Research Paper:
Relationship Between the History of Injury and Functional Movement Screening Scores in Iran National Team Wrestlers

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ABSTRACT

Introduction: Wrestling is one of the most popular Olympic sports in Iran. Therefore, preseason screening and the prevention of sports injuries are very important. This study aimed to investigate the relationship between the history of injury and Functional Movement Screen (FMS) scores of the national team wrestlers and determine the cut-off point.

Methods: The statistical sample included 136 national team wrestlers. The obtained data were analyzed using the Pearson correlation coefficient, t-test, ROC curve, and contingency table.

Results: The results showed that FMS scores were higher in the wrestlers without previous injury compared to the injured ones. The t-test results demonstrated no significant difference between deep squat, straight and active leg raise, trunk stability push-up, and rotatory stability. According to the results, there is a poor negative, but statistically significant, the relationship between the number of previous injuries and FMS scores. Based on the ROC curve for FMS, the cut-off point of 16.5 was reported with the sensitivity and specificity values of 0.587 and 0.658, respectively.

Conclusion: The results indicated that FMS can be used for fast and accurate control of injury probability in wrestling athletes. Therefore, besides the medical tests, FMS tests should be employed by wrestling coaches as a valid tool for injury prevention and the identification of athletes prone to injury.

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Introduction

Wrestling is one of the first ancient Olympic games [1]. The national prestige and popularity of this sport in Iran attract many fans to the gym [2]. Also, Iranians have high expectations of success for their wrestlers. Because of the nature of this sport, it leads to a high rate of injury, compared with other sports [3]. The current information on wrestling injuries is mostly related to high school and college wrestlers in the USA [2]. Halloran (2008) reported the injury rate of 9.6 per 1000 hours of activity, making it the second most injured sport after football [4]. Yard et al. (2008) reported the injury prevalence rate of 2.33 and 7.25 per 1000 hours of activity for high school and college wrestlers, respectively. They also described a higher injury rate in freestyle wrestling (7 per 1000 hours) than in Greco-Roman wrestling (4.6 per 1000 hours) [5].

Agel et al. (2007) stated that more than 40% of competition injuries and 31% of exercise injuries occur in the lower extremity, while about 26% of competition injuries and 20% of exercise injuries occur in the upper extremity. About 22% of knee injuries, 8% of ankle injuries, and 6% of shoulder injuries happen for athletes. At the least, 34% of competition injuries and 28% of exercise injuries prevent the athletes from exercises for a minimum of 10 days [1]. Despite a large number of wrestling athletes in Iran, this field is associated with a considerable risk of injury that makes athletes absent from the exercises and competitions. Ebrahimi et al. (2012) reported the injury incidence rate of 13.62 per 1000 wrestling athletes and the high cost of treatment (approximately, IRR 90000000000) during three years in Iran; about 10% of this cost (IRR 9500000000) has been spent on treating wrestling injuries [6].

Nowadays, preseason screening is common in competitive and professional sports because of the increasing rate of sports injuries. Screening is done to prevent injury and improve implementation strategies [7]. Cook et al. (2006) introduced the Functional Movement Screen (FMS) tests considering the preseason screening and implementation-related factors [8]. Recently, researchers have investigated the FMS test and its association with the risk of sports injuries. Okada et al. (2011) found no correlation between core stability and the FMS test, in non-athlete healthy subjects. These researchers specified that the FMS could only determine the potential risk of injury in an individual [9]. Loudon et al. (2014) performed this functional test in a group of endurance runners and evaluated the scores obtained across different age ranges and genders. They found a relationship between the FMS scores and the reduced risk of sports injuries [10]. Also, Kiesel et al. (2007) investigated the relationship between FMS scores and the occurrence of lower and upper extremity injuries among soccer players. Athletes who scored under 14 in the FMS test were 6 times more prone to physical injuries [11]. In Iran, Shujauddin and Haddinejad (2013) investigated 100 male and female university students and found that athletes who scored under 17 in the FMS test were about 4.7 times more prone to lower limb injury, compared with those who scored over 17. There was a significant difference in FMS scores between the ankle and knee injury groups and healthy groups [12].

