and the best value was recorded. The athletes were asked to show maximum performance in each movement section, and to inform the expert if there was anything that caused them pain or discomfort while executing the movements. According to the FMS scoring principles, each of the seven movement patterns were scored from 0–3 points, and the sum created an FMS score ranging from 0–21 points for each participant [17].

2.5 Hand grip-back-leg strength measurement

A Takei brand hand grip-leg-back dynamometer was used to determine the strength parameters of the athletes. Each participant performed this test twice with a 2-minute rest interval between measurements, and the highest value was recorded.

2.6 Flamingo balance test measurement

The flamingo balance test is a singled-leg balance test used to evaluate the static and overall body balance. While being supported by the instructor by holding the test candidate's right hand and standing on a balance board, the candidate was asked to lift his left leg off the ground, hold his left knee with his left hand to maximum flexion, and then let go of the instructor's support. When the subject released the supporting hand of the instructor, the stopwatch was started and it was stopped when the subject released his flexed left leg or when any point of his body touched the ground. Following each balance disturbance, the instructor helped the subject to bring himself to the correct position. The number of errors made during a 1 minute test period was recorded as a score. The same test was applied for the right foot lifted off the ground [18]. This test assesses the strength of the standing leg, pelvic, and trunc muscles and the dynamic balance.

2.7 Y balance test measurement

Y dynamic balance test was used to determine the dynamic balance of the lower extremities of the athletes. During this test, bear-footed athletes with their hands held steady on their waist are standing on one foot rested on the center pad of a Y-shaped dynamic balance test platform. From that position, the test candidates aim to reach as far forward as possible with the non-weight bearing leg and push blocks with the toes in the anterior (0°), posteromedial (45°) and posterolateral (45°) directions of the Y-shaped test area. If a participant loses balance and cannot return to the starting position in a balanced manner, or if the weight bearing leg comes off the center platform during the test, the trial is considered invalid and the test is being repeated. After the test was successfully repeated 3 times in each of the three directions (anterior, posteromedial, posterolateral), the composite reach distance was calculated by summing the maximum reach distances of the non-weight bearing extremity in three directions. To account for differences in leg lengths between candidates, the maximum reach distances are divided by three times the extremity length [19].

2.8 Data analysis

A correlation test was used to determine the direction and magnitude of the linear relationship between each participant's FMS total score and variable pairs of strength and balance performances Linear regression analysis was used to determine the relationship between a dependent variable and one or more independent variables. In order to examine whether the data were suitable for normal distribution, the Shapiro-Wilk test was used since the number of measurements was less than 50 (n = 41) [20]. Pearson's R was used for correlation analysis of data with normal distribution ($p > 0.05$), and Spearman's rank (ρ) correlation coefficient was used for data that did not meet the normal distribution assumption ($p < 0.05$). In addition, the mean, standard deviation, quartiles, minimum and maximum values of the variables were calculated. The significance level in the study was accepted in the range of $p = 0.01$ and $p = 0.05$.

3. Results

Descriptive statistics of the participants in the study are given in Tables 1 and 2. The average age of the participants was 13.51 ± 1.73 years old, and their average body weight was 50.82 ± 14.27 kg. Their average height was 157.32 ± 15.23 cm and their average total FMS score is 13.93 ± 2.70 points. The average, standard deviation, minimum and maximum values of the Y balance test and flamingo balance test components recorded for each of the athletes are given in Table 2.

According to the normality test results given in Table 3, it is understood that the variables right hand grip strength (W = 0.872; $p < 0.01$), left hand grip strength (W = 0.845; $p < 0.01$), leg strength (W = 0.888; $p = 0.001$), back strength (W = 0.902; $p = 0.002$), right leg flamingo test (W = 0.869; $p < 0.01$) and left leg flamingo test (W = 0.856; $p < 0.01$) did not meet the normal distribution assumption.

