

Correlation between the Functional Movement Screen (FMS) Test with Dynamic Balance and Core Endurance in Male and Female Volleyball Players in Kerman Province

Sara Pourheydari^{a*}, Rahman Sheikhhoseini^a, Seyyed Ghasem Hosseini^b

^a Department of Health and Sport Medicine, Faculty of Physical Education and Sport sciences, Allameh Tabatabaie University, Tehran, Iran; ^b Department of Health and Sport Medicine, Faculty of Physical Education and Sport sciences, University of Tehran, Tehran, Iran

*Corresponding Author: Sara Pourheydari. Department of Health and Sport Medicine, Faculty of Physical Education and Sport sciences, Allameh Tabatabaie University, Tehran, Iran. E-mail: pourheydari.s@yahoo.com

Submitted: 2018-03-09; Accepted: 2018-06-02

Abstract

Introduction: Functional movement screen (FMS) test may be able to detect athletes who may be at risk of further injury by identification of muscle imbalances and movement impairment syndromes. The aim of this study was to examine the correlation between FMS test and dynamic balance and endurance of core muscles in male and female volleyball players. **Materials and Methods:** FMS test, the Y balance test and the McGill trunk endurance tests were employed in the present study to evaluate the quality of movement, dynamic balance and the core muscle endurance, respectively. Subjects voluntarily participated in the study for three consecutive days. The correlation coefficient was employed to investigate the relationship between variables. All statistical analyzes were carried out at confidence interval of 95% ($P < 0.05$). **Results:** 30 volleyball players (men=15, height $183/80 \pm 7/82$ cm, Weight $74/93 \pm 9/58$ kg) (Women=15, height $168/93 \pm 8/25$ cm, Weight $58/13 \pm 9/41$ kg). The results showed that there is only a significant correlation between the men's trunk flexor muscles and the left foot balance of the women's with functional movement test ($P < 0.05$). There was no significant relationship between other measured factors. **Conclusion:** Considering the results and limitations of the present study, it seems that the correlations between FMS scores and the core endurance and balance may be different between males and females; therefore, further studies are strongly recommended to clarify the issue.

Keywords: Athletic Injuries, Lumbosacral Region, Muscle Fatigue, Risk Assessment

Please cite this paper as: Sara Pourheydari. Correlation between the Functional Movement Screen (FMS) Test and Dynamic Balance and Core Endurance in Male and Female Volleyball Players in Kerman Province. J Clin Physio Res. 2018; 3(2): 64-69.

Introduction

Volleyball is a popular sport amongst other team sports and is regarded as one of the most popular sports among men and women worldwide. Considering the popularity of this sport, it is imperative to design strategies to forestall injuries occurring in this sport due to its availability to different age groups, the minimum equipment needed and the possibility of being played at and outside the home (1). There is limited information on the extent and pattern of injury in international volleyball competitions. The four-year information obtained from the 32 major competitions by the International Volleyball Federation (FIVB) Injury Surveillance System (ISS) has shown that the ankle (25%), knee (15.2%), fingers (10.7%) and waist (8.9%) are the most frequently injured body parts. Most injuries affect the shoulder, knee and waist of volleyball players due to excessive repetitions (2). Functional tests are a group of

physical skill tests that are employed for the following purposes: determining the ability of an athlete to compete at the desired level in a sport, career, recreational activity or return to activity in a safe manner and at the right time without functional limitation. Functional tests are used to evaluate the actual functional ability of a person; in other words, these tests estimate the overall performance of a person, not a part of his/her body (3). Functional movement screen (FMS) test is designed to identify individuals with a compensatory movement pattern developed in the kinematic motor chain. This test can be implemented as an efficacious and efficient technique for many individuals. FMS can be employed as a test for screening individuals and allows specialists to make an accurate evaluation of movement disorders (4). In order to assess the athlete's readiness to perform different activities that occur during physical activity, functional movements should be evaluated before participating in the sport in order to

