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The Relationship Between Functional Movement Screening Scores and Neuromuscular Asymmetry Performance in Football Players: A Cross-Sectional Study

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Research Article
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Abstract

This study investigates the effect of Functional Movement Screening (FMS) components on neuromuscular asymmetry performance in football players. A total of 44 male football players (mean age: 22.93±2.69 years; height: 1.77±0.03 m; body mass: 75.29±2.38 kg; sports experience: 9.84±1.71 years) participated. The study was conducted over two sessions, 48 hours apart. In the first session, anthropometric measurements and FMS tests were performed. In the second session, dominant, non-dominant, and bilateral countermovement jump (CMJ) tests were applied to determine neuromuscular asymmetry levels. Statistical analyses were conducted using JASP 0.18 software. The relationship between FMS scores and neuromuscular asymmetry was evaluated using Pearson's correlation coefficient, while linear regression determined the effect size. A significant negative correlation was found between neuromuscular asymmetry and FMS components, including deep squat ($r=-0.548$), hurdle step ($r=-0.639$), inline lunge ($r=-0.429$), active leg raise ($r=-0.373$), and total FMS score ($r=-0.507$) ($p<0.05$). Neuromuscular asymmetry also negatively impacted FMS scores ($p<0.05$). A one-unit increase in neuromuscular asymmetry significantly reduced deep squat (-0.02), hurdle step (-0.04), inline lunge (-0.03), active leg raises (-0.02), and total FMS scores (-0.09) ($p<0.05$). In conclusion, the study identified a negative relationship between FMS scores and neuromuscular asymmetry levels in football players, indicating that movement quality influences neuromuscular asymmetry. Both FMS and neuromuscular asymmetry play critical roles in athletic performance and injury prevention among athletes.
Keywords: Football, Functional movement screen (FMS), Neuromuscular asymmetry, Risk of injury

Futbolcularda Fonksiyonel Hareket Ekranı Skorları ile Nöromüsküler Asimetri Performansı Arasındaki İlişkinin İncelenmesi: Kesitsel Bir Çalışma

Öz

Bu araştırmanın amacı, futbolcularda fonksiyonel hareket taraması (FMS) bileşenlerinin nöromüsküler asimetri performansına etkisini incelemektir. Çalışmaya 44 erkek futbolcu (yaş: 22.93±2.69 yıl; boy: 1.77±0.03 m; ağırlık: 75.29±2.38 kg; spor geçmişi: 9.84±1.71 yıl) katılmıştır. Araştırma 48 saat arayla iki seansta gerçekleştirilmiştir. İlk seansta antropometrik ölçümler ve FMS testi uygulanırken, ikinci seansta dominant, non-dominant ve bilateral countermovement jump (CMJ) testleri yapılmıştır. Sporcuların nöromüsküler asimetri seviyeleri CMJ testlerinden belirlenmiştir. Analizler JASP 0.18 programıyla gerçekleştirilmiş, Pearson korelasyon katsayısı ve doğrusal regresyon kullanılmıştır. Sonuçlar, nöromüsküler asimetri ile deep squat ($r=-0.548$), hurdle step ($r=-0.639$), inline lunge ($r=-0.429$), active leg raise ($r=-0.373$) ve toplam FMS puanı ($r=-0.507$) arasında negatif ve anlamlı bir ilişki olduğunu göstermiştir ($p<0.05$). Nöromüsküler asimetrideki bir birimlik artışın, deep squat (-0.02), hurdle step (-0.04), inline lunge (-0.03), active leg raise (-0.02) ve toplam FMS puanını (-0.09) negatif yönde etkilediği bulunmuştur ($p<0.05$). Sonuç olarak, futbolcularda FMS ile nöromüsküler asimetri düzeyi arasında negatif bir ilişki olduğu belirlenmiştir. Hareket kalitesinin nöromüsküler asimetrik performansı etkilediği ve her iki değişkenin de atletik performans ile sakatlanma riskinde önemli rol oynadığı tespit edilmiştir.
Anahtar Kelimeler: Fonksiyonel hareket taraması (FMS), Futbol, Nöromüsküler asimetri, Sakatlanma riski

