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ORIGINAL SCIENTIFIC PAPER

The Relationship between the Functional Movement Screen and the Star Excursion Balance Test in Non-Professional Soccer Players

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Abstract

Soccer is a very popular sport with a high incidence of injuries. Clinical screening tools are an important component of injury prevention. The aim of this study was to investigate the relationship between two screening tools, the Functional Movement Screen (FMS) and Star Excursion Balance Test (SEBT), and whether there are differences regarding SEBT scores, injuries, and painful symptoms in participants below and above the FMS cutoff score of ≤14. The research was performed as a secondary analysis of a longitudinal cohort study and included 42 non-professional soccer players from Eastern Croatia (age 25.5±6 years, training experience 15.8±6.6 years). Participants were surveyed regarding their sociodemographic data, soccer playing, and FMS and SEBT tests were performed. They were followed for 3.5 months when an additional set of data regarding injuries and painful symptoms was obtained. Moderate to good correlation was found between FMS total score and posterolateral reach of dominant and non-dominant legs (r=0.503, p=0.001; r=0.525, p<0.001). Significant correlations were found between FMS total score and SEBT composite scores for dominant and non-dominant legs (r=0.486, p=0.001; r=0.453, p=0.003). Numerous significant correlations were found between individual items of FMS and SEBT. Participants with FMS score ≤14 had a higher occurrence of injuries and painful symptoms (p=0.018; p=0.034) and lower results of SEBT composite scores for dominant and non-dominant legs (p=0.010; p=0.001). There is a significant relationship between FMS and SEBT scores. Players with FMS scores ≤14 are more prone to injuries and painful symptoms and they have lower SEBT scores.

Keywords: *football, amateur athletes, injury prevention, clinical screening, postural stability*

Introduction

Soccer is a worldwide popular sport with a high risk of injuries. The incidence of injuries in non-professional soccer ranges from 2.7 to 4.5 per 1000 h of practice, and it is even higher during the game where it ranges from 12.3 to 24.7 per 1000 h (van Beijsterveldt et al., 2014; Hammes et al., 2015; Hägglund, Waldén, & Ekstrand, 2016). Furthermore, participation in soccer can play part in the development of strength asymmetries which could have a significant role in injury occurrence (Fousekis, Tsepis, & Vagenas, 2010). Sports-related injuries have significant short- and long-term consequences. Short-term consequences include pain, functional limitations, as well as absence from the practice and the game. Long-term consequences may include residual pain, degenerative conditions of the musculoskeletal system, disability, lost income, healthcare costs, and decreased quality of life.

Injury prevention plays an important factor in reducing injury risk in amateur soccer (Thorborg et al., 2017; Faude, Rommers, & Rössler, 2018). An important component of injury prevention is the use of clinical screening tools. Their purpose

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is to identify individuals with a higher risk of injuries. These tools test movement quality, improper movement patterns and asymmetries, joint range of motion, sensorimotor dysfunction, balance, and postural stability. The results of these tools can be used in the planning of preventive strategies with the goal of injuries risk reduction. Two very common screening tools are the Functional Movement Screen (FMS) (Cook, Burton, & Hoogenboom, 2006a; Cook, Burton, & Hoogenboom, 2006b) and the Star Excursion Balance Test (SEBT) (Hertel, Miller, & Denegar, 2000; Plisky, Rauh, Kaminski, & Underwood, 2006). FMS measures movement capacity with elements of postural control, stability, mobility, and neuromuscular control while SEBT evaluates dynamic postural stability (Harshbarger, Anderson, & Lam, 2018). Previous studies suggest that the FMS score ≤14 is frequently used as a cutoff for determining increased injury risk (Moore, Chalmers, Milanese, & Fuller, 2019). Furthermore, anterior and posteromedial reach asymmetry of ≥4 cm and normalized composite SEBT score <89.6% were associated with future injury risk in the literature (Plisky, Schwartkopf-Phifer, Huebner, Garner, & Bullock, 2021).

