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The Effects of Balance Training on Postural Sensory Organization against External Disturbances in People with Chronic Ankle Instability

Hadi Miri[1*], Seyed Sadrodin Shojaedin[2], Amirhossein Barati[3], Malihe Hadadnezhad[2], Shahram Ahajan[1]

[1] Department of Physical Education and Sport Sciences, Amirkabir University of Technology, Tehran, Iran.
[2] Department of Biomechanics and Sports Injury, School of Physical Education and Sport Sciences, Kharazmi University, Tehran, Iran.
[3] Department of Sports Injury, School of Physical Education and Sport Sciences Shahid Beheshti University, Tehran, Iran.

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Abstract

Background: *Injury to the ankle sensorimotor control system and impairment in the integration of sensory information and awareness of the sense of motion is an important factor in reducing balance and consequently re-injury. This study aimed to investigate the effects of balance training on postural sensory organization against external disturbances in people with chronic ankle instability.*

Methods: *In this quasi-experimental study, 30 male athletes with chronic ankle instability purposefully selected and randomly divided into experimental and control groups. Both groups were pre-tested and the experimental group had six weeks of balance training. Against the perturbation, post-test performed again on both groups, using a dynamic computerized post-chromography device to measure postural organization. Data were analyzed using analysis of covariance. Statistical operations performed by SPSS software version 22 at a significant level of 0.05.*

Results: *The score of postural sensory organization in the experimental group in the first condition is higher than other conditions and in the sixth condition is lower than other conditions. The mean score of postural sensory organization in the exercise group was significant compared to the control group (Pvalue≤0.05).*

Conclusions: *The results showed that the subjects in the exercise group had better sensory organization against external disturbances than the control group. Motion control and faster sending of sensory information, which ultimately leads to improved postural sensory organization.*

Keywords: Balance training, Sensory organization, External disturbances, Chronic ankle instability.

[*]Corresponding to: H Miri, **Email:** hd.miri@aut.ac.ir

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Introduction

An ankle sprain is one of the most common lower extremity problems that people at risk, such as athletes in the United States, are 2.5 out of every 1,000 people per year.[1] About 20% to 40% of ankle sprains are not curable and after a while, they become ankle instability.[2] If people with functional ankle instability are in double duty and a gait position, they face changing walking conditions and increased risk of re-torsion. Walking speed, temporal-spatial variables during walking, as well as their variability, or in other words, the number of fluctuations in temporal-spatial patterns of walking, are considered as measures of dynamic balance and step-taking continuity of walking time, which is used to determine the body's sensory-motor coordination and control.[3,4] In athletes, it has been investigated that the time away from training and racing after external ankle sprain injury was the longest compared to other injuries so that one-sixth of the total time away from training was due to ankle injury. It has been reported that approximately 25% of the time away from practice in disciplines such as football and basketball is caused by ankle injury.[5] Therefore, appropriate treatment is always needed in this area. Suggested treatments for ankle sprain include manual treatments, ultrasound, braces, and other modalities, physiotherapy to reduce pain and swelling, balance and proprioception exercises, to improve ankle function, which is effective for faster return to activity, reduce swelling and instability, increase range of motion and prevent re-torsion.[6] Injury to the ankle sensory-motor control system is known as the main cause of recurrent ankle instability.[6] Athletes who have a former ankle ligament compression show a decrease in proprioception and awareness of the sense of movement, reducing proprioception and awareness of movement sense is an important factor in reducing balance and postural control and consequently re-injury.[7] Ankle joint plays an essential role in balance and postural control1 while maintaining balance is necessary for daily activities and optimal exercise performance.[8]