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INTRODUCTION

Football is a team sport, usually played professionally, in which periods of high-intensity activity alternate with long periods of low-intensity activity (Buchheit et al., 2014; Oliva-Lozano et al., 2020; Rampinini et al., 2007). For instance, straight-line sprints are among the most frequently executed actions during goal scoring, evading opponents, and shooting at the goal (Faude et al., 2012). Furthermore, the majority of sprints are conducted over distances of 20 meters (Di Salvo et al., 2010; Vigne et al., 2010); data has shown that accelerations and decelerations contribute up to 7-10% and 5-7% of the total player workload, respectively (Dalen et al., 2016). Moreover, qualitatively, players execute an average of 30.7% of game movements and manoeuvres by moving backwards, sideways, diagonally, and in arcs (Bloomfield et al., 2007). Therefore, the development of multiple physical attributes is crucial for the athletic development of football players (Sarmento et al., 2018).

Professional football players cover approximately 10 km per match, with only 10% of the total distance being completed at high intensity (Palucci Vieira et al., 2018). However, these high-intensity periods particularly impact neuromuscular fatigue, thereby increasing the risk of injury (Palucci Vieira et al., 2018). The issue of functional asymmetries in the lower limbs has been the focus of numerous recent studies in contact and non-contact sports (D'Hondt et al., 2022; Fort-Vanmeerhaeghe et al., 2022; Sannicandro et al., 2019). According to research conducted in different types of sports, strength asymmetries in the lower extremities of athletes are considered an inherent risk factor for injury (Sannicandro et al., 2014). In such cases, compensation strategies are employed to prevent, eliminate, or at least limit the degree of asymmetry, thereby mitigating the potential long-term negative consequences of these asymmetries on athletes' health. Functional Movement Screen (FMS) can be regarded as one of these preventive measures. FMS consists of seven tests assessing fundamental movement patterns to identify dysfunctional, asymmetric, and painful movements which may contribute to future injuries (Cook et al., 2014).

Pain and asymmetry are assessed as two distinct outcome categories in FMS. Pain is determined by the presence or absence of discomfort during FMS tests, meaning whether the individual experiences pain or not when performing the test. Asymmetry is based on the movement differences between the left and right sides of the body, which is identified if a discrepancy is detected between the two sides in at least one FMS test result. A meta-analysis of preliminary studies on FMS has demonstrated a significant difference between the FMS scores of individuals who sustained injuries and those who did not experience injuries later (Dorrel et al., 2015). Studies investigating the relationship between FMS asymmetry and injuries in other sports or occupations have reported mixed results. Additionally, studies exploring the link between FMS and injury have generally focused on the composite score as a predictor variable, yielding inconsistent findings (Moran et al., 2016; Moran et al., 2017). In sports such as football, lower extremity strength asymmetries are considered a significant factor that increases the risk of injury (Ekstrand et al., 2016; Moreno-Perez et al., 2022).

Since asymmetries in the lower extremities can have adverse effects on the performance of football players, it is believed that preventive and compensatory strategies should be implemented. In this context, the study aims to investigate the relationship and impact of each FMS component on neuromuscular asymmetry performance.

METHOD

Research design

A correlational research design was used to determine the relationship between functional movement screens and neuromuscular asymmetry performances of football players. The relational research design involves examining the connections between two or more variables to gain insights into potential cause-and-effect mechanisms (Büyüköztürk et al., 2024).