The post-injury financial issues, such as the cost of surgery and rehabilitation and psychosocial factors necessitate the application of injury prevention programs [13; 14]. Besides the financial costs, the loss of the entire sports season and long-term disability are the consequences of the injury [15]. The injuries lead athletes to stay away from the sports for a long time and have permanent negative effects, therefore, preseason screening and the prevention of these injuries are extremely important. Given that wrestling is one of the most popular contact sports with a high probability of injury in Iran, the question is whether the FMS test scores correlate with the injury history of national wrestling team athletes.

Materials and Methods

In this descriptive correlational study, the relationship between FMS test scores and the previous injuries of the Iran national team wrestlers was investigated. The research sample consisted of 136 national wrestling athletes aged 18-25 years. They exercised at the Wrestling House No. 2 of the Wrestling Federation and Shahid Rezaie Majd Wrestling Academy. The inclusion criteria included a history of joining national wrestling teams, regular participation in wrestling exercises, and not being injured at the time of testing. Athletes should not have been injured, which might disqualify them from exercise or competition, for 30 days before testing, or had a surgery restricting their participation in sports by physician's order [7].

The history of wrestlers' injuries in the past six months was collected and recorded using a researcher-made injury questionnaire. The questionnaire was developed based on the forms presented in reliable articles on wrestling injuries and included the definition of injury, the date of injury occurrence, the occurrence setting

- The upper body is parallel to the tibia.
- The femurs are parallel to the ground.
- The knees are exactly placed above the feet.
- The rod is parallel to the ground.

Figure 1. Deep Squat Test

- Femur, knees, and ankle joints are in the same direction on the sagittal plane.
- There is no movement in the lumbar region.
- The rod and hurdle are parallel.

Figure 2. Hurdle Jumping Test

(exercising or competition), the location of the injury, and the cause of injury [5, 16-18]. Minick et al. (2010) evaluated the internal validity of the FMS in 40 athletes and reported a high degree of agreement between the four different examiners [19].

To perform the FMS test, the researcher carried the FMS kit to the wrestler's exercise site. The FMS test was performed after 5 minutes of warm-up. The test includes the deep squat (Figure 1), hurdle step (Figure 2), the in-line lunge (Figure 3), shoulder mobility (Figure 4), Active Straight Leg Raise (ASLR) (Figure 5), trunk stability push-up (Figure 6), and rotatory stability (Figure 7). Initially, the participant performed a trial, then, each movement was repeated for three times. The method of scoring in this test was as follows: The score of 3, performing the movement correctly without compensatory movements; the score of 2, performing the movement with the compensatory movements; the score of 1, inability to do the compensatory movements; and the score of 0, pain during movement or detection test [20-22]. According to this scoring, the total maximum score

- The rod is in contact with the vertebral column in the open position.
- There is no movement in the trunk.
- The rod and feet remain on the sagittal plane.
- The knee touches the heel of the front foot.

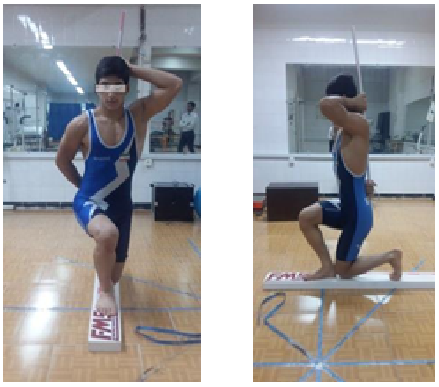

Figure 3. In-Line Lunge Test

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- The fists are 20 cm apart (3 points).
- The fists are 30 cm apart (2 points).
- The fists are more than 30 cm apart (1 point).

