ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2019; **3**(26): 129-135
ISSN 2299-9590
DOI: 10.23829/TSS.2019.26.3-5

Relationship between core stability and Functional Movement Screening test in athletes

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Abstract
Introduction and Aim. **Functional Movement Screening (FMS™) tests provide beneficial information regarding the movement and stability in the kinetic chain. The core region of the body, as the basis of movement chain, accounts for the facilitation of force and torque transmission. The aim of the present study was to investigate the relationship between functional movement screen composite scores and core stability muscles endurance in athletes.** Material and Methods. **Forty-five male athletes with FMS scores ≤14 (LoFMS) and forty-five male athletes with FMS scores >14 (HiFMS) were studied. Stability of core muscles of the participants was investigated and compared using the McGill's test.** Results. **The results of this study showed a significant difference in the mean stability of the anterior trunk muscles (p = 0.001), right side trunk muscles (p = 0.005) and left side trunk muscles (p = 0.001) between the athletes with LoFMS and HiFMS scores. Muscles' endurance in the group with HiFMS score was significantly higher than the group LoFMS score (p = 0.001). However, there was no significant difference in the mean stability of the posterior trunk muscles between the two groups. In general, a significant difference was found between sum of core stability scores obtained from lumbar-pelvic stabilizer muscles in the posterior, anterior and lateral sides of athletes LoFMS and HiFMS scores.** Conclusions. **The results of this study showed that weakness in core stability can have a negative influence on movement patterns.**

KEYWORDS: Functional Movement Screening (FMS™), core stability, movement pattern.

Received: 15 August 2019
Accepted: 17 September 2019

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Introduction

On average, more than 10,000 Americans daily need medical treatment due to injuries from sports and recreational activities [8]. Findings of various studies showed that 50 to 80% of these injuries result from muscle overuse and are not trauma-related injuries [2, 12]. These injuries can be due to weakness, neuromuscular incoordination and previous injuries [28]. Higher core stability significantly prevents sports-related injuries [10]. Core stability is described as movement control and muscle capacity of the waist, hip, and thighs. Core muscles maintain postural alignment and dynamic balance during functional activities, and that helps to prevent false movement patterns. [30]. Restrictions in strength and stability of the core muscles do not allow proper sports techniques and lead to injury of the athlete [14]. Ideal core stability allows normal co-contraction of agonist and antagonistic muscles, ideal lower extremity joint kinematics during functional movement chain and maximizes stability during lower extremity movements [24]. Core stability as an interface contributes to performing proper exercises with effective transfer of force produced in the lower extremity to the upper extremity through the trunk [18]. Various studies have shown that stabilizing muscles are recruited before lower extremity movement at all movement planes. This strengthens the spine and creates a stable backbone. The scholars also believe that athletes should strengthen their thigh and trunk muscles to add to the stability of motion planes [23]. Decreased proximal muscle strength (pelvis and thighs) decrease strength and stability of muscles, the function, and extent of force exerted on the lower extremity. This core instability predicts injury in the lower extremity [5]. Core muscle weakness also increases injuries in the lower extremity, especially in exercises involving jumping, lounges and fast running. On the other hand, enhanced core stability increases neuromuscular recall to reduce pain in the lower extremity and lower back and prevents injuries in the lower extremity [15]. Various studies have indicated that the strength and stability of the core stabilizing muscles in people with lower limb injuries are smaller than in those without a history of injury [7]. These findings are consistent with the closed-chain motion theory, which claims that strength and stability of the upper segments are necessary to control the lower segments and prevent injury. If one of the upper joints does not function properly, other joints will also be affected [21]. Pre-season screening is one of the methods to reduce the incidence of injury among athletes in order to specify the athletes vulnerable to injury [28]. Traditionally, a medical test in addition to several performance tests including sit-ups, pull-ups, endurance running, sprint running and agility activities are performed in a pre-season screening. These performance tests often provide objective information about a function and cannot assess the quality of athletes' capabilities. Cook et al. [9] reported that these pre-season screening tests do not provide accurate information on functional movement dysfunction that may potentially make athletes vulnerable to injuries. Thus, Cook et al. designed a test that can predict injuries to lower and upper extremities. They called this test Functional Movement Screening (FMS™). In general, FMS test assesses trunk stability, range of motion, movement quality and symmetry during fundamental functional movements [22]. The maximum score in this test is 21. According to various reports, FMS score less than 14 shows vulnerability to injury. These movement patterns require controlled neuromuscular movement in various sports exercises. Athletes, although maybe they perform their exercises properly, are always at risk of injury when exhibiting inefficiencies in motor strategies. Wieczorkowski [28]studied high school basketball players and reported that ones with LoFMS score are more prone to injury. Studies on professional soccer players showed that athletes with LoFMS score are 6 times more at the risk of injury in general and 51% more vulnerable to severe injury [4]. Scholars also studied female athletes and found out that female athletes with LoFMS score are four times more likely to be injured [6]. As mentioned earlier, weakness or incoordination in core muscles can reduce the effect of correct movement patterns, incidence of compensatory movement patterns, muscle strain, overuse and ultimately injury. Hence, weakness in core stability can have a negative influence on movement patterns. The FMS test seems to be helpful in identifying this issue. However, the relationship between core stability and the functional movement pattern has not been confirmed yet. Several studies have addressed core stability and the incidence of sports-related injuries and movement patterns in various parts of the body. Thijs et al. [27] examined the relationship between hip strength and knee movement in the frontal plate during lunge. They showed that knee is affected during varus and valgus movements and is related to such factors as thighs proprioception and stability. Akuthota et al. [1] stated that trunk displacement was greater in people with knee, ligaments, or anterior cruciate ligament injuries than in healthy people. They stated that lateral trunk displacements predict injury in the knees and ligaments. Akuthota et al. [1] also associated proximal muscles weakness and core muscles weakness with more injuries in the lower extremities. Nesser et al. [18] conducted a study on soccer players with varus knee deformity and normal knee. They showed that core stability in the participants with varus knee deformity is significantly lower than participants with normal knee [19]. As mentioned earlier, no study has examined the relationship between movement patterns of whole body and core stability so far. Therefore, the present study aimed to answer whether the weakness in movement pattern is related to core stability or not.

