Effects of balance training on movement control, balance and performance in females with chronic ankle instability

Salim Vahedi Namin [1] Amir Letafatkar [2] Vida Farhan [3]

[1] Department of Physical Education and Sport Science, Faculty of Education & Psychology, University of Mohaghegh Ardabili, Ardabil, Iran.
[2] Department of Biomechanics and Sport Injuries, Faculty of Physical Education and Sport Science, Kharazmi University, Tehran, Iran.
[3] PhD Student, Department of Biomechanics and Sport Injuries, Faculty of Physical Education and Sport Sciences, Kharazmi University, Tehran, Iran.

Received 8 July, 2017 Accepted 26 Sep, 2017

Original Article

Abstract

Introduction: Although chronic ankle instability (CAI) is a condition characterized by numerous ankle sprains and the recurring sensation of ankle instability, which result in activity limitations and participation restrictions. Repetition based balance training protocols on type of the balance exercises may improve the deficits often associated with CAI. The objective of this study was to determine the effect of 6 weeks repetition based balance training on movement control, balance and performance in females with CAI.

Methods: A total of 30 active female with CAI were selected for this study and randomly divided into control and experimental groups. Before and after the 6 weeks repetition based balance training intervention, participants were tested by completing the Mischiati test for movement control, Y balance test for balance and the Figure-8 hop and triple- crossover hop for performance. For statistical analysis, we conducted paired and sample t tests the data were analyzed using software SPSS 16 $P \leq 0.05$ was considered significant.

Results: The repetition-based balance protocol group improved the movement control ($P=0.004$), balance ($P=0.006$), figure-8 hop ($P=0.001$) and triple- crossover hop ($P=0.003$) performance.

Conclusion: Despite some limitations, the findings clearly support the use of repetition-based balance training exercises to improve movement control, balance and performance in females with CAI. Thus, future researchers should consider not only larger sample sizes but also longer-duration training programs to ensure the presence of notable adaptations in sensorimotor control that can.

Correspondence:
Salim Vahedi Namin, MD.
Sports Medicine Specialist, Faculty of Education and Psychology, University of Mohaghegh Ardabili.
Ardabil, Iran
Tel:+98 4531505635
Email:
vahedis@uma.ac.ir

Key words: Chronic, Performance, Movement

Citation: Vahedi Namin S, Letafatkar A, Farhan V. Effects of balance training on movement control, balance and performance in females with chronic ankle instability. Hormozgan Medical Journal 2017;21(3):188-199.

Introduction:

Ankle sprain is one of the main causes of the impediment of activity, and 20–40% of patients with sprained ankles progress into having chronic ankle instability. These injuries can cause damage to the ligaments, muscles, nerves, and mechanoreceptors that cross the lateral ankle (1).

Repetitive occurrences of lateral ankle sprains can lead to chronic ankle instability (CAI), which is characterized by a subjective feeling of recurrent instability, repeated episodes of giving way, weakness during physical activity, and self-reported disability (1,2).

Chronic ankle instability is defined as a subjective feeling of the ankle giving way, which results from a pattern of instability involving an initial ankle sprain followed by repeated ankle sprains. CAI can be defined as the state caused by the experience of multiple ankle sprains, with instability resulting from restricted joint range of motion and limited movement. In addition, stability of the ankle can have a positive effect on standing balance, and even influence the stability of such movements as walking and jumping (3).

CAI can occur as a result of inappropriate treatment following an initial injury and pain in the lateral part of the ankle joint is reported to be the most common cause. Due to instability and discomfort during sudden changes of direction or stopping actions, patients with CAI report reduced balance performance. Therefore, when ankle injury occurs, the mechanical receptors in the joint become damaged, leading to functional instability (2). Although the precise mechanisms of functional ankle instability have not been elucidated, the condition presents with ligament damage, reduced muscle strength, delayed muscle response time, and proprioceptive deficits in the ankle.

Patients with CAI often exhibit deficits in functional performance, proprioception, and strength.

Because muscle weakness is associated with CAI, strength training is an essential part of the rehabilitation protocol to reduce the residual symptoms and, we hope, to prevent further episodes of instability from occurring (2).

Moreover, mounting evidence demonstrates that various balance-training programs improve postural control and reduce the recurrence of musculoskeletal injuries (eg, ankle sprains).

Similarly, lower extremity force production improves after balance training in healthy young adults, but conflicting evidence exists. Research in those with recurrent ankle sprains also demonstrated mixed results (1-5).

Identifying and classifying movement faults are fast becoming an essential tool in contemporary rehabilitative neuromusculo-skeletal practice (6). A common feature of movement control faults is reduced control of active movements, or movement control dysfunction (MCD). The MCD is identified by a series of clinical tests. The tests are based on the concept known as dissociation, defined as the inability to control motion at one segment while concurrently producing an active movement at another joint segment (7).

The retraining of efficient control of uncontrolled movement (UCM) will depend on the pattern of the dysfunction and the site and direction of the UCM. From the assessment the translation and range of UCM and restriction will have been identified. Correcting length and recruitment dysfunction is the priority of the global system. Addressing the UCM and restriction is the key to rehabilitation (6-8).

