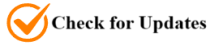


Exploring Functional Movement and Balance in Young Female Athletes

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Abstract: This study investigated the relationship between functional movement screening (FMS) scores and balance performance in young female athletes across various sports disciplines. The sample comprised 27 girls aged 9 to 11 years with at least two years of consistent training in swimming, taekwondo, or volleyball. FMS scores were assessed alongside dynamic balance, measured using the Y-balance test, and static balance, measured using the Flamingo balance test. Given the non-normal distribution of the data, Spearman's rho was employed to examine correlations. Statistical significance was set at $p < .05$. Revealed no statistically significant correlation between total FMS scores and performance on either the Y-balance test or the Flamingo balance test ($p > .05$). While a moderate negative correlation was observed between body mass index (BMI) and both in-line lunge performance and total FMS scores ($p < .05$), BMI did not correlate significantly with dynamic or static balance performance ($p > .05$). In conclusion, these findings suggest that functional movement screening scores are not significantly associated with static or dynamic balance in this cohort of young female athletes.

Keywords: Functional movement screen, y-balance test, flamingo balance test, female athletes.

1. Introduction

In order to optimize athletic performance and ensure successful execution of sport-specific technical skills, precise and detailed evaluation of athletes' motor abilities is essential, followed by the implementation of appropriate training programs (Pamuk et al., 2023). Throughout a season, athletes engage in intensive training and numerous competitions, exposing them to various injury risks due to the frequency and intensity of physical exertion. Contributing factors include training duration and intensity, athletes' anthropometric characteristics, playing position, sport-specific skill level, flexibility, asymmetries, previous injuries, and playing surfaces (Dick et al., 2007). Identifying and assessing these risk factors is crucial for injury prevention and enhancing athletic performance. These challenges are particularly prevalent among young athletes, who are often subject to muscular imbalances resulting from unilateral loads, single-axis exercises, and training that focuses on only certain body regions (e.g., upper extremity, lower extremity, or one side of the body). Such imbalances can negatively impact both the quality of daily life and athletic performance, with the potential for serious injuries or even the premature termination of sports participation. Therefore, it is necessary to evaluate physical fitness and performance parameters to assess the athlete's readiness, suitability, and skill level for sports participation (Arslan et al., 2024).

In this context, the Functional Movement Screen (FMS) provides an effective and reliable test battery. It is designed to assess joint range of motion, trunk strength and stability, asymmetries in functional movement patterns, and weaknesses in motor function through observation (Cook, 2003; Perry & Koehle, 2013). Compared to other test batteries, the FMS is relatively low-cost and easily administered, allowing for simultaneous evaluation of both sides of the body

(Cowen, 2010). The test comprises seven fundamental movement patterns (deep squat, obstacle crossing, single-line lunge, shoulder mobility, active straight leg lift, trunk stability push-ups and rotation stability), which are suitable for individuals from all age groups. As these movements are closely associated with normal growth and development, the FMS is particularly applicable to young athletes who are still growing (Cook et al., 2006). Balance, a fundamental motor skill, significantly influences the development of other motor abilities essential for athletic performance, ranging from postural maintenance to the execution of complex sports skills (Butler et al., 2013). It underscores the importance of trunk stability in generating, transferring, and controlling force or energy during integrated kinetic chain activities, thereby facilitating effective trunk and limb movements in human locomotion (Okada et al., 2011). Balance skills are crucial in various sports disciplines, enabling athletes to perform sport-specific movements such as changing direction, manipulating objects, stopping, and maintaining specific body positions (Şahin et al., 2022). This skill is particularly vital in combat sports where maintaining balance while engaging an opponent is paramount, necessitating robust postural stability. Furthermore, postural stability is essential not only for athletes but also for individuals in everyday life (Moran Navarro et al., 2015). Athletes with superior balance are more likely to effectively execute the technical skills required in their respective sports during competitions or training sessions (Gribble et al., 2012). The Y-balance test, which assesses dynamic balance through various lower and upper extremity movements, provides a comprehensive evaluation incorporating strength, flexibility, joint positioning, and movement perception. This test is used to measure athletes' physical performance across different sports, compare balance capabilities, and provide insights into injury susceptibility by assessing trunk rotation, limb mobility, and chronic ankle instability (Olmsted et al., 2002). Numerous studies have explored the relationship between functional movement screening and balance in athletes across various sports and age groups (Kozlenia & Domaradzki, 2021; Misegades et al., 2020; Sikora & Linek, 2022). Therefore, this study investigated the correlation between functional movement screening scores and balance performance in 9- to 11-year-old girls participating in various sports.

