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The Utility of Functional Movement Screen in Male PE Candidates

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ABSTRACT
Context: The sport injures situation in PE candidates have deteriorated continuously due to the increase number of the PE candidates. FMS is a relatively inexpensive and time-efficient tool for measuring multiple movement factors, intending to predict the general risk of musculoskeletal conditions and injuries. Although the utilization of FMS has been extensively studied, the FMS test has not been validated for use in PE candidates. **Objective:** Study the relationship between FMS scores and sports injuries, to provide reference data for high school physical educator and coaches when formulating corresponding training plans. **Participants:** Thirty male PE candidates were collected from senior high school students participated. **Main Outcome Measures:** The FMS composite score was calculated from seven movement tests. The incidence of injuries was collected from daily survey in PF test preparation period. T-test and a receiver operator characteristic (ROC) curve were performed to analyse the data. **Results:** a) The total injury rate reached 46.7%, and the lower body injury rate reached 65%. b) FMS scores showed that there was a statistically significant difference between injury group was (15.14±1.61) and non-injury group was (15.56±0.96) P=0.009. DS and ILL have statistically significant differences among the seven tests (P=0.011), (P=0.018). c) the area under the ROC curve is 0.775. When the score is determined to be 15.5, the sensitivity (0.875) and specificity (1-0.357=0.643) scores were at the highest level. **Conclusions:** PE candidates generally have four functional movement mode defects, such as RS, DS, HS, and ILL.FMS has medium accuracy for predicting injury in PE candidates.

***Keywords**: PE candidates, FMS, Cut-off score, Sports injuries.*

1. INTRODUCTION

The national college entrance examination for physical education undergraduate majors in China is an examination system for the selection of sports talents based on the "*Interim Regulations for the Enrollment of Physical Education in General Universities*" [1]. The entrance examination is divided into the cultural examination and the physical examination. The physical examination is for the physical fitness and sports specialty of candidates who apply for physical education program and other subjects related to sports [2]. Physical fitness tests (PF test) include: 100m sprint, 800-meters-track, in-situ shot put, standing long jump, and the sports specialty include each sport items. Students who take this exam are called "College Entrance Examination Students of Physical Education." referred to as PE candidates in this research.

In China PE candidates are the leading force of sports development in the future[1]. Due to the time limitation for PF test preparation, the intensity of regular training, the diversity of training content, the lack of scientific sports training knowledge; the imbalance of physical fitness, function level, frequently caused injuries occur in PE candidates[3]. Relevant studies indicates that the incidence of sports injury of PE candidates reaches about 80% [3] [4]. However, with the increasing number of students, this situation will continue to be a thorny problem for coaches and physical educator , and also disturbs school's sports work.

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The functional movement screen (FMS): the use of fundamental movements as an assessment of functions considered to assess athletes' risk of becoming injured and identify deficiencies in functional movement, neuromuscular control, balance and trunk stability[5][6]. Some studies have shown that with a low composite score (14) and movement asymmetry score on the FMS are at high risk of injury [7][8]. Some systematic reviews presented controversy about the potential ability of the FMS to be used as an injury prediction tool [9-11]. Two reviews concluded the FMS was a poor predictor of injury-risk because of small and heterogeneous samples, inconsistent injury definitions, and lack of control for confounding variables (e.g. previous history of injury) [10][11]. However, the third review concluded that the FMS composite score demonstrates the predictive injury value[9]. A recent study found that the screen can be used to help design specific corrective exercises for athletes, that may minimize injury[12]. The maximum FMS composite score an individual can receive is 21 points. Previous studies had demonstrated a cutoff score of ≦14 on the FMS was a predictor of injury [7] [13][14]. However, other studies have used different cutoff scores as possible predictors of injury, which can challenge the reliability and validity of the FMS [15-18].

To the best of our knowledge, the FMS test has not been validated for use in PE candidates. Identifying at-risk PE candidates before PF test preparation with FMS can potentially decrease the number of injuries, decrease medical costs to parents and schools, and keep PE candidates from injury-related school absences and time deficient of PF test preparation. Establishing a split point based on the FMS test score and the results of the candidate's sports injury survey is an efficient way for FMS score and sports injury incidence prediction. Therefore, the FMS testing diagnosis can help coaches to arrange groups for PE candidates according to the results when instructing training, to give them more scientific training guidance.