Hall et al. (2015) stated that after 6 weeks of resistance-band protocol no improvements were seen in the triple-crossover hop or the Y- Balance tests of CAI participants (2). Also Cug et al. (2016) compare an error-based progression (ie, advance when proficient at a task) with a repetition-based progression (ie, advance after a set amount of repetitions) style during a balance-training program in healthy individuals (1). Reported that balance-training program consisting of dynamic unstable-surface exercises on a BOSU ball improved dynamic postural control and ankle force production in healthy young adults (9,10). These results suggest that an error-based balance-training program is comparable with but not superior to a repetition-based balance-training program in improving postural control and ankle force production in healthy young adults. Ju (2017) studied the effects of ankle functional rehabilitation exercise on the ankle joint functional movement screen and isokinetic muscular function in patients with chronic ankle sprain and reported significant improvements in ankle joint functional movement screen and in isokinetic muscular function after the exercise (11). Nam et al (2017) examined the effect of a 4-week balance exercise with medio-lateral unstable sole on ankle joint functional ability and reported after intervention Star Excursion Balance Test scores did not show a significant difference between pre- and post-exercise. Nam suggested a future study with increased level of medio-lateral perturbation during outcome measurements and exercises with addition of supervision in the exercise training and home program (12).

Because a high percentage of ankle sprain cases are associated with residual functional deficiencies, there is a need to identify effective clinical interventions that address the long-term deficits associated with CAI (4,10). Despite the effectiveness of balance training in improving these outcomes, the exact parameters needed to maximize the benefits of balance-training programs remain unknown. One factor that has gained interest of late is the progression style (1). However, individual differences in the rate of self-organization and movement proficiency for a given task could vary significantly and thus may be a reason why this progression style has not been investigated empirically until recently. In the case of CAI, because dynamic movement is restricted and balance and gait abilities are impaired, conservative treatment via rehabilitation exercise is thought to be important. The objective of this study was to determine the effect of repetition based balance-training protocol on movement control, balance and performance in females with CAI.

Methods:

Group and design

A quasi- experimental design was used to quantify the effects of the repetition based balance-training intervention on females with CAI in this study. Control and experimental subjects were pretested 1 week before the initial training session. Post-testing was performed approximately 6 weeks after the pretest on control and experimental subjects (2 days after the final training session).

Forty nine recreationally active individuals volunteered, after screening based on inclusion and exclusion criteria 30 subjects were selected that were randomly assigned to two groups, a repetition based balance- training group and a control group and finally 30 women completed the study.

Table 1. Baseline demographic characteristics of the population studied (m±SD)

	Balance group (n=15)	Control group (n=15)	P
Age (yr)	28.13±1.53	24.5±3.9	0.43
Height (cm)	174.2±7.14	170.3±4.16	0.51
Mass (kg)	71.33±4.54	69.14±7.29	0.65

Those in the repetition based balance- training protocol group participated in their assigned treatment protocol 3 times/wk for 6 weeks. Each person met individually with the investigator and progressed at the same rate to allow consistency among participants. After 6 weeks, posttest measures for strength, dynamic balance, functional performance, and movement control were tested in all participants. Those in the control group participated only in the pretest and posttest. All testing and rehabilitation sessions were performed in the athletic training research laboratory.

We defined recreationally active as participating in 30 minutes of physical activity 3 times each week during the 6 months before the study (13).

Volunteers were excluded if they had a lower limb injury at the time of the study or a history of lower limb surgery. Lower limb injury was defined as any injury that prevented normal exercise in the 6 months before testing. All participants provided written informed consent, and the study was approved by the Mohagheghi Ardabil University Ethics Committee.

Procedures

Participants were block allocated into 2 groups (control group n=15; experimental group n=15), with the first participant allocated to control, the second participant allocated to repetition based balance training, and so on. The investigators were not blinded to which group participants were allocated while collecting movement control and performance data.

Experimental group completed 3 training sessions per week for 6 weeks. 2 sessions were supervised, and the other 1 session was home exercise programs. Movement control, balance and performance data took place at baseline assessment, and 6 weeks.

Balance-Training Intervention

After pre test, participants were randomly assigned to 1 of 2 groups (a control and a repetition-based balance-training group). Experimental group then underwent a total of 18 sessions training, lasting about 30 minutes each over a 6-week period while the control group did not participate in any injury prevention exercises. The balance-training program used in the current investigation was a modification of the program initially described by McKeon et al. (2009) (14). The following exercises were performed during each training session: 1) hop to stabilization onto and off a BOSU ball in 4 directions (anterior, lateral, antero-medial, and antero-lateral), 2) mini squats on a BOSU ball while in a single-limb stance, 3) unanticipated reach sequences while stabilizing on a BOSU ball in a single-limb stance, and 4) static single-limb stance on a BOSU ball (Table 2). Participants returned for post-testing over the 2-day period immediately after completing the 18th training session.

Table 2. Repetition-based Balance-Training Intervention

Exercise	1st week	2nd week	3rd week	4th week	5th week	6th week
Single-Limb Hops to Stabilization onto a BOSU Ball	The 45.72-cm hop	The 45.72-cm hop	The 68.58-cm hope	The 68.58-cm hope	The 91.44-cm hop	The 91.44-cm hop
Stabilization and Unanticipated Reach	take 5 seconds per move while standing on a dome	take 5 seconds per move while standing on a dome	take 3 seconds per move while standing on a hard surface and with 2 cones at altered heights and 2 cones farther away	take 3 seconds per move while standing on a hard surface and with 2 cones at altered heights and 2 cones farther away	take 3 seconds per move while standing on a dome and with 2 cones at altered heights and 3 cones farther away	take 3 seconds per move while standing on a dome and with 2 cones at altered heights and 3 cones farther away
Squat on a BOSU Ball	Single-limb squat to 30° and return to stabilized position	Single-limb squat to 30° and return to stabilized position	Single-limb squat to 45° and return to stabilized position	Single-limb squat to 45° and return to stabilized position	Single-limb squat to 60° and return to stabilized position	Single-limb squat to 60° and return to stabilized position
Single-Limb Stance	Stand for 30 seconds	Stand for 30 seconds	Stand for 45 seconds	Stand for 45 seconds	Stand for 60 seconds	Stand for 60 seconds