Figure 4. Shoulder Mobility Test

- Ankle or rod head should be parallel to the mid-thigh and anterior superior iliac spine of the pelvis (3 points).
- The ankle or rod head should be parallel to the midpoint of the thigh and mid-patella or joint line of the knee (2 points).
- The ankle or rod head should lie parallel to the point below the mid-patella or joint line of the knee (1 point).

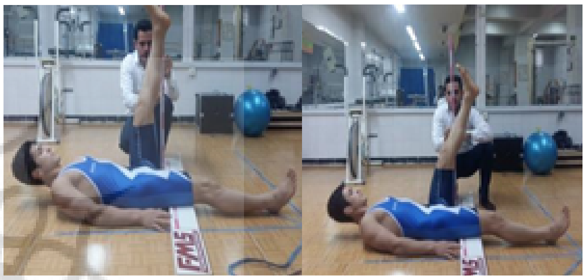

Figure 5. The ASLR Test

of this test is 21 [7]. The procedure of scoring at each stage is listed below.

Descriptive statistics were used to describe the data. Then, the Pearson correlation coefficient, independent t-test, ROC curve, and contingency table were used to investigate the relationship between FMS scores and the previous injuries, in SPSS. P values of less than 0.05 were considered significant.

Results

Overall, 73 out of the 136 participated wrestlers had a history of injury in the past six months. Table 1 reports the descriptive characteristics of the injured and uninjured wrestlers. Also, the result of the t-test showed no significant difference between the mean age, weight, height, and BMI of the uninjured and injured wrestlers ($P<0.05$).

- Performing one repetition in the position where the thumb is parallel to the forehead (3 points).
- Performing one repetition in the position where the thumb is parallel to the chin (2 points).
- Not to align the vertebral column with the lower extremity (1 point).

Figure 6. Trunk Stability Push-up Test

Performing a correct repetition while the vertebral column is parallel to the ground. The knee and elbow touch each other.	

Figure 7. Rotatory Stability Test

Table 2 presents the FMS scores of the uninjured and injured wrestlers. The results showed that the uninjured wrestlers significantly outperformed the injured ones in terms of the FMS score. The mean score of uninjured and injured groups was 16.42 and 15.36, respectively. In the subtests performed for both groups, the results were similar: The uninjured wrestlers scored higher in all cases. Also, the results of the t-test showed no significant differences between the two groups in the deep squat, SLR, push-up, and rotatory stability (P<0.05). However, this difference was significant in the overall FMS score, hurdle step, in-line lunge, and shoulder mobility (P≥0.05). The Pearson correlation coefficient was used to examine the relationship between the number of previous injuries and the FMS scores. Results showed a poor significant relationship (r=-0.204, P=0.017) between the number of previous injuries and the FMS scores.

Table 1. Descriptive characteristics of the study sample

Variables	Subjects				t	P
	Uninjured (63)		Injured (73)			
	Mean±SD	SE	Mean±SD	SE		
Age (y)	19.09±1.86	0.23	19.05±1.53	0.17	0.139	0.89
Weight (kg)	70.65±16.84	2.12	73.41±16.02	1.87	-0.978	0.33
Height (cm)	173.57±11.39	1.43	176.46±9.21	1.07	-1.638	0.1
BMI (kg/m²)	23.17±2.82	0.35	23.43±3.37	0.39	-0.489	0.62

Table 2. Distribution of uninjured and injured wrestlers by fms score and its dimensions

Variables	Subjects				t	P
	Uninjured (63)		Injured (73)			
	Mean±SD	SE	Mean±SD	SE		
FMS score	16.42±2.12	0.26	15.36±2.07	0.24	2.938	0.004
Deep squat	2.28±0.48	0.06	2.19±0.54	0.06	1.051	0.295
Hurdle step	2.36±0.51	0.06	2.17±0.56	0.06	2.008	0.047
In-line lunge	2.47±0.61	0.07	2.23±0.67	0.07	2.174	0.031
Shoulder mobility	1.85±0.82	0.1	1.53±0.97	0.11	2.074	0.04
ASLR	2.76±0.42	0.05	2.69±0.51	0.06	0.768	0.444
Trunk stability push-up	2.69±0.58	0.07	2.57±0.62	0.07	1.182	0.239
Rotatory stability	1.98±0.28	0.03	1.94±0.32	0.03	0.733	0.465