The purpose of this study was to determine: a) if the FMS is a qualified screening tool to recognize deficiencies in movements for PE candidates. b) whether the FMS is a valid predictor of injury in PE candidates. Results of the study would also be used to examine if a score of 14 out of 21, as determined by previous researches[13, 14], is an appropriate cutoff score in predicting injury in PE candidates.

2. METHODS

2.1 Design and Setting

This was a cross-sectional study that investigated whether component and composite FMS scores were associated with PE candidate's deficiencies in movements. The associations between the incidence of injuries in the preparation period of PF test and FMS scores were evaluated. This research was conducted at a high school in the Xinjiang Uygur Autonomous Region of China.

2.2 Participants

The data was collected from senior high school students(boys) who were preparing for PF test, and we called PE candidates (mean body mass: 70.03±6.24kg; mean body height 179.63±5.87cm; BMI: 21.69±1.41 kg/m2). Before the study, all PE candidates had been practicing for the college entrance examination (PE test) regularly for at least two years (mean: 2.83±0.53). This was a sample of convenience. The inclusion criterion was: a) had not experienced an injury that prevented participation in training or competition for longer than one week during the four months before the examination; b) able to perform the FMS and PF test. Participants were excluded if they had any history of surgery or were unwilling to participate.

We informed about all the procedure of research to all participants and their parents or legal guardians in verbally and written form. And written information about consent to participation were provided. The study was granted approval by the ethics commission.

2.3 The Functional Movement Screen

The FMS is composed of 7 movement tasks: 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)[19][20]. Performance on all tasks was assessed on a 0 to 3 scale, scoring criteria for FMS as shown in "Table 1", Each task was performed three times, and the best result was used for further analysis[5][6]. In the case of tasks completed on the left and right side, the lower score was used in the calculation of the total FMS score.

Table 1. Scoring criteria for FMS

Score	Criteria
3	Ability to correctly complete the movement pattern without any predefined compensation
2	Performing the movement with any one of the movement pattern-specific compensations
1	Inability to perform the movement pattern
0	Presence of pain during any portion of the movement pattern

2.4 Procedures

Test steps: preparations before the test, training testers, requiring all participating testers to be familiar with the test content and scoring requirements, and make demonstration actions as much as possible. Before the actual test, introduce the test content, scoring criteria to the participants in detail. Send the pre-printed scoring form to the participants. Participants fill in the name, gender, and date of birth on the day, complete the numbering and test in the order of numbering. Work during the test: Before the test, question was asked from participants about sports injury record. The test sequence is carried out clockwise according to 7 actions. After completing one action, two qualified sports prescribers give the corresponding scores in the subject's score table according to the score criteria, and review the video of the items with objection, and re-grade them. At the same time as the test, two testers took pictures from the side and front with the camera and recorded the content of the experiment to avoid scoring errors caused by the viewing angle. After the experiment, follow-up analysis was checked. Note: The participants wore loose-fitting sportswear and sports shoes, and did not warm up before the test [21]. Experimental observation period: a total of 16 weeks, during which the participants's training team was monitored for injuries, and the sports injuries and locations of injuries occurred were recorded.

Based on previous studies [22] [23], we adopted the following criteria to define the incidence of injury, which were collected injuries date and used to divide the participants into Injury and Non-injury groups. The damage level is defined as (a) the injury occurred as a result of participating in a PE test practice or game, and (b) the injury was severe enough to continuously prevent the individual from participating in a practice or game for at least one week. (c) Actively or passively seek medical help. (d) Those who cannot meet the training requirements or cannot complete the training due to sports injuries. The type of injury is defined as record any injury is defined as tendon, ligament, muscle, bone injury (not including contusion), and then organize all the data and analyze the experimental results. The type definition is shown in "Table 2", and the tick option is the type of damage to be recorded.