^{0} degree

Balance Testing

Proprioception was dynamically tested using the Y-Balance test (15). The Y-Balance test is reliable [composite ICC=0.89] in the measurement of individual reach directions: anterior, postero-medial, and postero-lateral. The orientation of the reach direction is relative to the stance limb.

Participants stood on the involved limb with the great toe behind the line on the platform located at the center of the 3 diverging lines. Measurements were taken as the participant pushed the target plate along the polyvinyl chloride pipe with the opposite leg. The participant returned to the starting position without losing balance after each trial. One to 4 practice trials were performed for each direction, so the participant became comfortable performing the task. For testing, the participant performed 3 consecutive trials in 1 direction. After each trial, the examiner recorded the distance indicated by the target plate and then returned it to the center so the participant could perform the next trial. The maximum distance (centimeters) for each reach direction was recorded.

The participant had a 30-second rest before moving on to the next direction. Reach distances were normalized to the participant's leg length, which was measured in centimeters from the anterior-superior iliac spine to the distal tip of the medial malleolus. The composite score (percentage) was calculated by taking the average of the 3 maximal reaches divided by the participant's limb length, multiplied by 100. That value was used for statistical analysis (15).

Functional Performance Testing

Functional performance testing included the figure-8 hop and the triple- crossover hop tests (Figure 1) (16,17).

The figure-8 hop test was performed by having participants hop in a 5-m course around the cones in an ‘‘8’’ design on the involved ankle. The participants were instructed to hop as quickly as possible twice through the course. If the right ankle was being tested, then he or she started on the left side and finished on the right side.

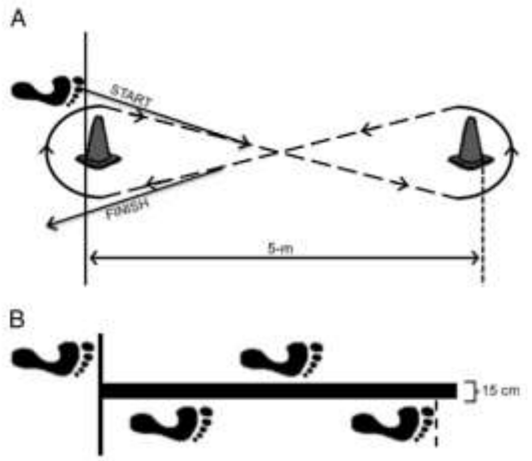

Figure 1. A, Figure-8 hop test for time is a single-legged hop twice around the course. B, Triple-crossover hop is a distance test.

If the left ankle was being tested, he or she began on the right and finished on the left. Speed was timed in seconds with an electric timer. The fastest time was used for analysis.

The modified triple-crossover hop for distance was measured in centimeters using a cloth tape measure. For this testing, the participant stood on the involved leg and hopped 3 times as far as he or she could in a zigzag fashion over a 15-cm tramline. If the involved limb was on the right side, then he or she started on the left side of the line and vice versa for the left limb. The distance was measured from the starting point to the location of the great toe on the last hop. The trial with the maximum distance was used for analysis (16,17).

Movement Control Testing

Participants assessed using the battery screening protocol comprising nine movement control tests (Table 3) (6). Digital cameras (Casio) were used to record participants performing the tests, and were set up to give anterior, posterior and lateral views. Tripods and angle adjustment allowed for variation in positioning of the tests. All participants wore black Lycra shorts and a sports top that allowed observation of movement and bony landmarks.

Nine of the 10 movement control tests of The Foundation Matrix were used (Table 3). Each of the 10 tests in the Foundation Matrix has five criteria posed as questions (n=50) which require an observational judgment regarding the person's ability to adequately control movement to a pass or fail benchmark standard. Not all movement evaluation criteria on movement control faults could be evaluated (6-8).

Each test was repeated up to three times, and the researcher recorded their scores of performance. The order of the tests was standardized (Table 3) to ensure all participants were assessed the same way as recommended by Luomajoki et al. (2007). The test sessions took approximately 20 minutes (8).

Table 3. Order of tests performance

The tests are reported by the name of the test in The Foundation Matrix (TFM).
NB Test 6 was not included in the present study (see Methods section of text)
Standing Tests
1- Double Knee Swing (Low threshold TFM Test 1)
2- Single leg ¼ squat+hip turn (Low threshold TFM Test 2)
3- Controlled shoulder internal rotation (Low threshold TFM Test 4)
4- Split squat+fast feet change (High threshold TFM Test 9)
5- Lateral stair hop + rotational landing control (High threshold TFM Test 10)
Floor Tests
6- Bridge + straight leg lift & lower (Low threshold TFM Test 3)
7- 4 point - arm reach forward and back (Low threshold TFM Test 5)
8- Plank + lateral twist (High threshold TFM Test 7)
Wall test
• One arm wall push (Low threshold TFM Test 8)

