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Quality of functional movement patterns and injury examination in elite-level male professional football players

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The purpose of this study is to examine the quality of functional movement patterns among one of Hungary's first league soccer clubs, where the elite male football players ($N = 20$) utilize the well-established Functional Movement Screen™ (FMS) system; a comprehensive functional program designed to determine and identify the quality of movement and the greatest risk factors for non-contact injuries. Furthermore, an additional purpose of this program is to examine injuries over the course of 6 competitive months. Focusing on the mechanisms of injuries and their causes in the lower extremities during this period is one of the key objectives. Over the course of 6 months we found significant differences between ankle injuries and the FMS Hurdle Step exercise ($p < 0.05$), and the FMS Deep Squat exercise and knee and hip injuries ($p < 0.05$). The FMS pre-screening system found lower limb asymmetry present in 40% of the participants. The authors believe that the importance of preventative measures and structural sport specific pre-screening cannot be overemphasized, and that there is a growing need for further transparent research in this field in order to be more effective with regard to programs dedicated to injury prevention and the enhancement players' physical performance.

Keywords: functional movement, injury, football, prevention, performance

Today, football is one of the most widely viewed spectator sports in the world. In the game of football, a match consists of two 45-minute halves with a 15-minute break in between (63). The popularity of the sport as a spectator sport can be attributed to a system by which, on the international level, people have the opportunity to watch an average of 2–3 matches a day. This means that modern professional football places ever higher physical and mental demands on athletes; one of the consequences of which is an increase in the number of injuries during matches (9, 18). This underlies the fact that professional male football tends to have the broadest high range of risk factors regarding injuries when compared to other sports (19, 49, 62, 64). As a result of linear and significant developments in recent years, athletes are required to prove that they possess the extraordinary physical capabilities necessary to be competitive.

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It is therefore of particular importance to investigate sport specific associations between match load and recovery time, as well as assess the risk exposure, injury epidemiology, circumstances of injury and both injury and recurrence rates (5, 60). The accelerated pace of football brings about increased physical strain (13), while in the course of structured preparation, the application of special training methods is becoming more and more important (7). For this reason, pre-screening, model of prevention strategies and functional movement quality have increased significance, alongside abilities measured in motor tests, warm-up exercises, cool-down, structured application of stretching and appropriate medical care (16, 43, 58). Partly in view of these aspects, football's international world organization, Fédération Internationale de Football Association (FIFA), has conducted a 15-year scientific research representing the most extensive study in this sport, the F-MARC project. The research focused on studying injuries specific to football, in addition to the mechanism of injury and preventive strategies specific to football. One of the most important findings of the F-MARC program has been the significant increase in the occurrence of non-contact injuries in football, which has also been shown by several other authors in international studies (3, 18). To reduce the frequency of injury potential, FIFA has created a structured set of warm-up exercises in the form of a "The 11+" preventive program that has repeatedly proven its efficiency in the field of prevention, performance improvement, muscular strength and balancing (8, 50, 54). The exercises of the program focus on core stabilizations, neuromuscular and proprioception exercises, static and dynamic stabilizations and the development of plyometric skills (40). There is a significant amount of earlier international research that prove the high ratio of injuries in football (30, 31, 37, 48) and the fact that these injuries most frequently occur in the lower extremities (20, 21), where the largest single risk factor for the footballers consists of the non-contact injury of the anterior cruciate ligament (ACL) (1, 22, 59). Furthermore, the quality of movement patterns, especially the lower extremity patterns, is an important and modifiable factor that may influence the risk of ACL injury as well as play a critical role in injury mechanism (2, 6, 14). In order to reduce the frequency of these injuries, advice regarding prevention and rehabilitation is needed with actual strengthening programs for the treatment of the muscle imbalance, stretching exercises to moderate muscle stiffness, as well as proprioceptive programs for the improvement of balance and bodily movement (4, 27, 47). Moreover, increased importance is attributed to continuous pre-screening and warm-up exercise programs based on sports-specific, position-specific drills (35). These drills contain stabilizations (26) as well as proprioceptive and strength trainings (46) to reduce the risk of the occurrence of injuries (52) and to improve physical performance and rehabilitation (10, 42). The Functional Movement Screen (FMS) system determines the strength of the muscle system, flexibility, the articular range of movement, stability and mobility function and coordination. It further defines individual movement limitation, musculoskeletal discomfort and functional asymmetry in the movement patterns, which is one of the areas which carry the largest risk factors for injuries (11). The results of the international FMS tests confirm that if an athletes' performance is under 14, out of a maximum of 21 points, then the occurrence of non-contact injuries is more likely (39).

The aims of this study were to investigate the movement limitations in teams of elite footballers, and in addition, to investigate the quality of functional movement patterns at the positional level, anthropometric parameters and injury characteristics, and to describe the variations of injury incidence and circumstances during half competitive seasons, and to find correlations among the data.

