Science Arena Publications
Specialty Journal of Sport Sciences
ISSN: 2521-3156
Available online at www.sciarena.com
2018, Vol, 3 (1): 19-28

Comparison Function, Strength and Endurance in Volleyball Players with and without Chronic Ankle Instability

Fatemeh Ahmadusefi

Department of pathology and sport corrective Exercises, Islamic Azad university, Karaj branch, Alborz, Iran.

***Corresponding Author**
Email: Fatemeh.ahmadu.1372@gmail.com

Abstract: *Objective: Lateral ankle sprain is one of the most common injuries in sports. The purpose of the present study is comparison between function, strength and endurance of selected central muscle in volleyball players with and without chronic ankle instability. Material and methods: A total of 40 female volleyball player (age=24 years) were participated in this study. McGill endurance tests, MMT, Y balance test, Figure-eight jump and lateral jump test were used to measure trunk endurance, strength, balance and function of volleyball players of two groups, respectively. Results: According to the results of an independent t-test, significant differences were observed between groups including thigh abduction (p=0.006) and thigh's external rotation strength (p=0.02), the Sorensen test (p=0.02), 60° flexion test (p=0.02), abdominal bridge (p-0.03), internal posterior directions (p=0.02) and external posterior directions (p=0.08), Y balance test and total Y test (p=0.008), Figure-eight hop tests (p=0.02) and lateral jump test (p=0.03) in the two groups including with and without chronic ankle instability. Conclusion: According to the results, if the previous ankle sprain as a factor is accompanied with lack of rehabilitation program, this can have a negative impact on athletes' strength and endurance of the trunk and thigh region, balance and performance. Accordingly, using rehabilitation and training programs of the thigh and trunk region and also balance training are suggested in order to prevent recurrence of ankle sprain.*

Keywords: *Chronic Ankle Sprain, Strength, Endurance, Balance, Functional Tests*

INTRODUCTION

Ankle joint is one of the most common positions of injuries in beginner and professional athletes (Faraji et al., 2012). Approximately 10-28% of all sports injuries and 86% of ankle injuries includes ankle sprain (Callaghan, 1997). This injury is particularly common in sports that involve jumps and sudden changes such as football, volleyball and basketball (Faraji et al., 2012). External ankle structures are one of the most common musculoskeletal disorders so that ankle sprain dedicate 40 percent of all the lower limb injuries to itself (Li et al., 2015) and meanwhile, 85 percent of different types of ankle sprain are twisted to the inside and as a result of damage to the external structures of ankle (Li et al., 2015). Ankle injury in volleyball players due to frequent jumps and landings is one of the common injuries which often lead to a common symptom called functional ankle instability following these sprains (Li et al., 2015) which is reported by patient as a feeling of instability and joint dislocation in normal conditions in which joint instability is not expected (Doherty et al., 2015). The reason of functional instability following the ankle sprain is disorder in the functioning of the ankle's sensory-motor system (Doherty et al., 2015). This system's function is to homeostasis maintenance in joint organization or the same joint functional stability. In addition to creating functional instability as the results of ankle sprain and damage to its external structures, equilibrium in the standing position will have a problem (Evans et al., 2014). Because the function of the ankle's motor-sensory system influences the ability to maintain the vertical and standing position. In the standing position, the torque produced by the muscles around the ankle and the mechanisms for controlling the functions of these muscles play an important role in maintaining the center of gravity in the region of reliance level (Doherty et al., 2015). Thus, the ankle-sensory-motion impairment disturbs the functions of the state control system and, as a result, the standing balance also becomes disturbed (Kemler et al., 2011). According to the researches, the increase in ankle joint laxity and motor-sensory impairment due sprain is associated with imbalance and impairment in status control (Nazakatolhosaini et al., 2012). In this regard, the research's results of Akbari et al (2007) showed that after the first and second grade lateral sprain which followed by chronic ankle instability, the balance problems will be caused that is due to deep sense disorder, especially the unconscious part of the deep sense that is in contrast to the conscious part. This agent probably plays an important role in the return of sprain (Akbari et al., 2007). In another study, Shokohi et al. (2015) compared the postural stability of soccer players with and without chronic ankle injury in a jump-landing test on 28 soccer players (14 with chronic ankle instability and 14 healthy examinees) that in this study, a significant difference was shown between the soccer players with and without the chronic ankle instability in forward jump of displacement variable of the pressure center in the internal, external and anterior-posterior direction, the displacement of the center of pressure in the internal, external and anterior-posterior direction in the way that the shift of the center of pressure in football players with more instability was more than the healthy players (Shokouhi et al., 2015). On the other hand, it was specified that the central muscle of the body contributes to the stability of the spine, pelvis and functional movement chains, and the transverse abdominal and multiphydus muscles are activated 30 milliseconds before the shoulder movement and 110 milliseconds before the lower limb movement in order to stabilize the spine (Jacobs et al., 2007). It seems that any weakness in these muscles leads to a delay in activation of the lower limb muscles and the occurrence of various injuries. These muscles are also responsible for maintaining the stomach region of the lumbar-pelvic region, and the weakness of these muscles leads to loss of the right lumbar-pelvic region and consequently, lower limb muscles which attached to this region suffer from loss of performance and susceptibility due to changes in the relationship between length-tension (Jacobs et al., 2007). Accordingly, it is possible that the strength and endurance of the trunk and thigh muscles in persons with ankle instability were less than those without this complication and since Moradi et al (2015) referred to the effects of exercises of central stability region on improving postural fluctuations in patients with ankle instability in their research (Moradi et al., 2015), therefore, these two hypotheses are more strengthened. However, by reviewing the research background, it was not found a research that comprehensively examines all these factors in two groups including persons with and without chronic ankle instability. Accordingly, the researchers in this study seek to compare the balance and performance, strength and endurance of the selected central muscle in volleyball players with and without chronic ankle instability.

