

Effect of Motor Learning Strategies Exercises on Peak Hip Abduction Moment, Peak Knee Valgus Angle and Performance in Active Participants

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Submitted: 2017-09-21; Accepted: 2017-11-28

Abstract

Introduction: Previous studies indicated that anterior cruciate ligament damage prevention programs have been successful in the short term. Motor learning strategies with an internal focus (IF) to body movements have traditionally been utilized, but may be less suitable than an external focus (EF) for the acquisition and control of complex motor skills required for sports. The purpose of the current study was to investigate the effect of feedback training on kinetic, kinematic, and functional factors of active subjects. **Materials and Methods:** A total of 24 men (age 24.83 ± 2.77 years, height 176.79 ± 4.05 cm, and mass 72.20 ± 9.30 kg) were randomly assigned to feedback and control groups. Participants completed feedback training for 8 weeks. Peak knee valgus angle was measured using 3D motion analysis during landing and peak hip abduction moment measured using isokinetic set as well as functional movement was measured by triple hop cross test. For data analysis repeated measure analysis of variance, independent-sample, and paired t tests were used. **Results:** Our findings revealed that feedback training caused significant differences in peak hip abduction moment ($P=0.004$) and triple hop cross test ($p=0.005$). However, there was no effect on peak knee valgus ($P=0.117$). **Discussion:** Our study confirms large effect size of feedback training on peak hip abduction moment and functional movement of participants. Therefore, it is recommended to use the feedback training by coaches and athletes to prevent the anterior cruciate ligament damage and increase athletic functional performance.

Key words: Anterior Cruciate Ligament, Damage Prevention, Feedback, Focus of Attention, Kinematic

Please cite this paper as: Abbaszadeh Ganati H, Letafatkar A, Abbasi A. Effect of Motor Learning Strategies Exercises on Peak Hip Abduction Moment, Peak Knee Valgus Angle and Performance in Active Participants. J Clin Physio Res. 2018; 3(1): 21-28.

Introduction

Knee joint is one of the largest joints in the body. The ligaments in the joints are damaged in various sport activities frequently. The most common knee ligament damage is anterior cruciate ligament rupture (ACL) which is more common in young athletes aged 15-25 years (1). Its mechanism is about 70% non-contact and 30% contact (2). ACL defect and damage have a strong impact on static and dynamic knee stability and the lower extremity of the person. This defect provides effective sensory feedback in the damaged knee, which can reduce performance, balance, and cause damage to the knee joint (3). Non-collision damage of ACL usually occurs during acceleration, jump-landing, or when rotate and prepare for jump maneuvers (4). This damage, in addition to the high annual cost of treatment, leads to non-participation in sports and even losing the whole sports season, mental and

psychological problems, and causes secondary damages such as osteoarthritis, meniscus tear (10 times increase) (4). Kinematic analysis of subjects at non-contact ACL injury risk show that there are specific movement patterns and particular position in subject joints at injury risk, these movement patterns effects on loading and applied strain of ligaments. (5). In fact, the common motor pattern during ACL damage includes reduced angles of flexion of the knee, thigh, and trunk along with an increase in knee valgus and the inner spin of tibia internal rotation (5). Palmer *et al.* (6) investigated the effect of a five-week program of strengthening the thigh abductor in an isolated way and the effect of functional motion control program on the kinematics of the knee and the strength of the thigh muscles in two squat and landing exercises. In this study, 29 volunteers participated who had no symptoms of enlargement in knee valgus and the inner thighs spin. This study showed that there was no significant difference in knee valgus

