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The relationship of functional movement screen scores with flexibility, speed and agility in 17-15- year- old male students

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Abstract

Background: Functional Movement Screening (FMS) is a tool to determine the individual's potential for the possibility of sports injury.

Aim: The purpose of this study was to determine the relationship between functional movement screening scores with flexibility factors, speed and agility in male students in Lorestan province.

Materials and Methods: 370 male volunteer students aged 15 to 17 years participated in this study. Spearman correlation coefficient was used to determine the relationship among flexibility, power, speed and agility.

Results: The present study showed that there were significant relation between scoring screen for functional movement and flexibility of the left leg, long jumping, high jumping in 15- year- old students. There were significant relations between scoring screen for functional movement and flexibility, flexibility of the right leg, flexibility of the left leg, long jumping, high jumping in 16- year- old students. In addition, in the 17- year- old students, there were significant relation between scoring screen for functional movement and flexibility of left leg, flexibility of the right leg and height jumping.

Conclusion: In general, there were significant relation between FMS scores and flexibility and power in three groups of students. The probable cause of this connection can be attributed to in- line lunge tests, Hurdle step, active straight-leg-raise and deep squat, which are directly related to flexibility and power. Therefore, in order to improve the FMS scores of students, it is recommended that students be flexible and able to include in their training program.

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1. Introduction

Recently, sports scientists, physiotherapists and doctors believe that the evaluation of functional movements and training strategies can be useful in improving athletic performance, prevention and reduction of sports injury rates [1, 2, 3, 4]. Functional motion is defined as the ability to produce and maintain a balance between stability and motion along the motor chain while the individual implements basic motion patterns accurately and efficiently [5]. Hence, functional fitness components have been proposed as the ability to stand, sit, or move properly and efficiently during daily activities, recreation, and sports activities.

Over the years, sports scientists have tried to reduce musculoskeletal injuries and improve athletic performance by teaching the correct techniques [5]. Due to increased participation in sports activities, high number of competitions and more serious competition in high school students than elementary and middle school students, the number of injured young athletes is also higher [6, 7]. More than 2 million high school students in the United States have been injured, 500,000 need to see a doctor and 30,000 have been hospitalized; These huge number of sports-related injuries may be associated with long-term disability [8].

In schools, physical education instructors try to strengthen and raise the factors of physical fitness by using exercises and performing physical fitness tests. Flexibility, aerobic and anaerobic power, muscle strength and endurance, and agility affect performance [9]. Therefore, developing and promoting flexibility, strength and endurance of lower limb muscles, speed and agility are among the main goals of students' training programs.

There are several tests to evaluate the quality of functional movement patterns [10, 11, 12]. In an attempt to introduce a standard protocol for evaluating functional movements, Functional Movement Screening tests (FMS) is a used. Cook et al. (2006) reported that there was a significant association between trunk stability push up, right hurdle step, right shoulder mobility, and right rotational stability with throwing the Madison ball backwards. There was also a significant relationship between stepping on right hurdle step, linear lunge on the left, mobility of the right shoulder and agility [3].

Parchman and McBride (2011) reported that there was no relationship between performance 10 m speed, 20 m speed, vertical jump, agility time with golfers' FMS scores [1].

Lockie et al. (2015) examined the relationship between FMS scores and women's athletic performance in team sports. Their results showed that there was a significant relationship between FMS combined scores, active leg elevation on the left and right, and left linear lunge with flexibility [13]. The results are also contradictory. Previous research has also been done on people who exercise recreationally, and the relationship between FMS scores and fitness factors has been less studied in students.

Since the nature of sports is different and in schools, special functional characteristics are emphasized in each age group, in this study, we tried to select variables as sports performance. Therefore, the aim of the present study was to determine the relationship between FMS scores and tool composed of seven specific tests to assess an individual's overall functional movement capacity. Tests are scored on a 0–3 ordinal scale and include the squat, hurdle step, forward lunge, shoulder mobility, active straight leg raise (ASLR), push-up, and rotary stability.

A score of 3 indicates the subject who was able to perform the movement correctly and without pain. A score of 2 indicates that the subject could complete the movement without pain but with some level of compensation. A score of 1 is given when the subject is unable to complete the movement as instructed. A score of 0 is recorded if the subject experiences pain with any portion of the movement. Overall FMS scores can range from 0 to 21.