Material and Methods

Participants

This study was a causal-comparative research design with selective sampling. The statistical population consisted of 16-21 year-old male athletes who played volleyball, basketball, soccer, and handball professionally. They were active in these sports activities and played in these fields regularly for three years, at least three sessions a week in a professional club. Ninety athletes were selected using purposive sampling method by FMS test. They were divided into two groups. forty-five male athletes with FMS scores ≤14 (LoFMS) and forty-five male athletes with FMS scores >14 (HiFMS) were studied. The participants had no history of pain and injury in the last year in the trunk and lower extremities.

Procedure

Prior to measurements, the objective of the study and the test procedure were explained to the participants. Participants were free to exit the project at any time. The height was measured using a measurement tape and the weight was measured using a digital scale. FMS test was used to evaluate basic movement patterns. This test consists of seven elements, namely deep squat, hurdle step, lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability [26]. The test is scored as follows. If the athlete performs the right task without compensatory movement, he earns three points. If he performs the task with compensatory movements or is not able to do the task, he earns two or one points respectively. If he feels pain during the exercise, he earns no point [26].

Core testing

The protocol established by McGill was used to determine muscle endurance of the torso stabilizer muscles. The protocol consists of four tests that measure all aspects of the torso via isometric muscle endurance: trunk flexor test, trunk extensor test, and left and right lateral musculature test. A handheld stopwatch was used to measure the length of time participants were able to hold each isometric position. Individuals were given a minimum of 5 minutes of rest between each test [29] (Figure 1).

Trunk Flexor Test. The flexor endurance test begins with the person in a sit-up position with the back resting against a jig angled at 60° from the floor. Both knees and hips are flexed 90°, the arms are folded across the chest with the hands placed on the opposite shoulder, and the feet are secured. To begin, the jig is pulled back 10 cm, and the person holds the isometric posture as long as possible. Failure is determined when any part of the person's back touches the jig [29].

Trunk Extensor Test. The back extensors are tested with the upper body cantilevered out over the end of the test bench and with the pelvis, knees, and hips secured. The upper limbs are held across the chest with the hands resting on the opposite shoulders. Failure occurs when the upper body drops below the horizontal position [29].

Lateral Musculature Test. The lateral musculature is tested with the person lying in the full side-bridge position (left and right side individually). Legs are extended, and the top foot is placed in front of the lower foot for support. Subjects support themselves on one elbow and on their feet while lifting their hips off the floor to create a straight line from head to toe. The uninvolved arm is held across the chest with the hand placed on the opposite shoulder. Failure occurs when the person loses the straight-back posture and/or the hip returns to the ground [29].