Table 4. Test details and scoring system for movement efficiency criteria

Test Details	Marking Criteria
Double Knee Swing In standing, bend the knees into a ¼ squat position Swing both legs simultaneously to the left, then right to 20° of hip rotation The pelvis should not rotate or laterally shift to follow the knees Keep the 1st metatarsal head fully weight bearing on the floor	Can you prevent the pelvis and back rotating to follow the legs? Can you prevent side bending of the trunk and lateral movement of the shoulders? Can you keep the trunk upright and prevent further forward bending at the hips? Can you prevent the foot from turning out as the knee swings out to 20°? Can you prevent the big toe from lifting as the knee swings out to 20°?
Single Leg ¼Squat+Hip Turn Stand on one foot keeping pelvis and shoulders level, and arms across the chest Take a small knee bend 30°, and hold this position for 5 seconds Then moving the trunk and pelvis together, turn 30° away from the standing foot Hold this position for 3 seconds Turning back to the front straighten the knee Repeat the movement, standing on the other leg	Can you keep the pelvis facing straight ahead as you lower into the small knee bend and hold the position for 5 seconds? Can you prevent side bending of the low back and trunk in the small knee bend position or during the rotation? Can you prevent the trunk from leaning further forward in the small knee bend position? Can you prevent the (WB) knee turning in across the foot to follow the pelvis as you turn the pelvis away from the standing foot? Can you prevent the (WB) arch from rolling down or toes clawing?
Bridge + Heel Lift + Single Straight Leg Raise & Lower Lying in crook lying position, lumbopelvic neutral position, arms folded across the chest Maintaining position, lift the pelvis just clear of the floor (about 2 cm) Lift heels into full plantar flexion Maintaining position, slowly take weight off one foot and straighten that knee keeping thighs level. Then slowly raise the straight leg, moving the thigh up towards the vertical position, then slowly lower the straight leg (extend the hip) to horizontal Return to crook lying and repeat on the opposite side	Can you prevent low back flexion as the straight leg raises? Can you prevent low back extension as the leg lowers? Can you prevent pelvic rotation against asymmetrical single leg load?
Controlled Shoulder Internal Rot Stand tall with the scapular in neutral position, shoulder abducted to 90°, 15-30° forward of the body in scapular plane, elbow flexed to 90° Ensure humeral head and shoulder blade, are in neutral position Maintaining upper arm and scapular position rotate the arm to lower the hand down towards the floor. Monitor the scapular at the coracoid with one finger and the front of humeral head W with another finger during medial rotation There should be 60° of independent medial rotation of the shoulder joint	Can you prevent the upper back and chest from dropping forward as you rotate the arm? Can you prevent the upper back and chest from turning as you rotate the arm? Can you prevent the coracoid rolling or tilting forward? Can you prevent forward protrusion of the humeral head?
4 Point - Arm Reach Forward and Back Start on all fours, knees under the hips and hands under the shoulders Position the spine, scapulae and head in neutral mid position Maintaining neutral position, shift body weight onto one hand; slowly lift the other arm off the floor to reach behind you to 15° shoulder extension. Then move to lift and reach the arm in front to ear level. Repeat to other side	Can you prevent either shoulder blade hitching? Can you prevent either shoulder blade dropping or tilting forward? Can you prevent winging of the weight-bearing shoulder blade? Can you prevent forward protrusion of the head of the shoulder joint as the non weight-bearing arm extends?
Plank + Lateral Twist Lie face down supported on elbows, positioned under shoulders and fore-arms across the body, side by side. Maintaining the knees and feet together, bend the knees to 90°, and push the body away from the floor taking the weight through the arms into a ¾ plank, keeping a straight line with legs, trunk and head. Maintaining lumbopelvic neutral position shift the upper body weight onto one el-bow, during the weight shift the body should move laterally (approx 5-10cm). Turn the whole body 90° from the (WB) shoulder to a ¾ side plank, the trunk, pelvis and legs should turn together and remain in a straight line. Return to starting position again maintaining position. Repeat the movement to the other side	Can you prevent the weight-bearing shoulder blade dropping? Can you prevent the weight-bearing shoulder blade winging or retracting? Can you prevent forward protrusion of the humeral head of the weight-bearing shoulder joint as you turn onto one arm? Can you prevent the low back from arching? Can you prevent the pelvis from leading the twist as you turn from the front plank position towards the side plank position?