Bonazza et al. (2017) reported that people with a combined FMS score of less than 14 were 2.7 times more likely to experience neuromuscular injuries [14]. Most people with a combined FMS score above 14 are more likely to develop musculoskeletal injuries [15].

Some studies have also reported that there is no significant relationship between dysfunction or motor asymmetry during FMS tests and high risk of injury [16, 17]. Cook et al. (2006) suggested that high FMS scores indicate proper skeletal muscle stability and movement, which improves athletic performance and reduces the rate of sports injuries [4]. Bushman et al. (2016) also reported that low FMS scores have detrimental effects on athletic performance and increase the rate of sports injuries [18]. Flexibility, muscle strength, agility, coordination and movement efficiency are essential components for achieving functional movements and exercise-related skills. Few studies have examined the relationship between FMS scores and fitness factors, and their results are inconsistent. Okada et al. (2011) examined the relationship between FMS scores and athletic performance of healthy men and women who exercised recreationally. They reported that there was a significant association between trunk stability push up, right hurdle step, right shoulder mobility, and right rotational stability with throwing the Madison ball backwards. There was also a significant relationship between stepping on right hurdle step, linear lunge on the left, mobility of the right shoulder and agility [2].

2. Materials and Methods

The present study is cross-sectional, based on the nature and method of data collection, and applied in terms of purpose. The statistical population was all high school male students in Lorestan province. A total of 370 subjects (mean height 175.26±0.071cm and weight 65.90±13.04 kg) were randomly selected as a statistical sample according to the research criteria. The sample size was calculated according to the number of students in each grade and using Morgan (1970) table in each group. Based on this, the number of samples in the first year students was 150, in the second year 120 and in pre-university 100 students. In this way, considering that different regions of Lorestan province have different social, economic and cultural conditions. Lorestan education areas were divided into five regions: north, south, east, west and center, which were considered as clusters:

- North includes: Boroujerd-Ashtrinan
- South includes: Poldokhtar-Mamolan-Kuhdasht-Romeshkan
- West includes: Alshtar-Noorabad
- East includes: Doroud-Azna-Aligudarz
- Center: Khorramabad (areas 1 and 2).

After determining the areas, one area was randomly selected from each area (The areas that were selected according to the lottery from the five districts are: Khorramabad-Borujerd-Aleshtar-Doroud-Mamolan).

After determining the areas related to students in Lorestan province, the list of high schools related to the regions was prepared. Then, two high schools were randomly selected from the names of schools in each region based on the number of students in each region compared to the total number of students in the province. The percentages of the total students are included individuals who were randomly identified from these two high schools.

Table 1. Number of students in each city separately in each degree

City	Number of students in first year	Number of students in the second year	Number of pre-university students
Khorramabad	52	42	32
Boroujerd	20	24	18
Doroud	20	20	20
Alshtar	24	21	20
Mamolan	34	13	10
Total	150	120	100

Inclusion criteria: Age range 15-17 years, studied in the 97-96 academic year.

Exclusion criteria: History of injury and surgery in the past year, existence of prosthesis in the lower limb, excessive joint laxity (survey using Beaton index) [19].

Subjects completed the voluntary participation consent in the study before starting the study. The tests were performed in three separate sessions. At the beginning of each session, the subject warmed up for 10 min by brisk walking, then performed stretching exercises. In the first session, a set of FMS tests was performed according to the instructions of Cook et al. (2006) [3, 4]. This set of tests is designed to simultaneously assess mobility and stability using seven motor tests. Previous researchers intra-tester reliability (95% C I, 0.69-0.92) and between testers (0.95 CI, 0.70-0.92) reported for these tests [20, 21]. FMS test scores were recorded from both front and side views during FMS tests [4]. The second session of the subjects' sports performance with standard field tests includes flexibility, power and speed tests. In third session, right and left leg flexibility and agility, respectively with sitting and bending forward tests, vertical jump (sergeant) and pair jump, 20 m speed test and 4×9 m test were evaluated.

2.1. Functional Movement Screen

Each subject was evaluated based on their performance in seven functional movements. The scoring of these tests was performed according to the instructions of Cook et al. (2006) [4]. A score of 3 indicates the subject was able to perform the movement correctly and without pain. A score of 2 indicates that the subject could complete the movement without pain but with some level of compensation. A score of 1 is given when the subject is unable to complete the movement as instructed. A score of 0 is recorded if the subject experiences pain with any portion of the movement. Overall FMS scores can range from 0 to 21. Five tests out of seven tests (in- line lunge, hurdle step, active straight-leg-raise, shoulder mobility rotary stability) were scored independently on the right and left sides of the body. Because of the association between neuromuscular asymmetry and the right and left, the FMS scoring system emphasized asymmetry and the lowest score was considered as the overall score for that movement. To get the final score, the total scores of each test were added together. Therefore, the subject could have a final score of zero (if there is pain in each movement test) to 21 (if the subject scored 3 in each test) [3].