2. Materials and Methods

2.1. Research Group and Design

Twenty-seven girls aged 9 to 11 years, who had trained regularly for at least two years in swimming, taekwondo, or volleyball at clubs affiliated with the Zonguldak Youth and Sports Provincial Directorate, voluntarily participated in this study. Prior to participation, legal guardians of all participants provided written informed consent. Participants and their guardians received comprehensive information about the study.

2.2. Data Collection Tools

2.2.1. Anthropometric measurements

Body mass index (BMI) was calculated for each participant's weight in kilograms divided by height in meters squared (kg/m^2).

2.2.2. Functional movement screening (FMS) test

The FMS assesses 7 fundamental movement patterns: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability. Each movement is scored on a 0-3 scale: 3 points for performing the movement without compensations, 2 points for performing with compensations, 1 point for inability to perform the movement, and 0 points if pain is experienced during the movement. The total FMS score ranges from 0 to 21, calculated by summing the scores for each of the 7 movements (Cook et al., 2006). Prior to the FMS examination, participants were briefed by a medical expert on the proper execution of the test movements. After a warm-up, the movements were demonstrated, explained, and participants were able to ask questions. During the test, each movement was repeated 3 times, and the best score was recorded. Participants were encouraged to give their best performance on each movement and report any pain or discomfort experienced during the movements.

2.2.3. Flamingo balance test

The test was conducted with a balance board. Participants were instructed to stand on one leg on the board while lifting the contralateral leg off the ground, flexing the knee of the raised leg to its maximum degree, holding the raised foot with the corresponding hand, and focusing on a fixed point at eye level. A researcher provided initial support to the

participant. A stopwatch was activated at the precise moment the researcher released their grip. Timing ceased when the participant released their foot from their hand or any part of their body touched the ground. The researcher assisted the participant in regaining the correct position after each loss of balance. Three trials were performed for each leg, and the average time maintained was recorded. The number of balance errors within one minute was also documented for each leg (Kumar et al., 2023).

2.2.4. Y-balance test

The Y-balance test was conducted on both the dominant and non-dominant legs of each participant. Participants, wearing non-restrictive athletic attire and with bare feet, stood on the Y-balance test platform with their hands on their hips and their feet centered on the designated starting point. They were then instructed to maintain a single-leg stance while reaching with the toes of the opposite leg to push blocks in three directions: anterior (0°), posteromedial (45°), and posterolateral (45°). After each reach, the reaching leg returned to the starting point without contacting the ground. The test was repeated three times in each direction for each leg. Reach distances were recorded and normalized using the standardized formula (Kinzey & Armstrong, 1998).

2.3. Data Analysis

Descriptive statistics, including means and standard deviations, were calculated for all variables. Given the small sample size ($n < 30$), the non-parametric Spearman's rho correlation coefficient was used to assess the magnitude and direction of associations between variables.

2.4. Ethical Approval

Ethical approval was granted by the Selçuk University Faculty of Sports Sciences Non-Interventional Clinical Research Ethics Committee (05.03.2024- E.716427-33). This study adhered to the principles of the Declaration of Helsinki.

3. Results

Descriptive statistics of the participants are presented in Table I. Participants' ages ranged from 9 to 11 years (10.26 ± 0.76 years), body weight ranged from 23.0 to 54.0 kg (31.46 ± 6.20 kg), and height ranged from 128.0 to 151.0 cm (136.85 ± 6.95 cm). The average total FMS score was 15.44 ± 2.52 points.

Table 1. Descriptive statistics of participants and their performances (n=27)