dynamics and the inner thighs spin following interventions for the isolated strengthening of thigh abductor and functional control. The difference between the groups in terms of knee angles was not significant (6). Myer *et al.* (7) investigated the effect of plyometric exercises, balance exercises, and sustainability stability on lower limb biomechanics during the landing to show that both groups witnessed a decrease in the angle of the knee valgus when landed. Ford *et al.* examined the effect of the neuroscientific practicing interventions on dynamic valgus of the lower body. Their findings demonstrated that these types of exercises could probably correct dynamic valgus of the lower extremity during landing and prevent damage to the anterior cruciate ligament. Ericksen *et al.* (9) in a study investigated the effects of instantaneous feedback on the kinematics of jump-landing. For this purpose, 36 healthy women were divided into 3 groups of combination (timely feedback and subsequent feedback), the subsequent feedback group, and control group. They did not observe any change in knee valgus angle among the groups. (9) Herman *et al.* investigated the effect of feedback exercises alone and in combination with strength training on the lower extremity biomechanics in a jumping task. Fifty-eight female athletes divided into two groups of combined exercises (power and feedback) and feedback exercises. In this study, video feedback strategies were applied. Results showed that valgus angle of the knee in the combined exercises group increased, but no change was observed in the feedback exercises group. (10). Therefore, the feedback exercises should be applied in different verbal, visual, and auditory ways to obtain more accurate results. Instructors use feedback educational instructions while teaching skills to improve motor function and strengthen it and also to optimize performance at all levels of skill. One of the important roles of educational instruction is to direct individual's focus of attention. This direction may be internal or external as internal attention instructions attract individual's attention to body movements and external attention instructions attract the focus of the individual to the outcome of their movements; for example, to imagine sitting on a chair when landing (11). According to reports, ACL damage prevention programs in the past effectively decreased the risk of ACL damage in short term, but one of the causes of their weakness can be difficulty in maintaining and transferring learned motor skills such as the precise direction of the thighs, knees, and ankles in the correct positions of landing (11). Despite these programs, the incidence of ACL damage is still high; therefore, improving the prevention strategies is essential. Potential limitations of current workouts of ACL damage prevention can be defective transmissions of consciousness, repeating optimal motor strategies during training sessions for automatic movements required for sports activities, and unpredictable events in the disciplines. Educational strategies

with an internal focus on attention have traditionally been used, but they are not optimal in acquiring the control of the complex motor skills required for sports. Conversely, educational strategies for external attention can enhance the acquisition of skills more effectively and promote the transfer of improved motor skills for sports activities (11).

In the last two decades, many studies have been conducted on the impact of exercise interventions on prevention of knee ligament damage. These studies often investigated the effects of these programs on reducing the amount of ACL damage and improvement of kinematic and kinetic factors of the knee. There are many disagreements regarding severity, time, number of repetitions, and other components of these training programs. Proper landing position during training, obvious instructions and feedback techniques, skill retention and improvement, transfer to sport feature are skills that needs to be added in ACL injury prevention programs. Therefore, the purpose of this study is to investigate the effect of feedback exercises on selected kinetic and kinematic variables and motor activity of active individuals.

Materials and Methods

Given the intervention, the presence of control group, and targeted selection of subjects, the methodology of the study was semi-experimental to conduct this study, individuals selected as subjects who performed a regular physical activity (basketball, volleyball, and handball) at least one-fifth hour a week. For this purpose, subjects were asked to attend at specified hours to the lab if they would like to do initial checkups. It was also explained to them that they can quit the study at any time of the research process if they are reluctant to continue cooperation. Data collection form was used to select subjects. This form contained information related to personal characteristics (height, weight, age, athletics and history of the game), history of damage (damage mechanism and area involved in damage), and the amount of physical activity per week. According to the inclusion criteria and Beck Inventory Scores, information in the form was used to select subjects. The statistical sample of this study comprised of 24 healthy men (having at least 3 one-fifth hour sessions of regular physical activity per week) with an average age of 24.83 ± 2.77 years, weight of 72.20 ± 9.30 kg, and the height of 176.79 ± 4.05 cm. Samples were selected purposefully and they were randomly divided into experimental and control groups. Then the subjects were investigated for evaluation of variables under study and after completing pretest measurements, experimental group performed 8 weeks of feedback exercises and eventually posttest was given 48 hours after the last training session like the pretest and the information was analyzed.



Figure 1. Feedback exercise

Isokinetic evaluation

To evaluate the maximum thigh abduction torque, isokinetic device model *biodex3* was used. Before the test started, all subjects following a 5-minutes of sub maximal warm-up and performed extension gestures. To be familiar with the device, subjects performed 4 to 5 repetitions below the maximum range of sub-maximal effort. The maximum torque of subjects' thigh abduction in standing position was evaluated and their dominant leg was attached to Dynamometer Resistance Lever with a sticking strap above the knee. The durable handle was used to ensure the stability of the subjects. The range of motion of the throat abduction test was from 10 degrees to 30 degrees of thigh abduction and an angular velocity of 60 degrees per second. Subjects were asked to impose force against the lever with maximum power and the maximum torque of the thigh abduction was calculated considering the (relative) weight of the subjects (12).

Evaluation with the motion analyzer

To evaluate the maximum angle of the valgus of the knee of the subjects, 6 Camera Motion Analysis System, Raptor-4 Digital Real Time System (rapture 4-digital real time system, California, USA) was used and had a precision of 0.5 mm of transitional movement and 0.5 degrees of torque in a 4×4 meter volume. Using Cortex (2.5.0.1160) software, kinematic information of subjects were registered in the system. For marking Plug-In-Gait method (13) was employed and 9 mm stickers were used for connecting anatomical markers to the dominant leg. The frequency of the

camera of motion analysis system was set to 250 Hz. Subjects performed landing task with a marked leg on the box with a height of 30 cm on the force screen in a way that they should maintain their balance for 10 seconds (14).