Test Details	Marking Criteria
One Arm Wall Push Stand tall in front of a wall, hold the arm at 90° flexion, hand placed on the wall, scapular in neutral, move the feet one foot length further back away from the wall, lean forward and take body weight on the hand Keeping the shoulder blade, trunk and pelvis in neutral, slowly bend the elbow to lower the forearm down to the wall Lower the elbow so the forearm is vertical and fully weight-bearing against the wall, then push the body slowly away from the wall to fully straighten the elbow Do not allow the trunk and pelvis to rotate or arch towards the wall. Repeat with the other arm	Can you prevent the upper back from flexing or rounding out as the arm pushes away from the wall? Can you prevent the upper back from rotating? Can you prevent the weight-bearing shoulder blade from hitching or retracting? Can you prevent forward tilt or winging of the weight-bearing shoulder blade?
Split Squat + Fast Feet Change Step out with one foot (4 foot length), feet facing forwards and arms folded across chest Keeping the trunk upright, drop down into a lunge, rapidly switch feet in a split squat movement, control the landing Then lift the heel of the front foot to full plantar flexion and hold this heel lift in the deep lunge for 5 seconds, then lower the heel and without straightening up, rapidly switch feet in a split squat movement, control the landing After the landing, again lift the heel of the front foot to full plantar flexion and hold this heel lift in the deep lunge for 5 seconds Repeat the heel lift twice with each leg in the forward position	Can you prevent side bending of the trunk? Can you keep the trunk upright and prevent the trunk leaning forward at the hips towards the front foot? Can you prevent the front knee moving in across the line of the foot? Can you prevent the foot from turning out or the heel pulling in as you land? Can you prevent the heel of the front foot from rolling out during the heel lift?
Lateral Stair Hop + Rotational Landing Control Stand side on to a box/step (approx 15 cm) with the feet together, and arms by your side Keeping the back straight bend the knees into a 'small knee bend' position, lift the outside leg off the floor to balance on the inside leg Hop laterally up onto the box/step / keeping the back upright and controlling the landing into the 'small knee bend' position Hold this position for 5 seconds Then hop back down off the box to rotate through 90° to land on the same leg turning to face away from the box/step Repeat with the other leg	Can you prevent the trunk or pelvis from rotating? Can you prevent side-bending of the trunk as you land on the hop down? Can you prevent the body from leaning forwards at the hip as you land? Can you prevent the landing knee turning in across the foot as you hop down? Can you prevent the arch from rolling down or toes clawing as you hop down??

As the participant carried out the movement task, researcher recorded their observation on the efficacy the participant's ability to control movement by a number of criteria, which involved scoring a pass or fail to a set of criteria (Table 4) (6). Since the intention of the foundation matrix is to measure impairment, a low score indicates less impairment and a high score indicates greater impairment. Therefore, fail is rated as 1 and pass is rated as 0. After the researcher had recorded their observations, the participant was taught the next test and the procedure repeated until all nine tests had been recorded.

The video recordings were viewed on a laptop with a maximum of three views per test based on Ekegren et al. (2009) (7). As before, the researcher observations on the control of movement were recorded. All scoring sheets were transcribed to an Excel spread sheet for analysis.

Statistical analyses

Descriptive statistics were used for reporting the mean and standard deviation of data. The Shapiro-Wilk statistical test was used for data normality distribution testing. Paired t-test was used to compare pre- and posttest values for the control and training group to determine statistical significance. An independent sample t test was applied to statistical comparisons to between groups. All data were analyzed using SPSS software (version 16.0; SPSS Inc, Chicago, IL) for Microsoft Windows. The alpha level was set at $P \leq 0.05$ for statistical significance.

Results:

All athletes completed 18 training sessions. There were no injuries sustained that caused any athlete to stop training. Because each session was supervised, all athletes completed all jumps and sports-specific drills and exercises.

A total of 30 subjects participated in this study, with 15 subjects in the experimental group and 15 in the control group. The general characteristics of the study subjects are summarized in Table 1.

There were no significant differences in the baseline values between the experimental and control groups.

The Y balance, figure 8 hop and triple-crossover hop scores increased significantly in the experimental group ($P<0.05$), with a significant difference in the score changes of the two groups ($P<0.05$) (Table 5).

Also the movement control scores decreased significantly in the experimental group ($P<0.05$), with a significant difference in the score changes of the two groups ($P<0.05$) (Table 5).

Tabble 5. Movement control, balance and performance scores at pre- and post-training

Test	Groups	Pre training	Post training	Paired t test
Movment Control	Experimental (n=15)	33.32±4.14	26.95±3.52	0.004*
	Control (n=15)	31.17±5.41	32.68±3.92	0.891
	Sample t test	0.721	0.023#	-
Y balance test (cm)	Experimental (n=15)	97.3±4.6	105.4±7.2	0.006*
	Control (n=15)	99.4±6.7	99.1±3.18	0.541
	Sample t test	0.614	0.021#	-
Figure-8 hop (s)	Experimental (n=15)	11.4±1.3	10.3±1.2	0.001*
	Control (n=15)	11.1±1	11±1.4	0.276
	Sample t test	0.713	0.011#	-
Triple-crossover hop (cm)	Experimental (n=15)	452.3±66.6	479.5±73.42	0.003*
	Control (n=15)	548.2±86.15	538.3±67.9	0.438
	Sample t test	0.622	0.001#	-

Values are expressed as mean±SD. *, A significant change between the pre- and post- repetition based balance program intervention; #, a significant difference between the experimental and control groups ($P<0.05$).

Conclusion:

This study was performed to determine the effects of the repetition based balance training protocol, an active therapeutic intervention; focusing on retraining the normal balance movement of the ankle joint. This study showed that the six-weeks training had significant effects on movement control, balance and performance in the experimental group. However, the control group showed no marked difference in dependent variables compared with the experimental group.

Repetition based balance training protocol had a clinical effect on dynamic balance or functional performance as measured by the figure-8 hop test (9% improvement), the triple-crossover hop test (6% improvement), movement control (19% improvement) and the Y-Balance test (8% improvement).

Based on previous research (2), it is expected that with improvements in strength, improvements in balance and functional performance would follow. However, that was not the case in our study. We believe our findings conflict with those of previous investigators for several reasons. Earlier authors focused their testing more specifically at the ankle, including simple measures such as ankle-joint position sense and single-legged balance (1-4).

Subsequently, both their training protocols and testing focused solely on the ankle. Our training protocol were localized to the ankle, but our testing included more advanced, dynamic tasks, which required coordination of the hip, knee, and ankle.