Variables	Group	Mean	SD	Minimum	Maximum
Anthropometric tests	Age (years)	10.26	0.76	9.00	11.00
	Weight (kg)	31.46	6.20	23.00	54.00
	Height (cm)	136.85	6.95	128.00	151.00
FMS test	Deep squat	2.26	0.71	1.00	3.00
	Hurdle step	2.00	0.55	1.00	3.00
	In-line lunge	2.30	0.54	1.00	3.00
	Shoulder mobility	2.41	0.75	1.00	3.00
	Active straight-leg raise	2.41	0.50	2.00	3.00
	Trunk stability push-up	2.33	0.48	2.00	3.00
	Rotary stability	1.74	0.53	1.00	3.00
	Total score	15.44	2.52	10.00	21.00
Y balance test	Right leg anterior	82.62	7.31	65.82	100.00
	Left leg anterior	81.21	7.38	65.82	97.30
	Right leg postero-medial	81.68	7.12	67.82	94.67
	Left leg postero-medial	78.74	8.34	59.46	92.11
	Right leg postero-lateral	74.61	8.30	54.79	92.59
	Left leg postero-lateral	75.92	9.80	58.02	91.67
	Right leg composite	76.33	5.33	69.00	91.00
	Left leg composite	76.33	5.37	70.00	91.00
Flamingo balance test	Right leg flamingo	8.04	4.38	1.00	18.00
	Left leg flamingo	10.19	4.96	2.00	21.00

FMS: Functional Movement Screen; SD: Standard deviation

Table 2. Correlations between FMS and balance scores

Variable		RLA	LLA	RLP-M	LLP-M	RLP-L	LLP-L	RLC	LLC	RLF	LLF
FMS	q	.201	.249	.102	.276	.212	.176	.222	.23	.043	.059
	p	.315	.21	.612	.164	.288	.379	.266	.249	.832	.771

RLA: Right leg anterior, LLA: Left leg anterior, RLP-M: Right leg posteromedial, LLP-M: Left leg posteromedial, RLP-L: Right leg posterolateral, LLP-L: Left leg posterolateral, RLC: Right leg composite, LLC: Left leg composite; RLF: Right leg flamingo; LLF: Left leg flamingo

Spearman's correlation analysis revealed no statistically significant correlations ($p > .05$) between FMS scores and performance on the Y-balance test or the Flamingo balance test (right and left) (Table 2).

Table 3. Correlations between balance tests and physical characteristics

Variables		RLA	LLA	RLP-M	LLP-M	RLP-L	LLP-L	RLC	LLC	RLF	LLF
Weight (kg)	q	-.243	-.126	-.165	.109	.028	-.104	.458*	.472*	.015	.165
	p	.221	.531	.412	.588	.889	.607	.016	.013	.94	.412
Height (cm)	q	-.088	-.227	.03	.167	.074	.102	.680**	.707**	-.02	.201
	p	.664	.255	.881	.406	.715	.612	.000	.000	.922	.314
BMI (kg/m2)	q	-.321	-.109	-.216	-.187	.06	-.278	.061	.066	.012	.074
	p	.103	.587	.28	.349	.768	.16	.762	.744	.952	.713

* $p < .05$; ** $p < .01$; BMI: Body mass index; RLA: Right leg anterior, LLA: Left leg anterior, RLP-M: Right leg posteromedial, LLP-M: Left leg posteromedial, RLP-L: Right leg posterolateral, LLP-L: Left leg posterolateral, RLC: Right leg composite, LLC: Left leg composite; RLF: Right leg flamingo; LLF: Left leg flamingo

Analysis of the relationships between participants' physical characteristics and balance performance revealed no significant correlation between body mass index (BMI) and balance performance ($p > .05$). However, moderate positive correlations were found between body weight and composite scores for both the right leg (RLC) ($q = .458$; $p = .016$) and left leg (LLC) ($q = .472$; $p = .013$). No other significant correlations were observed between body weight and balance performance ($p > .05$). In contrast, height was strongly positively correlated with both RLC ($q = .680$; $p < .01$) and LLC ($q = .707$; $p < .01$). No significant correlations were found between height and other balance parameters ($p > .05$) (Table 3).

Table 4. Correlation between FMS scores and physical characteristics

Variables		DS	HS	ILL	SM	ASLR	TSP	RS	FMS
Weight (kg)	q	-.359	-.048	-.19	-.343	.083	-.249	.128	-.249
	p	.066	.811	.342	.08	.681	.211	.525	.211
Height (cm)	q	.093	.189	.127	-.048	.389*	.111	.242	.258
	p	.643	.346	.527	.812	.045	.58	.224	.193
BMI (kg/m2)	q	-.363	-.253	-.423*	-.366	-.068	-.313	-.059	-.451*
	p	.063	.202	.028	.06	.737	.112	.77	.018

* $p < .05$; BMI: Body mass index; DS: Deep squat; HS: Hurdle step; ILL: In-line lunge; SM: Shoulder mobility; ASLR: Active straight-leg raise; TSP: Trunk stability push-up; RS: Rotary stability