Both screening tools have acceptable reliability (Munro & Herrington, 2010; Shultz, Anderson, Matheson, Marcello, & Besier, 2013; Gribble, Kelly, Refshauge, & Hiller, 2013). They also share some similar components. Both of them assess balance, core stability, and sensorimotor control (Harshbarger et al., 2018). While FMS provides more insight into functional movement patterns, SEBT assesses dynamic reaching motion which can also offer relevant information. There are limited data regarding a potential relationship between these two screening tools. Only two previous studies investigated the relationship between the FMS and SEBT (Armstrong, 2020; Harshbarger et al., 2018), however, none of them included senior soccer players. Exploring the potential relationship between these two screening tools could provide valuable information regarding the contributions of each tool to the screening process, save time and positively affect athletes' health. The purpose of this study was to examine the relationship between the FMS and SEBT. The secondary purpose was to explore whether there are differences in SEBT score and occurrence of injury and painful symptoms in participants below and above FMS cutoff score of ≤14. We hypothesized that there will be significant correlations between FMS and SEBT scores and that those below FMS cutoff score of ≤14 will have significantly lower SEBT scores.

Methods

Study design and participants

This was a secondary analysis of a longitudinal cohort study that analyzed possible prediction of injuries based on FMS and SEBT scores in 42 non-professional male soccer players (age 25.5±6 years, body height 181±6.3 cm, body mass 78.8±8.1 kg, training experience 15.8±6.6 years) from three amateur soccer clubs from Eastern Slavonia region of Croatia. Sixty non-professional soccer players were invited to participate in the trial, however, 42 accepted the invitation and fulfilled the inclusion criteria. The study was carried out in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee for Biomedical Research, Faculty of Health Studies, University of Rijeka, Croatia (21/02/2019). Participants gave their written consent. To be recruited, participants had to meet the following criteria: being non-professional soccer player, being involved in regular practice and games in the soccer club at least six months before the beginning of the study, being active soccer player for at least 5 years, and non-existence of injury or painful symptoms in the period of performing screening tests. Exclusion criteria were serious medical conditions including surgery or concussion 6 months prior to testing.

Procedures

All participants were asked to complete an intake form that collected baseline information. It included demographic data, medical history, height and body mass, duration of soccer playing, training load in the past 6 months, tactical position, injuries, and painful symptoms in the past 6 months, and leg dominance. Leg length was measured in centimeters on each lower limb three times for each leg, from greater trochanter to lateral malleolus. Body mass index (BMI) was calculated according to the standard equation. After the initial interview, leg length measurements, and 10 minute warm-up, participants had their first assessment – FMS. On the next day, after 10 min warm-up, participants had their second assessment – SEBT. After 3.5 months follow-up interview was conducted. It included information on training load, injuries, and painful symptoms in the period after screening.

Functional Movement Screen

Seven subtests (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability) and 3 control tests (impingement test, spinal extension test, and spinal flexion) were used according to the protocol described in the literature (Cook et al., 2006a; Cook et al., 2006b). Each movement was scored from 0 to 3 based on the following criteria: 0 – participant experiences pain during movement, 1 – participant fails to complete functional movement, 2 – participant performs the compensatory movement, and 3 – participant performs the movement without compensatory movement and as demonstrated. Individual task scores were summed to produce a composite score that ranges from 0 to 21, with a higher score suggesting better movement capacity (Cook et al., 2006a; Cook et al., 2006b). For each test, the correct procedure was demonstrated to the participants. Three trials were performed for each subtest, and the best score was recorded and used for the analysis. In the bilateral tests, the lower score was recorded as the final score.

Star Excursion Balance Test

The SEBT comprises a single-leg balance with an oppositional reaching movement. It was performed according to the previous report (Plisky et al., 2006) measuring anterior, posterolateral, and posteromedial reach of both legs. Test and testing procedures were demonstrated to the participants and they practiced 6 trials in each direction prior to formal testing. Athletes were positioned with their foot centered in the middle of the testing grid which was created by aligning a series of three tape measures secured on the floor. Participants were told to keep their hands on their hips, head facing forward, keep their stance foot flat on the floor, and to reach as far as possible in the three directions with the toe of the other foot and make single, light toe touch on the tape measure. Reach distance was measured by marking the tape with a pen and then measured using a tape measure. The greatest of 3 trials for each reach direction was used for analysis. The trial was repeated if the participant failed to maintain a unilateral stance, lifted or moved the stance foot from the center of the grid, touched down with the reach foot, or failed to return the reach foot to the starting position. The distance reach was normalized to leg length using the following calculation: excursion distance divided by leg length and then multiplied by 100. Composite scores were calculated by using the sum of the three reach directions divided by 3 times leg length and then multiplied by 100.

