J. Phys. Ther. Sci. 32: 850–855, 2020

The Journal of Physical Therapy Science

Original Article

Reliability assessment of the functional movement screen for predicting injury risk in Japanese college soccer players

Takayuki Miyamori, PhD[1, 5)*], Masashi Nagao, MD, PhD[2–4)], Yu Shimasaki, MS[4)], Takayuki Okazaki, MS[5)], Naoki Akiyoshi, PhD[4)], Hirofumi Nishio, MD, PhD[2, 4)], Yuji Takazawa, MD, PhD[2, 5)], Masafumi Yoshimura, PhD[4, 5)]

[1)] *Department of Physical Therapy, Faculty of Health Science, Juntendo University: 2-1-1 Hongo, Bunkyo-ku, Tokyo 113-8421, Japan*
[2)] *Department of Orthopedic Surgery, Faculty of Medicine, Juntendo University, Japan*
[3)] *Medical Technology Innovation Center, Juntendo University, Japan*
[4)] *Department of Sports Science, Faculty of Health and Sports Science, Juntendo University, Japan*
[5)] *Graduate School of Health and Sports Science, Juntendo University, Japan*

Abstract. [Purpose] This study aimed to assess the reliability of the Functional Movement Screen and explore whether this evaluation tool can predict the risks of personal injuries in Japanese soccer players. [Participants and Methods] Seventy-five Japanese college soccer players who participated in our 1 year prospective cohort study underwent a Functional Movement Screen assessment. Demographic data, athletic characteristics, and types and frequency of injuries sustained, were analyzed with the assessment results. [Results] There was no significant difference in the mean Functional Movement Screen composite scores between genders. Although the Functional Movement Screen showed excellent inter-rater reliability (0.92), low overall internal consistency (0.35) was observed. A maximum score of 3 in straight leg raise occurred in 94% of the females and was considered a ceiling effect. None of the cut-off point scores of the Functional Movement Screen were associated with the number of overall injuries, lower limb injuries, and traumatic injuries, or time to return to play. The Functional Movement Screen composite score of ≤15 represented the maximum sensitivity of 76.92% and specificity of 34.78% with 0.56 in the area under the curve. [Conclusion] Functional Movement Screen composite scores do not have sufficient sensitivity and specificity for predicting injuries in Japanese college soccer players.

Key words: Functional movement screening, Injury prediction, Soccer players

(This article was submitted Jul. 25, 2020, and was accepted Sep. 22, 2020)

INTRODUCTION

Soccer is the most popular sport in the world and its popularity and participation rates are continuously growing[1)]. It is an intermittent sport where players walk, kick, run, and sprint. The rates of injury incidences in soccer are reported to be higher compared to many other sports[2)], and most of the soccer players experience injuries that occur mainly in the lower extremities.

Numerous components have been proposed as risk factors for overall injuries. Regarding playing actions, roughly half of the injuries are related to physical contact such as tackling, being tackled and collisions, which are mostly believed to be unintentional; the rest are related to non-contact actions such as running, turning, jumping, and heading[3)]. Since short- and

*Corresponding authors. Takayuki Miyamori (E-mail: t.miyamori.hi@juntendo.ac.jp);
Masafumi Yoshimura (E-mail: msyoshi@juntendo.ac.jp)

the long-term absences from games could potentially affect athletes' careers, identifying a whether a player is at high risk for action related injuries is necessary.

The Functional Movement Screen (FMS) is an evaluation tool that attempts to assess the fundamental movement patterns of an individual[4]. The FMS consists of 7 movement patterns that assess balance, mobility, and stability. It was designed to evaluate the functional movements required to participate in higher-level sports. Some previous studies demonstrated that low FMS scores were associated with serious injuries or high injury rates in sports[5, 6]. The FMS is gaining international acceptance, and many professional sports teams have utilized it as an injury risk screening measure. However, recently, a meta-analysis showed that the FMS had an insufficient predictive value and a cohort study in male soldiers reported a low predictive value for injury risk[7, 8].

In the present study, we evaluated the reliability of the FMS and assessed whether an FMS score could predict a player at high risk of injury in Japanese elite college soccer players.

