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Reliability of Functional Movement Screen and sexual differentiation in FMS scores and the cut-off point among amateur athletes

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Abstract
Introduction. **Functional Movement Screen (FMS) is a tool used in injury prediction based on the quality of movement patterns. Crucial is to determine the cut-off point which indicates the injury risk increment. Most of the researches regard professional athletes.** Aim of Study. **The aim of this study was to determine the reliability of the FMS test, and sexual differentiation in the value of the FMS total score test and subtests. Furthermore, the study aimed to evaluate the values of injury risk cut-off point in the FMS test in young male and female individuals from the moderately-active population.** Material and Methods. **The study group consisted of 89 physically active individuals not involved in high-performance sport: 42 males aged 20.5 ± 1.10 years, and 47 females aged 20.0 ± 0.68 years. FMS, a questionnaire concerning the previous injury history of 12 months preceding the study were used. The interclass correlation coefficient (ICC) was used to evaluate the reliability of the FMS test and a receiver operating characteristic curve (ROC) for FMS cut-off scores was calculated.** Results. **The FMS test showed excellent agreement between two screenings. There were some differences in the quality of movement patterns between men and women in subtests. The values of injury risk cut-off scores were different between sexes, 14 points for males and 17 points for females.** Conclusions. **The FMS test is a highly reliable research tool. For the average population of physically active young male and female amateur athletes, the cut-off score values in the FMS test should be evaluated separately between sexes to determine injury risks.**

KEYWORDS: FMS test reliability, cut-off score, physical activity.

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Introduction

Athletes involved in high-performance sport and the average population taking up various kinds of physical activity are exposed to the risk of injuries [18]. With the increasing number of people in society taking up regular physical exercise, the problem of injuries, related to physical activity, concerns not only the elite sport but becomes rather a common phenomenon [24]. Knowledge of factors conducive to the occurrence of injuries makes it possible to intervene appropriately early and to limit injury risk. The factors indicated as predisposing to injuries include functional disorders of the locomotor system resulting in incorrect movement patterns [8, 13]. Cook designed a test assessing fundamental movement patterns in terms of mobility, stability, and motor control within the locomotor system termed the Functional Movement Screen (FMS) [4, 5]. This test was developed for professional athletes and people involved in occupations requiring a high level of physical fitness. It is a tool that, by assessing movement patterns, allows for predicting an injury risk of an individual. The FMS test has been used for injury risk assessment among soccer players [4], rugby players [7], runners [3], or people in such occupations as military service [9] and firefighting [10]. The FMS was also utilized for the average population of physically active people. However, the number of such studies is small [16, 19]. However, the problem with injuries related to physical activity is also common for the average population [4]. Therefore, the diagnosis of injury risk is critical as a first step in the prevention of the average population of physically active people.

The use of the FMS for the evaluation of injury risks requires the determination of cut-off scores. The most widely applied and accepted cut-off score on the FMS point scale is the value of 14 points. This minimum value was obtained by Kiesel et al. [13] in a group of professional football players based on the data collected for injuries, the FMS test, and the use of the receiver operating characteristic curve (ROC) [10]. The results were confirmed by Garrison et al. [8]. However, there is a likelihood of a variation in the cut-off score that may cause some misinterpretation of the FMS score. In studies attempting to determine injury risk, the factors typical for a given group (e.g. sex) are not often taken into consideration. However, some sex differences in cut-off scores may occur [16]. Therefore, it is required to establish classifying values in the FMS test for the individual groups of participants. This is crucial for the accurate categorization of an injury risk level as the first step into injury prevention.

Regardless of the sports skill level, all physically active people are exposed to injury risks [15, 18, 24]. The FMS test is commonly used in high-performance sports [7, 11, 13] or representatives of professions requiring a high level of physical fitness [17, 22]. Because the FMS test is an inexpensive tool, it can be applied even in the average population, where no access to more advanced tools is available. Till now only a few studies have conducted the FMS test in the population of average physically active individuals in injury risk assessment [16, 19].

Aim of Study

The aim of this study was to determine the reliability of the FMS test, and sexual differentiation in the value of the test and subtests. Furthermore, the study aimed to evaluate the values of injury risk cut-off scores in the FMS test for young male and female individuals from the average physically active population.

Material and Methods

Participants

Data of 89 students of the University School of Physical Education in Wrocław (42 men and 47 women) was collected. Nonprobability sampling according to inclusion and exclusion criteria was used in the study. The following inclusion criteria were established: participant age (19-25 years), not having suffered an injury throughout the 6 weeks preceding the study and declared participation in regular sports activity without experiences in professional sport.