Methodology

The statistical population of this study includes female volleyball players in Tehran clubs with an average age of 24 years. After distributing and analyzing the CAIT questionnaire and confirmation of physiotherapist, 20 ankle instabilities and 20 volleyball players without this complication were selected from the statistical population as the statistical sample of the study. Finally, all examinees were investigated with full knowledge of the purpose and method of the research, as well as by completing the consent form. The tape meter was used to measure the height and the digital scale was used to measure the weight. The BMI (Body Mass Index) was also calculated by the weight formula in kilograms divided by the height squared in meters. The McGill tests (bridge from left, right bridges, bridges from the abdomen, 60 degree flexion, Sorensen) were used to assess endurance and MMT test was used to evaluate flexural and extension strength of the trunk, external rotation, abduction and extension of the hip and data related to trunk strength and endurance are divided by length of the trunk and expressed as a percentage in order to normalize the data and also data related to the strength of the lower limb (abduction, extension, and external thigh rotation) are divided into length of leg and multiplied by 100. Y balance test, Side jump and Figure-eight Hop test were used in this study in order to evaluate balance and function of lower limb. Since there were 40 examinees in this study including 20 persons with ankle instability and 20 healthy people), Shapiro-Wilk test was used to assess data distribution normality. Given that the results of Shapiro-Wilk test have not been significant, so, data distribution has been normal and descriptive statistic was used to evaluate data average and parametric independent t-test was used for data analysis.

Endurance test of the central body region

For this purpose, the McGill valid protocol was designed to determine the endurance of trunk stabilizing muscles. This protocol consists of five tests that measure the endurance of all trunk muscles including trunk flexor test, trunk extensor test and plank and side plank. A manual time-meter was used to record the isometric duration of the examinees. At least 5 minutes of rest were determined between each test. The results of previous studies show that these tests have high validity coefficients: intra-class correlation coefficient (ICC) of trunk flexor test is equal to .97, ICC of extensor trunk is 0.97 and ICC of plank test is equals 0.99 (Okada et al., 2011) (Figure 1).