Statistical analysis

Statistical analyses were performed using SPSS 25.0 (IBM, Armonk, NY, USA). Descriptive statistics were performed for all variables of interest and presented as mean±standard deviation or frequency and percentages. FMS and SEBT composite scores, as well as FMS subtest and individual reach scores in three directions, were analyzed using a Pearson's correlation coefficient (r). Correlation coefficients were interpreted as little or no correlation (0.00-0.25), fair correlation (0.25-0.50), moderate to good correlation (0.50-0.75), and good to excellent correlation (>0.75) (Portney & Watkins, 2007). As a secondary analysis, for between-group analyses regarding FMS cutoff score, we used independent samples T-test for continuous variables and Fisher's exact test for nominal variables. Results were considered significant for $p<0.05$.

Results

Participants' baseline variables and sociodemographic data are presented in Table 1. Majority of participants, 19 of the total sample (45.2%), had the tactical position of midfielder. There were 10 (23.8%) strikers, 7 (16.7%) defenders, and 6 (14.3%) goalkeepers. Results of the Functional Movement Screen and the Star Excursion Balance Test are shown in Table 2. FMS score ≤14 was recorded in 29 participants (69%). None of the participants had anterior asymmetry ≥4 cm, however 5 (11.9%) participants had posteromedial asymmetry ≥4 cm. All but one participant had their SEBT score <89.6%.

We recorded several significant positive correlations (Table 3). Moderate to good correlation was found between FMS to-

Table 1. General Characteristics of the Participants (N=42)

Variable	mean±SD
Age (years)	25.5±6
Body height (cm)	181±6.3
Body mass (kg)	78.8±8.1
Body mass index (kg/m2)	24±2.1
Training experience (years)	15.8±6.6
Weekly training load six months before screening tests (min)	334.5±134.6
Weekly training load three months after screening tests (min)	310.5±131.7

Note. N: sample; SD: standard deviation.

Table 2. Results of the Functional Movement Screen and the Star Excursion Balance Test (N=42)

Variable	mean±SD
Functional Movement Screen	
Deep squat	1.8±0.7
Hurdle step	1.7±0.6
In-line lunge	1.7±0.8
Shoulder mobility	1.5±0.8
Active straight leg raise	2.2±0.5
Trunk stability push-up	2.6±0.6
Rotary stability	1.4±0.6
Total score	12.9±2.5
Star Excursion Balance Test (normalised (%))	
Dominant leg	
Anterior reach	58.5±2.5
Posteromedial reach	99.2±4.5
Posterolateral reach	96.2±3.8
Composite score	84.7±3.1
Non-dominant leg	
Anterior reach	59.4±2.5
Posteromedial reach	100.4±4.1
Posterolateral reach	97.2±3.6
Composite score	85.7±2.9

Note. SD: standard deviation.

tal score and posterolateral reach of dominant leg (r=0.503, p=0.001), as well as non-dominant leg (r=0.525, p<0.001). Fair correlations were recorded between FMS total score and anterior reach of dominant leg (r=0.323, p=0.037), posteromedial reach of dominant (r=0.407, p=0.007) and non-dominant leg (r=0.390, p=0.011) and composite SEBT score of the dominant (r=0.486, p=0.001) and non-dominant leg (r=0.453, p=0.003). Deep squat and hurdle step were fairly positively correlated with posterolateral reach of dominant (r=0.313, p=0.044; r=0.406, p=0.008) and non-dominant leg (r=0.425, p=0.005; r=0.401, p=0.009), as well as composite scores of dominant (r=0.305, p=0.049; r=0.342, p=0.027) and non-dominant leg (r=0.378, p=0.14; r=0.344, p=0.026). Active straight leg raise was fairly correlated with posterolateral reach of dominant (r=0.317, p=0.041) and non-dominant leg (r=0.368, p=0.017). Rotary stability was fairly correlated with anterior reach (r=0.347, p=0.024) and a composite score of the dominant leg (r=0.330, p=0.033).