PARTICIPANTS AND METHODS

A 1 year prospective cohort study was conducted from March 2014 to March 2015 in Japan. We recruited 77 elite college soccer athletes. All athletes were members of college soccer teams, which are classified as division 1, according to the Kanto University Soccer League and the Kanto University Woman Soccer League. Their training and gaming surfaces were mostly third-generation artificial turf or natural grass. Exclusion criteria were as follows: the use of a mobility aid or prophylactic device such as a knee brace, or athletes with a recent (<6 weeks) musculoskeletal or head injury. We excluded 2 athletes had recent musculoskeletal injuries and enrolled 75 (47 males and 28 females) soccer players in this study. Injuries were monitored by a physiotherapist (TM), and diagnosed by medical doctors in interviews, physical examinations, and /or medical imaging included X-rays. Both traumatic and overuse injuries were included in the analysis. A traumatic injury referred to an injury caused by a specific, identifiable event, while an overuse injury was categorized as repeated microtrauma injuries without a single identifiable event responsible for the injury[9]. Rehabilitation treatment after injuries was performed by an athletic trainer once a week.

A survey was administered to collect information of personal characteristics and demographics of the participants such as age, body height, body weight, body mass index (BMI), years of experience, position and leg dominance.

The present study was approved by the ethics committee of Juntendo University (approval number: 27-18), and informed consent was obtained from all the participants.

An assessment with the FMS was conducted at the beginning of the study. The FMS included 7 movement patterns: a deep squat, hurdle step, in-line lunge, shoulder mobility test, active straight leg raise, trunk stability push-up, and rotary stability test. Each movement pattern was scored on a range of 0–3, with a possible maximum score of 21. Details of the 7 FMS movement patterns are previously described[4, 10]. Each participant was given a general overview of each movement before the test. The FMS was recorded by video cameras from a standardized frontal and sagittal view and assessed by 2 experienced physiotherapists, who had the experience in conducting the FMS test and had worked for professional or national-level youth soccer teams for over a decade.

Descriptive statistics were performed with the participants' personal characteristics and demographic data. The FMS composite score was compared for males and females with unpaired Student's t-tests. Inter-rater reliability was assessed using the Kappa Statistic, and internal consistency reliability was assessed by Cronbach's α[11]. Cronbach's α between 0.70 and 0.95 is considered a strong correlation[12], and a minimum of 0.90 is considered a tolerated score when measuring individuals[13]. For floor and ceiling effects, those are considered present when more than 15% of respondents score with the lowest or highest possible score[12]. To analyze the association between the potential predictive baseline variables including age, body height, body weight, and BMI, and the FMS score, we conducted univariate regression analyses. To evaluate the associations between either the number of injuries, lower limb injuries, traumatic injuries or time to return to play and the FMS composite score, the score of ≤14, ≤15, ≤16, ≤17, and ≤18 were used as cut-off points in the univariate and multivariate logistic regression models. For the multivariate logistic regression model, we adjusted age and BMI as continuous variables to obtain odds ratios[14] and 95% confidence interval (95% CI). For the variable of time to return to play, cumulative days away from the full training or games were classified into 5 categories: within a week, 1–2 weeks, 2–4 weeks, 1–2 months, and over 2 months. The receiver operating characteristic (ROC) curve was constructed, and the area under the ROC curve (AUC) was calculated to acquire the diagnostic accuracy. The specificity and sensitivity were further calculated. All p values were 2-sided, and p values less than 0.05 were considered statistically significant. Statistical analyses were performed with Stata 13.0 (Stata Corp LP, College Station, TX, USA).

RESULTS

A total of 75 (males, 47; females, 28) Japanese soccer players completed the FMS assessment Participants' characteristics of age, body height, body weight, BMI, years of experience, position on the team, and leg dominance at the time of the FMS assessment are shown in Table 1. The total of 82 injuries were reported; 34.1% were overuse injuries, and 67.1% were traumatic injuries (Table 2). Of the overall injuries, 87.8% were in the lower limbs. Thirty-one of male (66.0%) and 21

(75.0%) of female players reported at least 1 injury. The time for return to play was also shown in Table 2. The composite mean score on the FMS for males and females was 16.04 (95% confidence interval [95% CI], 15.62–16.46) and 16.46 (95% CI, 15.89–17.04), respectively (Table 3), and there was no statistical difference between each gender.