Lee's single-leg triple crossover hop functional test

Before testing, subjects warmed up for five minutes below the maximum level and performed extension exercises. First, they took this test three times for familiarization and after resting a while, they performed Lee's single-leg triple crossover hop test on a tape of fifteen centimeters width and six meters length. After three successive jumps, the maximum jump value was measured with a tape measure and recorded as the score of the subjects (15).

Feedback exercise protocol

Feedback exercises include eight types of exercises: two-leg squat, single-leg squat, walking in Lunge, two-leg landing jump, single-leg standing on the unstable surface, PO box cutting maneuver, long distance single leg lee, and countermovement jump. Verbal and visual feedback instructions were given by using external focus of attention strategies during exercises. Experimental group performed feedback exercises (11) for eight weeks and three times a week every other day. Duration of training per session was about 45 minutes. Usually, each exercise was performed in two to three sets and each set was done for 30 seconds to 1 minute. First and second week included the following exercises: two-leg squat, single-leg squat, and walking in Lunge. Third to fifth week

included the following exercises: single-leg squat, two-feet landing, single-leg standing on the unstable surface, and Pobox cutting maneuver. Exercises in week sixth to eighth included the following: single-leg standing on the unstable surface, sidestep cutting maneuver, long distance single-leg Lee jump, Single-leg hop for distance and countermovement jump.

Kinematic data were low-pass filtered at 15 Hz cutoff frequency with a fourth-order Butterworth filter. Data of three successful landing recorded and saved for each subjects. After analyzing data using MATLAB software (Matlab R2013b) for every 3 attempts of each subject, mean of knee valgus angle on the frontal screen calculated and considered as the subject's score. In the analysis of the isokinetic device data, the maximum torque of the subject's thigh abduction was calculated, taking into account the (relative) weight of each subject.

Eventually, after collecting data, subjects' characteristics such as age, height, and weight, research variables in two sections of descriptive and inferential statistics were analyzed using the SPSS version 18. The Kolmogorov-Smirnov statistical test and the Leven test were used to verify the naturalness of data and the homogeneity of the variance of the groups, respectively. In addition, using the covariance analysis, the effect of independent variable on the dependent variables of the research was studied. A significance level of study was considered to be at 95% with an alpha smaller than or equal to 0.05.

Results

Descriptive characteristics (mean and standard deviation) of the variables of research are reported in Table 1, separately in pre-test and post-test.

Results obtained from the Leven test in Table 4 shows that presumption of the homogeneity of the variance of the subjects' scores in all of the research variables in pretest is supported ($P > 0.05$).

To determine whether the intervention has a significant effect on dependent variables, the effect of independent variable is feedback exercises on dependent variables (peak hip abduction moment, peak valgus angle, and triple hop cross test) was investigated using covariance analysis test.

As can be seen in Table 5, eight weeks of feedback exercises had a significant effect on the maximal torque of thigh abduction ($P = 0.004$) and the record of Lee's single-leg triple crossover hop ($P = 0.005$), but it had no significant effect on the knee valgus angle ($P = 0.117$) of active people at risk of damage to the anterior cruciate ligament. Moreover, the largest effect size observed was related to the maximum torque of thigh abduction indicating that the exercises used for this variable are most effective.

Discussion

The goal of this study was to investigate the effect of eight weeks of feedback exercises on the maximum torque of thigh abduction, maximum knee valgus angle, and the motor activity of active people. The results showed that the feedback exercises had a significant effect on the maximum torque of thigh abduction ($P = 0.004$) and motor function ($P = 0.005$) of active people, but it did not show any discernible effect on the knee valgus angle ($P = 0.117$).