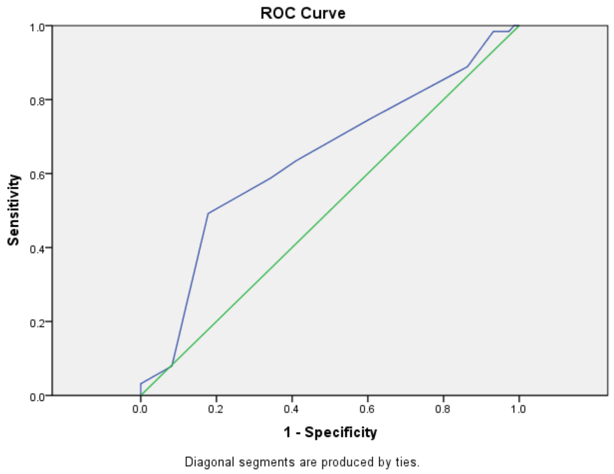

Figure 8. ROC curve for FMS

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Figure 8 shows the ROC curve for the FMS. This curve has been used to determine the cut-off point [23]. The cut-off point of 16.5 was obtained with the best equilibrium between the sensitivity and specificity values of 0.587 and 0.658, respectively. Accordingly, those who scored below 16.5 were more prone to injury. Using the cut-off point of 16.5, the contingency table of the wrestlers was divided into two groups (Table 3). Findings indicated that most athletes who scored below the cut-off point were placed in the injured category. However, most of the athletes who scored higher than the cut-off point were in the healthy category and uninjured group; the difference between the categories was significant based on the Chi-square test ($P \geq 0.05$).

Discussion

The FMS test is a fast, non-invasive, inexpensive, and easy-to-observe tool that assesses the multiple FMS patterns of an individual to detect asymmetries and movement limitations that are thought to affect the risk of injury in sports [11, 24, 25]. The effectiveness of the FMS test has been demonstrated for assessing injury risk among American professional football players [11], NCAA athletes [7, 26], recreational athletes [20], naval officer volunteers [27, 28], and firefighters [29]. Also, FMS has shown high intra-examiner reliability among trained evaluators [30, 31]. Previous studies have represented that low FMS composite scores and the presence of asymmetries [32] are associated with a much greater risk of injury in some sports and occupations [7, 12, 26-29].

The results of the present study showed that wrestlers without injury had better FMS scores than the injured wrestlers, and the difference was statistically significant ($P \geq 0.05$). The primary purpose of the FMS tests is to evaluate the kinetic chain system of the body. It is believed that all parts of the body are interconnected, and sometimes, act distally rather than initially in motions. The FMS tests provide valuable information about stability and mobility, and ultimately, lead to the formation of precise movements in individuals. In five tests of the FMS tests, scores are calculated for both legs, but in

Table 3. Injury contingency based on the FMS scores

FMS	Previous Injury No. (%) Yes	Previous Injury No. (%) No	Total
Less than 16.5	26 (35.1)	48(64.9)	74 (100)
More than 16.5	37 (59.7)	25 (40.3)	62 (100)
Total	63 (46.3)	73 (53.7)	136 (100)

P=0.004, phi=-0.245

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two tests, only one overall score is given. People who scored below 14 (cut-off score) on FMS tests were prone to lower extremity injuries. However, the study that mentioned this cut-off score had a small sample size (N= 46), and its participants only included the professional soccer players. So, this score cannot be generalized to all athletes and individuals in society, and more detailed studies are needed to determine more accurate scores [11].