The inter-rater reliability of the FMS composite score among the 2 examiners was 0.92, which indicated excellent inter-rater reliability. The Cronbach's α was calculated, and the overall internal consistency was 0.35, which indicated low reliability. Since 96.4% of the females had a maximum score of 3 in the straight leg raise tests, this was considered a ceiling

Table 1. Baseline values of body composition and other demographics of the study population

	Male (N=47)	Female (N=28)	p value
Age ± SD, range (years)	19.9 ± 1.4	19.8 ± 1.4	0.35
Body height ± SD (cm)	174.3 ± 6.2	160.1 ± 4.6	**<0.001
Body weight ± SD (kg)	67.8 ± 5.5	54.9 ± 4.6	**<0.001
BMI ± SD (kg/m^2)	22.3 ± 1.1	21.4 ± 1.5	**<0.001
Years of experience (years)	14.2 ± 2.1	11.3 ± 3.9	**<0.001
Position (n)			
FW	6	4	
MF	19	12	
DF	16	9	
GK	6	2	
Leg dominance, right/left (n)	41/6	28/0	0.08

SD: standard deviation; BMI: body mass index; FW: forward; MF: mid fielder; DF: defender; GK: goal keeper.

Table 2. Types of injury and duration for returning to play

	Male (N=47)	Female (N=28)	Total (N=75)
Total number of injuries (n)	44	38	82
Pattern of injury			
Overuse injuries (%)	44 (34.1%)	38 (34.2%)	82 (34.1%)
Traumatic injuries (%)	32 (72.7%)	23 (60.5%)	55 (67.1%)
Site of injury (%)			
Ankle	14 (31.8%)	13 (34.2%)	27
Thigh	13 (29.5%)	6 (15.8%)	19
Knee	8 (18.2%)	6 (15.8%)	14
Leg	3 (6.8%)	3 (7.9%)	6
Back	1 (2.3%)	4 (10.5%)	5
Foot	1 (2.3%)	2 (5.3%)	3
Hip	0	3 (7.9%)	3
Shoulder	1 (2.3%)	1 (2.6%)	2
Others	3	0	3
Time to return to play (%)			
Within a week	11 (25.0%)	17 (44.7%)	28
1–2 weeks	8 (18.2%)	6 (15.8%)	14
2–4 weeks	10 (22.7%)	4 (10.5%)	14
1–2 months	7 (15.9%)	5 (13.2%)	12
Over 2 months	6 (13.6%)	4 (10.5%)	10
Unknown	2 (4.5%)	2 (5.3%)	4
Number of injury			
0	15	7	22
1	23	10	33
2	6	6	12
3	3	4	7
4	0	1	1

effect. No floor effects were observed in both genders.

The mean FMS composite scores in both genders were comparable. The score (95% CI) of the individual tests in males and females are shown in Table 3. The mean score of the active straight leg raise was significantly higher for females compared to males. Univariate regression analysis showed that age, body weight, body height, and BMI were not associated with the FMS composite scores and the β-coefficients (95% CI, p-value) were 0.18 (−0.63 to 0.43, p=0.14), −0.01 (−0.05 to 0.03, p=0.61), −0.01 (−0.05 to 0.02, p=0.47) and −0.03 (−0.28 to 0.22, p=0.80), respectively. None of the cut-off points in either the univariate or multivariate models were associated with the number of injuries (Table 4). The same trend was also observed in the association with lower limb injuries, traumatic injuries and the time to return to play. ROC analysis showed that an FMS composite score of ≤15 maximized sensitivity and specificity for the number of injuries. The AUC was 0.56 (95% CI, 0.44 to 0.67). The cut-off points represented a sensitivity of 76.92% and specificity of 34.78%.