Statistical analysis

Descriptive and inferential statistics were used to analyze the collected data. Kolmogorov Smirnov test was used to investigate data normality. Independent t-test was used to examine the difference in the endurance of core stability of the athletes with LoFMS and HiFMS at 0.05 significant level. All statistical operations were performed using SPSS version 16 (version 16, SPSS Inc., Chicago, IL). Assessment assumption was done with 95 percent significance and $\alpha \leq 0.05$.

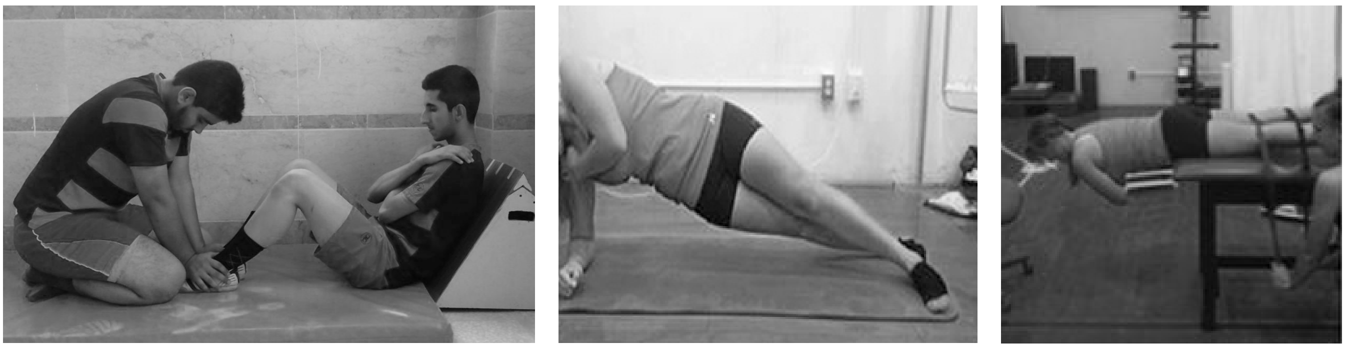

Figure 1. How to perform a McGill core stability test (from left to right: trunk flexion test, side bridge test, Sorenson test)

Results

Mean values and standard deviations of anthropometric data of subjects from both groups are given in Table 1.

Table 1. Demographical information of subjects

Variable	HiFMS (Mean ± SD)	LoFMS (Mean ± SD)	t	p
Age (year)	18.27 ± 1.40	18.11 ± 1.26	–0.55	0.580
Height (cm)	1.74 ± 0.03	1.75 ± 0.05	1.31	0.190
Weight (kg)	67.67 ± 3.03	69.71 ± 7.50	1.69	0.090
BMI	22.30 ± 1.22	22.64 ± 0.35	0.87	0.390

* $p \leq 0.05$; t = Student's t-test

McGill test result

The results of the core muscles' stability tests between two groups of athletes are presented in Table 2. The results of this study showed a significant difference in the mean stability of the anterior trunk muscles ($p = 0.001$), right side trunk muscles ($p = 0.005$) and left side trunk muscles ($p = 0.001$) between the athletes with LoFMS and HiFMS scores.

The Biering-Sorensen test results showed no significant difference in the mean values of the core stability of the posterior trunk muscles between the athletes with LoFMS and HiFMS ($p = 0.090$).

The results of the trunk flexion test showed a significant difference between the mean value of the core stability of the anterior trunk muscles in athletes with LoFMS and HiFMS ($p = 0.001$). Core stability of the anterior trunk muscles in athletes with LoFMS was 28 seconds less than in HiFMS.

The result of the right-side bridge test showed a significant difference between mean value of the core stability of the right lateral trunk in athletes with LoFMS and HiFMS ($p = 0.005$). Core stability of right lateral trunk in athletes with LoFMS was 20 seconds less than in HiFMS.

The result of the left-side bridge test showed a significant difference between the mean value of the core stability of left lateral trunk in athletes with LoFMS and HiFMS ($p = 0.001$). Core stability of left lateral trunk in athletes with LoFMS was 18 seconds less than in HiFMS athletes.