Differences between participants with FMS score ≤14 and those with FMS score ≥15 regarding their weekly training load, the occurrence of injury and painful symptoms, and SEBT results are presented in Table 4. While there were no differences in weekly training load before and after screening between groups, we found that those with FMS score ≥15 had a lower occurrence of painful symptoms lasting longer than 24h (p=0.034), and injury or pain which caused temporary absence from practice sessions (p=0.018). Furthermore, those with FMS score ≤14 had also lower results of posteromedial reach of dominant (p=0.010) and non-dominant leg (p<0.001), posterolateral reach of dominant (p=0.011) and non-dominant leg (p=0.004), and a composite score of dominant (p=0.010) and non-dominant leg (p=0.001).

Table 3. Correlations Between the Functional Movement Screen and Star Excursion Balance Test

	Dominant leg SEBT				Non-dominant leg SEBT			
FMS	Anterior reach	PM reach	PL reach	Composite score	Anterior reach	PM reach	PL reach	Composite score
Deep squat	0.198	0.262	0.313*	0.305*	0.258	0.259	0.425*	0.378*
Hurdle step	0.182	0.267	0.406*	0.342*	0.110	0.299	0.401*	0.344*
In-line lunge	0.007	0.180	0.291	0.207	-0.033	0.205	0.292	0.212
Shoulder mobility	0.146	0.296	0.169	0.250	0.081	0.277	0.228	0.251
Active straight leg raise	0.213	0.228	0.317*	0.294	0.146	0.218	0.368*	0.299
Trunk stability push-up	0.274	0.000	0.183	0.121	-0.103	-0.030	0.092	-0.005
Rotary stability	0.347*	0.278	0.254	0.330*	0.162	0.216	0.193	0.233
Total score	0.323*	0.407*	0.503*	0.486*	0.158	0.390*	0.525*	0.453*

Note. FMS: Functional Movement Screen; SEBT: Star Excursion Balance test; PM: posteromedial; PL: posterolateral; *significant correlation p<0.05.

Table 4. Differences Between Participants with FMS Score ≤14 and FMS Score ≥15 (N=42)

Variable	FMS ≤14 (N=29) (N(%) or mean±SD)	FMS ≥15 (N=13) (N(%) or mean±SD)	p
Weekly training load six months before screening tests (min)	320±136.5	366.9±129.6	0.302
Weekly training load three months after screening tests (min)	310.9±134.2	309.2±131.2	0.971
Painful symptoms lasting longer than 24h			
Yes	17 (58.6)	3 (23.1)	0.035a*
No	12 (41.4)	10 (76.9)	
Injury or pain which caused temporary absence from practice sessions			
Yes	13 (44.8)	1 (7.7)	0.018a*
No	16 (55.2)	12 (92.3)	
Star Excursion Balance Test (normalised (%))			
Dominant leg			
Anterior reach	58.2±2.7	59.2±1.8	0.194
Posteromedial reach	98±4.5	101.8±3.6	0.010b*
Posterolateral reach	95.3±3.7	98.4±3.1	0.011b*
Composite score	83.8±3.2	86.5±2.1	0.010b*
Non-dominant leg			
Anterior reach	59.2±2.8	60±2	0.325
Posteromedial reach	99.2±4.3	103±1.9	<0.001b*
Posterolateral reach	96.2±3.6	99.5±2.5	0.004b*
Composite score	84.8±3	87.6±1.6	0.001b*

Note. FMS: Functional Movement Screen; N: sample; SD: standard deviation; *statistically significant; aFisher's exact test; bIndependent samples T-test.

Discussion

This study aimed to examine if there is a relationship between FMS and SEBT scores in non-professional soccer players. Furthermore, the secondary purpose was to explore if significant differences in the occurrence of injury, painful symptoms, and SEBT scores exist between participants with FMS score ≤14 and ≥15. The results confirmed our both hypotheses. We reported numerous significant correlations between FMS and SEBT scores. Players who scored ≤14 on the FMS had a higher occurrence of injuries and painful symptoms, and all their SEBT scores, except anterior reach, were significantly lower than in those with FMS score ≥15. To the best of our knowledge, only two previous studies have examined the relationship between FMS and SEBT scores, and none in non-professional soccer players, which makes a comparison of our study with other studies difficult.