DISCUSSION

We performed a 1 year prospective study to explore whether the FMS was reliable and capable of predicting if an individual had a high risk for injury in Japanese elite college soccer players. Our study demonstrated excellent inter-rater reliability but a low value for the internal consistency reliability on Cronbach's α. Additionally, we demonstrated a low FMS composite score of ≤15 maximized the sensitivity, specificity, and AUC for the number of injuries. However, the predictive values were not sufficient for use as an injury screening tool. Though some studies showed high predictive values[5, 6], our results were consistent with the recent extensive cohort studies in the military, in which the FMS had low predictive values for predicting if an individual had a high risk of injury[7, 15]

With regards to the inter-rater reliability of the FMS, recent studies have indicated that the FMS demonstrated good to excellent agreement[16, 17] However, some studies have shown a low inter-rater reliability when the raters were not well trained in the FMS methods[18, 19]. A previous study reported that athletic trainers (ATs) who were certified for the FMS method demonstrated an excellent reliability of 0.95 in intraclass correlation coefficients (ICC) compared to less experienced ATs

Table 3. Functional movement screen scores by 7 movement patterns

Test	Male (95%CI) (N=47)	Female (95%CI) (N=28)	p value
Deep squat	2.17 (1.98–2.36)	2.18 (1.97–2.39)	0.95
Hurdle step	2.11 (2.00–2.22)	2.18 (2.02–2.33)	0.43
Lunge	2.19 (2.02–2.37)	2.18 (1.99–2.36)	0.92
Shoulder mobility	1.94 (1.74–2.13)	2.18 (1.90–2.46)	0.15
Active straight leg-raise	2.77 (2.63–2.91)	2.96 (2.89–3.03)	0.04*
Trunk stability push-up	2.85 (2.75–2.96)	2.75 (2.58–2.92)	0.28
Rotary stability	2.02 (1.93–2.12)	2.04 (1.87–2.20)	0.87
Total FMS	16.04 (15.62–16.46)	16.46 (15.89–17.04)	0.23

95%CI: 95% confidence interval.

Table 4. Univariate and multivariate logistic regression analysis to investigate the risk of overall injury

FMS	N	Number of injuries			
		Univariate		Multivariate	
		Odds ratio (95%CI)	p value	Odds ratio (95%CI)	p value
≤14	10	1.61 (0.41–6.37)	0.49	1.49 (0.37–6.02)	0.57
>14	65	1		1	
≤15	20	1.78 (0.61–5.20)	0.29	1.81 (0.61–5.39)	0.29
>15	55	1		1	
≤16	47	1.17 (0.42–3.26)	0.76	1.28 (0.44–3.75)	0.65
>16	28	1		1	
≤17	62	0.99 (0.27–3.63)	0.99	1.03 (0.26–4.08)	0.96
>17	13	1		1	
≤18	70	1.83 (0.19–17.37)	0.60	1.71 (0.17–17.54)	0.65
>18	5	1		1	

95%CI: 95% confidence interval.
Logistic regression analysis adjusted for age, body mass index, and gender.

(ICC=0.76) and AT students (ICC=0.37)[19]. Another study indicated that the evaluation of movement patterns from different view angles is necessary to rate the FMS scores[20]. In the present study, 2 FMS experienced sports physiotherapists assessed the quality of each functional movement using recorded video from the frontal and sagittal planes. This multiangle video assessment could help to improve the precision of scoring between each rater (k=0.92).

Previous studies of young military officers and a broad population of adults showed low values of Cronbach's α, in which the ranges were 0.37 to 0.64[21, 22]. The present study showed a value of 0.35 as similar to recent studies. We are also concerned about the ceiling effects regarding interpretability since a ceiling effect was observed in the straight leg raise test among females. Asian athletes are known to have different physical features in flexibility and strength from Caucasians. Therefore, modifying the flexibility threshold for Japanese athletes may be needed to avoid ceiling effects. Taken together with the data above, the current form of the FMS composite score is not enough to be reliable to predict injury risk in Japanese elite college soccer players.

The mean FMS scores between males and females were comparable. Also, the FMS composite score was not associated with age, body weight, height, and BMI. A previous study investigating the FMS with a wide range of adult population showed an inverse correlations between the FMS composite score and age, as well as BMI[22]. While the mean ages of the 1,113 participants were 53.4 for males and 49.3 for females in that study, our study recruited college athletes, and the range of the ages was 18 to 21 years. Due to a limited age range and BMI, the FMS composite score was not associated with those 2 factors in the present study.