The FMS test scores had a positive but low level correlation with right leg postero-medial (RLP-M) ($r = 0.318$; $p = 0.042$), right leg composite (RLC) ($r = 0.340$; $p = 0.030$) and left leg composite (LLC) ($r = 0.348$; $p = 0.026$). Furthermore, there was no statistically significant correlation between right leg anterior (RLA), left leg anterior (LLA), left leg postero-medial (LLP-M), right leg postero-lateral (RLP-L) and left leg postero-lateral (LLP-L) variables and FMS ($p > 0.05$), (Table 4).

According to the results of the Spearman Correlation Coefficient analysis given in Table 5, there is a positive and low-level correlation between the FMS total score and back strength ($\rho = 0.375$; $p = 0.016$), and a moderate negative correlation ($\rho = -0.403$; $p = 0.009$) between the left leg flamingo test and FMS scores. No statistically significant correlation was found between the FMS scores and right hand grip, left hand grip, leg strength and right leg flamingo test ($p > 0.05$), (Table 5).

Since the variables must be normally distributed in order to perform simple regression analysis [21], the analyses were performed using RLA, LLA, RLP-M, LLP-M, RLP-L, LLP-L, RLC and LLC variables to predict FMS scores. Table 6 summarizes the statistical findings regarding the predictive power of these independent variables on FMS scores. Accordingly, the results revealed that the predictive power of the independent variables on FMS scores is low. In general, the auto-correlation between the dependent variable and the predictor variables was found to be at an acceptable level (1.768 < Durbin-Watson < 2.196). The independent variable with the highest predictive power is the LLC variable with 12.1%. This variable is followed by the RLC variable (11.5%). The variable with the lowest predictive power is the RLA variable (3.9%) as summarized in Table 6.

TABLE 1. Descriptive statistics of participants and their performances (n = 41).

Variables	Mean	SD	Quartiles			Minimum	Maximum
			25%	50%	75%		
Age (yr)	13.51	1.73				13	17
Body weight (kg)	50.82	14.27				31.0	83.0
Height (cm)	157.32	15.23				134.0	190.0
FMS (score)							
Deep squat	1.85	0.73	1.00	2.00	2.00	1	3
Hurdle step	1.95	0.50	2.00	2.00	2.00	1	3
In-line lunge	1.95	0.59	2.00	2.00	2.00	1	3
Shoulder mobility	2.05	0.89	1.00	2.00	3.00	1	3
Active straight-leg raise	2.20	0.56	2.00	2.00	2.50	0	3
Trunk stability push-up	2.27	0.59	2.00	2.00	3.00	1	3
Rotary stability	1.66	0.69	1.00	2.00	2.00	1	3
FMS total score	13.93	2.70	12.00	14.00	16.00	9	20
Strength (kg)							
Hand grip (right)	26.66	11.86	18.50	24.00	29.30	10.7	57.7
Hand grip (left)	25.23	11.24	17.95	22.40	26.65	12.0	56.2
Leg	71.25	33.09	48.75	64.00	79.50	25.0	170.5
Back	85.89	37.12	57.25	76.50	94.75	27.0	181.1

SD: Standard deviation; FMS: functional movement screening.

TABLE 2. Mean, standard deviation, minimum and maximum values of the Y balance and flamingo balance test components of the participants (n = 41).

Variables	Mean	SD	Quartiles			Minimum	Maximum
			25%	50%	75%		
Y balance test (cm)							
Right Leg							
Anterior	80.51	7.57	74.26	80.00	86.28	62.89	98.68
Postero-Medial	85.89	9.33	79.74	84.71	93.23	66.67	101.08
Postero-Lateral	77.41	9.85	71.08	77.11	85.29	56.52	97.83
Composite	86.98	8.87	79.00	87.00	94.00	73.00	109.00
Left Leg							
Anterior	78.93	7.34	72.93	79.31	84.08	64.58	94.05
Postero-Medial	81.06	9.05	74.67	81.58	86.63	58.89	103.06
Postero-Lateral	80.02	9.74	72.69	80.49	88.54	59.78	97.94
Composite	87.02	8.98	78.50	87.00	94.50	72.00	109.00
Flamingo balance test score							
Right Leg	6.71	4.52	4.00	6.00	8.00	0.00	22.00
Left Leg	7.66	4.61	5.50	7.00	9.00	0.00	24.00

SD: Standard deviation.