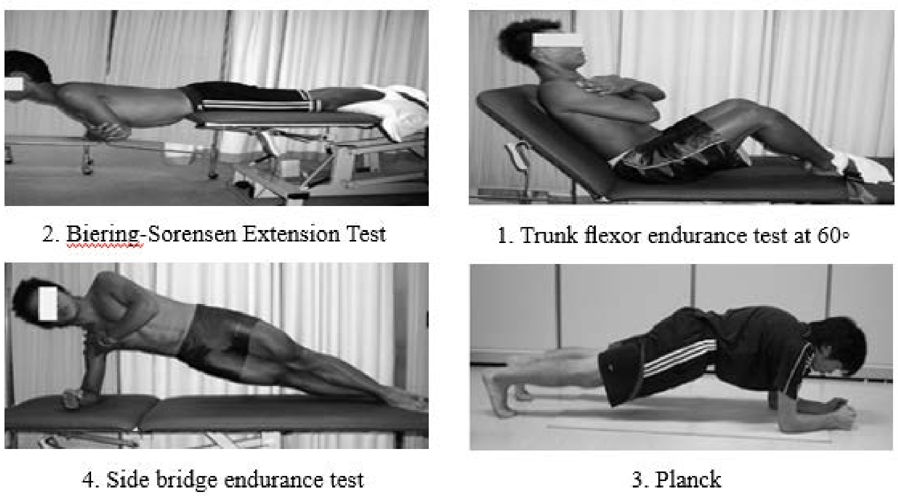

Figure 1. Endurance test of central body region

Strength assessment

For the purpose of measuring the isometric strength of the trunk flexors, the examinee was lying back, while the knee joint was in a 90 degree of flexion. The feet were tightened by the helper to the exam desk. The head of MMT (Manual Muscle Testing) was placed on the chest and in the center of the chest (Figure 1-2). To measure the isometric strength of the trunk extensors, the lying legs were firmly fixed to the examination desk by the fixating band. The head of MMT was at the lower angle of the scapula and in the center of the back of the body between the shoulder blades (figure 2-2). The procedure for measuring the isometric strength of hip abduction was based on the method described by Bohannon. For this purpose, the examinee was lying flat on the treatment bed and the manual dynamometer (Nicholas, Lafayette, USA) was placed on the side of the thigh, 5 cm proximal point toward the knee lateral joint line. There was a large padding between the legs of the examinee, so that both thighs are fixed to the left and right ASIS connectors in 0 degrees of abduction. The examinee was asked to move his foot upwards with his maximum effort (Fig.2-3). The test-retest reliability was estimated 0.95 to measure the force (Willson et al., 2006). The isometric power of thigh external rotators was performed based on the method proposed by Cahalan et al. The examinee sat down on the treatment bed so that his thighs and knees were in a 90-degree flexion position. The dynamometer was placed in such a way that the center of the force plate was fixed directly on a 5 cm proximal point toward the inner ankle of the subject foot. The person was asked to turn his foot around the dynamometer with his maximum effort (figure 2-4). The test-retest reliability of force measurement with this method was equal to 0.83. The subject lay on his back on treatment bed in order to assess the isometric strength of the thigh. The dynamometer was placed in such a way that the center of the power plate was directly on the 5 cm point above the knee. The person was asked to extend his leg with maximum effort toward the extension dynamometer (figure 2-5) (Willson et al., 2006).