Because of poor factor congruity between different cohort studies, the FMS composite score is affected by the level of play and is population specific. Kiesel et al.[5] reported the mean score of the FMS was an identifiable risk factor for injury in professional soccer players. A recent systematic review also reported that a FMS composite score of ≤14 was a valid predictor for musculoskeletal injury[23]. However, as the result of univariate and multivariate analyses in our study, the cut-off points in the FMS composite of ≤14, ≤15, ≤16, ≤17 and ≤18 were not associated with any of the parameters for number of injury, lower limb injury, traumatic injury or the time to return to play. Although 61% of reported scores represented were between 14 and 16, the injury rates were increased depending upon the level of play[24]. Additionally it was suggested that the FMS composite score does not predict injuries in youth academy soccer players[25]. Therefore, the heterogeneity of study population in previous FMS studies makes it difficult to synthesize similar outcomes in Japanese elite college soccer players.

Furthermore, the present study demonstrated that the FMS composite score has poor predictive abilities as a diagnostic tool for any injury type and severity. Despite the ROC analysis having shown an FMS score of ≤15 maximized sensitivity and specificity for a history of any injuries per person, the AUC was as low as 0.56 with a sensitivity of 76.92% and specificity of 34.78% in this study. A previous study suggested that the FMS score predicted identifiable risk factors of injury in professional soccer players[5]. Newton et al.[25] however, also reported a poor predictive association between the FMS composite score and the ROC curve, with 0.59 in non-contact injuries, 0.63 in overuse injuries, and 0.52 in severe injuries in youth academy soccer players. The AUC of a ROC curve can provide evidence of the diagnostic accuracy from the screening examination. It was suggested that an AUC=0.5 indicates a no predictive value as a diagnostic tool, whereas AUC=1.0 indicates a perfect test, leading to no false positive or negative results[23]. We clearly demonstrated that the FMS composite score at any cut-off value was not associated with injury risks in the present sample of Japanese elite college soccer players.

The major strengths of this study are: the 1 year follow up of the prospective design; injuries were carefully monitored by a physiotherapist and diagnosed by medical doctors; the injury prediction of the FMS used by Japanese college soccer players had never been evaluated.

Several limitations of this study should be acknowledged. First, the outcomes could have been influenced by the participants' characteristics. We recruited soccer players from 2 university college teams. A wider population range was needed to minimize the width of interval estimation and to improve the reliability of the point estimation for outcome data. Second, we did not monitor any training for injury prevention based on the FMS score, and it may have caused a low risk of bias. Third, we only assessed the relationships between the FMS score and injuries but not the athletes' performances. Therefore, we could not conclude that the FMS is not useful for predicting potential performance of the athletes.

Funding and Conflict of interest

The authors have no conflicts of interest to declare.

ACKNOWLEDGMENT

This work was supported by the Joint Research Program of Juntendo University, Faculty of Health and Sports Science.

REFERENCES

1) Warden SJ, Creaby MW, Bryant AL, et al.: Stress fracture risk factors in female football players and their clinical implications. Br J Sports Med, 2007, 41: i38–i43. [Medline] [CrossRef]

