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Research Article

Effects of Preoperative Training on Static and Dynamic Balance among Female Athletes with Injured ACL

Parastoo Shamseh Kohan[1]*, Heidar Sadeghi[2] and Maziar Meghdadi[3]

[1]Assistant Professor, School of Physical Education and Sport Science, Community Health Research Center, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran

[2]Full Professor, Department of Sports Biomechanics and Injuries, Faculty of Physical Education and Sports Sciences, Kharazmi University, Tehran, Iran

[3]Faculty of Physical Education and Sport Science, Community Health Research Center, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran

Abstract

Aims: The purpose of this research was to study the effects of preoperative training on static and dynamic balance among female athletes with injured ACLs.

Methods: This semi-experimental study involved a 2-group pretest-post-test design. Subjects were 36 (19 control and 17 experimental) female athletes with injured ACLs, that were chosen with the available sampling method. The experimental group did the preoperative training in the eight weeks and the control group did not participate in any training program during this period. Static and dynamic balance and lower body muscle strength were measured. The paired sample T-test was used to compare pre and post-test results and the independent sample T-test achieved comparisons between the two groups.

Results: The results indicated that static (with eyes opened and closed) dynamic balance and muscle strength were improved significantly ($p < 0.05$) in the exercise group, but no significant change ($p > 0.05$) was found in the control group. Also, significant differences were found in improvement changes results between the two groups ($p < 0.05$).

Conclusion: Results of the study confirmed that preoperative training can have a beneficial effect on improving static and dynamic balance among female athletes with injured ACLs.

More Information

***Address for correspondence:**
Parastoo Shamseh Kohan, Assistant Professor, School of Physical Education and Sport Science, Community Health Research Center, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran, Email: parastooshams@yahoo.com

https://orcid.org/0000-0002-0093-4669

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Keywords: Preoperative training; Static & dynamic balance; Injured ACL; Female athletes

Introduction

Injury to the Anterior Cruciate Ligament (ACL) constitutes one of the most serious disabling injuries in sports [1]. Anterior Cruciate Ligament (ACL) injury is a transformative and demoralizing knee injury commonly affecting athletes who participate in activities where jumping, cutting, and pivoting maneuvers are frequently used [2,3]. The substantial growth of sports participation across all ages and genders of athletes has unfortunately been accompanied by an increase in the prevalence of ACL injury [4,5]. Muscles also play a very important role in knee stabilization. They react to the amount of stress placed on them. With a decreased amount of stress (e.g. immobilization, protection, non-weight bearing), the muscles weaken and atrophy (waste away). For this reason, the exercises in this program are extremely important to help injured people recover from the initial injury and to prepare them for surgery [6]. To prevent higher ACL injuries, the conditions under which sensory information is needed have to be improved in such a way that the muscles of the effector's system are activated and balance is stimulated, one of the means adopted to promote such stimuli is physical exercise [7-9]

Also, injury prevention for the ACL can take many forms, including a variety of training protocols, athlete education, and bracing. Current studies focus on different training as a preventive measure, with programs that include strength, flexibility, plyometric, sport-specific agility drills, speed enhancement, balance, and athlete education [10-12]. With accruing ACL injuries, there is a significant loss of functional balance in injured persons [5,13]. This loss of balance is brought on by specific deterioration in the function of various neural and musculoskeletal systems [14,15], placing injured persons at higher pain reporting, injury from fractures, and loss of sports performance. Fortunately, loss of balance is reversible through exercise training. Preoperative training is one attempt to improve outcomes after ACL injury and reconstruction [6]. One preoperative training study showed that preoperative training had several important benefits such as improving the recovery after ACL reconstruction surgery, returning the range of motion to normal and decreasing the risk of postoperative stiffness, increasing muscle strength of legs and core, improving balance, and maintaining fitness in preparation for surgery [6]. The results of these studies didn't show any significant differences before and after preoperative training.