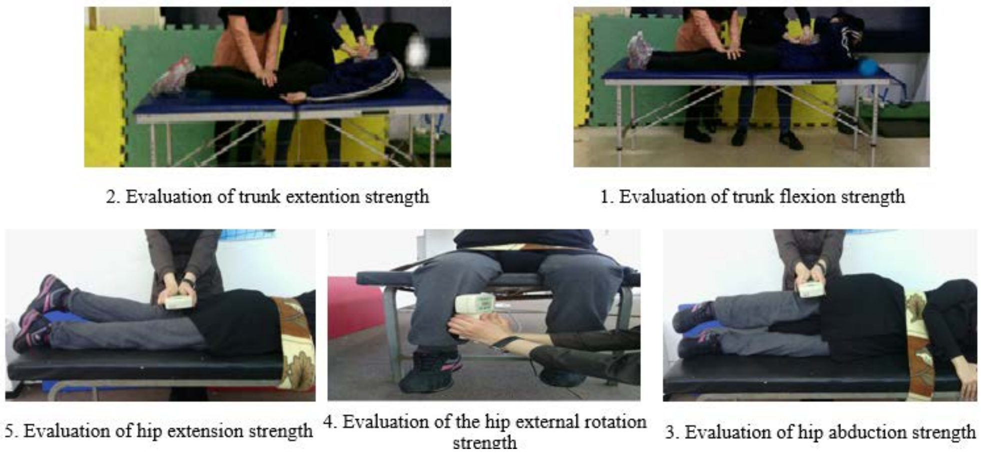

Figure 2. Assessment of selected muscles strength by using MMT

Y Balance Test: Y Balance Test was used to assess dynamic equilibrium with reliability (0.91). In this test, the three directions (anterior, posterior, internal and posterior-external) are aligned in the Y form at 135, 135 and 90 degrees angles toward each other. The subject will practice the test three times to learn how to execute it (the subject with the top right leg performs the test in counterclockwise direction and the subject with top left leg performs the test the in the clockwise direction). The subject stands in the center of the test site and with the other leg in the direction that the examiner selects and performed the maximum achievement without error and returned to its original state. The subject randomly initiated the test in the direction that the examiner chose, the point of contact of the foot to the test center was measured in cm by the examiner (figure 1-3). The test was repeated three times for each subject, and the best record divided by the length of the leg was then multiplied by 100 to achieve a distance in terms of the length of the foot, if an error was occurred such as the foot that was in the center was moving or the balance of the person was impaired, so the subject was asked to repeat the test again (Ahmadi et al., 2015).

Figure-eight hop test: This test was used to measure the power, speed and balance of the lower limb with emphasis on the control over one leg with reliability (0.99). This test takes place in the form of eight Latin with a length of five meters and a width of one meter. The subject passed the route with his upper leg twice (as hopping and at maximum speed) (Figure 3-2). The subject's record was recorded with stopwatch with an accuracy of 0.01 sec (Hasanpour et al., 2014).

Lateral jump test: The subject stood beside the starting line with the foot that he intended to do the test (upper leg) and the other leg was bent slightly on the hip and knee joints in order to avoid touching the ground. The subject then passed a distance of 30 cm as hopping 10 times in a round-trip manner with a maximum speed which was marked with two pieces of parallel paper adhesive on the ground and the time taken was recorded with a precision of 0.01 sec as his score (figure 3-3). The subject was asked to hold his hands over his iliac crest during the test to avoid the swinging movements of the hands. It should be noted that the subject did the test with sports shoes. The subjects performed one to three experimental attempts and he performed two runs with a 30 second for testing and recording scores and his better record was used to analyze the data. If the subject landed on the ground with two pieces of parallel paper glued or lost his balance during the test, it would be considered as an error and the test would be repeated (Hasanpour et al., 2014).

Research's findings

Subjects' descriptive information including age, length, weigh and BMI was presented in table number 1.

Table 1. subjects' descriptive statistic

Variable	group	Number	Standard deviation± mean
Age	With injured ankle	20	24.60± 1.90
	Without injured ankle	20	24.55± 1.82
Length (meter)	With injured ankle	20	1.81±0.46
	Without injured ankle	20	1.79± 0.09
Weight (kilogram)	With injured ankle	20	69.50± 6.79
	Without injured ankle	20	69.80± 10.34
Body mass index (Kilograms per square meter)	With injured ankle	20	21.01± 1.78
	Without injured ankle	20	21.61± 2.10

Information related to difference between tests of central stability among two groups including with and without ankle chronic instability was presented in table 2.