Table 2. Classification of sporting injuries (adapted from privies studes22-24)

Grades of sprain/tear	Classification by emergency of injury	Classification by sport technique	Classification by the integrity of the skin and mucous membrane	Classification by the type of injury	Classification by contact mode
Grades i☑	Acute injuries☑	Technopathy sports injury☑	Open injury	Muscle And tendon☑	Direct / contact injury
Grades ii☑	Overuse injuries	Non-technopathy sports injury☑	Closed injury☑	Bone And joint☑	Indirect / non-contact injury☑
Grades iii☑				Articular cartilage And bursa☑	
				Ligament And skin☑	

2.5 Data Analysis

The mean was utilized as a measure of central tendency to evaluate differences in composite FMS scores between the injured and non-injured groups. T-test was performed to determine if this group difference approached statistical significance. To determine the threshold value, a receiver operator characteristic (ROC) curve was calculated plotting sensitivity versus 1-specificity. For the threshold value, the value chosen provided the best balance of maximizing sensitivity while minimizing 1-specificity. Data analysis was performed using R Core Team 2013 (R Foundation; Vienna, Austria).

3. RESULT

During the observation period 14 candidates was injured out of 30 candidates. The main types of injuries were quadriceps strain, posterior calf muscle strain, hamstring muscle strain, and sprains of various joints. The total injury rate reached 46.7% (14/30), and the location of sports injury occurred, as shown in "Figure 1". The rotator cuff injury rate reached 14%, elbow joint 7%, back 7%, hip 7%, thigh 22%, knee Joint 7%, calf 22%, ankle joint 14%. The upper-body injury rate reached 35%, and the lower body injury rate reached 65%.

The participants had the most occurrences of 2-point action pattern in every single test, followed by 3-point action pattern, and the number of occurrences of 1-point action pattern was the least. From the average point of view, DS (2.13±0.56), HS (2±0.52), ILL (2.17±0.52), RS (1.73±0.51), the average of the four movements is significantly lower than the three-movement modes of TSPU (2.67±0.47), SM(2.37±0.66), ASLR (2.83±0.37). Although, the average score of 15.9±1.45 is not low, the functional performance of participants is severely skewed. The low average movement patterns include; DS, HS, ILL, and RS. (table3)

The data showed that there was no significant difference in morphological indicators between the injury group (N=14) and the noninjury group (N=16). FMS test scores, showed that there was a statistically significant difference between injury group was (15.14+1.61) and non-injury group was (15.56+0.96) P=0.009. From the individual items of the FMS, only DS and ILL have statistically significant differences among the seven tests (P=0.011), (P=0.018). (Table4) .

Through the ROC curve analysis of the data of 30 participants, the area under the ROC curve is 0.775, the standard deviation is 0.09, and the 95% confidence interval is 0.598-0.951. When the score is determined to be 15.5, the sensitivity (0.875) and specificity (1-0.357=0.643) scores were at the highest level. (Figure2, Table6, Table7)

4. DISCUSSION

The results of This study showed that during the observation period of 16-weeks, the injury rate of the PE candidates reached 46.7% (14/30). The injury rate is lower than previous studies, for instance, Xia Xuehao[3] mentioned, the Injury rate of PE candidates is as high as (89.11%), Chen QiZheng et al[24] founded that the total injury rate was as high as 73.15% (218/298) during an injury survey of 298 PE candidates.. Although the injury rate of this study is lower than that of the former, it may be due to the definition of injury, but the injury rate of 46.7% of the PE Candidates group should not be underestimated. The training period of PE Candidates is generally short, at the initial stage of sports training, high training intensity and complex training content and other reasons, resulting in injuries in PE candidates are more common[25].

In the sports injury statistics of PE candidates who participated in the college entrance examination in 2014-2015, Li Zhen26 found that the occurrence of injuries was mainly concentrated in the calves, knee joints, joint joints, thighs, shoulders and wrist joints. Zhang Leilei4 mentioned that the lumbar spine, lower extremities and ankles are the high-incidence sites of injuries for PE candidates. The injury site research results ("Figure 1") of this study are the same as the previous research. The content of PF test is the same in most provinces (100m/800m run; in-situ shot put; stand-up long jump). The parts have high consistency.