TABLE 3. Normality test results (Shapiro-Wilk).

Variables	Shapiro-Wilk Test Statistics		
	Statistics	*df*	*p*
FMS total score	0.961	41	0.165
Hand grip (right)	0.872	41	<0.001*
Hand grip (left)	0.845	41	<0.001*
Leg strength	0.888	41	0.001*
Back strength	0.902	41	0.002*
Anterior (right)	0.978	41	0.609
Anterior (left)	0.980	41	0.664
Postero-Medial (right)	0.966	41	0.261
Postero-Medial (left)	0.994	41	0.998
Postero-Lateral (right)	0.989	41	0.958
Postero-Lateral (left)	0.980	41	0.673
Composite (right)	0.959	41	0.144
Composite (left)	0.964	41	0.212
Flamingo (right)	0.869	41	<0.001*
Flamingo (left)	0.856	41	<0.001*

**p < 0.01; df: Degree of freedom; FMS: functional movement screening.*

TABLE 4. Relationship between participants' FMS scores and Y balance test components (Pearson correlation test).

	RLA	LLA	RLP-M	LLP-M	RLP-L	LLP-L	RLC	LLC
FMS								
r	0.198	0.107	0.318*	0.230	0.216	0.204	0.340*	0.348*
p	0.216	0.504	0.042	0.148	0.175	0.200	0.030	0.026

**p < 0.05; RLA: right leg anterior; LLA: left leg anterior; RLP-M: right leg postero-medial; LLP-M: left leg postero-medial; RLP-L: right leg postero-lateral; LLP-L: left leg postero-lateral; RLC: right leg composite; LLC: left leg composite.*

TABLE 5. Relationship between participants' FMS scores and strength and flamingo balance tests (Spearman correlation test).

	Hand grip (right)	Hand grip (left)	Leg strength	Back strength	Flamingo (right)	Flamingo (left)
FMS						
ρ	0.214	0.242	0.167	0.375*	−0.282	−0.403**
p	0.178	0.127	0.297	0.016	0.074	0.009

*$p < 0.05$, **$p < 0.01$.*

TABLE 6. Regression analysis of independent variables' predictive power on FMS scores.

Independent variables	R	R^2	Adjusted R^2	Standard error of estimate	Durbin-Watson
RLA	0.198	0.039	0.014	2.677	1.768
LLA	0.107	0.012	−0.014	2.715	1.794
RLP-M	0.318	0.101	0.078	2.588	2.117
LLP-M	0.230	0.053	0.029	2.657	2.062
RLP-L	0.216	0.047	0.022	2.666	2.057
LLP-L	0.204	0.042	0.017	2.673	2.103
RLC	0.340	0.115	0.093	2.568	2.196
LLC	0.348	0.121	0.099	2.560	2.185

RLA: Right leg Anterior; LLA: Left leg Anterior; RLP-M: Right leg Postero-Medial; LLP-M: Left leg Postero-Medial; RLP-L: Right leg Postero-Lateral; LLP-L: Left leg Postero-Lateral; RLC: Right leg Composite; LLC: Left leg Composite.

4. Discussion

This study examined the relationships between FMS total scores and balance and strength performances of young male athletes interested in team sports. One of the most important results from this study was the recognition of a positive correlation between FMS total score and Y balance test components postero-medial (right), composite (right and left) and back strength, albeit at a low level. Another important result was a negative correlation between FMS total score and left leg flamingo test, seen at a medium level. It was also observed that the predictive power of independent variables on FMS scores was quite low.