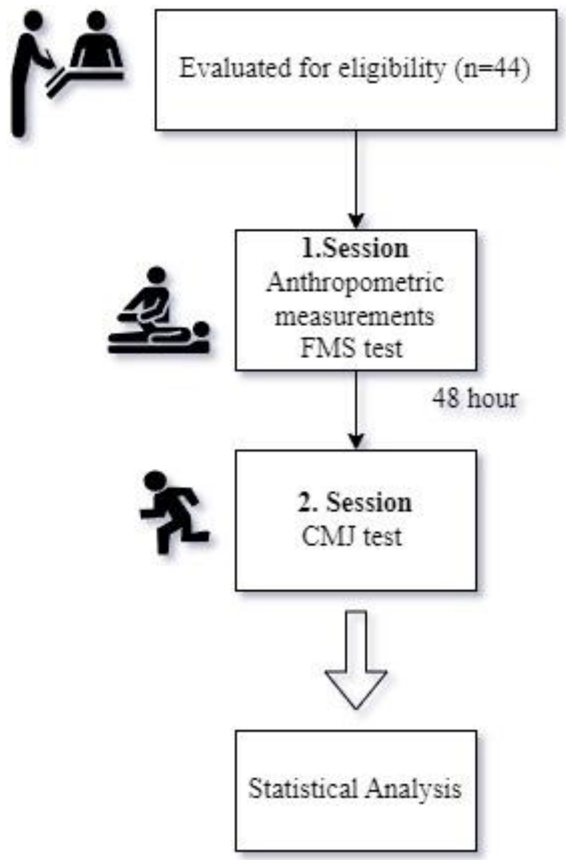

Figure 1. Research design

Sample size

The study's sample size was calculated using the G*Power program (ver 3.1.9.2; α=0.05, Power=0.80 (1-ß)). According to the exact analysis, the number of participants for linear regression analysis was calculated as n=33. To increase the validity of the research and prevent data loss, the study was completed with 44 participants.

Participants

A total of 44 male soccer players participated in the research. The training age of the athletes is 9.84±1.71 years, age is 22.93±2.69 years, height is 1.77±0.03 m, body mass is 75.29±2.38 kg and BMI is 24.06±0.72 kg/m^2.

Participant Criteria

Being a licensed football player between the ages of 18-30.

Actively playing football in the league.

Not having an acute or chronic injury.

Not using sleep-inducing medications.

Exclusion Criteria

Those with lower extremity injuries or recurrent musculoskeletal problems in the last six months.

Those diagnosed with chronic insomnia, sleep apnea or other sleep disorders.

Individuals diagnosed with psychiatric conditions, such as anxiety and depression, are undergoing medication treatment.

Individuals who smoke regularly or consume high levels of alcohol.

Procedure

The study consisted of two sessions, 48 hours apart. Athletes underwent anthropometric measurements and functional movement screen tests in the first session. In the second session, athletes were subjected to dominant, non-dominant and bilateral countermovement jump (CMJ) tests. Neuromuscular asymmetry levels of athletes were determined from CMJ tests. Before all visits, athletes were made to do 5-minute running, 10-minute stretching and general warm-up exercises accompanied by their trainers. All measurements were carried out in semi-professional Adaletgücü sports club facilities. The study was conducted in July during the off-season. The tests were performed on the same athlete, by the same person, at the same time of day to minimize the effect of circadian rhythm that could affect athletes' performance (Öztürk et al., 2023).

Warm-up Protocol: A 15-minute general warm-up protocol was applied to the athletes. Athletes applied general warm-up with 5 minutes of jogging and 10 minutes of stretching under the direction of the coach and researchers. The athletes used the protocols of the groups they were included after 4 minutes of passive rest.

Ethics

The study was approved by the institutional review board of the Erciyes University Social and Human Sciences Ethics Committee (approval number: 2024-494). The principles of the Declaration of Helsinki were conducted in all procedures. Informed consent was obtained from all participants after detailed information about the study was provided.

Data Collection

The data collection process took place between 11-15 December 2024. Measurements were carried out at 16:00–18:00 and in sports facilities.

Body Mass and Height Measurement: Participants' height (Seca stadiometer) and body mass were measured using a Tanita BC418 body analyser. Participants’ demographic characteristics (age and sports age) were determined using a questionnaire.

Neuromuscular Asymmetry Tests

Unilateral Counter Movement Jump: Athletes' dominant and non-dominant legs (unilateral) were determined. This test was measured using the Witty Microgate jumping mat. Athletes jumped to the highest point at the centre of the jumping mat with their hands fixed on their waists. The athlete's jump height (cm) was recorded during the measurement. The measurement was repeated thrice, and the average time was recorded (Turkeri et al., 2024). Scores obtained from athletes' vertical jump performance (with dominant and non-dominant legs) were used to determine asymmetry (Impellizzeri et al., 2007). The asymmetry value was calculated by dividing the difference between the dominant and non-dominant sides by the dominant side and expressing it as a percentage [(Dominant – Non-Dominant) / Dominant × 100] (Impellizzeri et al., 2007).