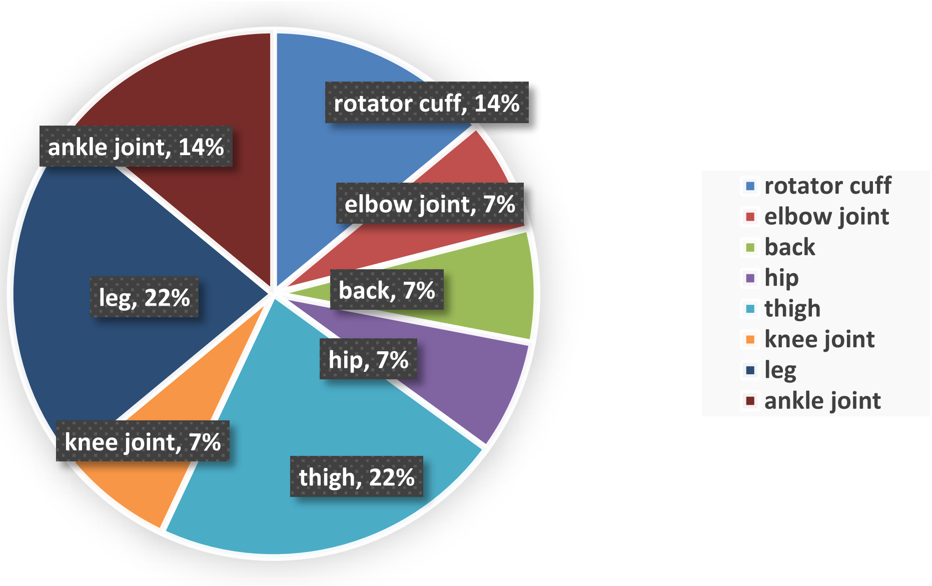

Figure 1 Sports injury statistics of PE candidates.

Descriptive statistical results of individual FMS tests, ("Table 3") the participants has the highest number of occurrences of the 2-point action pattern in every single test, followed by the 3-point action pattern, and the number of occurrences of the 1-point action pattern is the least. The overall appearance of the 1-point action pattern can make the individual Performing modern compensatory movements when completing a specific movement or exercise results in unbalanced work of the bilateral muscles and brings a higher risk of injury to the individual[27][28]. Therefore, the appearance of the 1-point action mode is particularly important. Pay more attention to the PE candidates who can only complete the test with the 1-point action mode when completing the test.

Table 3. Descriptive statistics of FMS score

Test items	FMS Component Score			FMS Composite Score	
	1	*2*	*3*	*Mean*	*SD*
DS	3 (10%)	20 (66.7%)	7 (23.3%)	2.13	0.56
HS	4 (13.3%)	22 (73.4%)	4 (13.3%)	2	0.52
ILL	2 (6.7%)	21 (70%)	7 (23.3%)	2.17	0.52
SM	3 (10%)	13 (43.3%)	14 (46.7%)	2.37	0.66
ASLR	0 (0%)	5 (16.7%)	25 (83.3%)	2.83	0.37
TSPU	0 (0%)	10 (33.3%)	20 (66.7%)	2.67	0.47
RS	9 (30%)	20 (66.7%)	1 (3.3%)	1.73	0.51
Total score	21 (10%)	111 (52.9%)	78 (37.1%)	15.9	1.45

a 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).

4.1 Cause of low score in The Deep Squat Test (DS)

DS action is an integral part of many functional actions. During the screening process of the DS test observation, the lack of limbs flexibility of the participants, posture control, stability of the pelvis(hips) and core[19]. In this screening, the mean of the subjects was the third-lowest score among the seven screenings (2.13±0.56). 76.7% of the participants could not complete the movement according to the three-point movement standard. In observation, it was founded the main reasons were poor stability and control, limited flexibility of the lower extremities, and weak closed kinematic chains of the dorsiflexion of both feet and ankles. The heel cannot be attached to the ground when squatting. Weak flexion and extension of both hips and knees is another primary reason for failing to reach full marks [29].