According to the data obtained from the current study, the average FMS total score of young male athletes participating in the study was determined as 13.9 ± 2.7. In the literature, many studies report on FMS test scores of male athletes in in different sports disciplines and age groups [22–27]. Anderson *et al.* [22] determined the total FMS average score as 15.3 for male athletes with an average age of 16 years old, who were members of school teamsin different types of team sports. In other studies, the FMS scores of young male athletes interested in various sports such as cross country, football, soccer, swimming, tennis, volleyball were determined as 13.0 points [23]. For young male hockey players FMS scores of 12.6 points were reported [24]. Başar *et al.* [25] determined that the average FMS total score of swimmers in the 11–12 year old age group was below 14 points. It has been emphasized that low FMS scores indicate a risk of injury for many athletes. In addition, low FMS scores are a signal of decreased joint mobility, motor control, core strength, muscle balance and kinetic chain efficiency required for athletic physical activity. According to Lee *et al.* [26], high FMS total scores in athletes can have a positive effect on physical performance. Notably, training programs that correct functional disabilities or asymmetric movement patterns can be organized to help increase physical performance for players with low FMS total scores. FMS research results indicate that total FMS scores of athletes within similar age groups can be different. It has been speculated that such differences may be due to the distinct functional movement patterns that predominate in each sports discipline. Furthermore, the body composition in athletes differ according to the sport performed, and this parameter can play an important role in FMS results [27].

It is known that static and/or dynamic balance are performance-determining factors for many sports types [28]. Studies examining the relationship between FMS test scores and balance performance have indicated a correlation between these two parameters [29–36], while there are also studies indicating no correlation [37, 38]. In an analysis of female university dancers (age = 20 years old), active straight leg raise and shoulder mobility were found to be related to dynamic balance. In addition, the researchers stated that active straight leg raise and shoulder mobility measurements should be considered as the basic elements to be measured during screening [29]. Kramer *et al.* [32] found significant positive correlations between the composite FMS score and left Y balance test (YBT) scores and composite YBT scores in male high school athletes (mean FMS total score: 12.7 points, mean age: 16.8 ± 0.9 years old). In a different study, Scudamore *et al.* [34] reported that the FMS composite score positively correlated with dynamic balance measurements in healthy, active adults (18–30 years old). Also importantly, physically active male and female adults who obtained lower scores in the deep squat, trunk stability push-up, shoulder mobility, and rotational stability components of the FMS were reported to have poor dynamic balance and likely a higher risk of musculoskeletal injuries. Sikora and Linek [33] found a moderately significant positive correlation between the composite FMS score and the composite Y Balance Test score in youth football players (mean age: 14 ± 2.3 years old). In addition, significant positive correlations were observed between FMS subtests and most of the YBT results for each direction, ranging from weak to moderate strength. Similarly, Chang *et al*. [30] reported that deep squat, hurdle step, sequential lunge and rotary balance exercises in FMS had moderate to good correlations with balance test components in young athletes. Unlike the above research results, Smith *et al*. [38] stated that there was no relationship between FMS total score and static and dynamic balance tests in male high school athletes interested in different sports disciplines (total FMS mean score = 16, mean age 13–18 years old). The researchers reported that the lack of relationship between FMS and other balance measurements required more than one screening test to provide a comprehensive evaluation of adolescent athletes. Similarly, in different study reported that there was no relationship between composite FMS and composite Y balance test scores in female university student dancers [37]. In the current study, a low level positive correlation between FMS total score and the postero-medial (right) and composite (right and left) values of the Y balance test components was seen and a moderate level of negative correlation was found with the left leg flamingo test. It is possible that the discrepancies between results from this study and other reports are due to the age, gender, sports discipline and training protocols differences of the participants.