Developed with the intentions of tracking rehabilitation and determining return-to-play criteria, functional performance testing provides an unbiased means of measuring functional ability. Most of the research on functional performance testing relates to the knee and, more specifically, to testing individuals with anterior cruciate ligament-deficient and reconstructed knees. Functional performance tests range from general lower extremity tests to unilateral hopping tests. Second, the improvement in Y-Balance scores that seen with either rehabilitation protocol conflicts with the findings of an earlier study that used a multi-component rehabilitation protocol that resulted in significant improvements in scores of Star Excursion Balance Test (12). However, it is likely that the improvements seen in that study stemmed from the balance exercises included in that protocol, rather than the strengthening exercises (2). To generate improvement in dynamic tasks, such as the triple-crossover hop and the Y-Balance tests, rehabilitation strategies may require greater emphasis on knee and hip neuromuscular control. Therefore, we suggest that a strengthening program focusing on the entire lower extremity, not just the ankle, may improve performance on these dynamic balance and functional tasks (1-4,9,10,17,18).

Some portion of our results is consistent with Hall et al (2015) results. Hall stated that a resistance-band and proprioceptive neuromuscular facilitation protocols both improves strength and pain. Whereas the reported that this programs have no improvements in the triple-crossover hop or the Y-balance tests that was inconsistent with our results (2).

Therapeutic exercise can use movement as a tool to decrease pain, to increase joint range and muscle extensibility, to enhance muscle performance and to promote wellbeing (18).

Rehabilitation will focus on re-establishing control of the site and direction of UCM including functional integration. The key to delivering effective treatment is to understand the principles behind assessment and sound clinical reasoning (6). In the subjective examination, patients define their perspective in terms of pain, disability and dysfunction (7). These factors will be further influenced by contextual factors such as fear of pain/provocation, their coping ability, their work and social requirements, their belief systems, etc. Therapeutic exercise needs to address real everyday functional limitations. However, it is important to establish a clear diagnosis of the movement faults and from this diagnosis develop an appropriate rehabilitation strategy (19). The therapist requires a sound knowledge of exercise concepts so a patient-specific retraining program can be developed (6-8).

Furthermore, this study showed that after the six-week repetition based balance training protocol, balance scores in experimental group was significantly improved. Altered postural control has been identified during static and dynamic balance tasks in patients with CAI. Additionally, decreased postural stability has been identified as a potential risk factor for sustaining an initial or recurrent ankle sprain. Evidence suggests that balance-training program of short to moderate duration over the course of at least 4 weeks can improve objective and subjective measures of function in persons with musculoskeletal injuries (eg, CAI) and uninjured control participants. Using a progressive style, 4-week balance-training programs including a combination of low-impact and dynamic activities have also improved self-assessed disability and postural control in those with CAI (1,20-24).

McKeon et al observed SEBT improvements in the posteromedial- and posterolateral-reach directions (14), whereas Schaefer et al, who used the same balance-training program, demonstrated SEBT improvements in the anterior-reach direction in those with CAI (18). A large effect size for the total SEBT reach distance has been reported after a 4-week balance-training program in healthy adults. The larger effect sizes observed in those with CAI may be due to the sensorimotor deficits and dynamic postural-control impairments that were present in the CAI sample and absent in our sample of uninjured healthy controls. Differences between the findings of the current investigation and those of Rasool and George are likely due to differences in balance-training exercises and volume of training (17). Although both programs lasted 4 weeks, Rasool and George had participants train 5 days a week for 60 minutes a day, whereas we required 3 training sessions a week, each lasting about 30 minutes.

The applied repetition based balance training protocols used in these studies included several levels of difficulty from simple to more challenging. Examples of this progress included beginning with double-limb stance on firm surfaces with eyes open continuing to less stable surfaces such as balance boards, allowing multiaxial movements of the ankle on a BOSU ball, raising the center of support height, reducing visual control by closing the eyes, and progressing to squat and single-limb stance, in that same order. Clinicians who include balance training as a rehabilitation intervention in subjects with CAI to address sensorimotor control should consider the variety of tasks that can be performed to gain improvements in postural stability. This portion of our results is consistent with Nam et al (2017) that reported after intervention Star Excursion Balance Test scores did not show a significant difference between pre- and post-exercise but only differences was in instrumentation that them used star excursion balance test (12).

Although the movement control, balance and performance impairment is common in CAI, the repetition based balanc training protocol should be identified as an effective treatment as well for improving these variables in individuals with CAI. Of course, as with any rehabilitation protocol, those decisions should be based on the specific goals and objectives being addressed.

The authors recognize there were some limitations in this study. First, we only studied the women. Second, because the data were only collected at the beginning and end of the training protocol, the long-term effects could not be determined. Finally, the sample used in this study consisted only of healthy women recreational athletes. Future studies should investigate the biomechanical effects of each repetition based balance training protocol in healthy elite woman athletes.

Despite some limitation, the findings clearly support the use of repetition based balance training program to improve movement control, balance and performance in females with CAI. Thus, future researchers should consider not only larger sample sizes but also longer- duration training programs to ensure the presence of notable adaptations in sensorimotor control that can.

We conclude that female athletes who train with a repetition based balance training program designed for injury prevention can gain simultaneous performance enhancement and significant improvements in movement control and balance. It is also likely that playing without injury enhances an athlete's productivity across his or her sports season. We suggest that off-season and preseason conditioning programs include components of repetition based balance training program plus other previous suggested trainings. It may be claimed that different program components may be combinatory and cumulative in their effects of increasing performance and improving lower-extremity biomechanics and control.