Table 2. The results of independent t-test in order to compare the difference in strength and endurance test in two groups including with and without ankle chronic instability

Variables	group	Standard deviation±mean	T value	Significance level
Age	Without injured ankle	24.60±11.90	0.08	0.93
	With injured ankle	1.81 ±0.46		
Length (meter)	Without injured ankle	1.81 ±0.46	1.05	0.29
	With injured ankle	1.79 ±0.09		
Weight (kilogram)	Without injured ankle	65.50 ±6.79	-0.10	0.91
	With injured ankle	69.80 ±10.34		
Body mass index (Kilograms per square meter)	Without injured ankle	21.01 ±1.78	-0.96	0.34
	With injured ankle	21.61± 2.10		
right bridge (sec)	Without injured ankle	81 ±34.07	0.02	0.97
	With injured ankle	80.73 ±25.15		
Left bridge (sec)	Without injured ankle	76.78 ±32.76	0.55	0.59
	With injured ankle	71.75 ±19.73		
abdomen bridge (sec)	Without injured ankle	81.62 ±14.44	2.23	0.03*
	With injured ankle	72.22 ±12.06		
Sorensen (sec)	Without injured ankle	106.15± 34.22	2.37	0.02*
	With injured ankle	85.62 ± 18.8		
60-degree trunk flexion(sec)	Without injured ankle	68.38 ±8.57	2.20	0.03*
	With injured ankle	61.81 ±10.19		
	Without injured ankle	7982 ±20.64	0.14	1.50

Average endurance tests (sec)	With injured ankle	74.43 ±13.84		
Trunk flexion power (kg)	Without injured ankle	17.28 ±1.43	0.07	0.94
	With injured ankle	17.24± 2.12		
Trunk extension power (Kg)	Without injured ankle	17.23± 2015	0.81	0.72
	With injured ankle	16.67± 2.23		
Thigh abduction power (kg)	Without injured ankle	21.60 ±4.11	2.91	0.006**
	With injured ankle	18.34 ±2.83		
Thigh's external rotation power (kg)	Without injured ankle	15.89± 1.84	2.34	0.02*
	With injured ankle	14.56± 1.75		
Thigh extension power (kg)	Without injured ankle	23.66± 4.10	0.04	0.13
	With injured ankle	22.04 ±2.27		

*Significance level of 0.05
** Significance level of 0.01

According to the results of independent t-test, there was a significant difference between two groups of athletes with and without chronic ankle instability in the thigh abduction strength tests (p = 0.006) and thigh external rotational power (p = 0.02) and also endurance tests such as abdomen bridge (p = 0.03), Sorensen test (p = 0.02) and 60-degree trunk flexion (p = 0.03) were significantly different.
Information on the difference between the Y balance tests between two groups including persons with and without chronic ankle instability was presented in tables 3.

Table 3. The results of independent t-test in order to compare the difference in Y balance test in two groups including persons with and without chronic ankle instability.

Balance	group	Standard deviation± mean	t value	Significance level
Anterior direction (cm)	Without injured ankle	79.75± 5.92	0.24	0.80
	With injured ankle	79.27 ±7.26		
internal posterior direction (cm)	Without injured ankle	108.78 ±7.26	2.44	0.02*
	With injured ankle	103.61± 6.06		
external posterior direction (cm)	Without injured ankle	99.69±8.22	2.81	0.008**
	With injured ankle	91.80 ±9.45		
Total	Without injured ankle	96.07 5.53	2.38	0.02*
	With injured ankle	91.56 6.39		

Significance level of 0.05*

The dynamic balance of two groups of independent t-test showed a significant difference in posterior directions (p = 0.02), external posterior (p = 0.008) and total Y (p = 0.02).

Table 4. Information on the difference between functional tests between two groups including persons with and without chronic ankle instability

Variables	Group	Standard deviation± mean	t value	Significance level
Figure-eight (sec)	Without injured ankle	12.06 1.41	-2.38	0.02*
	With injured ankle	13.25 1.72		
Lateral jump	Without injured ankle	8.09 0.87	-2.25	0.03*
	With injured ankle	8.93± 1.41		

Significance level of 0.05*

Independent t-test also showed a significant difference in the figure- eight (p = 0.02) and lateral jump (p = 0.03) tests in both groups with and without chronic ankle instability.