Functional Movement Screen (FMS): FMS consists of seven movement patterns: "deep squat, hurdle step, in-line lunge, active straight leg raise, trunk stability push-up, shoulder mobility and rotary stability" tests. Two researchers performed the evaluation simultaneously. Each movement is scored between 0-3. "0" indicates pain and inability to perform the movement due to this, and "3" indicates correct movement form. The highest score that can be obtained from the seven subtests is 21. In receiving the total score, the lower score of the subtests applied bilaterally was taken. In addition, the "clearing test" was used in three of the subtests. These tests were performed after "shoulder mobility, trunk stability push-up and rotation stability tests" were applied. If the athlete experienced pain during the "clearing test", "0" points were given for these subtests regardless of the score received (Cook et al., 2014). The movements evaluated in the FMS test are listed below.

Statistical Analysis

Statistical analysis was conducted using the JASP 0.18 software package. To assess the normality of the data, skewness and kurtosis values were calculated, and the data were found to follow a normal distribution based on the criteria outlined by Tabachnick and Fidell (Tabachnick et al., 2013). According to the normality test, it was determined that the data showed normal distribution. The relationship between the functional movement analysis of football players and their neuromuscular asymmetric performance was determined by the Pearson correlation coefficient, and the effect level was determined by linear regression. The study interpreted Pearson correlation strength (r-value) according to standard definitions. The r value in the research findings is 0.00–0.19, "very weak", 0.20–0.39 ", weak", 0.40–0.59 ", moderate", 0.60–0.79 ", strong", and 0.80–1.0 was interpreted as "firm (Campbell, 2021). In this study, the significance level was accepted as $p<0.05$.

RESULTS

Table 1. Demographic characteristics

Variable	N	Min.	Max.	X̄	S
Age (year)	44	20.00	29.00	22.93	2.69
Height (m)		1.74	1.86	1.77	0.03
Body mass (kg)		70.00	80.00	75.29	2.38
BMI (kg/m^2)		22.15	24.96	24.06	0.72
Training Age (year)		8.00	13.00	9.84	1.71

BMI: Body mass index

A total of 44 male football players with a training age of 9.84 ± 1.71 years, an age of 22.93 ± 2.69 years, a height of 1.77 ± 0.03 m, a body mass of 75.29 ± 2.38 kg, and a body mass index of 24.06 ± 0.72 kg/m^2 participated in the study (Table 1).

Table 2. FMS and jump performance averages

Variable	N	Min.	Max.	X̄	S
Deep Squat	44	1.00	3.00	1.72	0.49
Hurdle Step		1.00	3.00	2.11	0.61
Inline Lunge		0.00	3.00	1.70	0.85
Active Leg Raise		1.00	3.00	2.36	0.65
Shoulder Mobility		1.00	3.00	2.40	0.58
Trunk Stability Push-Up		2.00	3.00	2.79	0.40
Rotary Stability		2.00	3.00	2.22	0.42
Total FMS		12.00	18.00	14.93	1.73
Dominant CMJ (cm)		15.00	34.00	24.45	4.75
Non-Dominant CMJ (cm)		14.00	35.00	25.68	7.35
Bilateral CMJ (cm)		30.00	57.00	42.61	6.18
Asymmetry (%)		3.03	29.62	18.29	9.49

CMJ: Countermovement Jump, **FMS:** Functional Movement Screen

Total FMS scores of the football players were found as 14.93±1.73, dominant CMJ 24.45±4.75 cm, non-dominant 25.68±7.35 cm, bilateral jump 42.61±6.18 cm and asymmetry 18.29±9.49 % (Table 2).

Table 3. Relationship between neuromuscular asymmetry and FMS

		Deep Squat	Hurdle Step	Inline Lunge	Active Leg Raise	Shoulder Mobility	Trunk Stability Push-Up	Rotary Stability	Total FMS
Asymmetry (%)	r	-.548**	-.639***	-.429**	-.373*	-.197	-.088	-.026	-.507***
	p	<.001	<.001	.004	.013	.199	.569	.868	<.001

*p<0.05, **p<0.01, ***p<0.001

The relationship between football players' neuromuscular asymmetry (%) and FMS performance was examined. Accordingly, a significant negative relationship was found between asymmetry and deep squat (r=-0.548), hurdle step (r=-0.639), inline lunge (r=-0.429). active leg raise (r=-0.373) and total FMS score (r=-0.507) (p<0.05) (Table 3).