The survey questionnaire concerning the history of injuries: the participants filled in a short questionnaire containing questions concerning the number of injuries in 12 months preceding the study.

Measurements

Functional Movement Screen (FMS) is composed of 7 movement tasks (subtests) of which 5 tests are performed on the left and right body side. They allow for the assessment of the functional status of the locomotor system. The seven subtests are: (1) Deep Squat, (2) Hurdle Step, (3) In-Line Lunge, (4) Shoulder Mobility, (5) Active Straight Leg Raise, (6) Trunk Stability Push-Up, and (7) Rotary Stability. Additionally, there are three tests provoking pains: Impingement Clearing Test used with Shoulder Mobility, Press-Up Clearing Test used with Trunk Stability Push-Up and Posterior Rocking Clearing Test used with Rotary Stability. Each task is performed maximally 3 times and assessed on a scale of 0 to 3 points. The zero score means pain (reported by the participant), 1 point is the inability to perform movements correctly, 2 points is a movement performed with compensatory movements, and 3 points mean a movement performed correctly. Clear guidelines concerning the scores were developed for every single task [4, 5]. The maximum total result is 21 points. The FMS overall score includes the highest grade from each test. In the case of tasks performed on two sides, the lower grade is considered. The tests provoking pains are considered only in the case of a positive result. In this case, the score of 0 is given for the main trial. According to the literature, 14 points is the critical value, above which the injury risk is significantly growing [5, 6, 13].

Statistical analysis

The validation of the FMS test as a tool to predict the risk of injuries was carried out for physically active individuals on a sample coming from the Polish population. The reliability of the measurements conducted by the researcher was assessed. From the research group, 20 individuals (10 males and 10 females), were randomly selected for repeated FMS test assessment 7 days later. The simple, non-refundable random draw was conducted. The sampling frame was a list of respondents in alphabetical order. The tools available in Statistica v13.0 were used. The ICC (interclass correlation coefficient) was adopted as a criterion of measurement reliability [20]. In this study, the ICC (2,1) model was used. This model is used when the same judge takes the measurement twice on the same test group [14]. Furthermore, the analysis of the FMS test reliability was complemented by comparisons between first and second FMS assessment scores. The following tests were carried out: dependent samples Student's t-test (for the total sum of points) and Wilcoxon test (single modules of FMS). The test was found reliable if the differences were statistically insignificant and the effect size was very low. The Cohen's d defined as a difference between means divided by the standard deviation for the sample was used to assess the effect size in the total number of points in the FMS test [3].

The Student's t-test for independent samples (total point score in the test) and the Mann–Whitney U test (individual modules) was employed to determine the sexual differentiation of morphological traits and the results of the FMS test.

The cut-off values indicating higher and lower injury risks were evaluated using the receiver operating characteristic (ROC) method, which is a tool for measuring the quality and correctness of a classifier. Based on the number of injuries (data collected by survey) a cut-off score was determined for the total FMS score. The curve allows for the determination of the optimal point of data division into two subgroups according to the adopted criterion [10].

Ethical clearance

The study was approved by the Research Ethics Committee of the University School of Physical Education in Wroclaw and was consistent with institutional ethical requirements for human experimentation under the Declaration of Helsinki (consent No. 16/2018). The participants were fully informed about the used procedures and the experimental risk.

The examinations and statistical calculations were conducted in May 2018 in the Biokinetics Research Laboratory of the University School of Physical Education, holding the Certificate of the Quality Management System (PN-EN ISO 9001:2009, the certificate registration No. PW-48606-10E). Statistical analyses were carried out using a computer suite of statistical programs (Statistica 13.0, Statsoft, Poland).

Results

Table 1 illustrates the profile of age and morphology of male and female study participants. As expected, men were taller and heavier than women.

Table 1. Descriptive statistics of age and morphological features of structure and BMI of men and women. Comparisons between men and women. Results of the t-Student test

Group	Men	Women	Statistics	
Variable	Mean ± SD	Mean ± SD	T	p
Age [years]	20.5 ± 1.10	20.0 ± 0.68	2.457	0.016
Height [cm]	182.2 ± 5.71	167.7 ± 6.40	11.167	<0.001
Body mass [kg]	79.0 ± 8.17	58.5 ± 7.78	12.097	<0.001
BMI [kg/m^2]	23.9 ± 1.98	20.8 ± 2.14	6.849	<0.001