4.2 Cause of Low Score in Hurdle Step Test (HS)

The HS mode is a part of the body's displacement and acceleration. It can reveal the compensation or asymmetry during the stepping motion. This action has high requirements for stability[19],[30]. For example, when the participants maintain the body weight on one leg and the other leg is active, the stability of the ankle joint, knee joint, and the hip joint supporting to the leg. The requirements also include the flexibility of the hips, knees, and ankles; with the stability and control of the pelvis and core of the body [31]. In the HS test, 86.7% of the subjects failed to meet the 3-point standard, and only four participants achieved the 3-point standard, accounting for 13.3% of the total. The average value of the subjects was (2±0.52), which was the second-lowest score action. During the test, it was found that the stability of the support legs of most of the participants were seriously insufficient. In order to compensate for the occurrence of unbalanced movements, most participants had upper body swaying and stepping legs. The main reason is that the stability of the support legs and the flexibility of the stride legs are insufficient.

4.3 Cause of low score in In-line Lunge Test (ILL)

The ILL movement is an integral part of various deceleration movements and direction changes produced in competitions, training and daily sports activities. This action examines the stability of the participant's spine, pelvis, and core. It also has high requirements of stability of the participant’s hips, knees, and ankles [19][30]. The screening results of this action mode show that the average value of the participants is (2.17±0.52), which is the fourth-lowest score action, 76.7% of the test cannot complete the action according to the standard, only 7% of the test can be of high quality in the screening to complete the action mode. It can be attributed to the lack of dynamic stability of the subjects [32][33]. During the screening, the participants were found problems such as insufficient stability of the spine and hip joints.

4.4 Cause of Low Score in Shoulder Mobility Test (Sm)

Through the screening of the SM assesses, the flexibility of the bilateral shoulder chest, the stability and flexibility of the scapula can be adequately evaluated. Also, the natural complementary effects of scapula, thoracic spine, and thoracic cavity during the motion are displayed [20], [34]. In this screening, the participants showed a correct standard of action mode, the average value of the participants reached (2.37±0.66), 46.7% of the participants could complete the 3-point standard action mode, indicating that nearly half of the participants, Also, the bilateral shoulder blades and chest have excellent flexibility and stability, enough to reach the full mark standard. However, 53.3% of the participants still showed varying degrees of dysfunction, mainly since the muscles of the pectoralis minor, latissimus dorsi, deltoid, rectus abdominis and other muscle groups were over-trained, and above the flexibility of the muscles leads to a decrease in the flexibility of the shoulder joint and scapula [30].

4.5 Cause of Low Score in the Active Straight Leg Raise test (ASLR)

The ASLR test examines the ability of the lower limbs to split legs under no-load conditions. Challenges the human body's ability to split legs when the pelvis and core are stable and has a high demand for active flexibility for the posterior thigh muscles, gastrocnemius muscle, and soleus muscle20. The average value of this test is (2.83±0.37), which is the highest score item among the seven tests. 83.3% of the participants reached the standard of 3-point action mode, and the 1-point action mode did not appear. 16.7% of the participants completed the action on a two-point scale; the main reason is that some participants have poor flexibility across the multi-joint muscle group, which is caused by the lack of flexibility of the gluteus maximus and the posterior thigh muscles[30][35].

4.6 Cause of Low Score in the Trunk Stability Push-up Test (TSPU)

TSPU examines the reflex stability of the core. It requires that the participants have no movements on the hips, spine, and shoulders when they push the body up with push-ups. The test requires heels, knees, hips, back, shoulders present a straight line [20]. The average value of this test is (2.67±0.47), the second-highest score action in all tests, 66.7% of the participants reached the 3-point standard, the 1-point action pattern did not appear in the screening, and the two-point standard completed the action participants reached 33.3%. The main problem was that the buttocks collapsed when the movement was completed, the left and right hands were not balanced when the upper limbs were exerted, and the spine appeared to swing left and right. Wanting sex and insufficient stability of hip and chest vertebral columns [30][36].