In studies investigating strength performance with FMS test scores, Silva *et al*. [39] stated that FMS individual scores were better than total FMS scores in surfing athletes (n = 18, age = 18 years old) to explain physical variables, and that only the trunk stability push-up test was a reliable indicator that predicts physical performance of surfing athletes. Okada *et al*. [40] found a negative relationship between total body strength and right shoulder mobility and a positive relationship with correct rotational stability in adult recreational athletes. In addition, a negative relationship was observed between lower body muscle endurance and right shoulder mobility. In a different investigation conducted on healthy women studying at the faculty of physical education and sports, it was stated that the flexibility and strength of the abdominal muscles were significantly related to the FMS general score and the quality of the FMS movement patterns. The researchers found that flexibility and abdominal muscle strength are very important in properties that determine the quality of movement pattern in young women [41]. In children aged 8–11 years old, a statistically significant but low-level positive correlation was found between total FMS score and core strength [42]. Similarly, Rowan *et al*. [43] reported that the FMS values (total score and the number of asymmetries determined) of elite young (17–19 years old) hockey players were significantly correlated with leg strength. In another study involving young amateur football players, a negative moderate correlation was observed between the athletes' FMS total scores and leg strength. The researchers stated that since the dominant leg is stronger in football, even if the dominant and recessive foot work is at the same level as in the applied training programs, the player's movement habits may affect the results in the FMS total score asymmetrically [44]. Contrary to these research findings, Kara and Kaplan [45] observed that there was no significant relationship between FMS total scores and handgrip strength (right and left), push-up (30 s and 60 s) and sit-up (30 s and 60 s) tests of professional football players (average age 22.4 years old). Similarly, according to Hernandez *et al*. [46], no relationship was found between FMS or Y balance test performance and strength/weight ratio for 1 repetition maximum tests in adult individuals. In the current study, a low-level positive correlation was determined between FMS total score and back strength, while no statistically significant relationship was found between handgrip (right/left) and leg strength. The differences between the research results can be explained by the strength measurement methods used and the training levels of the participants.

The current study had some limitations. First, we exclusively included young male athletes from a specific region and different sports disciplines. Since the sample size of athletes from different branches constituting our study was insufficient, the difference between branches could not be examined since they would not represent that branch. In future studies on this subject, studies can be conducted with larger sample groups in different branches. Second, the measurement and evaluation of physical performance in the current study was carried out in field tests only. Using different measurement methods in a laboratory setting may alter the research results. Finally, parameters that may have affected the functional movement, strength, and balance results for each participant in our study, including previous injuries, balance-strength training, and current training history in our study cohort, were not documented and included for consideration. and included for consideration.

5. Conclusions

As a result, FMS scores in this athlete sample were associated with dynamic balance, static balance and strength performance. It was also observed that the predictive power of independent variables on FMS scores was quite low. In addition, FMS, a low-cost and time-efficient screening tool, provided useful information for coaches to assess musculoskeletal coordination, and analyze movement, balance and strength towards athletic performance evaluation of young male athletes in training.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

Şİ, MA, HG and SR—designed the research study. MA and SR—performed the research. MA and HG—analyzed the data. Şİ and SR—wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethics committee approval was obtained from the Selçuk University, Faculty of Sports Sciences, Non-Interventional Clinical Research Ethics Committee's letter dated 05 March 2024 and numbered E-40990478-050.99-716420. Participants participated in this study voluntarily. In addition, all athletes were asked to sign a voluntary consent form stating that they would participate in the study after obtaining the necessary permissions from their clubs and families.

ACKNOWLEDGMENT

The authors would like to express their gratitude to all athletes and their coaches who participated in this research.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Şükran İribalcı, Mert Aydoğmuş, Serkan Revan, Harun Genç. Relationship between functional movement screening (FMS) scores and balance and strength performance in young male athletes. Journal of Men’s Health. 2024; 20(12): 130-137. doi: 10.22514/jomh.2024.208.