determine who has the capability to perform certain basic movements (5). Compensatory functional movement patterns can increase the risk of injury in female athletes, which can be identified using FMS (6). FMS is a tool that may be able to determine the individual's potential to suffer from injury (7). FMS consists of seven movement patterns that require balance, mobility and stability, and these tests place one in severe situations; weakness and imbalance can be seen in the case of lack of appropriate stability and mobility (5). On the other hand, balance is one of the criteria that can be used to assess the risk of injury in athletes. All sports activities require balance control in the static and dynamic states. Functional balance tests focus on dynamic balance, balance in weight transfer, equilibrium response to the imbalances and functional mobility. Functional balance is a precondition for many sporting activities and requires proper interaction between sensory and motor systems (8). Researchers have identified "core stability" as another criterion for evaluating the risk of injury. The core stability is defined as the ability to control the trunk position on the pelvis in order to effectively produce and transfer force to the extremities of the body during sports activities (9). The core stability refers to the capability of the lumbopelvic hip complex to forestall spinal instability and return to balance after a disturbance. Since the core muscles are activated before performing movements, the stability and strength of these muscles are of high significance. Core stability is an axis for efficacious biomechanical function of the organs, and acts by increasing the production of force and reducing articular loads in all types of sports activities. The frailty or decreased harmony of the body's core muscles can lead to abnormal movement patterns, compensatory movement patterns, or a variety of sports injuries such as strain or workload related injury (10). The proper functioning of the core muscles of the body has many benefits, including promotion of exercise performance, prevention of injuries, and reduction and treatment of musculoskeletal disorders. On the other hand, it is recommended that specialized exercises be carried out in the central part of the body to prevent injury, and it is beneficial to include them in the training program of volleyball players (11). Since various criteria have been proposed for evaluating the risk of injury in athletes, knowing the relationship between these factors seems to play an imperative role in the clinical decision-making of specialists in the field of movement science. Consequently, there are many studies in this field. Linek *et al.*, measured the vulnerability of volleyball players using FMS and performed the exercise protocol to strengthen the core muscles of the body. They later observed an increase in the FMS score (11). Huxel *et al.*, found in a research that the vulnerability level decreased by strengthening the core muscles, and the exercises on the core muscles could be employed in the formulation of an injury prevention program (12). To the best of the knowledge of the researchers, there has been no study conducted to examine

and compare the relationship between the results of FMS test and the balance and endurance of the core muscles of the body in both women and men; therefore, the aim of this research was to investigate the relationship between FMS and dynamic balance and endurance of core muscles in male and female volleyball players.

Materials and Methods

The present cross-sectional study was carried out on 30 volleyball players who had a history of playing in the national league, including 15 women and 15 men. Since we wanted the geographical area of their place of residence be the same, we did not continue with collection of more samples other than the ones previously collected, which was one of the limitations of the present research. Prior to the start of the test and during the familiarization session, general explanations about the test procedure were given to each individual and then the athletes completed the informed consent form and responded to the health questionnaire questions. All athletes were given assurance that all information obtained from their test would remain confidential and that they could withdraw from the research at any time without any explanation. Individuals who met the following criteria participated in the study: at least three years of regular exercise, weekly exercise at least three sessions a week, no history of orthopedic surgery in the trunk and lower limbs. The exclusion criteria were as follows: history of chronic back pain for more than 3 months, a history of athletic injury in the past six months, which, according to the time loss index, prevent the athlete from performing the training for at least one week (13), a history of upper and lower motor neuron diseases that are associated with musculoskeletal disorder or imbalance (such as MS, polio, cerebral palsy, etc.), as well as female athletes who were in their menstrual cycle period. In this study, FMS was used as a test to evaluate the quality of functional movement patterns, which included seven deep squat tests, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability (14) (Figure 1). These seven tests in this type of functional balance evaluation require balance, neuromuscular control and joint mobility (15). Minick *et al.*, demonstrated in a study that this technique could be highly reliable in evaluating athletes' movement patterns (16). After completing these seven tests, the subject obtained a total score from these seven tests, which was calculated out of 21. The scoring procedure was done in such way that a score ranging from 0 to 3 was assigned to each of the seven tests (17). If the person feels pain while performing the movement, (s) he would score zero and scores ranging from 1 to 3 were assigned to individual based on the quality of movement patterns performed (18). It



Figure 1. How to do the functional movement screen (FMS)



Figure 2. How to do the Y Balance Test (YBT)