Ethical Approval:

Institutional Review Board (IRB) or Ethical Committee: Ethics approval center for study was the University that this center ethic review board previously reviewed the study protocol and then study were done. Each subject signed the informed consent and completed the health history questionnaire; we then reviewed the questionnaire for inclusion and exclusion criteria.

Competing Interests:

No conflict of interest was reported for this study.

Acknowledgments:

Gratitude is expressed to the subjects that participated in this study as well as to each of the assistants who were instrumental in the collection of the data.

References:

1. Cug M, Duncan A, Wikstrom E. Comparative Effects of Different Balance Training Progression Styles on Postural Control and Ankle Force Production: A Randomized Controlled Trial. Athl Train. 2016;51(2):101-110.

2. Hall EA, Docherty LC, Simon J, Kingma JJ, Klossner CJ. Strength-Training Protocols to Improve Deficits in Participants with Chronic Ankle Instability: A Randomized Controlled Trial. Athl Train. 2015;50(1):36–44.

3. Docherty CL, Arnold BL, Gansneder BM, Hurwitz S, Gieck J. Functional-performance deficits in volunteers with functional ankle instability. Athl Train. 2005;40(1):30-34.

4. Donovan L, Hart JM, Saliba SA, Park J, Feger MA, Herb CC, Hertel J. Rehabilitation for Chronic Ankle Instability with or without

Destabilization Devices: A Randomized Controlled Trial. Athl Train. 2016;51(3):233-251.

5. Kewwan K, Kyoungkyu J. Development of an efficient rehabilitation exercise program for functional recovery in chronic ankle instability. J Phys Ther Sci. 2016;28(5):1443-1447.
6. Mischiati RC, Comerford M, Gosford E, Swart J, Ewings S, Botha N. Intra and Inter-Rater Reliability of Screening for Movement Impairments: Movement Control Tests from The Foundation Matrix. J Sports Sci Med. 2015;14(2):427-440.
7. Ekegren CL, Miller WC, Celebrini RG, Eng JJ, Macintyre DL. Reliability and validity of observational risk screening in evaluating dynamic knee valgus. J Orthop & Sports Phys Ther. 2009;39(9):665-674.
8. Lomajoki H, Kool J, Bruin ED, Airaksinen O. Reliability of movement control tests in the lumbar spine. BMC Musculoskel Disord. 2007;8:90.
9. Smith BI, Docherty CL, Simon J, Klossner J, Schrader J. Ankle strength and force sense after a progressive, 6-week strength-training program in people with functional ankle instability. J Athl Train. 2012;47(3):282-288.
10. Kosik BK, McCann SR, Terada M, Gribble AP. Therapeutic interventions for improving self-reported function in patients with chronic ankle instability: a systematic review. Br J Sports Med. 2016.
11. Ju SB, Park DG. Effects of the application of ankle functional rehabilitation exercise on the ankle joint functional movement screen and isokinetic muscular function in patients with chronic ankle sprain. J Phys Ther Sci. 2017; 29(2):278-281.
12. Nam S, Choi B. Effect of a 4-week balance exercise with medio-lateral unstable sole on ankle joint functional ability. J Phys Ther Sci. 2017;29(7):1134-1136.
13. Dawson JS, Herrington L. Improving Single-Legged–Squat Performance: Comparing 2 Training Methods with Potential Implications for Injury Prevention. J Athl Train. 2015; 50(9): 921–929.
14. McKeon PO. Cultivating functional variability: the dynamical systems approach to rehabilitation. Athl Ther Today. 2009;14(4):1-3.
15. Plisky PJ, Gorman PP, Butler RJ, Kiesel KB, Underwood FB, Elkins B. The reliability of an instrumented device for measuring components of the Star Excursion Balance Test. N Am J Sports Phys Ther. 2009;4(2):92–99.
16. Delahunt E, Coughlan GF, Caulfield B, Nightingale EJ, Lin CW, Hiller CE. Inclusion criteria when investigating insufficiencies in chronic ankle instability. Med Sci Sports Exerc. 2010;42(11):2106-2121.
17. Rasool J, George K. The impact of single-leg dynamic balance training on dynamic stability. Phys Ther Sport. 2007;8(4):177-184.
18. Schaefer JL, Sandrey MA. Effects of a 4-week dynamic balance training program supplemented with Graston instrument-assisted soft-tissue mobilization for chronic ankle instability. J Sport Rehabil. 2012;21(4):313-326.
19. Noyes RF, Barber-Westin DS. Neuromuscular Retraining in Female Adolescent Athletes: Effect on Athletic Performance Indices and Noncontact Anterior Cruciate Ligament Injury Rates. Sports. 2015;3(2):56-76.
20. Nam S, Kim W, Yun CK. Effects of balance training by knee joint motions on muscle activity in adult men with functional ankle instability. J Phys Ther Sci. 2016;28(5):1629-1632.
21. Kim JH, Uhm YH. Effect of Ankle Stabilization Training Using Biofeedback on Balance Ability and Lower Limb Muscle Activity in Football Players with Functional Ankle Instability. J Kor Phys Ther. 2016;28(3):189-194.
22. Kim T, Kim E, Choi H. Effects of a 6-Week Neuromuscular Rehabilitation Program on Ankle Evertor Strength and Postural Stability in Elite Women Field Hockey Players with Chronic Ankle Instability. J Sport Rehabil. 2017;26(4):269-280.
23. Firoozkoohi Moghadam Z, Ebrahimi Atri A, Hashemi Javaheri S AA. Comparing the Effect of Open and Closed Kinetic Chain Exercises in Patients Suffering From Patellofemoral Pain Syndrome. Int J Basic Sci Med. 2016;1(2):53-57.
24. Ali Sholi G, Ghanbarzadeh M, Habibi A, Ranjbar R. The Effects of Combined Exercises Intensity (Aerobics-Resistance) on Plasma Cortisol and Testosterone Levels in Active Males. Int J Basic Sci Med. 2016;1(1):18-24.