Table 4 presents the results of the analysis examining the correlation between the components of the FMS, total FMS scores, and physical characteristics. The findings indicate no statistically significant correlations between body weight and FMS scores or individual FMS components ($p > .05$). Regarding the correlation between height and FMS parameters, a low-level positive significant correlation was observed only with the ASLR ($q = .389$; $p = .045$), while no significant correlations were detected with the other components ($p > .05$). Additionally, an analysis of the correlation between FMS measurements and BMI revealed negative moderate correlations with the ILL ($q = -.423$; $p = .028$) and total FMS scores ($q = -.451$; $p = .018$), whereas no statistically significant correlations were found with the remaining variables ($p > .05$).

4. Discussion

The Functional Movement Screen (FMS) is used to assess the quality of movement patterns that require motor control, balance, and flexibility, and to identify potential injury risks. Balance, a key determinant of performance in various sports, significantly influences the execution of complex athletic skills. Deficits in balance can negatively impact performance and increase injury risk. This study examined the relationship between total FMS scores and balance performance in girls with an average age of 10.26 ± 0.76 years who participated in various sports. The results indicated no statistically significant correlations between FMS scores and performance on static or dynamic balance tests.

This study investigated the relationship between dynamic and static balance scores and FMS total scores in female athletes with at least two years of regular training in various sports disciplines. Dynamic balance was assessed using anterior-posterior and medial-lateral directions, while static balance was evaluated with the flamingo test. No statistically significant correlations were found between these balance measures and FMS scores. This absence of correlation may be explained by the distinct focus of such assessments: the FMS evaluates overall body function, whereas the balance tests specifically target lower extremity function. This observation is consistent with previous research indicating that FMS and balance tests measure different aspects of movement competence ([Harshbarger et al., 2018](#); [Kazman et al., 2014](#); [Lockie et al., 2014](#)).

Similarly, Functional Movement Screen (FMS) did not correlate positively with athletic performance parameters such as agility (T-test), speed (20-m sprint), and strength (vertical and broad jumps). Specifically, higher scores in hurdle step, in-line lunge, and active straight-leg raise were associated with poorer performance in the 505 and T-test ([Kozlenia & Domaradzki, 2021](#)). [Misegades et al. \(2020\)](#) found an average composite Y-balance test score of $86.6\% \pm 8.2\%$ in dancers with an average composite FMS score of $15.3 \pm 2.3\%$, concluding that total FMS scores did not correlate with Y-balance test scores. They did, however, note a moderate correlation between the single-leg lunge from the FMS and the Y-balance test. Conversely, [Teyhen et al. \(2014\)](#) reported correlations between the Y-balance test and both total FMS scores and specific FMS components, including the hurdle step, in-line lunge, shoulder mobility, and deep squat. Furthermore, significant differences in Y Balance Test scores (anterior, posterolateral right, and posterolateral left) specifically between adolescent basketball players with varying FMS total scores ([Xie et al., 2024](#)).

In contrast to these findings, positive low-level relationship between FMS total scores and balance measures, specifically in the right postero-medial and left leg composite of the Y balance subtests, but it does not specifically address basketball, soccer and volleyball players ([İribalçı et al., 2014](#)), football players ([Sikora & Linek, 2022](#)), swimmers ([Fitton Davies et al., 2022](#)) and wrestlers ([Kara et al., 2021](#)). Furthermore, [Song et al. \(2020\)](#) demonstrated that a 10-week body stability exercise program significantly improved balance ability in secondary school volleyball players, with significant increases in FMS total scores from 10.90 ± 1.30 (pre-test) to 13.81 ± 0.60 (post-test). They concluded that the 10-week physical stability exercise program effectively enhanced speed, agility, functional movement, and balance, potentially contributing to the prevention and reduction of injuries among injury-prone volleyball players. In addition, it has been suggested that improving FMS scores through appropriate training interventions can reduce the risk of injury in football players ([Bayrakdar & Kılınç Boz, 2020](#)).