2.2. Test sitting and bending forward

This test is a field test that assesses lower limb flexibility. The subject sat in front of the box with bare legs and elongated knees while the upper body was perpendicular to the legs and stretched on the calibrated board as much as possible by placing the hands on top of each other. After a pause of 5 seconds, the score was recorded. This operation was repeated three times and the best score was recorded for him. The subject was asked to take the test if one leg was perpendicular to the ground and bent (Sole on the ground) and the other foot was stretched (heel on the support of the box). This operation repeated three times for both feet and the best score for each foot was recorded.

2.3. Runing test 20 m speed

A 20 m path was marked with cones or funnels placed at the level of the hall. The subject was placed behind the starting line, which was 30 cm away from the designated route. As the start signal (whistle), it quickly crossed the desired 20 m and the stopwatch stopped. The best score was recorded [13].

2.4. Vertical jump test (sargent)

Vertical jump test evaluates the explosive power of the legs. The subject stood on the side of the superior hand against the wall and the fingertips of his superior hand while the non-superior hand was next to the body and the superior hand was stretched and comfortably above the head. It was placed on a graduated plate mounted on the wall. After marking the point, the subject was asked to jump in place (pair of legs) by bending the knees and swinging the arms and touch the highest point of the wall as much as possible at the peak of the jump. This operation was repeated three times (1 min break between attempts). The difference between the first point and the peak point of the jump was the score that the subject gained. The best score that the subject achieved in three rounds was registered for him [13].

2.5. Pair jump test

The subject was standing behind the jump line with his legs about 30 cm apart. The subject swung his arms back to prepare for the jump and bent his knees. The jump was then performed by simultaneously throwing the arms forward and straightening the knees. The jump distance was measured from the back of the heel to the starting line of the jump. The maximum amount of jump was recorded for the subject from three test runs [18]. Due to the fact that the pair jump and vertical jump test (sargent) are used to evaluate the explosive power of the leg muscles in this study, we used two tests to determine the relationship between each of them and functional motor screening tests.

2.6. Running test 4 × 9 m

Running test 4 × 9 m assesses agility. The test was performed on a volleyball court (9 m). We placed two wooden blocks behind one of the drawn lines and the subject was behind the opposite line at a distance of 9 m. With the sound of the whistle, the subject started running towards the wooden blocks, picking up one of the blocks and he quickly went back to the starting line and put the block behind the line and came back again and picked up another wooden block and quickly went back to the starting line. He was crossing it, crossing the line, ending his work, and the stopwatch stopped. The best time was recorded for the individual after taking the test twice. The subjects rested for 3 min between turns [13].

2.7. Statistical analysis

Descriptive statistics including frequency, mean, standard deviation and confidence intervals were used to analyze the data. Also, to examine the relationship between components of functional motor screening test and flexibility factors agility, speed and power spearman correlation coefficient was used because the scales of FMS test components were ranked. All analyzes were performed using $SPSS_{22}$ at a significance level of 0.05.

3. Results

The demographic characteristics of the subjects are reported in Table 2. Scores of functional movement screening tests are ranked; Therefore, Spearman correlation coefficient test was used to investigate the relationship between functional movement screening test scores and research variables. The findings of the present study in Table 3 show that in 15-year-old students, there is a significant relationship between functional movement screening score and left leg flexibility tests, pair jump, height jump. There is no significant relationship between functional movement screening score and flexibility, speed and agility tests. Table 4 also shows that in 16-year-old students, there is a significant relationship between functional movement screening score and flexibility tests, left leg flexibility, right leg flexibility, pair jump, and height jump. There is no significant relationship between functional movement screening score and speed and agility tests. Also, the results of research in Table 5 show that in 17-year-old students, there is a significant positive relationship between functional movement screening score and tests of right leg flexibility, left leg flexibility, high jump and a significant negative correlation with speed. There is a significant correlation between FMS scores and physical fitness of the three groups in general (Table 6).