Figure 3. How to do the McGill test

Table 1. Average, standard deviation and Shapiro–Wilk test

Variable	Men		Women	
	Mean (SD)	Shapiro–Wilk test	Mean (SD)	Shapiro–Wilk test
Age	21.33 (2.32)	0.03	20.27 (2.28)	0.01
Height (cm)	183.80 (7.82)	0.60	168.93 (8.25)	0.01
Weight (kg)	74.93 (9.58)	0.20	58.13 (9.41)	0.97
Body Mass Index (BMI)	22.16 (2.47)	0.46	20.26 (2.22)	0.29
Functional movement Screen (FMS)	14.13 (2.06)	0.55	13.60 (2.74)	0.72
Balance Y on the right	71.40 (9.21)	0.26	67.00 (10.21)	0.34
Balance Y on the left	68.93 (7.42)	0.73	70.40 (9.12)	0.32
Trunk flexor endurance	67.00 (41.64)	0.00	54.97 (32.94)	0.52
Trunk extensor endurance	81.41 (18.77)	0.24	78.03 (31.78)	0.84
Trunk endurance on the right	49.59 (18.50)	0.75	35.62 (14.03)	0.63
Trunk endurance on the left	53.22 (15.90)	0.49	34.03 (17.67)	0.20

Table 2. Relationship between the functional movement test scores and the scores obtained from the Y balance test and trunk muscle endurance (n =15 men, 15 women)

Functional movement test Other tests	Men			Women		
	r	r ²	p	r	r ²	p
Balance Y on the right	0.18	0.03	0.51	0.45	0.20	0.09
Balance Y on the left	0.16	0.02	0.56	0.58	0.33	0.02*
Trunk flexor endurance	0.53	0.28	0.03*	0.08	0.00	0.75
Trunk endurance on the right	0.17	0.02	0.53	0.46	0.21	0.07
Trunk endurance on the left	0.11	0.01	0.69*	0.47	0.22	0.07
Trunk extensor endurance	0.38	0.14	0.15	0.45	0.20	0.08

is to be noted that the testing technique was shown to the examinees in video form in order to prevent individuals from having a pre-knowledge of the pre-test. The subjects performed 15 minutes of warm up, which included slow running and performing static and dynamic stretching exercises, which put the subjects in a better feeling mood (17). Each test was performed three times and the individual's score was entered on the score sheet. An interval of about five seconds and one minute was given between each experiment and test, respectively.

To evaluate dynamic state control, the star excursion balance test (SEBT), also called the "Balance Y Test," was employed. In this test, there are three directions (anterior, anterior, anterior, lateral) with angles of 90, 135, 135°, respectively (19). Gribble *et al.*, considered this test a valid test for assessing the dynamic balance (20). The intra and inter-rater reliability coefficient for different directions was between 0.85 to 0.91 and 0.99 to 1, respectively. The intra and inter-rater reliability coefficient for the total score was reported to be 0.91 and 0.99, respectively (21). The subject stood with the testing leg in the center of the test site while trying to achieve maximum level in the three directions, as well as maintain his/her balance and be able to return to his/her initial position (Fig. 2). The value of the resulting number was recorded

as its reaching distance. All subjects repeated the movement three times, and its mean was recorded; then the total reaching distance of the three directions was divided by three times the length of the person's foot, multiplied by 100, and recorded as the person's score. The length of the foot of the test was equal to the distance between the internal ankle and the anterior superior iliac spine (ASIS) which was evaluated using a standard tape meter while the subject was in the supine position (3).

In order to assess the core muscles of the body, the MacGill trunk muscle endurance test was used. Previous studies showed that four isometric endurance tests of the core muscles of the body used in this study had high reliability coefficient (17). First, individuals experimentally performed each test up to 5 seconds once each time to prevent fatigue, then each test was performed twice, and their maximum retention time was recorded with a precision of 0.1 second. To investigate the trunk flexor muscular endurance, the athlete sat half-seated and fixed his/her legs, while leaning on a slope of 60 degrees from the horizontal line and holding his/her hands on his/her shoulder crosswise. The subject was asked to maintain his/her trunk posture and the support was pulled back. The researcher computed the time difference between the moment the support was removed and when the athlete hit it back again. To

examine the trunk extensor muscular endurance, the subject was placed in the prone position on a height in such way that the pelvis and upper trunk were placed on the edge of the surface and outside of the platform, respectively. The hip and legs of the individuals were fixed to the platform and the examiner asked them to hold their hands on their shoulders crosswise while maintaining their trunk on the horizontal surface. The time was recorded from the moment the athlete took his hands from the bench placed in front of him/her until the moment his/her hands touched it again. To investigate the muscular endurance of the lateral core muscles, the subject was placed in lateral position in such way that the upper leg and hip joint were in front of the lower leg and at zero degrees of flexion, respectively. The examiner asked them to keep their body straight out on the ground and tolerate their weight on the lower elbow and legs (Figure 3). The time was measured until the trunk's posture was lost or pelvic was in contact with the ground again. This test was conducted on both sides (22).