Materials and Methods

Participants

The physical parameters, functionalities and injuries of elite footballers involved in the research were examined at one of the first league football clubs in Hungary. All the members of the team (N = 20) were assessed for joint hypermobility using the Beighton scale (57) at the start of the season. This is an inclusion and exclusion criterion in the examination. In terms of their positions, 2 of the footballers involved in the examined sample were goalkeepers, 8 were defenders, 6 were midfielders and 4 were forwards.

Anthropometry

We have studied the body height, body weight and Body Mass Index (BMI) of footballers. Athletes' body height was measured by wall-mounted stadiometer and body weight was analyzed with the body composition analyzer (Inbody 720, Biospace Co.). BMI was later calculated according to a protocol outlined by Nevill et al. (44).

Injury protocol

The injuries of the examined footballers were measured for 6 months, from August 2012 until January 2013. The injuries of the participants and the associated circumstances were monitored with the use of a standardized injury register similar to the system described by Hagglund et al. (28) which was developed by the medical committee of the team and the technical staff. We collaborated closely on a weekly basis with the team's medical board via telephone and e-mail, and met them in person once a month. The seriousness of the injuries was determined in view of the duration of the individual injuries: minimal (duration: 1–3 days); moderate (duration: 4–7 days); average (duration: 8–28 days) and serious (> 28 days) (9, 24).

Functional Movement Screen

In this pre-screening study, the quality of the footballers' functional movement patterns was measured. The FMS measurement procedure was used. The test practices established the risk factors with respect to non-contact injuries. The seven movement tests of pre-screening are Deep Squat (DS), Hurdle Step (HS), In-line Lunge (ILL), Shoulder Mobility (SM), Active Straight Leg Raise (ASLR), Trunk Stability Push-Up (TSPU) and Rotary Stability (RS). The positions and movements of the players were evaluated on a scale of 0–3 (3-2-1-0) where 3 reflected correct movement without compensation, 2 stood for correct movement with the occurrence of compensation, 1 represented incorrect and compensated movement, and 0 where an occurrence of pain could be ascertained (25). After the seven exercises, the athletes could achieve maximum 21 points. An FMS specialist conducted the tests.

Statistical analysis

For data processing, the SPSS 21.0 Statistical Program was used, while descriptive statistics and analysis were applied to characterize the samples and determine the differences of position, respectively, by ANOVA test with post hoc comparison (Scheffe process). To prove the relationship between injuries and FMS, Pearson's correlation study was conducted. The significance level was set at $p < 0.05$. The statistical power was 0.56.

Results

Participants in the study ($N = 20$) had an average age of 23.00 ± 3.00 years with 182.25 ± 5.02 cm average body height, 76.75 ± 6.97 kg average body weight, and an average BMI value 23.09 ± 1.73. We have not been able to show a significant difference of anthropometric characteristics because of the small sample size studied. The average FMS value was 14.75 ± 1.51 points. The average value of the 7 different screening exercises applied by FMS was DS 2.05 ± 0.51; HS 1.95 ± 0.39; ILL 1.70 ± 0.65; SM 2.30 ± 0.73; ASLR 2.25 ± 0.78; TSPU 2.35 ± 0.67; RS 2.00 ± 0.0.

After the FMS measurements, the examined players were monitored for an additional 6 months. Altogether 29 injuries were recorded during half of the competitive season. These injuries included 6 ankle joint injuries (21%), 6 knee joint injuries (21%), 6 hip joint injuries (21%), 3 shoulder joint (10%) injuries and 8 muscle strains (27%). In total, 29 injuries were registered, with 24 (83%) occurring during matches and 5 (17%) during training loads. On average, a player sustained 1.5 injuries per half competitive season, resulting in 29 injuries per 6 months in a team of 20 football players.

Only 4 of the examined players did not have any injuries during the 6 months. Of the 29 injuries suffered, the mechanisms of 19 injuries (66%) were not contact type, while 10 injuries (34%) were of some contact type. Looking at the durations of the injuries, we found 5 minimal (duration: 1–3 days), 11 moderate (duration: 4–7 days), 13 medium (duration: 8–28 days) and 0 serious (> 28 days) injuries during the aforementioned term of 6 months. The dominant limb of each player was determined by the Hoffman method (33). The FMS study identified a dominant leg and non-dominant leg functional performance for each player and established lower limb asymmetry for 40% of the participants. Five of the 20 footballers had left leg dominance, while in 15 cases right leg dominance could be ascertained. After half a year, it could be established that 19 of the 29 injuries were suffered on the right side, whereas 10 injuries occurred on the left side. This supports the earlier international studies of Hawkins et al. (31), which has shown that football players are more likely to injure themselves on the dominant side than the non-dominant side (Tables I and II).