The results of this study are consistent with previous findings of Herman *et al.* (10), Ericksen *et al.* (9), Palmer *et al.* (6), Baldon *et al.* (16), but not with the results of Myer *et al.* (7) and Ford *et al.* (8). To explain the inconsistency, we can mention a number of factors such as the difference between training variables, number of subjects, and design of training protocols. Palmer *et al.* (6) showed that there was no significant difference in knee valgus dynamics and the thigh's inner spin following the interventions for the isolated strengthening of thigh abductor and functional control. They also showed that there was no significant difference between the groups in terms of knee angles. Despite that the real reduction in the size of the knee valgus is 10 degrees in functional exercises and 5 degrees in the isolated strengthening of thigh abductor exercise, and a significant improvement in thigh abduction power was observed in the functional motor control group and also in the strengthening training group. The results of their study are in line with the current study in terms of thigh abduction-power variable, but inconsistent in terms of knee valgus angle. The reason for the inconsistency can be due to the type of exercise protocol, duration of the training period, and a different method for measuring knee valgus. Exercise interventions focused on the thigh joint of healthy athletes were used for knee damage prevention strategies (6). Although the application of intervention programs focused on thigh joint is varied, these programs improve the power of extension, abduction, and external rotation of the hip. Ericsson *et al.* (9), in their study, stated that after providing instant feedback, there was no change in the knee valgus angle of the subjects. Also, the results of this study are not in line with the study of Ford *et al.* (8) and Myer *et al.* (7). The reason for this inconsistency might be the type of exercise protocol, gender, and the number of subjects.

In this study, an increase in the torque of the aqueous abductors was observed by running the feedback exercise program for eight weeks, which could be effective in preventing ACL damage. More thigh power probably can prevent non-complicated ACL damage. A study by Baldon *et al.* (17) showed that increased thigh strength improved the kinematics of the lower extremity and is thought to be associated with damage to

Table 1. Feedback exercises schedule

Exercise	Two-leg squat	Performing lunge motion	Single-leg squat	Two-leg jump landing	Single-leg standing on unstable surface	Pobox cutting maneuver	Lee's single-leg Long distance	Countermovement jump
Repetition	Set/time	Set/time	Set/time	Set/time	Set/time	Set/time	Set/time	Set/time
First week	2 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds	1 set/each set 30 to 60 seconds					
Second week	3 sets/each set 30 to 60 seconds	3 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds					
Third week			2 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds	1 set/each set 30 to 60 seconds	1 sets/each set 30 to 60 seconds		
Fourth week			3 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds		
Fifth week			3 sets/each set 30 to 60 seconds	3 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds		
Sixth week					3 sets/each set 30 to 60 seconds	3 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds
Seventh week					3 sets/each set 30 to 60 seconds	3 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds	2 sets/each set 30 to 60 seconds
Eighth week					3 sets/each set 30 to 60 seconds	3 sets/each set 30 to 60 seconds	3 sets/each set 30 to 60 seconds	3 sets/each set 30 to 60 seconds

Table 3. Results obtained in pre-test and post-test regarding maximum torque power of thigh abduction, maximum angle of the knee valgus, and Lee's single-leg triple crossover hop (mean (SD))

Variable	Experimental group		Control group	
	Pre-test	Post-test	Pre-test	Post-test
Maximum torque of thigh abduction (Newton/meter)	236 (44.45)	264 (45.17)	231 (58.91)	245(45.78)
Maximum knee valgus angle (degree)	-6.46 (1.49)	-6.46 (1.62)	-6.7 (1.9)	-6.9 (2.13)
Lee's Single-leg triple crossover hop (meter)	5.05 (0.47)	5.13 (0.49)	4.94 (0.47)	4.93 (0.47)

Table 4. Leven test results in order to study the equality of variance of the groups in the research variables

Variable	Leven statistic	Degree of freedom	Level of significance
Maximum torque of thigh abduction	4.876	1.22	0.140
Maximum knee valgus angle	2.991		0.098
Lee's Single-leg triple crossover hop	5.795		0.125

Table 5. Analysis of one-way covariance to investigate the effectiveness of the exercises on the research variables

Variable	Resource of change	Degree of freedom	F	Level of significance	Size effect
Maximum torque of thigh abduction	Pre-test	1	31.315	0.001	0.926
	Group		5.168	*0.004	0.197
Maximum knee valgus angle	Pre-test		153.763	0.001	0.882
	Group		3.679	0.117	0.217
Lee's Single-leg triple crossover hop	Pre-test		1362	0.001	0.985
	Group		10.127	*0.005	0.925

the knee joints. Findings also show that screening method to assess the risk of ACL damage should include assessing the power of external rotation and abduction of the thigh (18). In addition, impaired thigh strength is only one of the several factors which physicians need to assess when evaluating risk factors for non-ACL damage. Khayyambashi *et al.* (18) investigated the predictive effect of thigh strength on non-contact ACL damage on women and men athletes. Before the season, they measured the isometric power of external rotation and abduction of the thigh using a manual dynamometer of 501 competitive contestants participating in different disciplines. During the season, ACL damage status was recorded and injured athletes were categorized based on damage mechanism (contact and non-contact). They mentioned that measuring pre-season isometric abduction power and the outer spin of the thigh could independently anticipate the likelihood of ACL damage in the future. They also reported that screening method for evaluating the risk of ACL damage should include an assessment of the abduction power and the outer spin of the thigh. Therefore, the improvement achieved in the desired variables in the present study can be considered an appropriate preventive approach.