SD – standard deviation

In Table 2 the FMS test reliability measurements. The interclass correlation coefficient (ICC) was used for reliability assessment. The calculations were performed both for the total tests' scores and single test modules. The excellent results (above 0.90 [14]) and were found for both total test replicability and the researcher's assessments (Table 3). The reliability of assessments in single modules was similar. The lowest reliability, but still at a good level (0.75-0.90 [14]) was obtained in rotary stability for the right side of the body. No statistical significance was found in the Student's t-test (FMS – Overall) and Mann–Whitney U test (individual FMS modules) ($p < 0.05$ see Table 3). Furthermore, the effect size computed for the FMS total score test was Cohen's d = 0.267. Cohen's range of 0.2 to 0.3 may mean a small magnitude of effect [3].

Table 3 summarizes the diversity of the FMS assessment in total score and all subtests scores between men and women. In the Active Straight Leg Raise test and Rotary Stability, in both subtests for the left and right limbs, women presented better movement quality. Furthermore, men had better results in the Trunk Stability Push-Up test than women. No statistically significant differences were found in other subtests and FMS total score.

The results provided the basis for another analysis, which consisted of considering cut-off score values in the FMS test indicating an increase in injury risk separately for men and women.

Table 2. Values of the interclass correlation coefficient (ICC (2,1)). Results of the t-Student test (FMS-Overall) and Wilcoxon test (FMS – single modules) comparison for the differences between means (the whole test) and medians (individual modules) $p < 0.05$

Variable	ICC	Level of agreement (Reliability)	(t-Student test and Wilcoxon test)
FMS – Overall	0.95	Excellent	Non-significant
Deep Squat	1.00	Excellent	Non-significant
Hurdle Step – left	0.92	Excellent	Non-significant
Hurdle Step – right	1.00	Excellent	Non-significant
In-Line Lunge – left	0.95	Excellent	Non-significant
In-Line Lunge – right	1.00	Excellent	Non-significant
Shoulder Mobility – left	1.00	Excellent	Non-significant
Shoulder Mobility – right	1.00	Excellent	Non-significant
Active Straight Leg Raise – left	1.00	Excellent	Non-significant
Active Straight Leg Raise – right	1.00	Excellent	Non-significant
Trunk Stability Push-Up	1.00	Excellent	Non-significant
Rotary Stability – left	1.00	Excellent	Non-significant
Rotary Stability – right	0.80	Substantial	Non-significant

Table 3. Characteristics and sexual diversity of the FMS test results. Comparison of Student's t-test for independent tests of FMS and U-Mann–Whitney global assessment for individual motor tasks

Variable	Men		Women		p
	Mean	SD	Mean	SD	
FMS – Overall	14.2	2.95	14.8	3.02	0.388
Deep Squat	2.1	0.80	1.9	0.69	0.205
Hurdle Step – left	1.9	0.69	2.2	0.68	0.056
Hurdle Step – right	2.0	0.67	2.2	0.64	0.182
In-Line Lunge – left	2.4	0.70	2.5	0.62	0.354
In-Line Lunge – right	2.0	0.84	2.2	0.75	0.286
Shoulder Mobility – left	2.3	0.81	2.4	0.99	0.457
Shoulder Mobility – right	2.4	0.81	2.7	0.71	0.074
Active Straight Leg Raise – left	2.2	0.65	2.6	0.57	**0.003**
Active Straight Leg Raise – right	2.2	0.67	2.6	0.48	**<0.001**
Trunk Stability Push-Up	2.5	0.64	1.8	0.82	**<0.001**
Rotary Stability – left	1.9	0.46	2.2	0.49	**0.004**
Rotary Stability – right	1.9	0.46	2.1	0.50	**0.011**

SD – standard deviation

Calculating the ROC curve allowed for the determination of the values of the cut-off scores for male and female participants in order to classify individuals as more exposed to injury risks in relation to the point value obtained in the FMS test. In the male group, the ROC value amounted to 14 points. In the case of the female group, this value was 17 points (Figure 1).