On the basis of the data obtained during the FMS assessment of the footballers participating in the study and the further examination of the injuries occurring during those 6 months, significant differences were found between ankle injuries and the HS exercise ($p < 0.05$), as well as DS and knee, and hip injuries ($p < 0.05$). We have uncovered the highest DS and TSPU scores for goalkeepers and considered that our findings were due to the specific physical demands being resulted from their position. During jump and collision, that are the most fundamental part of goalkeeper's football specific movements profile, DS and TSPU assessments are very important. We have found the best HS scores for defenders. The HS evaluation is a reflection of the essential skills required during slipping and tackles for defenders. Our study revealed average FMS performance for midfielders. We believe however that the results are very good considering their highest technical, intermittent endurance and physical demands during the game. We have seen the highest SM and ASLR scores for strikers that are a true reflection of their position specific physical demands and performances. Position-specific movements of strikers are best describe by hig-intensity acceleration, deceleration and sprint. Essential attribute for this is the optimal SM that can ensure adequate running speed and movement coordination. Furthermore the optimal ASLR support to extremely chances to scoring to goal (Table III).

Table I. Physical characteristics of the soccer players by playing position

	Mean ± SD (N = 20)	**Goalkeeper (N = 3)**	**Defender (N = 8)**	**Midfielder (N = 5)**	**Forward (N = 4)**
Age (year)	23.00 ± 3.00	22.67 ± 3.05	24.13 ± 3.18	22.60 ± 3.78	21.50 ± 1.29
Body weight (kg)	76.75 ± 6.97	82.33 ± 2.88	78.00 ± 5.9	71.00 ± 5.00	77.25 ± 9.84
Body height (cm)	182.25 ± 5.02	185.33 ± 1.52	181.25 ± 5.77	180.00 ± 5.14	184.75 ± 4.03
Body Mass Index	23.09 ± 1.73	23.96 ± 0.85	23.77 ± 1.91	21.90 ± 1.04	22.57 ± 1.95

Table II. FMS results of soccer players by playing position

	Mean ± SD (N = 20)	**Goalkeeper (N = 3)**	**Defender (N = 8)**	**Midfielder (N = 5)**	**Forward (N = 4)**
FMS main score	14.75 ± 1.51	15.00 ± 1.00	15.13 ± 1.72	14.40 ± 1.94	14.25 ± 0.95
Deep Squat	2.05 ± 0.51	2.33 ± 0.57	2.00 ± 0.53	2.00 ± 0.70	2.05 ± 0.03
Hurdle Step	1.95 ± 0.39	2.00 ± 0.00	2.13 ± 0.35	2.00 ± 0.06	1.50 ± 0.57
In-Line Lunge	1.7 ± 0.65	1.67 ± 0.57	1.75 ± 0.7	1.60 ± 0.89	1.75 ± 0.5
Shoulder Mobility	2.3 ± 0.73	2.33 ± 0.57	2.00 ± 0.75	2.40 ± 0.89	2.75 ± 0.43
Active Straight Leg Raises	2.25 ± 0.78	2.00 ± 1.0	2.50 ± 0.76	1.80 ± 0.83	2.53 ± 0.58
Trunk Stability Pushup	2.35 ± 0.67	2.67 ± 0.57	2.63 ± 0.51	2.20 ± 0.81	1.75 ± 0.5
Rotary Stability	2.0 ± 0.00	2.0 ± 0.00	2.0 ± 0.00	2.00 ± 0.00	2.0 ± 0.00