Table 2. Mean and standard deviation of height, weight and body mass variables of research subjects

Variable	Group 15 years Mean±SD	Group 16 years Mean±SD	Group 17 years Mean±SD	Three groups Mean±SD
Height (cm)	173.17±0.07	175.81±0.06	177.75±0.75	175.26±75
Weight (kg)	62.76±12.74	65.74±12.83	70.80±13.48	65.90±13.04
Body mass index (kg/m^2)	20.89±3.90	21.89±3.42	22.36±3.55	21.71±3.62

Table 3. Relationship between FMS and selected fitness factors of 15-year-old students

Variable	N	The correlation coefficient	The significance level
Flexibility	150	0.131	0.11
Right leg flexibility	150	0.122	0.14
Left leg flexibility	150	0.176	0.03
Power (vertical jump)	150	0.209	0.01
Power (pair jump)	150	0.169	0.04
Speed	150	-0.121	0.14
Agility	150	-0.158	0.05
Physicalfitness	150	0.181	0.02

Table 4. Relationship between FMS and selected fitness factors of 16-year-old students

Variable	N	The correlation coefficient	The significance level
Flexibility	120	0.291	0.00
Right leg flexibility	120	0.297	0.00
Left leg flexibility	120	0.308	0.00
Power (vertical jump)	120	0.197	0.03
Power (pair jump)	120	0.272	0.00
Speed	120	-0.035	0.70
Agility	120	0.077	0.40
Physicalfitness	120	0.352	0.00

Table 5. Relationship between FMS and selected fitness factors of 17-year-old students

Variable	N	The correlation coefficient	The significance level
Flexibility	100	0.161	0.11
Right leg flexibility	100	0.271	0.01
Left leg flexibility	100	0.238	0.08
Power (vertical jump)	100	0.367	0.00
Power (pair jump)	100	0.165	0.10
Speed	100	-0.402	0.00
Agility	100	-0.127	0.11
Physicalfitness	100	0.120	0.23

Table 6. Relationship between FMS test scores and physical fitness in three groups in general

Variable	N	The correlation coefficient	The significance level
Physicalfitness	370	0.228	0.00

4. Discussion

The aim of this study was to investigate the relationship between FMS scores and selected physical fitness factors of students aged 15-17 years. The results showed that flexibility is one of the variables related to FMS scores in these students. A possible cause of the association between FMS scores and flexibility can be attributed to lunge tests, hurdle step, and active leg raising, which require flexibility. The results of Spearman correlation test between the components of FMS test and flexibility in confirming this result showed that flexibility is correlated with active leg raising, linear lunge, and hurdle step tests. In other words, the subjects who scored higher on the sitting and leaning forward test, in the lounge tests, hurdle step, actively raising the leg, and scoring higher scores raising the leg is one of the components of the FMS test that assesses the flexibility of the hamstring, soleus, and gastrocnemius muscles [13]. Stretching has been accepted as an integral part of exercise to reduce the risk of injury and improve athletic performance [22].

Lunges is one of the movements used in many sports and affects the loading of the lower limb joints while increasing and decreasing acceleration. Lunge is also a movement used to strengthen the hamstring muscles and increase linear speed in football training [23]. Cook et al. (2006) stated that lunges and hurdle step tests require flexibility of the hip muscles [3, 4].

The results of the present study with the results of the research of Lockie et al. (2015) consistent that there is a positive correlation between active leg raising, lunge, and flexibility and overall functional movement screening test score [13]. The results of the present study also showed that there is a significant correlation between functional movement screening scores and power (vertical jump). In the present study, the height jump movement was used to evaluate the power. In other words, the more jumps, the better the FMS scores. Vertical jumping requires a strong central area to allow the force generated by the legs to be transmitted to the upper body. Trunk stability push up involves maintaining the stability of the trunk, which should allow the transfer of force from the body to the upper limbs. Trunk stability push up may provide a sign of central stability that can help balance the legs in the vertical jump movement [13].

Also, the positive correlation between the scores of functional movement screening tests and vertical jump can be attributed to the Deep squat test of FMS tests. The vertical jump test uses squat 's motion to produce the vertical motion force that can be seen in the Deep squat test [23]. Thus, people who can perform the Deep squat movement are easily able to provide the force and range of motion required to perform the vertical jump movement [23].