According to previous research, the rate of mechanical destruction of the joints, as well as the prevalence of ACL damage among men and women, is not the same [13]. Currently, the highest incidence of ACL is in women aged 14 to 17 years and in men aged 18 to 21 [16]. The difference in injury rates due to the gender factor in ACL injury is well documented, so in the same situation, women are 2 to 7 times more likely to be injured than men [17]. Gender differences in knee joint mechanics may seem to be one of the factors contributing to these differences [18]. The studies on the corpuscles indicate that the width of the ACL and the width of the ACL to the width of the split within the femoral condyle of the female are from men [19]. Therefore, in the present study, the effect of the training will be investigated separately among women. Overall, because of the contradictory results, this study was conducted to examine the effects of preoperative training on static and dynamic balance among female athletes with injured ACLs.

Methods

Subjects

This semi-experimental study involved a 2-group (experimental and control groups) pretest-post-test design. The sample for this study was made up of 17 to 27-year-old patients who had ACL surgery 3 months later and were chosen with the available sampling method. Fifty-one female athletes with injured ACL were volunteered to participate in the study, and just forty of them were qualified for this study. All were free of physical therapy, respiratory or cardiovascular diseases, metabolic diseases, infectious skin disorders, neurological illnesses, or severe vision or hearing impairment. The aim and methods of the study were explained to participants and after that, they completed the consent form with full awareness. The subjects were randomized into two groups: a preoperative training group (experimental group) (n = 20), and a control group (n = 20). All subjects were asked not to participate in any other training.

Procedures

The static balance, dynamic balance, and strength/endurance of the lower extremity of each subject were determined in the pretest and post-test by the test of Timed One Leg Stance Test (TOLS) with open and closed eyes, Timed Up and Go Test (TUG), and Senior's Chair Stand Test (SCS) were evaluated on the same terms. All tests and subjects were measured by only one examiner and a stopwatch (Model-CR2032. Q & Q, 5 Bar Resist Made In China-Bat).

TOLS test: One-leg stance was tested on the preferred leg indicated by each subject. This leg was used for weight-bearing while the subject kicked an imagined ball. The subject was asked to stand on the preferred leg while resting the hands at waist level, then to raise the other leg approximately 4 inches above ground for 60 seconds [20], first with eyes open and then with eyes closed on separate trials. The number of seconds the subject was able to maintain balance without moving the support leg, touching the ground with an elevated leg, removing hands from the waist, moving the weight-bearing feet to maintain the balance, grabbing the investigator for support, or opening his eyes during the eyes closed trials were recorded by a stopwatch. Two trials were given for each visual condition, and the average score was calculated and recorded [21,22].

TUG test: The purpose of the 8-foot Up-and-Go test assessment is to measure physical mobility involving speed, agility, and dynamic balance. The test began with the participant fully seated in the chair, arms crossed over the chest, and feet flat on the floor. On the signal "go", the participant was instructed to stand up from the chair as quickly as possible, walk around a cone placed 8 feet in front of the chair, and return to a seated position in the chair. The participant was told that the test was timed and that the object was to walk around the cone as fast as possible (without running) and return to a seated position. A timed score was recorded to the nearest 0.1 s from the time the signal "go" was given until the participant was allowed to walk through the test for practice. The participant's score was recorded as the better of the two most consistent times measured [23].

SCS test: The purpose of the 30-Second Chair Stand Test is to measure lower body strength without large and expensive equipment. The test began with the participant seated in the middle of a chair, back straight, and feet approximately shoulder-width apart and flat on the floor. The arms were crossed and held against the chest. At the signal "go", the participant raised to a full standing position (body erect and straight) and then returned to the initial seated position [24]. The participant was encouraged to complete as many full stands as possible within a 30-s time limit. Participants were given two or three practice repetitions. The score is the total number of stands executed correctly within 30s [23].