A significant difference was found between the sum of scores obtained from mean value of the core stability of posterior, anterior and lateral lumbar-pelvic muscles in athletes with LoFMS and HiFMS ($p = 0.001$). The overall core stability of muscles in athletes with LoFMS was 79 seconds less than in athletes with HiFMS.

Table 2. Comparison of core muscles' stability tests between two groups (n = 90)

Variables	HiFMS (Mean ± SD)	LoFMS (Mean ± SD)	t	p
Core stability of the posterior trunk muscles (s) (Biering--Sorensen test)	90.72 ± 6.58	88.74 ± 4.43	–1.66	0.090
Core stability of the anterior trunk muscles (s) (trunk flexion test)	79.74 ± 4.63	76.20 ± 4.30	–3.75	0.001*
Core stability of right lateral trunk (s) (right side bridge test)	70.83 ± 5.00	67.99 ± 4.42	–2.84	0.005*
Core stability of left lateral trunk (s) (left side bridge test)	70.60 ± 4.90	67.75 ± 3.04	–3.30	0.001*
Total (s)	77.12 ± 2.34	73.69 ± 1.89	–7.02	0.001*

* $p \leq 0.05$; t = Student's t-test

Discussion

The present study aimed to compare the core stability of muscles between two groups of athletes with LoFMS and HiFMS. The results of this study showed no significant difference in core stability of posterior muscles between the two groups. However, a significant difference was found in core stability of right and left lateral and anterior muscles separately. A significant difference was found in sum of scores obtained from mean core stability in two groups of athletes with LoFMS and HiFMS. The athletes with LoFMS have weaker core stability than HiFMS athletes. No study has compared core stability of athletes with LoFMS and HiFMS. The results of the present study are somehow consistent with the results of the study conducted by Thijs et al. [27]. The results of this study showed that the strength of hip muscles does not have a high correlation with varus and valgus movements of knee joint during lunge. They stated that other factors such as deep sense and strength of the trunk are the most important factors in knee joint movements during forward lunge. Zazulak et al. [30] found that factors related to core stability predicted the risk of athletic knee, ligament, and ACL injuries with high sensitivity and moderate specificity in female, but not male, athletes. Mitchell et al. [17] investigated the correlation between FMS score, core stability, posture, and body mass index in 77 children in Moldovan. Age group was from 8 and 11 years old. The results of the study showed a positive correlation between FMS test scores and core stability. Core stability exercises positively enhance FMS test scores. The results of this study are also consistent with the results of the study by Skotnicka et al. [25]. They showed that core stability exercises can have a positive influence on the quality of basic movement patterns.

On the other hand, the findings of this study are consistent with the findings obtained from the study by Okada et al. [20]. There was a weak correlation between core stability and basic movement patterns. The results of this study were not consistent with the results of the former study. One reason for confounding results is a different method and grouping. Okada studied the correlation between FMS scores and core tests in one group. However, two groups of people with LoFMS and HiFMS were studied in the present study. Then, McGill's core stability test scores were compared in the two groups. The mean age in the study by Okada was 24.4 years in both genders and only 18.70 years in the present study. The results of this study were not consistent with the results of study by Lederman [14], Sato and Mokha [24], Nesser et al. [18], Mannion et al. [15]. They did not confirm the role of the trunk muscles in maintaining core stability and its association with lower extremity function. These confounding results may be due to difference in method, tool and measuring instrument, sampling method and grouping. Mean age of the participants in the study by Sato and Mokha [24] was 36 years old. The participants in the study by Nesser [18] only consisted of females. Functional movement tests and core tests used in the former study differed from those used in the present study. Strength test, vertical jump test and shuttle run agility test were used in this study. The participants in the study by Mannion et al. [15] also suffered from low back pain. This was a difference between the former study and the present study.