Discussion and Conclusion

Given that it has been shown that the major part of the body sensation's messages of the ankle set are lost following ankle sprain and damage to its external ligaments (Gribble et al., 2010), obviously, the musculoskeletal system lose a large part of the ankle set required to adjust the motor functions, and thus it will not be able to properly adjust its function in various operating conditions (Evans et al., 2014).

The present study aimed to compare the strength and endurance of selected muscles, balance and performance in volleyball players with and without chronic ankle instability. The results showed a significant difference in the performance of the Figure-eight, lateral jump and Y balance in internal and external posterior directions and the whole and also abduction and thigh external rotation and endurance tests such as the abdomen bridge, Sorensen and the 60-degree flexion of the two groups of subjects. Strong and stable trunk provides a solid and stable foundation for the torques created in the limbs (Granacher et al., 2016) because the central region of the body is center of the movement chain of the sport activity. Control of strength, balance and movement of the central body increases the function of the upper and lower limbs of the upper and lower limbs (Lee et al., 2014). Activating the coordination of the muscles is crucial for stability and performance which requires control of the strength, balance and movement of the central region of the body (Kavcic et al., 2004). Previous studies have shown pre-activation of lower limb muscles (Kavcic et al., 2004) and trunk muscles before touching the ground during jump and landing movements. So that during doing the jump and landing movements, neuromuscular coordination of the trunk and lower limb muscles plays an important role in functional activities such as absorption of force, prevention of trunk falling, power generation and jump control (Iida et al., 2012). The importance of the role of central stability in dynamic equilibrium has been identified in studies that have observed the improvement of dynamic equilibrium following central stability training (Hasanpour et al., 2014). Neuromuscular coordination of the trunk and lower limb muscles and its negative effect on jumping and landing may possibly be a reason for the reduction of performance in the Figure-eight hop test and lateral jump test in this study because the reduction in the total muscle strength in the central muscle of the body leads to a reduction in overall force production in the upper and lower limb (Iida et al., 2012).

There was a significance difference between internal and external posterior directions and also total Y balance in term of balance. Moradi et al (2015) in their research showed that the displacement of the center of pressure in the internal and external direction in the injured group was higher than the healthy group (Moradi et al., 2015). In addition, Knapp et al (2011) showed that the amount of displacement of the center of pressure in the internal and external directions in the group with chronic ankle instability is significantly higher than the control group (Knapp et al., 2011). A pathomechanical model is presented by Fuller (1999), in which the cause of external ankle extension is due to an increase in the internal rotational force of the subtalar. Increasing the internal rotator force is affected by the intensity and position of the ground's vertical force at the moment of ground contact. Fuller has explained his theory in this way that if the displacement of the pressure center is placed at internal side of subtalar, the internal rotational force will be larger than the vertical response of the ground compared with the position in which pressure center displacement is at the external side of subtalar. This status leads to inversion intensification and internal displacement of the posterior part of the foot in the closed motor chain, consequently, the potential for damage to external ligaments will be increased (Fuller, 1999). Based on this model, this can be a factor in the difference between the internal and external posterior directions of the Y balance test, Figure-eight and lateral jump performance test. On the other hand, it has been reported that damage to the ankle ligaments can reduce the strength of the external rotational and thigh abduction and in this regard, in a study that examined maximal thigh and ankle eccentric torque in athletes with functional ankle instabilities, Darzi et al. (2012) stated that there is a significant difference between the maximum eccentric torque of the abductor muscles in patients with functional ankle instability and healthy ones (Darzi et al., 2012). This research's results showed this difference in two groups. Figer et al. (2014) reported that individuals with chronic ankle instability showed lower electromyography activity in lower limb muscles, including middle gluteus (Feger et al., 2014). Lee et al. (2014) also stated that ankle neuromuscular and biomechanics activity are changed in persons with weaker abduction muscular and they showed lower internal-poster postural stability (Lee et al., 2014) and this factor could be a reason to justify the results of this research in terms of performance and equilibrium tests. It is stated that the posterior part of the middle gluteus in early and mid-stance, and the anterior portion of the muscle in the mid-stance during the walking has a stabilizing role (Hwang et al., 2016). The result of an electromyography study indicates that the middle and upper gluteus muscles are active in the anterior, medial, posterior-internal directions when performing the star balance test (Norris et al., 2011). In the field of endurance of the trunk region, it is important to emphasize that muscles with long contraction are likely to be less tired and it also decrease the risk of injury or can continue the exercise. In line with the results of the current research, Razeghi et al. (2017) observed a significant difference between the central muscles' endurance of two groups of athletes with and without chronic ankle instability (Razeghi wt al., 2017), which can be argued that the stability and movement is determined by coordination of all the muscles around the lumbar region and trunk strength on the one hand and efficient movement on the other hand are necessary (Stevens et al., 2006), so that the weakness and inefficiency in coordination of the muscles of the central region can lead to a reduction in effective and efficient movements and consequently, creating a pattern of compensatory motions, strain and damage (Fredericson et al., 2005), therefore, the repetition of one-way activities can lead to asymmetry in the muscles and eventually damage (Fredericson et al., 2005). According to results, if the history of ankle sprain is accompanied with a lack of rehabilitation program, it can lead to a reduction in strength. In addition, this reduction and other control changes will reduce the balance and performance of these people. Therefore, the cause of reported injury in other studies may be related to these factors, and it seems that continuous assessment of strength and endurance can be helpful as a possible contributing factor in the prevention and treatment of patients with chronic ankle instability.