After the Pre-test, the protocol was performed by the preoperative training group for 8 weeks and the control group preserved the normal activities and did not participate in training. During the training program, 3 subjects from the experimental group were excluded from participating in the exercises because of personal problems (two subjects in the second week of the program), and disease (one subject in the third week of the program). Finally, the number of subjects in this group was reduced from 20 to 17. Also, one subject from the control group was traveling and did not participate in the post-test and the number of subjects in this group was reduced from 20 to 19.

Intervention

The experimental group did the preoperative training program in 8 weeks. All subjects completed 3 sessions each week and 24 sessions of training overall. The 60 to 70 minutes program, with the positions and activities that were carried out, is described below:

Phase I – warming up (10-15 minutes)

Walking: gait with progressive speed, up to 5 minutes - 7 minutes.

Stretching (the stretching positions were sustained for 10 seconds):

The spinal muscles, the anterior, posterior, medial, and lateral muscles of the thigh, and the dorsi- and plantar flexors muscles of the ankle.

Phase II – cardio exercises (20-30 minutes)

All low-impact, straight-line activities, e.g. elliptical trainer or biking

Phase III – strength exercises (10-15 minutes)

Exercise 1: Quadriceps Contraction - In sitting with the knee straight and the leg supported, tighten the thigh muscle to hold the knee straight. Avoid lifting the leg from the hip. Perform 5 -10 times holding each contraction for 5 secs. Progress to 30 times holding each contraction for 10 seconds, resting for 5 seconds in between reps.

Exercise 2: Straight Leg Raises - In the bridge position, tighten the thigh muscle while keeping the knee straight and lift the leg 3 cm - 5 cm. Perform exercise 5 times - 10 times holding each contraction for 5 secs. Progress to 30 times holding each contraction for 5 secs - 10 secs.

Exercise 3: Hip Adduction - In lying with knees bent, squeeze a soft ball or a pillow between knees. Perform exercise 5 times - 10 times holding each contraction for 5 seconds. Progress to 30 times holding each contraction for 10 secs - 15 secs, resting for 5 secs between reps.

Exercise 4: Calf Raises - Both legs: Start with feet shoulder-width apart and toes pointed straight ahead, and raise onto toes. Start with one set of 10, holding each raise for 5 seconds. Increase the number of reps up to 30 with 5 sec hold. Start by using support at a wall or table and progress to no support as able.

Single leg: Start on one leg with toes pointed straight ahead, and raise onto toes. Start with one set of 10, holding each raise for 5 seconds. Increase the number of reps up to 30 with 5 sec hold. Start by using support at a wall or table and progress to no support as able.

Exercise 5: Gluteals - In lying with knees bent and arms sides, squeeze buttocks and lift to create a bridge. Keep equal weight on each leg and straight alignment from shoulders to knees. Be careful not to push down on the neck or shoulders - use the buttocks to do the work. Start with one set of 10, holding each lift for 5 seconds. Increase the number of reps as strength increases. Once can complete 20 reps holding for 10 sec each, change to single-leg bridges.

Exercise 6: Hamstrings - In sitting place a resistance band around the ankle and also have it attached to a chair or table leg in the form of subject. Bend the knee backward slowly against the resistance of the band using the muscles under the thigh. Start with 1 set of 10 reps and increase to 3 sets of 15 reps.

Exercise 7: Squats (Quadriceps) - Slowly squat with equal weight on each leg. Bend knees from 0' to a maximum of 90' of flexion, making sure knees do not move beyond toes. Start with one set of 10, holding each squat for 5 secs, and increase the number of reps as strength increases, up to 30 reps x 15 secs hold. EMS can be used with this exercise with the 'contraction' time at least double the 'rest' time.

Exercise 8: Single leg squats - Standing on one leg, slowly squat bending the knee from 0' to a maximum of 90', making sure the knee does not move beyond the toes. Start with one set of 10, holding each squat for 5 secs, and increase the number of reps as strength increases, up to 30 reps x 15 secs hold.