Finally, data analysis was performed using descriptive statistics (mean and standard deviation) and inferential statistics (Pearson's and Spearman's moment correlation coefficient). Shapiro-Wilk test was employed to check the normal distribution of data. All statistical analyzes were performed at the significance level of $\alpha > 0.05$ using SPSS software, version 24.

Results

Table 1 shows results of mean, standard deviation obtained from Shapiro-Wilk test. The results of this statistical sample of volleyball players consisting of 15 men and 15 women showed a positive and moderate correlation between functional movement test and dynamic balance in the left side of women's body ($r=0.66$) ($P=0.07$) and trunk flexor endurance of men and the functional movement test scores ($r=0.53$) ($P=0.00$). In addition, no correlation was found between the functional movement test scores and balance in the right side and other trunk muscle endurance factors. The results are summarized in Table 2.

Discussion

The aim of this research was to investigate the relationship between the scores obtained from the functional movement screen (FMS) test and the core muscle balance and endurance among the volleyball players. Based on the results of this study, it seems that there was no correlation between the variables and there was a significant and strong correlation between the FMS scores and left balance, the right side of which was close to the significant level in women and the abdominal flexor muscles in

men. In a study on the relationship between balance and FMS among 118 female athlete students, Sohribi *et al.*, investigated the relationship between FMS and static and dynamic balance (3). They used Balance Error Scoring System (BESS) Y balance test to evaluate the static and dynamic balance, respectively. Their results showed a significant but moderate relationship between the static and dynamic balance of women and FMS test scores, which are consistent with the results of this study in case of women, but inconsistent in the case of men. Smith *et al.*, examined gender differences in postural stability and defined it as the ability to control and maintain center of mass (COM) at a base of support in order to prevent falls and to carry out specific activities; this maintenance process is recognized as balance (23). Concerning the relationship between endurance of the core muscles of the body and the FMS test scores, the results of the research showed a significant and positive relationship between flexor muscle endurance and FMS in men, while, there was no significance relationship in the four factors examined for core muscles endurance. Although this relationship was not significant, the level of relevance was close to the significance level and these results may change with increase in the number of samples. Okada *et al.*, conducted a study on 28 healthy men and women who had only recreational physical activity and who did not play sport professionally. They examined the relationship between performance, functional movements and core muscles endurance without gender segregation. They employed FMS to evaluate functional movements and observed no significant relationship between the endurance of the core muscles of the body and the functional movements; consequently, if a person has frail coordination and mobility, she/he cannot achieve success in the FMS test even with strong core muscles, or put in another way, having strong core muscles may not be enough to succeed in the FMS test (17).

Conclusion

The present research showed that women had better balance than men, which may be due to the complete processing of sensory input information in women (23). The difference in the result of the relationship between balance and FMS in the two gender groups may also be due to this fact. Considering the fact that Minonezhad *et al.*, also obtained similar results in women when they investigated the relationship between balance and functional movement in the two genders makes it imperative for further studies to be conducted in this regard. The results of the present study in the men's group were consistent with the above study; however, further studies are needed to clarify the issue of gender differences in this regard. Okada *et al.*, found no

correlation between core muscle stability and functional movement, which may be due to lack of gender segregation. However, this result was achieved in the present study due to gender segregation. The limitations of this research included small sample size, nutritional factors and lack of coordination of individuals in terms of physical readiness. Since this research is the first study to examine the relationship between these factors in terms of gender, therefore, considering the limitations of this research, gender segregation may seem to have contributed to the difference observed in the relationship between the results of FMS tests and lumbar stability. Overall, this issue should be clarified through further researches in this field of study.

Acknowledgement

This research has been conducted in collaboration with Rafsanjan Department of Labor, Kerman Province and sport coaches in this field. The authors would like to appreciate the management of the department and members of the cadre for their cooperation.

Conflict of interest:

None

Funding support:

None

Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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