However, balance and postural control depend on the integrated coordination of sensory messages caused by vestibular systems, visual and sensory-corporeal information. The postural control system includes controlling the body's position in space for dual purposes of postural stability and postural orientation to achieve these goals, the postural control system requires the integration of the input systems to determine the position and movement of the body in space and the output of systems (motor responses) to manage the body condition.[9,10] One of the important components of the somatosensory system is proprioception, which includes information learners from intra-joint receptors, muscles, and tendons, which is strengthened by exercise, especially balance exercises, and increases balance. Studies have been conducted to investigate the various causes of postural control disorder in musculoskeletal patients.[11,12] Zeich and his colleagues (2010) stated in a study that neuromuscular mechanism adaptations such as proprioception and spinal activity play a major role in dynamic balance, which balance exercises improve balance by using neuromuscular variables and coordination in the timing of stimulation of different muscles.[11] Moradi et al. by instantly examining the core stability exercises on the postural oscillation of athletes with functional ankle instability showed that core stability exercises affect the postural oscillation of athletes with functional ankle instability in closed eyes and significantly reduce postural oscillation. Although the above studies have used short-term core stability exercises, the results are in line with the present study which used long-term exercises for several weeks.[12] Most of the research conducted so far has been about the effect of unilateral ankle instability on static postural control,[13] and functional efficiency of lower extremity[14] and fatigue,[15] which have sometimes been associated with conflicting results. Since postural control and balance are the most important basic needs in daily activities and functional skills, defects in this system will lead to functional impairment and consequently disability.[16] Therefore, it seems necessary to investigate postural control abilities and their effective factors. Balance training is one of the most common and functional methods in the rehabilitation of chronic ankle instability that is designed to help retrain the proprioception system by improving the function of joint mechanical receptors and restoring normal neuromuscular feedback loop.[17] Therefore, it is necessary to pay attention to balance exercises and their role in the coordination of different senses in postural sensory organization and using effective motor strategy.[18] However, a study to investigate the effect of these exercises on the sensory organization of postural versus external disturbances in male athletes with chronic ankle instability is needed. Undoubtedly, investigating postural sensory organization indicators (visual, vestibular, and proprioception system) against external disturbances in response to balance exercises can provide the necessary information to design effective rehabilitation and exercise strategies for rehabilitation, a more suitable training program for use in exercise training and preventing chronic ankle instability and preventing the conversion of acute ankle sprain injury to chronic instability.

Materials and Methods

The present study was semi-experimental and 30 athletes with a chronic ankle sprain (20-30 years) were selected purposefully and randomly selected in experimental (n=15) and control groups (n=15). Subjects should score more or equal to 90% of the foot disability index questionnaire (FADI) and more or equal to 75% of the score of the foot disability sport index (FADI sport) on arrival. In the past six months, they have at least twice the feeling of ankle instability or feeling empty during daily or athletic activities, and when conducting the research, they should be able to fully bear weight, have normal walking, and have full ankle joint range of motion.[19,20] Subjects with a history of fractures or surgery of lower extremity joints, postural disorders of lower extremity, spine, history of neurological or vestibular system disorders, having acute torsion symptoms, history of ligament injury or knee minuscule and head trauma, taking any sedative drugs and alcohol during 48 hours before the test were excluded.[21] To evaluate the postural sensory organization, a dynamic computer postural device (DCP) was used. The operation of sensory systems affecting postural control.[22] This system has two power plates to investigate the variables affecting postural control, that the performance of each of the proprioception, local and visual systems. In postural control, it is evaluated and has 6 conditions in the first three situations, fixed force plates, and in the other three situations move in anterior and posterior directions. Three open-eyed and three closed eyes, three visually stable situations, and three other situations with the visual intervention were finally extracted from the combination of the above factors, which are as follows: The first condition (open eye, visual environment, and fixed platform), second condition (closed eyes, fixed platform), third condition (open eyes, moving visual environment, fixed platform), fourth condition (open eyes, fixed visual environment, moving platform), fifth condition (closed eyes, moving platform), sixth condition (open eyes, moving visual environment, moving platform). Each subject must maintain his posture for 20 seconds and each condition was repeated three times in each of the conditions of this test, score from 0 to 100 as an indicator of postural control. The individual is presented and the mean postural control index in 3 times the test is considered as the score of the person's postural control. The perform of study after receiving the clinical trial code (UMIN000044974) first athletes with the test chronic ankle instability was assessed by referring to the sports medicine staff and filling out the questionnaire and by a specialist physician to assess the conditions of their entry and exit to the study, 30 people were selected and after obtaining the consent and informing about their participation in the project, finally entered the study and each of the subjects with bare feet on the screen of postural system forces for pre-testing. Then, 15 subjects in the experimental group were taught the balance training protocol in one session. The experimental group performed balance exercises for six weeks, three sessions per week and one day in between, each session lasting about 60 minutes in three parts, 10 minutes of warm-up, 45 minutes of main exercises per session in three sets, and each set including twice consecutive exercises (five protocol levels) with 2 minutes' rest between each period, which took 45 seconds for each training level and rest. Then each exercise was 30 seconds and at the end of the five minutes, the cooling was done. The intensity and volume of the exercise changed with changes in the type of exercise and simple shape to complex, type of tool, changes in the thickness of the mattress and foam, its rigidity and hardness, and functional movements.[23] Finally, after six weeks of the training program, all variables were measured again in the post-test. Descriptive statistics indicators (mean and standard deviation) were used to describe the data and also inferential statistics indicators such as variance analysis tests were used to analyze the data at the level of $\alpha \leq 0.05$.