One of the previous studies examining the relationship between FMS and SEBT scores was performed by Harshbarger et al. (2018). They investigated the relationship between FMS and SEBT scores in 52 intercollegiate athletes of both genders from 8 team sports. Majority of their sample consisted of males playing American football (38.5%), and they only had 2 male soccer players (3.8%) in their sample. Contrary to our results, they reported little-to-no correlations between the composite scores of the FMS and SEBT. Furthermore, they reported no-to-fair correlations between FMS item scores and SEBT composite scores. The only significant correlations were reported between FMS rotary stability score and the anterior and posteromedial reach direction of the SEBT which were also reported in our study.

Another previous study, conducted by Armstrong (2019) also examined the relationship between FMS and SEBT scores in 47 female university dancers. Author reported 11 significant correlations between FMS and SEBT. In that study, FMS composite score positively correlated only with anterior reach of the dominant leg which was also present in our study, but we also recorded significant correlations between FMS composite score and other SEBT components. SEBT composite score in Armstrong's study only correlated with rotary stability while we also recorded correlations between SEBT composite score and deep squat, hurdle step, and total FMS score. Furthermore, in that study, posterolateral reach of non-dominant leg only correlated with rotary stability. On the contrary, in our study, posterolateral reach of non-dominant leg correlated with deep squat, hurdle step, active straight leg raise and total FMS score, but not with rotary stability. Furthermore, Armstrong (2019) found several correlations between anterior reach and FMS items (hurdle step, shoulder mobility, active straight leg raise) which we did not confirm in our study except the correlation between total FMS score and the anterior reach of the dominant leg.

Our results showed correlations between FMS total score and SEBT composite score as well as all but one component of the SEBT test. Although the previous two studies did not find such distinctive and strong correlations, our sample was quite different, especially in their FMS total score which was on average only 12.9. We had players with relatively low FMS score and almost all of them had SEBT score <89.6% which is a predictor of non-contact lower extremity injury (Plisky et al., 2021). These scores imply that we had a high-risk population of athletes with possibly significant deficits in their functional capacity of movement and significant potential for improvements in neuromuscular control. It seems that in this population FMS scores capture some of the same constructs for postural stability as SEBT, and that the FMS could be a good indicator of whole-body dynamic stability. The observed relationship between FMS items and SEBT components could also provide some ideas regarding performance interventions and preventive strategies using training of these specific movements for the purpose of reduction of musculoskeletal problems. Preventive exercise programs for soccer players, based on FMS screening, have proven not only to improve FMS results, but also decrease non-contact injury rates (Dinc, Kilinc, Bulat, Erten, & Bayraktar, 2017).

FMS is a very popular clinical screening tool (Cook et al., 2006a; Cook et al., 2006b), however, its predictive role is controversial. In our study, we compared players with FMS scores ≤14 and ≥15 and found that those with scores ≤14 are more affected by injuries and painful symptoms. A systematic review conducted by Bonazza, Smuin, Onks, Silvis, & Dhawan (2017) supported the injury predictive value of the FMS and reported that scoring ≤14 is associated with a small threefold increase in all-cause injury odds in athletes, firefighting and military population. However, Dorrel, Long, Shaffer, & Mayer (2015), and Moran, Schneiders, Mason, & Sullivan (2015) in their systematic reviews did not support its use as an injury prediction tool. A recent systematic review performed by Moore et al. (2019) reported that the FMS composite score ≤14 can be associated with small harmful effects in male and senior athletes, however, effect sizes are small.

The current study has some limitations. First, our sample was small and consisted of only male non-professional soccer players from three soccer clubs which makes it difficult to generalize our results. Also, our follow-up period was quite short and we did not analyze players' injuries regarding their type, mechanism, and region of the body. Future studies should consider a larger population which will include both male and female athletes, different sports, detailed analysis regarding injuries and painful symptoms, and a longer period of follow-up.

In conclusion, our data suggest a significant relationship between FMS and SEBT scores. Furthermore, it seems that non-professional soccer players with FMS score ≤14 are more prone to injuries and painful symptoms, and they have lower SEBT scores. Further studies are needed to confirm these findings.

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Conflict of Interest
The author declares that there is no conflict of interest.

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