4.7 Cause of Low Score in Rotary Stability Test (RS)

The RS test can observe the stability of the upper and lower limbs of the participant's during the joint braking, by observing the hip joint, core, and the shoulder. This action mode can be regarded as the most complicated item in the seven screenings. Not only requires neuromuscular coordination, but also the exceptional ability to transfer the energy of the trunk, and the coordination between stability and flexibility is the essential requirement to complete the action[20][30]. The average value of this action mode is (1.73±0.51), which is the lowest among all screening items. Only 3.3% of the participants reached the 3-point standard. 30% of participants can only complete this action on a 1-point scale, and the number of participants who get 1 point is the largest among all screening items. Most participants showed that when the body weight is displaced, the stability performance is reduced. They were unable to coordinate control of flexibility and stability, and unable to complete the test on a 3-point scale. When screened on a 2-point scale, the participants' control of the active legs and active hands is reduced, the stability of the supporting legs and hands is weak, and the movement Insufficient positioning and control capabilities are mainly due to insufficient stability of the scapula and hip, and limited flexibility of the knee, shoulder, spine, and hip.

T-test results showed that ("Table 4") significant differences between the injury group and the non-injury group were: the FMS composite scores and the two tests of DS and ILL. The research results are similar to previous research. For example, Wang Junsheng's research on the National Shooting Team founded that there are significant differences in the FMS composite scores, DS and ILL for the injured and non-injured players. The levels are P=0.009, P=0.037, P=0.004 [37]. Bardenett, S. M et al. researched high school athletes to verify whether FMS can be used as a tool for predicting sports injuries. Injury athletes in the FMS test, ILL and SM test scores are significantly different [38]. Therefore, it can be explained that when the FMS test score is low, special attention should be paid to the test results of DS and ILL of low score personnel.

Table 4. Intergroup T test result

	Group	N	Mean	SD	ES Mean	P-value
FMS score	Injury	14	15.14	1.61	0.43	0.009*
	Noninjury	16	16.56	0.96	0.24	
high (cm)	Injury	14	179.29	5.64	1.51	0.766
	Noninjury	16	179.94	6.23	1.56	
weight (kg)	Injury	14	69.21	6.53	1.75	0.513
	Noninjury	16	70.75	6.11	1.53	
BMI	Injury	14	21.51	1.57	0.42	0.550
	Noninjury	16	21.83	1.30	0.33	
Training years	Injury	14	1.79	.426	0.11	0.646
	Noninjury	16	1.88	.619	0.16	
DS	Injury	14	1.86	.535	0.14	0.011*
	Noninjury	16	2.38	.500	0.13	
HS	Injury	14	2.00	.555	0.15	1.000
	Noninjury	16	2.00	.516	0.13	
ILL	Injury	14	1.93	.475	0.13	0.018*
	Noninjury	16	2.38	.500	0.13	
SM	Injury	14	2.14	.663	0.18	0.088
	Noninjury	16	2.56	.629	0.16	
ASLR	Injury	14	2.86	.363	0.10	0.752
	Noninjury	16	2.81	.403	0.10	
TSPU	Injury	14	2.64	.497	0.13	0.805
	Noninjury	16	2.69	.479	0.12	
RS	Injury	14	1.71	.469	0.13	0.853
	Noninjury	16	1.75	.577	0.14	

a *= $p < 0.05$ 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).

4.8 Derivation of a Cut-off Score for Sports Injuries

The FMS score of 14 is generally regarded as a high score of sports injuries13. The risk threshold indicates that in the FMS, the participant's scored ≤14 points, and relative to participants with scores >14, there is a higher risk of sports injuries during high-intensity training or competition[13][14]. However, there are relevant studies show that the cut-off score for sports injuries will depending on the population and the project ("Table 5"). For example; Shojaedin et al. set the cut-off at 17 points when studying firefighters [17]. Dorrel et al. found that the cut-off score of 15 is the most sensitive by studying the Collegiate athletes[16]. Tee et al. set the cut-off score at 13 when studying Rugby union[18]. When researching the national table tennis players, Zhou Kangkang found that the injury cut-off score of this group was 12.5 points, which was significantly lower than the research of the former. The sample size has a certain degree of relationship. It is believed that sending some of these may be the reason for different thresholds[39]. Therefore, the establishment of cut-off score for sports injuries requires each event and crowd to determine the cut-off scores for sports injuries corresponding to the unique characteristics and the crowd through practice.