Results

The individual characteristics of the experimental and control groups are presented in table 1. The results of the statistical test did not show a significant difference, which indicates that the subjects were homogeneous.

Table 1. Average and standard deviation Individual Characteristics

Variable	Control group (n=15)	Experimental group (n=15)	Pvalue
Age (year)	24.26±1.86	24.40±2.13	0.85
Weight (kg)	69.80±8.89	72.20±9.76	0.48
Height (cm)	177.46±8.56	179.46±6.41	0.47

Table 2 shows the mean and standard deviation of sensory organization variable in 6 different sensory conditions (fixed and moving platform, open and closed eyes, and constant and moving visual environment) and its overall mean in athletes with chronic ankle instability in experimental and control groups.

The findings presented in table 3 show that the mean score of postural sensory organization in the experimental group in all 6 conditions is higher than the control group. Also, a comparison of sensory organization of experimental and control groups in pre-test and post-test showed that there was no significant difference between the experimental and control groups in the pre-tests, but in the post-test, the experimental group performed better than the control group. The results of covariance analysis showed that six weeks of balance training affects postural sensory organization against external disturbances in male athletes with chronic ankle instability (Table 3).

Table 2. Average and Standard Deviation sensory organizing Information

Conditions	Level	Control group (n=15)	Experimental (n=15)
Open eyes, visual environment, and fixed form	pre-test	89.96±3.36	89.32±3.57
	Post-test	90.51±3.24	92.41±3.67
Closed eyes, fixed platform	pre-test	84.30±6.32	84±6.44
	Post-test	85.71±6.12	91.88±3.09
Open eyes, moving visual environment, static platform	pre-test	82.38±5.84	83.08±6.56
	Post-test	83.92±5.56	90.88±3.84
Open eyes, steady visual environment, animated platform	pre-test	66.14±7.01	68.17±7.53
	Post-test	67.84±7.20	82.88±7.38
Closed eyes, animated platform	pre-test	52.05±9.54	53.84±10.39
	Post-test	53.54±9.34	69.11±7.56
Open eyes, animated visual environment, animated platform	pre-test	45.97±9.24	47.26±11.62
	Post-test	46.82±9.91	61.68±15.19
Overall average	pre-test	69.92±2.29	70.94±2.92
	Post-test	71.39±2.48	81.47±4.54

Table 3. The results of the covariance analysis of the sensory organizing in each of the condition

Condition	Source	Sum of squares	Degrees of freedom	Average of squares	F	Pvalue
1st sensory condition (C1)	Pre-test	257.92	1	257.92	88.38	0.000
	Group	18.79	1	18.79	6.43	0.017
Second sensory condition (C2)	Pre-test	325.10	1	325.10	26.28	0.000
	Group	286.59	1	286.59	23.17	0.000
3rd sensory condition (C3)	Pre-test	301.54	1	301.54	23.95	0.000
	Group	32.24	1	324.24	25.78	0.000
4th sensory condition (C4	Pre-test	556.31	1	556.31	16.07	0.000
	Group	1396.78	1	1396.78	40.36	0.000
5th sensory condition (C5)	Pre-test	473.82	1	473.82	8.25	0.000
	Group	1636.26	1	1636.26	28.50	0.000
Sixth sensory condition (C6)	Pre-test	1914.02	1	1914.02	19.18	0.000
	Group	1434.09	1	1434.09	14.37	0.001
Mean total sensory status (CO)	Pre-test	239.53	1	239.53	12.49	0.001
	Group	614.82	1	614.82	32.08	0.000