2) Hawkins RD, Fuller CW: A prospective epidemiological study of injuries in four English professional football clubs. Br J Sports Med, 1999, 33: 196–203. [Medline] [CrossRef]
3) Rahnama N, Reilly T, Lees A: Injury risk associated with playing actions during competitive soccer. Br J Sports Med, 2002, 36: 354–359. [Medline] [CrossRef]
4) Cook G, Burton L, Hoogenboom B: Pre-participation screening: the use of fundamental movements as an assessment of function - part 1. N Am J Sports Phys Ther, 2006, 1: 62–72. [Medline]
5) Kiesel K, Plisky PJ, Voight ML: Can serious injury in professional football be predicted by a preseason functional movement screen? N Am J Sports Phys Ther, 2007, 2: 147–158. [Medline]
6) Shojaedin SS, Letafatkar A, Hadadnezhad M, et al.: Relationship between functional movement screening score and history of injury and identifying the predictive value of the FMS for injury. Int J Inj Contr Saf Promot, 2014, 21: 355–360. [Medline] [CrossRef]
7) Bushman TT, Grier TL, Canham-Chervak M, et al.: The functional movement screen and injury risk: association and predictive value in active men. Am J Sports Med, 2016, 44: 297–304. [Medline] [CrossRef]
8) Dorrel BS, Long T, Shaffer S, et al.: Evaluation of the functional movement screen as an injury prediction tool among active adult populations: a systematic review and meta-analysis. Sports Health, 2015, 7: 532–537. [Medline] [CrossRef]
9) Fuller CW, Ekstrand J, Junge A, et al.: Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. Clin J Sport Med, 2006, 16: 97–106. [Medline] [CrossRef]
10) Cook G, Burton L, Hoogenboom B: Pre-participation screening: the use of fundamental movements as an assessment of function - part 2. N Am J Sports Phys Ther, 2006, 1: 132–139. [Medline]
11) Cronbach LJ: Coefficient alpha and the internal structure of tests. Psychometrika, 1951, 16: 297–334. [CrossRef]
12) Terwee CB, Bot SD, de Boer MR, et al.: Quality criteria were proposed for measurement properties of health status questionnaires. J Clin Epidemiol, 2007, 60: 34–42. [Medline] [CrossRef]
13) Oliva TA, Oliver RL, MacMillan IC: A catastrophe model for developing service satisfaction strategies. J Mark, 1992, 56: 83–95. [CrossRef]
14) Leeder JE, Horsley IG, Herrington LC: The inter-rater reliability of the functional movement screen within an athletic population using untrained raters. J Strength Cond Res, 2016, 30: 2591–2599. [Medline] [CrossRef]
15) O'Connor FG, Deuster PA, Davis J, et al.: Functional movement screening: predicting injuries in officer candidates. Med Sci Sports Exerc, 2011, 43: 2224–2230. [Medline] [CrossRef]
16) Smith CA, Chimera NJ, Wright NJ, et al.: Interrater and intrarater reliability of the functional movement screen. J Strength Cond Res, 2013, 27: 982–987. [Medline] [CrossRef]
17) Schneiders AG, Davidsson A, Hörman E, et al.: Functional movement screen normative values in a young, active population. Int J Sports Phys Ther, 2011, 6: 75–82. [Medline]
18) Shultz R, Anderson SC, Matheson GO, et al.: Test-retest and interrater reliability of the functional movement screen. J Athl Train, 2013, 48: 331–336. [Medline] [CrossRef]
19) Gribble PA, Brigle J, Pietrosimone BG, et al.: Intrarater reliability of the functional movement screen. J Strength Cond Res, 2013, 27: 978–981. [Medline] [CrossRef]
20) Onate JA, Dewey T, Kollock RO, et al.: Real-time intersession and interrater reliability of the functional movement screen. J Strength Cond Res, 2012, 26: 408–415. [Medline] [CrossRef]
21) Kazman JB, Galecki JM, Lisman P, et al.: Factor structure of the functional movement screen in marine officer candidates. J Strength Cond Res, 2014, 28: 672–678. [Medline] [CrossRef]
22) Koehle MS, Saffer BY, Sinnen NM, et al.: Factor structure and internal validity of the functional movement screen in adults. J Strength Cond Res, 2016, 30: 540–546. [Medline] [CrossRef]
23) Bonazza NA, Smuin D, Onks CA, et al.: Reliability, validity, and injury predictive value of the functional movement screen: a systematic review and meta-analysis. Am J Sports Med, 2017, 45: 725–732. [Medline] [CrossRef]
24) Pollen TR, Keitt F, Trojian TH: Do normative composite scores on the functional movement screen differ across high school, collegiate, and professional athletes? A critical review. Clin J Sport Med, 2018. [Medline] [CrossRef]
25) Newton F, McCall A, Ryan D, et al.: Functional Movement Screen (FMS™) score does not predict injury in English Premier League youth academy football players. Sci Med Footb, 2017, 1: 102–106. [CrossRef]