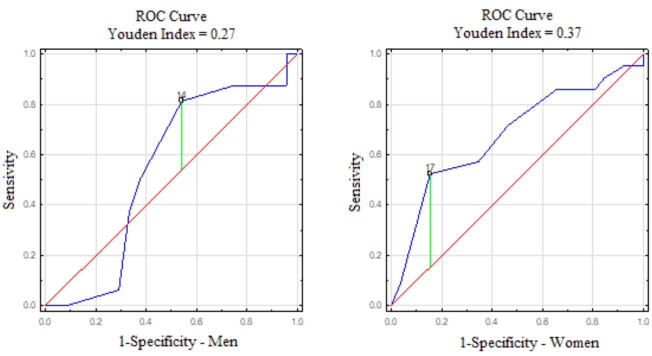

Figure 1. Receiver – operator characteristics (ROC) curve used to plot sensitivity vs 1-specificity for screening tests among men and women

Discussion

The FMS test is a highly reliable tool. Statistically significant differences were found in the scores of some FMS subtests between men and women, as well as in cut-off scores. Women performed better in Active Straight Leg Raises and Rotary Stability test, whereas men reached better scores in Trunk Stability Push-Up. The cut-off point of FMS total score was 14 points and for women 17 points. It could indicate differences in injury risk between sexes. For the average population of physically active young male and female amateur athletes, the cut-off score values in the FMS test should be evaluated separately between sexes to determine injury risks.

The first step of the analysis was to confirm the reliability of FMS screenings. This study demonstrated excellent reliability. Other researchers have also presented similar results concerning the high reliability of the test [9, 21, 23]. This result adds to the growing evidence for the high reliability of the FMS test. Numerous studies have shown that the FMS test is a valuable tool in predicting the prevalence of injuries in various groups of athletes [7, 8, 13] or firefighters [22], demonstrating correlations between the low result in the FMS test (below cut-off score) and injury risk [8, 13]. Based on the FMS score injury risk is determined according to the cut-off score. In literature this value is estimated on 14 points, however, some authors indicate slightly different values [8, 12].

The differences in movement patterns showed that women had better results in Active Straight Leg Raise and Rotary Stability, whereas men were better in Trunk Stability Push-Up, which points to males' stronger upper limbs and ability to stabilize the trunk in dynamic conditions. Similar observations were recorded by Schneiders et al. [19]. They found that the male group had better scores in Trunk Stability Push-Up, whereas women performed better in Active Straight Leg Raise. Chimera et. al. [2] observed that women performed better in Active Straight Leg Raise and Shoulder Mobility, whereas male participants had better scores in Trunk Stability Push-Up. However, mean FMS total scores did not vary between sexes [2, 19], whereas some differences in a subtest suggest that more attention is needed in the interpretation of the FMS total score. These findings were confirmed by Letafatkar et al. [16]. The differences in individual subtests can explain the phenomenon of motor differences between men and women. This is confirmed by a study by Kibler et al. [12] who confirmed that average male individuals demonstrate higher muscle strength than women, who, in turn, are more flexible than men.

The indicated statistically significant differences in individual subtests suggest that the cut-off point for the FMS score should be considered separately for male and female individuals. This study indicates, the cut-off value of 14 points for the male group. Similar findings were documented by Garrison et al. [8] and Kiesel et al. [13]. The results of this study showed this value should be higher (17 points) in the female group. The higher cut-off point values in the FMS test were also observed by Letafatkar et al. [16]. In their research, the value of the classifier (ROC) amounted to 17 points in the group of physically active university students. Furthermore, a higher value of ROC (15 points) was found in the study by Dorrel et al. [6]. However, these researchers analyzed female and male participants together. Chorba et al. [1] showed the ROC value of 14 points in the female group. Few previous studies have employed the FMS test to examine physically active young individuals not involved in high-performance training. This population is exposed to high injury risks, despite performing the physical activity at a lower level compared to professional athletes [15, 24]. It is suggested that the interpretation of the FMS score with co-existing factors may influence the prevalence of injury (e.g. sex, level of physical activity level, level of physical fitness, morphology, training experience, etc.). Further studies should focus on other co-existing factors of this kind. This will allow for the wider application of the FMS test and a more adequate interpretation of the FMS scores.

Conclusions

1. The FMS test is a reliable tool for the assessment of movement patterns. The assessment made by the same researcher with adequate competences ensures the perfect reliability of the results.
2. The statistically significant differences were found between men and women in individual subtests of the FMS. This suggests the necessity to compute injury classifiers separately for male and female athletes.
3. The differences in injury risk FMS cut-off scores between sexes are considerable. The assessment of injury risks based on the FMS test total score in the population of young physically active individuals not involved in high-performance sports should be made separately for men and women. This will allow for the accurate categorization of participants according to injury risk and implementation of adequate injury prevention programs.

The Functional Movement Screen is a simple and low-cost tool that is useful in the assessment of movement patterns. It indicates body function disorders which can potentially lead to injuries. The results of this study can be helpful in the interpretation and understanding of

FMS scores in the average physically active population with consideration for possible sex differences.

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