Table 5. Description of the cut-off scores in different population

Population	Cutoff	Sensitivity/specificity	Author
Recreational athletes	17	0.51/0.83	Shojaedin et al.
table tennis national athletes	12.5	0.811/0.886	Zhou, k.k
Collegiate athletes	14	0.61/0.49	Dorrel et al.
Rugby union	13	0.61/0.77	Tee et al.

In this study, through ROC curve analysis, in order to obtain the cut-off score of sport injury for PE candidates. ROC (receiver operating characteristic curve) refers to the binary classification outcome variable is sensitive to a specific influencing factor. In this study, it can be understood the two-category variable of sports injury is affected by the quality of functional action patterns.

"Table 6", the area under the ROC curve is 0.775, the standard deviation is 0.09, the 95% confidence interval is 0.598-0.951, P>0.05, indicating that the FMS score has a significant diagnostic benefit for the occurrence of sports injuries. Usualhe diagnostic value of 0.7-0.9 is medium, and the diagnostic value above 0.9 indicates that the diagnostic value is high [40]. Therefore, the area under the 0.775 curve obtained in this study can be considered to have a medium diagnostic value.

Table 6. The area under the ROC curve

TAUTC	SD	Sig.b	95% CI	
0.775	0.090	0.011	0.598	0.951

a TAUTC= the area under the ROC curve; SD= standard deviation; CI confidence interval.

The ROC curve coordinates ("Table 7") were obtained by performing ROC curve analysis on the data of 30 participants. When FMS score 14 is used as the threshold, the highest sensitivity can be found, and 100% of high-risk groups, the area under the curve is more significant than 0.5, because when the area under the curve is less than 0.5, it means that the sensitivity and specificity are very low and it is meaningless to distinguish. When looking at the specificity, there is a 29% probability of correctly excluding healthy groups, and the specificity is low. When the score is determined to be 15.5, the sensitivity (0.875) and specificity (1-0.357=0.643) are at the highest level, these scores would be used to screen out the potentially injured participant's group and effectively exclude healthy participants, so this study determined the cut-off score for PE candidates to be 15.5 points.

Table 7. ROC curve analysis

Cut-off Score	Sensitivity	1 - Specificity
11.00	1.000	1.000
12.50	1.000	0.929
13.50	1.000	0.857
14.50	1.000	0.714
15.50	0.875	0.357
16.50	0.500	0.214
17.50	0.188	0.071
19.00	0.000	0.000

5. CONCLUSION

Through the comparison of previous researches, this study found that the PE candidates have a high degree of consistency in the injury site, lower-body injury is higher than the upper to the injury. To a certain extent, FMS is a qualified screening tool to recognize deficiencies in movements for PE candidates.PE candidates generally have four functional movement mode defects, such as RS, DS, HS, and ILL.

FMS has medium accuracy for predicting injury in PE candidates, score of 15.5 have the highest sensitivity (0.875) and specificity (1-0.357=0.643) as compare to the other cut-off scores, so this study determined the cut-off score of injury for PE candidates at the threshold of 15.5 points.

The composite score of FMS was statistically lower in non-injured participants as compare to injured participants. There was a statistically significant difference between the two groups in DS and ILL. Therefore, stakeholders should pay more attention to the PE candidates whose FMS composite score lower than the predicted value of the injury, while the DS and ILL scores are lower than the average level.

AUTHORS' CONTRIBUTIONS

Bing Shi and Yikeranmu Yiming are responsible for experimental design, Yikeranmu Yiming analysed data, Yikeranmu Yiming wrote the manuscript, Qian Li and all other authors contributed to revising and editing.

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DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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