Table 4. Neuromuscular asymmetry effect on FMS scores

	β	Std. Eror	Beta	*t*	p	r	r^2
Asymmetry (%)							
Deep Squat	-0.029	0.007	-0.548	-4.249	<0.001***	0.548	0.301
Hurdle Step	-0.042	0.008	-0.639	-5.378	<0.001***	0.639	0.408
Inline Lunge	-0.038	0.012	-0.429	-3.076	0.004**	0.429	0.184
Active Leg Raise	-0.028	0.011	-0.373	-2.605	0.013**	0.373	0.139
Shoulder Mobility	-0.012	0.009	-0.197	-1.305	0.199	0.197	0.039
Trunk Stability Push-Up	-0.004	0.007	-0.088	-0.575	0.569	0.088	0.008
Rotary Stability	-0.001	0.008	-0.026	-0.167	0.868	0.026	0.001
Total FMS	-0.092	0.024	-0.507	-3.812	<0.001***	0.507	0.257

FMS: Functional Movement Screen
**p<0.01, ***p<0.001

The effects of football players' neuromuscular asymmetry levels on FMS scores were examined. Accordingly, it was determined that neuromuscular asymmetry significantly negatively affected football players' FMS scores (p<0.05). It was determined that a one-unit increase in neuromuscular asymmetry affected deep squat (-0.02), hurdle step (-0.04), inline lunge (-0.03), active leg raise (-0.02) and total FMS scores (-0.09) (p<0.05) (Table 4).

DISCUSSION AND CONCLUSION

Inadequate mobilisation and stabilisation of athletes limit the movement capabilities required for the sport they practice. When the compensation mechanism is activated, the necessary mechanical movements for the sport are performed, albeit to a limited extent. However, this results in an increased mechanical and physiological load on the athletes. Considering that most game mechanics in football (such as dribbling, shooting, long passes, short passes, sprints, changes of direction and repeated runs) are performed with the dominant limb at high intensity, it can be argued that the increased mechanical and physiological load may contribute to more significant neuromuscular asymmetry, decreased performance, and potentially increase the risk of injuries (Bishop et al., 2021; Gonzalo-Skok et al., 2017; Heil et al., 2020; Raya-Gonzalez et al., 2021). In football, the most popular sport in the world, such situations have led sports scientists to explore the effects of movement abilities on athletes' performance. A review of FMS research reveals that studies primarily focus on evaluating relationships with injuries, balance, and core strength (Johnson et al., 2018; Kelleher et al., 2017; Kiesel et al., 2007; Okada et al., 2011). However, no studies have examined the relationship and effect level between football players' FMS scores and neuromuscular asymmetry levels. In this context this study was conducted to determine the relationship between football players' functional movement analysis scores and their neuromuscular asymmetry levels.

Studies have shown that the increased demands of game mechanics in football (such as dribbling, shooting, long passes, short passes, sprints, changes of direction and repeated runs) often lead to neuromuscular asymmetries in football players. In their study Asimakidis et al. (2021) reported that repeated collective actions (such as dribbling, shooting long passes, passing, etc.) as well as direction changes and agility runs performed without the ball led to leg dominance (due to the actions typically being performed on the dominant side) and the formation of neuromuscular asymmetry in football players as a result of the nature of the game (Asimakidis et al., 2022). García-García et al. (2022) stated that the game mechanics of football lead to lateral dominance in football players and this condition creates asymmetry due to differences in joint range of motion (Garcia-Garcia et al., 2022). In another study Bromley et al. (2021) reported that dominant actions performed during the game may exacerbate existing asymmetries due to their high volume (Bromley et al., 2021). Findings in the literature highlight the causes of asymmetries in football game mechanics among players. However, they do not provide insight into the potential effects of these asymmetries on the evaluation of movement quality or neuromuscular asymmetry.