Phase IV - balance and proprioception exercises (10-15 minutes)

Exercise 1: Single leg stance (eyes open, eyes closed)

Exercise 2: Double leg squats on an unstable surface (thick carpet, foam block, camping mattress).

Exercise 3: Single leg stance on an unstable surface (thick carpet, foam block, camping mattress).

Exercise 4: Single leg squats on the trampoline - Standing on one leg, slowly squat bending the knee from 0' to a maximum of 90', making sure the knee does not move beyond the toes. Start with one set of 10, holding each squat for 5 secs, and increase the number of reps as strength increases, up to 30 reps x 15 secs hold.

Exercise 5: Squats on a BOSU - Slowly squat with equal weight on each leg. Bend knees from 0' to a maximum of 90' of flexion, making sure knees do not move beyond toes. Start with one set of 10, holding each squat for 5 secs, and increase the number of reps as strength increases, up to 30 reps x 15 secs hold.

Exercise 6: Lunges on a BOSU - Step forward/back and lunge as shown. Control the descent ensuring the knee that is forward does not move beyond the toes. Start with 1 set of 10, holding each lunge for 5 secs. Increase the number of reps as strength increases up to 3 sets of 10.

Phase V - cooling down (5 minutes)

Walking- Gait with regressive speed, for up to five minutes.

Statistical analysis

The SPSS 19.00 software (SPSS Inc., Chicago, IL, USA) was used to analyze the data. The Shapiro-Wilk test was applied to investigate whether the data was normally distributed. Control and intervention groups were tested for equivalence at baseline using unpaired t-tests. Independent sample t-tests were used to compare the change scores for control and intervention groups. In the analyses, the significance level was set at 0.05.

Results

The demographic information for each group is presented in Table 1.

The results showed the similarity in both groups. The results of the unpaired and independent sample t-test are shown in Table 2.

The results of the unpaired t-test showed that there was a statistically significant difference between the pre-test and post-test of the experimental group in the prehabilitation test (p = 0.00), static balance test with open eyes (p = 0.02), and closed eyes (p = 0.00), and dynamic balance (p = 0.00); and there was no statistically significant difference ($p > 0.05$) between pre-test and post-test of the control group. Also, the results of the independent sample t-test indicated that in all evaluated tests, there was no significant difference ($p \geq 0.05$) between the pre-test results of the two groups. While there was a significant difference between the post-test results of the two groups in the SCS test (p = 0.04) and static balance with close eyes test (p = 0.02). There was no significant difference ($p \geq 0.05$) between the post-test results of the two groups in the static balance with open eyes test and dynamic balance test. According to a significant difference between the pre-test and post-test of the experimental group in the dynamic balance test and static balance with open eyes; and also the difference in the results of these two tests in the pretest (not significantly) which can affect the post-test results; therefore, to clear the actual results of these tests and the other assessment tests, the progress in each subject was calculated by subtracting the pre-test and post-test scores. Then, the independent sample t-tests were done to examine the differences between groups and the results indicate significant differences between the progress results of the two groups (Table 2).

Table 1: Demographic information of exercise and control groups.

Variable	Group	Mean	Standard deviation
Age (year)	control	21.33	1.66
	exercise	23.86	3.34
Height (meter)	control	1.69	0.05
	exercise	1.68	0.04
Weight (kilogram)	control	55.26	6.41
	exercise	52.77	3.23

Discussion

Balance is a complex phenomenon, requiring the integration of sensory, musculoskeletal, and nervous systems [9,15]. Preoperative training challenges these systems while focusing on the principles of control, centering, precision, and concentration among athletes with injured ACLs. The results of our study demonstrated that female athletes with injured ACLs who participated in preoperative training had significant improvement in balance. We suspect that the subjects in our study who participated in eight weeks improved their lower extremity strength and balance and became more kinesthetically aware of how to recover from the initial injury and to prepare them for better surgery.

Table 2: Comparison of pre-test and post-test results of exercise and control groups.