The results of the present study are consistent with the results of the research of Lockie et al. (2015), stating that there is a significant correlation between the scores of functional movement screening tests and potency [13]. But the results of Parchman and McBride (2011) showed that there is no significant correlation between the scores of functional movement screening tests and power [1]. This discrepancy could possibly be due to the subjects' gender, level of activity, or type of sport, as Parchman and McBride's subjects were male and female golfers. According to the research results, there is a significant correlation between functional movement screening scores and placental jump in people aged 15 and 16 years. Also, there is no correlation between functional movement screening scores and pair jump in 17-year-olds.

One of the explosive performance tests is horizontal jump, which is different from vertical jump because stability in the landing stage is a large part of optimal performance [23]. People who are taller perform better in horizontal jumping, which may be due to their greater ability to move their center of mass. Tall people are easily able to move their center of mass, which can help with their jump length. Tall people have a farther center of mass away from the ground than short people, which is a point for the length of the jump. Tall people have a good length in their limbs, which they use to their advantage during the flight phase of the horizontal jump movement. Tall people also have longer arms that they can use by twisting their arms to produce more horizontal driving force [23]. However, in this study, there was no significant correlation between height and strength (vertical jump) and strength (pair jump) in the three age groups. This discrepancy could probably be due to the age of the subjects, level of activity and type of sport. Crouse 's subjects were male students and soccer players [23], while the present subjects were students who differed in terms of level of fitness in physical fitness factors.

According to the research results, there is no significant correlation between functional movement screening scores and speed. In general, in the case of functional movement screening tests, having functional motor patterns and better functional stability indicates better performance in speed and agility. In order to perform two-speed movement in an efficient manner, it is important to have a proper range of motion in the ankle, knee and thigh area. Limits in range of motion can alter a person's mechanical advantage while running at maximum speed and prevent performance and performance [13]. However, most of the flexibility created by stretching a muscle tendon unit may jeopardize strength-based activities such as sprinting. For example, more stretching of a muscle tendon unit has been associated with an increase in 20 m sprint time in sprinters [13].

According to the research results, there is no significant correlation between functional movement screening scores and agility. Lockie et al. (2015) did not observe a significant relationship between speed and jumping ability with combined FMS scores in team sports athletes who exercised recreationally [13]. In contrast, Woods et al.

(2018) reported that there was a significant relationship between speed of 20 m and vertical jump height with squat and linear lunge. In justifying their results, they stated that squat is a movement that requires hip mobility, spinal stability, chest mobility, and shoulder coordination, which is also required in rapid movements [24]. The probable reason for this discrepancy can be attributed to the level of activity of the subjects. The subjects of the study were professional footballers, while the subjects of the present study were students who differed in terms of the level of physical fitness. Woods et al. (2018) also reported that there was no relationship between agility and overall FMS scores [24].

The results of the research of Silva et al. (2017) also showed that there is no significant relationship between FMS scores and the performance of football players [25]. In interpreting these results, it can be stated that the main purpose of FMS is to identify functional disorders or compensatory movements using simple functional movements, and the FMS scoring system also reflects this goal. On the other hand, the method of scoring sports performance tests is quantitative and pays less attention to the quality of movement. Functional training is known as an important component of training interventions and FMS, which is used by sports scientists to identify weaknesses, muscle imbalances and compensatory movement patterns, can be corrected through training [26]. While FMS appears to be an effective tool to detect compensatory movements, these compensatory movements may have little effect on fitness scores or other methods such as motor program adaptation and skill development. Intrinsic physical demand for FMS and fitness tests are very different. For example, most individual FMS tests are performed slowly and evenly, while fitness tests are fast, explosive movements. So, fitness requires a high level of muscle strength, power and skill, while FMS focuses on stability, mobility and quality of movement. The homosexuality of the subjects was one of the limitations of the present study, and it is suggested that in future research, functional movement screening tests for female students be examined.

5. Conclusion

According to the findings, it can be stated that among the factors of physical fitness, flexibility and strength were significantly related to FMS scores. Possible causes of this connection can be attributed to linear launch tests, stepping over the obstacle, actively raising the leg, and deep squats, which directly require flexibility and power. Therefore, to improve students' FMS scores, it is recommended to include flexibility and power in their training program. The results also showed that there is no significant relationship between speed and agility and FMS scores. In general, there is a weak correlation between the physical fitness of the three groups of students and FMS scores. These results suggest that these variables have little effect on FMS scores. Based on this result, it can be stated that variables other than physical fitness such as postural stability, dorsiflexion range of motion, ankle flexion, thigh flexion and knee flexion may have a greater effect on FMS scores. It is suggested that these variables be examined in future research with a prospective research plan and different sports.

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