The declining trend of physical fitness in adolescents raises concerns about potential future challenges related to health and physical functionality ([Joensuu et al., 2021](#)). This study found moderate negative correlations between BMI and both total FMS scores and performance on the one-leg lunge test. While no statistically significant correlation was observed between body weight and FMS scores or individual components, a weak positive correlation was noted between height and the active straight leg raise test. These findings are consistent with existing literature. [Duncan and Stanley \(2012\)](#) reported a significant negative correlation between total FMS scores and BMI, coupled with a positive correlation with physical activity levels in children aged 10-11 years. They also observed that children with normal weight had significantly higher total FMS scores than their overweight and obese peers. Similarly, [García-Pinillos et al. \(2018\)](#) demonstrated that FMS scores in children aged 6-13 differed significantly across weight categories (normal weight, overweight, and obese), with total FMS scores decreasing as BMI increased. Significant differences were also evident in specific FMS components, including the deep squat, hurdle step, in-line lunge, shoulder mobility, straight leg raise, and push-up.

Further research has confirmed negative correlations between total FMS scores and both BMI and body fat percentage. Notably, significant differences were found in deep squat, hurdle step, and in-line lunge performance between individuals with a normal BMI and those classified as obese. Higher body fat percentages and BMI were associated with lower FMS scores, both total and for individual components, particularly in movements requiring lower extremity mobility and stability, such as the deep squat, hurdle step, and in-line lunge ([Nicolozakes et al., 2018](#)). Moreover, BMI and waist circumference have been shown to have an inverse relationship with FMS in children and adolescents, with a stronger correlation observed for locomotor skills than object control skills. This suggests that adequate FMS may be crucial in preventing unhealthy weight gain in this population ([Okely et al., 2004](#)).

Research in athletes across various sports has also identified significant correlations between movement patterns and body composition variables. Strong negative correlations were found between fat mass percentage, upper arm fat area, and total FMS scores, indicating that functional movement patterns and body composition are influenced by the specific demands of different sports. Achieving optimal body composition is essential for enhancing movement quality (Campa et al., 2019). A negative correlation between FMS total scores and body composition metrics like body weight, body fat percentage, and BMI in athletes from various sports (Sebastia-Rico et al., 2023).

While decreased balance stability is generally correlated with increased body weight (Hue et al., 2007), this study found no significant relationship between balance performance and BMI. However, a moderate positive correlation was observed between body weight and composite balance scores for both the right and left sides. This finding contrasts with Bramble et al. (2019), who reported no significant correlation between body fat percentage and static balance or anterior and posterolateral reach distances on the Y-Balance Test. They did, however, find a significant negative correlation between body fat percentage and posteromedial reach distance, indicating that increased body fat percentage was associated with reduced postural stability in the posteromedial direction during dynamic balance assessment. Conversely, Guzmán-Muñoz et al. (2018), found that static balance ability showed moderate positive associations with several body composition and physical characteristics, specifically body mass index (BMI), fat mass, total skinfold measurements, endomorphic body type, and postural control capabilities. In contrast, they found moderate negative correlations between dynamic postural balance, as measured by the Y-Balance Test, and these same variables. They concluded that children with higher levels of adiposity and/or a more endomorphic physique demonstrated poorer performance in both static and dynamic postural balance assessments.

5. Conclusions

As a result, no significant correlation was found between FMS total scores and dynamic or static balance performance. However, a moderate negative correlation was identified between BMI and both the single-leg lunge and total FMS scores. No correlation was observed between BMI and dynamic or static balance performance. This study has several limitations. Firstly, the research cohort consisted solely of female athletes from three specific sports within team clubs in Zonguldak province, resulting in a relatively small and homogenous sample. This limited demographic representation (age, gender, experience level, and training status) may restrict the generalizability of the findings to the broader athlete population. Future research with larger and more diverse cohorts, including male athletes and those from individual sports, is necessary to confirm these findings. Despite these limitations, this study provides valuable insights into the relationship between functional movement, balance, and body composition in female athletes.

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Data Availability Statement The data are publicly available.

Abbreviations

The following abbreviations are used in this manuscript:

FMS	Functional movement screening
BMI	Body mass index
RLA	Right leg anterior
LLA	Left leg anterior
RLP-M	Right leg posteromedial
LLP-M	Left leg posteromedial
RLP-L	Right leg posterolateral
LLP-L	Left leg posterolateral
RLC	Right leg composite
LLC	Left leg composite

RLF	Right leg flamingo
LLF	Left leg flamingo
DS	Deep squat
HS	Hurdle step
ILL	In-line lunge
SM	Shoulder mobility
ASLR	Active straight-leg raise
TSP	Trunk stability push-up
RS	Rotary stability

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