Discussion

The findings of this study showed that athletes with chronic ankle instability in the training group had better sensory organization and more postural stability against external disturbances than the control group. The mean score of sensory organization in the experimental group in the post-test was higher in all 6 situations than in the control group. Subjects in the first situation had better balance and postural control than the other five based on sensory organization stability score. There was no significant difference between the stability score in the second condition (elimination of visual and the presence of two senses of vestibular and proprioception) with the third condition (manipulation of vestibular sense and the presence of two senses of vision and proprioception) these results indicate that people are not dependent on visual and in the third condition to balance the second condition. However, there was a statistically significant difference between the second condition and the fourth condition (proprioception manipulation), fifth (visual elimination and proprioception manipulation) and6th (manipulation of vestibular and proprioception), and the subjects in the second condition had significantly better balance and postural control based on sensory organization stability score than the fourth to sixth conditions. Visual and vestibular feedback can be effective for improving balance in individuals.[24] Researchers have acknowledged that reductions in sensory integrity, decreased function of proprioception, visual and vestibular receptors lead to decreased postural balance.[25,26]Bulger et al. (2014) stated that due to the dependence of the postural system on sensory internalities, in case of reduction or discontinuation of one of the sensory internals, the body's oscillation increases and thus increases to maintain the balance of muscle activities.[27] Asadi (1400) investigated the effect of eight weeks of ICH training on balance, proprioception, and performance of elite female athletes with functional ankle instability. 30 female volleyball players, basketball players, and handball players with functional ankle instability were divided into two groups of 15 training and control. The results showed that the balance, proprioception, and performance of athletes improved after ICH exercises.[28] Hosseinzadeh and Nourasteh (2020) investigated two types of hoping and combined training (strength-balance) on the strength of selected muscles and the static and dynamic balance of athletes with ankle instability. The subjects consisted of 30 male athletes with ankle instability who were randomly divided into two groups. Both types of exercises were effective in improving the balance and strength of the subjects. However, selected exercises (strength-balance) are emphasized separately due to their comprehensiveness and strengthening of each variable.[29] In the standing position, the excessive displacement of the center of gravity to maintain the posture increases the oscillation, followed by the outer side of the foot as support to compensate for the increase in the postural oscillation with the ankle inversion that follows. If the ankle is unable to compensate for these external fluctuations, the thigh strategy is activated to prevent torque or excessive movement of the ankle inversion. Weakness of the thigh muscles reduces this auxiliary mechanism for controlling external fluctuations, while the possibility of serious ankle injury is provided. In the standing position, the postural oscillation on the outer side of the foot is higher than other parts.[30] In normal standing, the contribution and participation of visual and visual information in postural control and stability are low (approx. 10%),[31] but in neuromuscular fatigue conditions along with reduced reliability of proprioception information coming from tired muscles,[32] it increases the effect of visual information on the stability and postural control system.[33-35] In their research, Farber et al. (2007) stated that these differences are more pronounced for young people, especially when visual stimuli are eliminated or incorrect.[22] Annafaraldo et al. (2016) in a study that investigated postural changes related to aging and stability range in healthy subjects stated that the lowest scores for condition 5 (closed eyes and mobile platform) were obtained and a not significant difference was observed or at least,[10] as well as the results of the research olive et al. (2005), both of which are inconsistent with the present study. It was shown that the percentage and stability of the posture in the sixth condition when vestibular and proprioception senses are manipulated is lower than other situations, which may be due to differences in different samples.[36] The researchers stated that decreased proprioception causes disturbances in indicators such as sensory organization of postural and balance.[37]

Studies have shown that proprioception can be trained and rehabilitation and training programs, mainly including proprioception training, improve functional movements and postural stability. For proprioception training, involvement of this system in training is necessary, and therefore, special exercises are designed, a large group of proprioception exercises, including balance exercises on unstable surfaces,[38] training in unstable conditions stimulates proprioception receptors, gains feedback to maintain balance and recognize body position.[39] As shown in previous studies, proprioception feedbacks from the thigh play a role in controlling movement and internal-external stability during walking. Proprioception of the thigh plays a role in the process of stabilizing the position of the foot based on the mechanical position of the pelvis to control the position of the static foot and the foot of the oscillation.[40] Failure to limit the joint by damaged ligaments may cause internal-external balance disorder. Proprioception damage also plays a role in postural control deficiencies.[37] Some proprioception receptors are located in the ligaments of the outer ankle[41] proprioception receptor damage reduces neural activity and subsequently affects muscle activity to sustain the ankle during perturbation.[37] People with ankle instability have decreased postural stability and balance in external directions compared to healthy people,[37,38] although there are unknown mechanisms for how these people can maintain their stability level similar to healthy people.[8,42] Therefore, balance exercises on unstable surfaces such as equilibrium bed and moving screen have been suggested to improve proprioception disorders.[38] Also, performing balance exercises or training on unstable surfaces may cause muscles to be more actively involved and the central nervous system receives more appropriate and effective stimulations than neurotics of proprioception receptors of these muscles.[39] Considering the role of proprioception in postural stability and organization, athletes with ankle injuries can greatly overcome their stability and stability deficits by doing balance exercises and increasing lower extremity strength. It seems that balance exercises by stimulating different sensory receptors and increasing sensory-corporeal inputs and the vestibular system can have central effects on joint stabilizing motor programs, postural stability, and balance, which leads to more sensory organization and increase the percentage of postural stability with integrity and sending information from different sensory receptors (proprioception, etc) to be. Considering the effectiveness of balance exercises on sensory organization and stability in postural control indices of people with chronic ankle instability against disturbances, it is suggested that researchers and sports experts use perturbation balance exercises along with other methods in the rehabilitation of athletes with chronic ankle instability.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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