تأثیر تمرین تعادلی بر کنترل حرکت، تعادل و عملکرد زنان دارای بی ثباتی مزمن مچ پا

سلیم واحدی نمین [۱] امیر لطافت‌کار [۲] ویدا فرحان [۳]

[۱] گروه تربیت بدنی و علوم ورزشی، دانشکده علوم تربیتی و روانشناسی، دانشگاه محقق اردبیلی، اردبیل، ایران.

[۲] گروه بیومکانیک و آسیب شناسی ورزشی، دانشکده تربیت بدنی و علوم ورزشی، دانشگاه خوارزمی، تهران، ایران.

[۳] دانشجوی دکتری، گروه بیومکانیک و آسیب شناسی ورزشی، دانشکده تربیت بدنی و علوم ورزشی، دانشگاه خوارزمی، تهران، ایران.

مجله پزشکی هرمزگان سال بیست و یکم شماره سوم ۹۶ صفحات ۱۹۹-۱۸۸

چکیده

مقدمه: *بی‌ثباتی مزمن مچ پا شرایطی است که با پیچ خوردگی های مکرر و تکرار بی‌حسی ناشی از بی‌ثباتی مچ پا شناخته می‌شود و منجر به محدودیت در فعالیت و شرکت در فعالیت ورزشی می‌شود. تمرینات تعادلی بر پایه خطا به عنوان یکی از انواع مدل‌های تمرینات تعادلی احتمالاً بتواند بر بهبود نقص‌های مرتبط با بی‌ثباتی مزمن مچ پا تأثیرگذار باشد. هدف این مطالعه، تعیین تأثیر شش هفته تمرینات تعادلی بر پایه خطا بر کنترل حرکت، تعادل و عملکرد زنان دارای بی ثباتی مزمن مچ پا بود.*

روش کار: *در این مطالعه، ۳۰ زن فعال دارای بی ثباتی مزمن مچ پا انتخاب شده و به صورت تصادفی به دو گروه کنترل (تعداد=۱۵ نفر) و تجربی (تعداد=۱۵ نفر) تقسیم‌بندی شدند. قبل و پس از شش هفته مداخله تمرینات تعادلی بر پایه خطا، آزمون‌های کنترل حرکت میشیاتی (۲۰۱۵) برای سنجش کنترل حرکت، آزمون تعادلی وای برای سنجش تعادل و آزمونهای ۸ و هاپینگ سه گانه متقاطع برای سنجش عملکرد آزمودنی‌ها مورد استفاده قرار گرفتند. برای تجزیه و تحلیل آماری از آزمون‌های تی مستقل و وابسته استفاده گردید. تمامی داده‌ها در نرم‌افزار SPSS 16 انجام شد. $P \leq ۰/۰۵$ برای کلیه تحلیل‌ها معنی‌دار تلقی گردید.*

نتایج: *تمرینات تعادلی بر پایه خطا باعث بهبود کنترل حرکت (P=۰/۰۰۴)، تعادل (P=۰/۰۰۶) و عملکرد آزمونهای 8 (P=۰/۰۰۱) و هاپینگ سه گانه متقاطع (P=۰/۰۰۲) شدند.*

نتیجه‌گیری: *علیرغم برخی محدودیت‌ها، یافته‌های بدست آمده به روشنی به استفاده از تمرینات تعادلی بر پایه خطا برای بهبود کنترل حرکت، تعادل و عملکرد زنان دارای بی‌ثباتی مزمن مچ پا حمایت می‌کند. بنابراین، محققان آینده باید نه تنها حجم نمونه بالا بلکه زمان طولانی این تمرینات را جهت دستیابی به تطابقات حسی حرکتی مدنظر قرار دهند.*

کلیدواژه‌ها: *مزمن، عملکرد، حرکت*

نویسنده مسئول:
دکتر سلیم واحدی نمین
پزشک و متخصص پزشکی ورزشی،
دانشکده علوم تربیتی و روانشناسی،
دانشگاه محقق اردبیلی
اردبیل - ایران
تلفن: ۰۴۵۳۱۵۰۵۶۳۵ ۹۸+
پست الکترونیکی:
vahedis@uma.ac.ir

نوع مقاله: پژوهشی

دریافت مقاله: ۹۵/۱۲/۱ اصلاح نهایی: ۹۶/۶/۲۰ پذیرش مقاله: ۹۶/۴/۱۷

ارجاع: واحدی نمین سلیم، لطافت کار امیر، فرحان ویدا. تأثیر تمرین تعادلی بر کنترل حرکت، تعادل و عملکرد زنان دارای بی ثباتی مزمن مچ پا. مجله پزشکی هرمزگان ۱۳۹۶؛۲۱(۳): ۱۹۹-۱۸۸.