The overall scores of FMS and its tests were higher in uninjured wrestlers than in injured wrestlers. The differences were statistically significant between the injured and uninjured wrestlers in overall FMS scores, hurdle step, in-line lunge, and shoulder mobility (P≥0.05). These differences between the injured and uninjured groups can be caused by the effect of injury on overall body stability, disturbing balance, and the lack of proper control during the FMS test. These results are inconsistent with those of Schneiders et al. (2011) who reported no difference in FMS scores, between the individuals with and without a history of injury. The diverse levels of activity and the gender of the participants can be the reasons for this disagreement [33].

The previous studies of the FMS score and exercise-related injury have used the ROC curve to determine the cut-off point in the FMS [11, 12]. The cut-off point of the FMS tests was about 16.5. The results of the contingency table showed that the wrestlers who scored less than 16.5 in the FMS test were more prone to injury than those who scored higher than this cut-off point. The cut-off point obtained in this study differs from those found by Kiesel, Plisky, and Voight (2007) and Chorba et al. (2010), who reported a cut-off point of about 14.

Kiesel et al. (2007) examined the relationship between the FMS scores and the probability of serious injury in 46 professional football players. The mean FMS score of athletes with serious injuries was 14.3 (SD=2.3), while the mean score of athletes without serious injuries was 17.4 (SD=3.1). These mean values were significantly different. The ROC curve identified the cut-off score of 14 in the FMS. The incidence of serious injury was 51% for the players who scored below 14 in the FMS [11]. Chorba et al. (2010) used the FMS score of 14 to evaluate the ability of FMS to predict injuries in football, NCAA basketball, and volleyball athletes. The FMS cut-off point that best predicts the risk of injury for one sport may differ from the cut-off points in other sports, especially when considering contact versus non-contact sports [7]. The causes of this difference include differences in sports fields, gender, the competitive and skill levels of athletes, functional ability, exercise, and the athletic demands of athletes. On the other hand, differences in the definition of injury by Kiesel et al. and their small sample size could also be another reason for the differences in the research findings.

The results of this study were similar to those of Shujauddin et al. (2014) who examined the ability of FMS to predict lower extremity injuries in a young, active, and healthy population. Participants included 50 college male students and 50 college female students who had participated in basketball, handball, recreational, or competitive football for the past five years. As the study of Kiesel et al. (2007), Shujauddin et al. (2014) used the ROC curve to determine the cut-off score of the FMS. They specified the cut-off score of 17 in the FMS and observed a statistically significant difference between the mean scores obtained by injured and uninjured athletes [20].

The current findings provided further evidence for the usefulness of the FMS cut-off score in identifying at-risk athletes. Our results extend the generalizability of the FMS cut-off score from the professional American football players [11], volleyball, basketball, and NCAA women football players' athletes [7]; navy officer volunteers [27]; and firefighter volunteers to experienced and professional wrestlers. Previous studies have determined the cut-off score of the FMS in various sports and sports fields; this study was conducted on wrestling that is a popular Olympic sport in Iran.

Conclusion

The findings indicate that the quality of the base movements (assessed by the FMS) predicts the risk of time loss in professional wrestlers and should be considered as an important athlete assessment tool. The FMS test can be used to control quickly and accurately the probability of injury for wrestlers with a score of below 16.5. This cut-off point provides trainers with an accurate injury prevention model to predict the extent of injury in their athletes. Therefore, wrestling coaches should use FMS tests (along with medical tests) as a valid tool to assess the athletic injury, measure the functional level of their athletes before each competition, identify vulnerable individuals, and improve their capabilities. The FMS should be used in conjunction with other injury risk assessment tools. More definite results require more research with a different statistical population and a larger sample size.

Ethical Considerations

Compliance with ethical guidelines

The Ethics Committee of Research at University of Tehran, Department of Health and Sports Medicine approved the study.

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Authors' contributions

All authors were equally contributed in preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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