The results of the study by Willson et al. [29] showed a clear relationship between core stability, lower extremity injury and lower extremity function. Stronger muscles create better stability in the trunk, which enhances lower extremity mobility. Abdominal muscle complex consists of abdominal transverse muscle, external oblique, internal oblique, and right abdominal muscle. Co-contraction of these muscles contributes to core stability and strengthen lower extremity movements [11, 13]. Intra-abdominal pressure and thoracolumbar fascia tension increase as transverse abdominal muscle contracts. These contractions strengthen the movement and activate the muscle before movement. Abdominal right muscle, external oblique, and internal oblique muscles are also activated in a specific movement pattern based on limb movement and control the trunk. Kibler et al. [13] found out that activation of the trunk muscles in the movement pattern of lower extremities improves abdominal control and the trunk exerts activation of the trunk muscles to produce rotary force to move the limbs. Coordination between all muscles of the trunk and hip is essential for muscle control and normal posture of the spine [16]. The hip and thigh stabilizer muscles are responsible for maintaining the posture of lower extremities during dynamic movements. Therefore, weakness and decrease in the endurance of posterior, anterior, and trunk muscles reduce the strength and function of the muscles surrounding the thighs. The thigh muscles significantly transfer force from the lower extremity to the upper extremity and spine in the supine posture. As a result, weakness in core muscles impairs the correct posture of lower limbs during dynamic movements and the motor pattern in the lower extremity. Also thoracolumbar composite (TLC) is in a position to assist in maintaining the integrity of the lower lumbar spine and the sacroiliac joint. Therefore, weak core posterior muscles reduce the strength and endurance of the gluteus maximus and gluteus medius. Since the gluteus maximus and gluteus medius are attached to the iliotibial band [3], any inefficiency in these muscles affects the function of the iliotibial band. Therefore, reduced strength and endurance of gluteus maximus, gluteus medius enhances knee valgus through the iliotibial band, impair the posture of quadriceps muscle tendon and reduces the efficiency of the quadriceps muscle and ultimately the movement pattern [30].

Findings of another study showed that weakness of thigh muscles causes abnormal movements of thigh and tibia muscles [7], patella deformity, impaired patella function [7], exerts abnormal force on the knee joint and ultimately causes knee injury [7].

Conclusions

Compensatory fundamental movement patterns can increase the risk of injury in athletes and can be identified by using the FMS. A score of 14 or less in the FMS test resulted in an increased risk of injury in athletes participating in handball, soccer, volleyball, and basketball. The results of this study support the need for higher specificity in training planning – by adding core muscle strengthening exercises in order to control and prevent weakness in movement patterns and ultimately subsequent injury.