Table III. Comparison of FMS results and injuries

	Ankle injury		**Knee injury**		**Hip/Groin injury**		**Shoulder injury**		**Muscle strain**	
Groups	yes (N = 6)	no (N = 14)	yes (N = 6)	no (N = 14)	yes (N = 6)	no (N = 14)	yes (N = 3)	no (N = 17)	yes (N = 8)	no (N = 12)
FMS mean score	14.6 ± 1.2	14.7 ± 1.6	15 ± 1.89	14.64 ± 1.39	14.5 ± 1.64	14.86 ± 1.51	14.67 ± 0.57	14.76 ± 1.64	14 ± 2.09	15.07 ± 1.14
Deep Squat	2.17 ± 0.4	2 ± 0.55	1.67 ± 0.51*	2.21 ± 0.42*	1.67 ± 0.51*	2.21 ± 0.42*	2 ± 0	2.06 ± 0.55	2 ± 0.63	2.07 ± 0.47
Hurdle Step	1.67 ± 0.5*	2.07 ± 0.2*	2 ± 0	1.93 ± 0.47	2 ± 0	1.93 ± 0.47	2 ± 0	1.94 ± 0.42	2 ± 0	1.93 ± 0.47
In-Line Lunge	1.67 ± 0.5	1.71 ± 0.72	1.67 ± 0.81	1.71 ± 0.61	1.5 ± 0.54	1.79 ± 0.69	1.33 ± 0.57	1.76 ± 0.66	1.5 ± 0.54	1.79 ± 0.69
Shoulder Mobility	2.83 ± 0.4	2.07 ± 0.73	2.33 ± 0.81	2.29 ± 0.72	2.5 ± 0.83	2.21 ± 0.69	2.33 ± 0.57	2.29 ± 0.77	2.5 ± 0.83	2.21 ± 0.69
Active Straight Leg Raises	2.17 ± 0.7	2.29 ± 0.82	2.33 ± 0.81	2.21 ± 0.8	2.17 ± 0.75	2.29 ± 0.82	2.33 ± 0.57	2.24 ± 0.83	1.83 ± 0.98	2.43 ± 0.64
Trunk Stability Pushup	2.17 ± 0.7	2.43 ± 0.64	2.33 ± 0.81	2.36 ± 0.63	2 ± 0.89	2.5 ± 0.81	2 ± 1.	2.41 ± 0.61	2.33 ± 0.81	2.36 ± 0.63
Rotary Stability	2 ± 0	2 ± 0	2 ± 0	2 ± 0	2 ± 0	2 ± 0	2 ± 0	2 ± 0	2 ± 0	2 ± 0

* Significant difference between FMS exercises and the injuries $p < 0.05$

During the examination period injured players had lower FMS scores than non-injured ones. When analyzing the FMS scores and injuries on the basis of additional aspects, it was found that the players who did not have injuries typically achieved better FMS scores in their average results than their injured peers, though this difference was not significant in terms of the variables.

Discussion

The aim of this study was to identify correlations between the results of the quality of functional movement patterns and sustained injuries, and then to examine the associated aspects in view of the individuals, the team and football positions. Descriptive statistical analyses determined that in the examined sample, goalkeepers had the largest body heights and body weights (185.33 ± 1.52 cm; 82.33 ± 2.88 kg), while the smallest body heights and body weights (180.00 ± 5.14 cm; 71.00 ± 5.00 kg) belonged to the midfielders, which was confirmed by several other authors in their earlier scientific research studies (32, 56). The FMS results for the examined footballers have shown that defenders have the best total scores in comparison with the other positions of footballers (goalkeepers, 15.00 ± 1.00; defenders, 15.13 ± 1.72; midfielders, 14.40 ± 1.94; forwards, 14.25 ± 0.95). With respect to the positions, none of these groups fell under the 14-point limit internationally stated to be critical for FMS studies, while the entire team, the midfielders and forwards were similarly unable to exceed 15 points, which does not suggest optimal functional movement patterns in the functionalities of the footballers playing at the highest levels. Hagglund et al. (29) have reported that the altered movement patterns after a previous injury may provide higher injury risk factors for the following league season. The analysis of the 7 various screening exercises established and used by FMS has suggested that the poorest average results are brought about by ILL (1.70 ± 0.65) and HS (1.95 ± 0.39), while the best average results belong to the TSPU (2.35 ± 0.67) and SM (2.30 ± 0.73). *We assume that the underlying reason here is that there is an adaptation in the stability and mobility of the joints of the lower limbs and a reduced range of motion, not only in the joints, but in the entire muscle system as well resulting from the special physical requirements of football*. Another important finding was that the FMS study recorded higher instances of limb asymmetry, which is one of the highest risk factors for non-contact injuries. The related clinical conclusions refer to problems in connection with the functional immobility and instability of joints (55), as well as the improper functioning of proprioception (12). The risk factors of injuries can be reduced, and the right- and left-side asymmetries can be corrected with the application of progressive intervention programs (38), also resulting in an improvement in physical performance (51).

In modern football, there are a very large number of components that need to work optimally so that the highest possible level of physical performance can be achieved (34). The increased annual number of matches, the larger overall distance of running required in the matches, as well as frequent changes in direction, deceleration and cut movements of running (41) compel players to reach ever-higher levels of physical performance, which further raises the number of non-contact injuries (23). Consequently, the roles of experts working with the teams have become more important (61). The members of the technical staff support the development of players by analyzing the matches (15) and utilizing pre-screening routines, continuous structural injury surveillance, sport-specific and position-specific comprehensive efficiency prevention programs (36), and performance programs which include improved coordination and proprioception, flexibility, core strength, and dynamic joint stabilization and mobilization function. It has been proven that these factors reduce the frequency of injuries and improve physical performance (17, 45, 53). This particular study would be greatly served by an even larger sample size, therefore, the authors cannot emphasize enough the importance of an organized multimodal and collaborated research effort in elite level male professional football players.

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