Thanks and appreciation

We thank the trainers and volleyball players in Tehran Province because of the cooperation and participation in this research.

References

1. Ahmadi R, daneshmandi H. The Relationship between Intelligent Quotient with Dynamic Balance in Intellectual Disability Children. Exceptional Education. 2015; 2 (130):31-36. (Persian).
2. Akbari M, Ahan jan s, Akbari m. [ankle joint instability in national team athlets (wrestling, football and basketball)]. Journal of sabzevar university of medical sciences 2007; 13(4): 178-184.
3. Callaghan MJ. Role of ankle taping and bracing in the athlete. Br J Sports Med 1997; 31(2): 102-8.
4. Darzi, Z; Alizadeh, MH; Jamshidi, AA, A comparison between hip and ankle eccentric torque in female athletes with functional ankle instability, Journal of Research in Rehabilitation Sciences, 2012, 8 (2), 272-278. (Persian).
5. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Single-leg drop landing motor control strategies following acute ankle sprain injury. Scandinavian journal of medicine & science in sports. 2015;25(4):525-33.
6. Evans C, Yeung E, Markoulakis R, Guilcher S. An Online Community of Practice to Support Evidence-Based Physiotherapy Practice in Manual Therapy. Journal of Continuing Education in the Health Professions. 2014;34(4):215-23.
7. Faraji, E; Ebrahimi-Atri, Ahmad; Daneshmandi, Hassan; Onvani, Vahid; The effect of prefabricated ankle orthoses on balance in athletes with chronic ankle instability in fatigue condition, Research in Rehabilitation Sciences, 2012, 8 (4), 1-8.
8. Feger MA, Donovan L, Hart JM, Hertel J. Lower extremity muscle activation during functional exercises in patients with and without chronic ankle instability. PM&R. 2014 Jul 31;6(7):602-11.