References

1. Akuthota V, Nadler SF. Core strengthening. Arch Phys Med Rehabil. 2004; 85: 86-92. DOI: 10.1053/j.apmr.2003.12.005.
2. Almeida SA, Williams KM, Shaffer RA, Brodine SK. Epidemiological patterns of musculoskeletal injuries and physical training. Med Sci Sports Exerc. 1999; 31(8): 1176-1182. DOI: 10.1097/00005768-199908000-00015.
3. Bolgla LA, Malone TR, Umberger BR, Uhl TL. Hip strength and hip and knee kinematics during stair descent in females with and without patellofemoral pain syndrome. J Orthop Sports Phys Ther. 2008; 38(1): 12--18. DOI: 10.2519/jospt.2008.2462.
4. Brown M. The ability of the functional movement screen in predicting injury rates in division I female athletes. 2011; 50-88 (Doctoral dissertation, University of Toledo).
5. Brumitt J, Dale RB. Functional rehabilitation exercise prescription for golfers. Athl Ther Today. 2008; 13(2): 37-41. DOI: 10.1123/att.13.2.37.
6. Chorba RS, Chorba DJ, Bouillon LE, Overmyer CA, Landis JA. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. N Am J Sports Phys Ther. 2010; 5(2): 47-52.
7. Cichanowski HR, Schmitt JS, Johnson RJ, Niemuth PE. Hip strength in collegiate female athletes with patellofemoral pain. Med Sci Sports Exerc. 2007; 39(8): 1227-1232. DOI: 10.1249/mss.0b013e3180601109.
8. Centers for Disease Control and Prevention. Web-based injury statistics query and reporting system (WISQARS); 2002. Retrieved from: www. cdc. gov/ncipc/wisqars.
9. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function – Part 2. N Am J Sports Phys Ther. 2006; 1(3): 132-137.
10. Fredericson M, Moore T. Muscular balance, core stability, and injury prevention for middle-and long-distance runners. Phys Med Rehabil Clin. 2005; 16(3): 669-689. DOI: 10.1016/j.pmr.2005.03.001.
11. Hertel J, Braham RA, Hale SA, Olmsted-Kramer LC. Simplifying the star excursion balance test: analyses of subjects with and without chronic ankle instability. J Orthop Sports Phys Ther. 2006; 36(3): 131-137. DOI: 10.2519/jospt.2006.36.3.131.
12. Jones BH, Cowan DN, Tomlinson JP, Robinson JR, Polly DW, Frykman PN. Epidemiology of injuries associated with physical training among young men in the army (No. USARIEM-M78-91). Army Research Inst Of Environmental Medicine Natick Ma; 1993.
13. Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. Sports Med. 2006; 36(3): 189-198. DOI: 10.2165/00007256-200636030-00001.
14. Lederman E. The myth of core stability. J Bodyw Mov Ther. 2010; 14(1): 84-98. DOI: 10.1016/j.jbmt.2009.08.001.
15. Mannion A, Dvorak J, Taimela S, Müntener M. Increase in strength after active therapy in chronic low back pain (CLBP) patients: muscular adaptations and clinical relevance. Schmerz (Berlin, Germany). 2001; 15(6): 468-473. DOI: 10.1007/s004820100034.
16. Mascal CL, Landel R, Powers C. Management of patellofemoral pain targeting hip, pelvis, and trunk muscle function: 2 case reports. J Orthop Sports Phys Ther. 2003; 33(11): 647-660. DOI: 10.2519/jospt.2003.33.11.647.
17. Mitchell UH, Johnson AW, Adamson B. Relationship between functional movement screen scores, core strength, posture, and body mass index in school children in Moldova. J Strength Cond Res. 2015; 29(5): 1172-1179. DOI: 10.1519/JSC.0000000000000722.
18. Nesser TW, Huxel KC, Tincher JL, Okada T. The relationship between core stability and performance in division I football players. J Strength Cond Res. 2008; 22(6): 1750-1754. DOI: 10.1519/JSC.0b013e3181874564.
19. Nesser TW, Lee WL. The relationship between core strength and performance in division i female soccer players. J Exerc Physiol. 2009; 12(2).
20. Okada T, Huxel KC, Nesser TW. Relationship between core stability, functional movement, and performance. J Strength Cond Res. 2011; 25(1): 252-261. DOI: 10.1519/JSC.0b013e3181b22b3e.
21. Pantano K, White S, Gilchrist L. Differences in peak knee valgus angles between individuals with high and low Q-angles during a single limb squat. J Orthop Sports Phys Ther. 2006; 36(5): 341.
22. Parenteau GE, Gaudreault N, Chambers S, Boisvert C, Grenier A, Gagné G, Balg F. Functional movement screen test: a reliable screening test for young elite ice hockey players. Phys Ther Sport. 2014; 15(3): 169-175. DOI: 10.1016/j.ptsp.2013.10.001.
23. Robinson RL, Nee R J. Analysis of hip strength in females seeking physical therapy treatment for unilateral patellofemoral pain syndrome. J Orthop Sports Phys Ther. 2007; 37(5): 232-238. DOI: 10.2519/jospt.2007.2439.
24. Sato K, Mokha M. Does core strength training influence running kinetics, lower-extremity stability, and 5000-M performance in runners? J Strength Cond Res. 2009; 23(1): 133-140. DOI: 10.1519/JSC.0b013e31818eb0c5.
25. Skotnicka M, Karpowicz K, Bartkowiak S, Strzelczyk R. The impact of the corrective and stability exercises program on the quality of basic movement patterns among dance students. Trends Sport Sci. 2017; 1(24): 31-38.
26. Sorenson E. A. Functional movement screen as a predictor of injury in high school basketball athletes. 2009; 22-63 (Doctoral dissertation, University of Oregon).

27. Thijs Y, Van Tiggelen D, Willems T, De Clercq D, Witvrouw E. Relationship between hip strength and frontal plane posture of the knee during a forward lunge. Br J Sports Med. 2007; 41(11): 723-727. DOI: 10.1136/bjsm.2007.037374.
28. Wieczorkowski MP. Functional movement screening as a predictor of injury in high school basketball athletes. 2010; 34-66 (Doctoral dissertation, University of Toledo).
29. Willson JD, Dougherty CP, Ireland ML, Davis IM. Core stability and its relationship to lower extremity function and injury. J Am Acad Orthop Surg. 2005; 13(5): 316--325. DOI: 10.5435/00124635-200509000-00005.
30. Zazulak BT, Hewett TE, Reeves NP, Goldberg B, Cholewicki J. Deficits in neuromuscular control of the trunk predict knee injury risk: prospective biomechanical-epidemiologic study. Am J Sports Med. 2007; 35(7): 1123-1130. DOI: 10.1177/0363546507301585.