The relationship between FMS and neuromuscular asymmetry is crucial for performance optimization and injury prevention. Studies have demonstrated a negative relationship between FMS and asymmetry. In the study a significant negative relationship was found between football players' neuromuscular asymmetry levels and the deep squat ($r = -0.548$), hurdle step ($r = -0.639$), inline lunge ($r = -0.429$), active leg raise ($r = -0.373$), and total FMS score ($r = -0.507$) ($p < 0.05$). It was also determined that a one-unit increase in neuromuscular asymmetry negatively affected the deep squat (-0.02), hurdle step (-0.04), inline lunge (-0.03), active leg raise (-0.02), and total FMS scores (-0.09) scores. Sannicandro et al. (2019) conducted a study with professional football players and found a significant negative relationship between the hop test ($r = -0.56$ $p < 0.01$), side hop ($r = -0.74$. $p < 0.01$) and crossover hop tests ($r = -0.60$ $p < 0.01$) and the FMS score. They also stated that football players who scored low on the FMS test exhibited higher levels of lower extremity strength asymmetry (Sannicandro et al., 2019). In addition, it was stated that football players who scored low on the FMS test exhibited high levels of lower extremity strength asymmetry. Sannicandro et al. (2017) obtained similar results in another study ($r = -0.678$ $p < 0.01$). The study reported a negative relationship between jump asymmetry and FMS scores. Furthermore, the same survey found that an increase in FMS scores positively impacted CMJ height, an essential indicator of athletic performance. As FMS performance decreases the asymmetry rate increases (Sannicandro et al., 2017). This situation can lead to poor movement quality which in turn may cause more significant functional imbalances in the neuromuscular asymmetry level of athletes.

Functional movement deficiencies in athletes suggest that they may be more prone to neuromuscular asymmetry which can impair their athletic performance and increase their susceptibility to injury (Chalmers et al., 2017; Guan et al., 2023). Bishop et al. (2023) emphasised that neuromuscular asymmetries are often associated with decreased physical performance in football players. They stated that effective movement screening can help identify at-risk athletes (Bishop et al., 2023). The variability in individual responses to training and competition further complicates the relationship between FMS and neuromuscular asymmetry. Bishop et al. (2021) stated that there are significant differences in the asymmetry data of elite football players which may complicate the interpretation of FMS results and their effects on performance (Bishop et al., 2021). This variability highlights the need for individualized assessments and training programs for each athlete's unique movement patterns and asymmetries. Studies have also shown that training interventions can affect neuromuscular asymmetry and athletic performance. Strength and power training in particular has significantly reduced neuromuscular asymmetry while enhancing athletes' sprint speed and jumping performance (Loturco et al., 2019; Pardos-Mainer et al., 2020).

As a result, it was determined that there is a negative relationship between FMS scores and neuromuscular asymmetry levels in football players and that movement quality influences neuromuscular asymmetry. FMS and neuromuscular asymmetry significantly influence athletes' athletic performance and injury susceptibility. Therefore, it is believed that evaluating movement abilities, determining neuromuscular asymmetry levels, and creating individualized training programs accordingly can enhance athletes' performance and, in addition, reduce the incidence of injuries.

Limitations

Although the research was conducted based on the results of the G*Power analysis. The study's sample size of 44 participants may limit the generalizability of the findings. Therefore, conducting future research with a larger participant group is crucial for enhancing the generalizability of the results. The study only assessed the current situation which may be insufficient in evaluating the long-term effects. To address these future studies could track FMS scores and neuromuscular asymmetries throughout a season and assess their long-term impact. Additionally, the research solely utilized field tests FMS and unilateral CMJ tests which may be inadequate for comprehensively evaluating movement quality and reporting neuromuscular asymmetry. Incorporating laboratory tests physiological assessments. and psychological evaluations in subsequent studies may provide more detailed and practical insights.

Conflict of Interest:
There is no conflict of interest with any person or organisation in the study.

Researchers' Statement of Contribution Rate:
All processes of the research were carried out equally by the authors.

Ethical Approval
Board Name: Erciyes University Social and Human Sciences Research Ethics Committee
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