9. Fredericson M, Moore T. Muscular balance, core stability, and injury prevention for middle-and longdistance runners. Physical medicine and rehabilitation clinics of North America 2005; 16(3): 669-89.
10. Fuller EA. Center of pressure and its theoretical relationship to foot pathology. Journal of the American Podiatric Medical Association. 1999 Jun;89(6):278-91.
11. Granacher, U., Lesinski, M., Büsch, D., Muehlbauer, T., Prieske, O., Puta, C., . . . Behm, D. G. Effects of Resistance Training in Youth Athletes on Muscular Fitness and Athletic Performance: A Conceptual Model for Long-Term Athlete Development. Frontiers in physiology, 2016, 7.
12. Gribble PA, Taylor BL, Shinohara J. Bracing does not improve dynamic stability in chronic ankle instability subjects. Physical Therapy in Sport. 2010;11(1):3-7.
13. Hasanpour, A., Ghotbi, N., Naseri, N., & Jalaei, S. (2014). Pilot study of lower extremity dynamic balance in football, handball and taekwondo athletes: a comparison with functional tests. Journal of Modern Rehabilitation, 8(1), 72-80.
14. Hwang, W., Jang, J. H., Huh, M., Kim, Y. J., Kim, S. W., Hong, I. U., & Lee, M. Y. The effect of hip abductor fatigue on static balance and gait parameters. Physical Therapy Rehabilitation Science, 2016, 5(1), 34-39.
15. Iida, Y., Kanehisa, H., Inaba, Y., & Nakazawa, K. Role of the coordinated activities of trunk and lower limb muscles during the landing-to-jump movement. European journal of applied physiology, 2012, 112(6), 2223-2232.
16. Jacobs CA, Uhl TL, Mattacola CG, Shapiro R, Rayens WS. Hip abductor function and lower extremity landing kinematics: sex differences. Journal of athletic training. 2007;42(1):76.
17. Kavcic, N., Grenier, S., & McGill, S. M. Quantifying tissue loads and spine stability while performing commonly prescribed low back stabilization exercises. Spine, 2004, 29(20), 2319-2329.
18. Kemler E, van de Port I, Backx F, van Dijk CN. A systematic review on the treatment of acute ankle sprain. Sports medicine. 2011;41(3):185-9.
19. Knapp D, Lee SY, Chinn L, Saliba SA, Hertel J. Differential ability of selected postural-control measures in the prediction of chronic ankle instability status. Journal of athletic training. 2011 May;46(3):257-62.
20. Lee SP, Powers CM. Individuals with diminished hip abductor muscle strength exhibit altered ankle biomechanics and neuromuscular activation during unipedal balance tasks. Gait & posture. 2014 Mar 31;39(3):933-8.
21. Li H-Y, Zheng J-J, Zhang J, Hua Y-H, Chen S-Y. The Effect of Lateral Ankle Ligament Repair in Muscle Reaction Time in Patients with Mechanical Ankle Instability. International journal of sports medicine. 2015;36(12):1027-32.
22. Moradi, K; Minoonejad, H; Rajabi, R; The immediate effect of core stability exercises on postural sway in athletes with functional ankle instability, Rehabilitation medicine, 2015, 4 (3), 101-110. (Persian).
23. Nazakatolhosaini M, Mokhtari M, Esfarjani F. The effect of pilates training on improvement of motor and cognitive functions related to falling in elderly female. Journal of Research in Rehabilitation Sciences. 2012 Aug 30;1(1):489-501.
24. Norris, B., & Trudelle-Jackson, E. Hip-and thigh-muscle activation during the star excursion balance test. Journal of Sport Rehabilitation, 2011, 20(4), 428.
25. Okada T, Huxel K, Nesser T. Relationship between core stability, functional movement, and performance. J Strength Cond Res 2011; 25(1): 252-61.
26. Razeghi A, Rahnama N, Shokri E, Ghanbary A, Evaluation of Endurance of Core Muscles in Female Athletes with Chronic Ankle Instability, paramedical Sciences & Rehabilitation, 2017, 6 (1), 47-57.

27. Shokouhi, E; Norasteh, A S; Shamsi Majelan, a; Sanjari, MA; The comparison of postural stability in soccer players with and without chronic ankle injury in jump and landing functional test, Journal of Practical Studies of Biosciences in Sport, 2015, vol. 3, no. 5. 67-77. (Persian).
28. Stevens VK, Bouche KG, Mahieu NN, Coorevits PL, Vanderstraeten GG, Danneels LA. Trunk muscle activity in healthy subjects during bridging stabilization exercises. BMC Musculoskeletal Disorders 2006; 7(1): 75.
29. Willson J, Ireland M, Davis I. Core Strength and Lower Extremity Alignment during Single Leg Squats. Journal of the American College of Sports Medicine 2006; 38(5): 945-52.