Test		Variables				
		Mean (standard deviation)		A significant difference in the Independent sample t-test	Significant difference of unpaired t-test	
		Control (n = 19)	Exercise (n = 17)	Control and Experimental	Control	Exercise
Chair Stand Test (number)	Pre-test	14.11 (3.37)	14.00 (3.05)	0.95	0.72	0.00*
	Post-test	13.33 (2.87)	17.86 (3.44)	0.04*		
	Progress	0.22 (1.79)	3.86 (1.57)	0.00*	_	_
Static Balance Test with Open-eyes (second)	Pre-test	42.04 (12.86)	35.13 (19.44)	0.41	0.94	0.02*
	Post-test	42.22 (14.88)	47.98 (11.72)	0.41		
	Progress	0.18 (7.08)	12.86 (11.29)	0.01*	_	_
Static Balance Test with Close-eyes (second)	Pre-test	3.99 (1.44)	2.96 (1.05)	0.13	0.50	0.00*
	Post-test	4.26 (1.72)	6.40 (1.50)	0.02*		
	Progress	0.27 (1.14)	3.43 (0.88)	0.00*	_	_
Dynamic Balance Test (second)	Pre-test	6.97 (0.21)	7.15 (0.24)	0.15	0.69	0.00*
	Post-test	6.95 (0.34)	6.72 (0.14)	0.11		
	Progress	- 0.03 (0.19)	- 0.43 (0.15)	0.00*	_	_

*Statistical significance at $p < 0.05$.

The purpose of this research was to examine the effects of preoperative training on static and dynamic balance among female athletes with injured ACLs. The findings are similar to Grande, et al. (2016) and Yadegaripour, et al. (2013) stated that strength exercises cause a significant increase in static and dynamic balance [25,26]. A possible reason for the increase in balance in the experimental group could be increasing in muscle strength in the lower extremities after the exercise program, facilitating fast twitch motor units, increased muscle coordination [9,11], the process of decreasing disinhibiting and stimulating of muscles' spindles during strength training. In these conditions, muscle contraction stimulates the activity of Gamma efferent in muscles' spindles. Sensitivity enhancement of muscles' spindles may improve joint position sense which has an important role in postural control [12]. Few articles evaluated the static and dynamic balance after ACL reconstruction. One study showed that the athletes had a similar clinical performance in SEBT in both limbs and a reduction in anterior reach distance in the reconstructed limb compared with preinjury score after ACL reconstruction [27]. Moreover, Clagg, et al. (2015) revealed that anterior reach in modified SEBT was reduced in both involved and uninvolved limbs following ACL reconstruction [28].

As a treatment modality, preoperative training has the capability of improving the static and dynamic balance stability in subjects with injured ACLs. These results encourage implementation in the overall prehabilitation program for chronic ACL injury [18,29]. Muscles play a very important role in knee stabilization. Adding specific physical training to sports practice should be the most effective program to prevent ACL tears while improving performance in young female players [29]. They react to the amount of stress placed on them. With a decreased amount of stress (e.g. immobilization, protection, non-weight bearing), the muscles weaken and atrophy (waste away). For this reason, the exercises in this program are extremely important to help injured female athletes recover from the initial injury and to prepare them for surgery.

Conclusion

The purpose of this research was to study the effects of preoperative training on static and dynamic balance among female athletes with injured ACLs. Subjects were 36 (19 control and 17 experimental) female athletes with injured ACLs, that were chosen with the available sampling method. The experimental group did the preoperative training program for the eight weeks and the control group did not participate in any training program during this period. Static and dynamic balance and lower body muscle strength were measured. The results of the study confirmed that eight weeks of preoperative training can have a beneficial effect on improving static and dynamic balance among female athletes with injured ACLs. Thus, the preoperative training has the capability of improving the static and dynamic balance stability in subjects with injured ACLs. These results encourage implementation in the overall preoperative training for chronic ACL injury. The exercises in this program are extremely important to help injured female athletes recover from the initial injury and to prepare them for surgery.

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