Thigh abductors help control the alignment of the organs and maintain the pelvic stability while standing on a single leg. The weakness of the thigh abductor muscles can lead to compensation direction for knee valgus dynamics, which can subsequently exert increased pressure on the ACL ligament in a way that knee valgus movement is increased after ineffectiveness in thigh abductors (19). The results of this study showed that despite the increased abduction power of the thigh, no significant change was observed in the knee valgus angle. As in a study with isolated hip exercises resulted in non-significant change in knee kinematics (6).

Long-term results of ACL damage prevention programs can potentially improve, when external attention instructions are used alone or with the combination of internal attention (11). By exerting external attention, acquisition of skills is effectively enhanced and it causes the potential for transferring skills to exercise and sophisticated skills. Consistency with the external focus of attention can enhance the control of automatic movements and improve performance (20). According to the performance restriction hypothesis, focus on the effect of movements (external focus), improves unauthorized use or automation, while focusing on self-movement (internal focus) leads to conscious control, which limits the motor system and disrupts automated control processes such as focusing athlete's attention on the movements of his/her body (21). For example, encouraging athletes to improve awareness and knee control during standing, cutting maneuver, jumping, landing (internal focus) may not be optimal for quick acquisition and complex motor skills. Often an emphasis has been placed on the

correct direction of thigh, knee, and ankle during landing as the ACL damage prevention program, which in fact can have a detrimental effect on performance and learning, and can disrupt the implementation of automatic skills, especially when compared with the external focus of attention (22).

An external focus of attention can boost and maintain the movement economy and even improve performance (5). According to research findings, movement learning with an external focus of attention is very flexible in psychological conditions (23) and physiological fatigue (24). Fatigue, as a factor affecting ACL damage (25) reduces body movement control, and for this purpose teaching appropriate landing techniques through external focusing methods, fatigue and stress are less evident and the performance of individuals increases.

Olsson *et al.* reported increased jump record after six weeks of cognitive training (mental imaging) (26). This shows that imaging probably improves the essential components of a sophisticated motor skill and reduces the risk factors for ACL damage. The mental imaging means asking people to close their eyes, focus on the Earth, and imagine the proper landing task (positive feedback) that can increase the angle of flexion of the knee and reduce the knee valgus angle (27).

In the present study, performing rehearsal exercises by guiding the focus of attention to external attention increased the motor performance of the subjects. Therefore, when the instruction manual invoked the performer's attention to the involved organ in the movement, automated control processes facilitates and it leads to better self-organization of different devices. As a result, the individual's need to be engaged in more important neurological centers to control limbs is decreased and due to this, person's performance improves. In the other words, in the external attention, attention needs are reduced, while in internal attention processing processes are more involved and the attention needs an increase (11). Wolf *et al.* (28) witnessed increased jump height and decreased muscle electromyography activity by employing an external attention focus. The results showed that neuromuscular coordination improves with an external focus of attention; in a way that the external focus of attention facilitates the production of adequate and effective motor patterns. As evidence suggests, the external focus of attention has a positive effect on performance and learning strategies for different motor skills such as vertical jump (28) and long jump (29, 30).

Balance plays very important role in the ACL damage prevention program. Recent evidence suggests that the control of the center of the pressure is improved with an external focus of attention (31). In the present study, one of the equilibrium exercises was keeping a bar horizontally while keeping the balance on the unstable surface. In this research, performing exercises such as Lee's single-leg long distance

jump and countermovement jump enhanced the performance of the subjects in Lee's single-leg triple crossover hop. As reported by recent plyometric studies, the external focus of attention leads to an increase in jump height, more power generation, and shifting the center of gravity (more knee flexion), compared to the internal focus of attention (29). Common element in external focus of attention instructions was focusing on an outer object (hanging balls) to guide the attention away from the body.

Generally, single-leg squat, two-leg squat, Lunge, two-leg landing, standing on the unstable surface, and Sidestep cutting maneuver exercises are performed with the aim of modifying the pattern of movements and reducing knee valgus with the external focus of attention. Single-leg hop for distance exercise was performed with the aim to increase jump distance, reduce knee valgus, and increase thigh and knee flexion. Countermovement jump was also performed with the aim of increasing performance following maximum jump and reaching the hanging ball (11).

In this study, an introduction to the field of motor movement learning was presented which had the potential to improve the performance of motor skills and the possibility of facilitating preventive effects. Exercises provided in the form of feedback exercises attempted to reduce risk factors of damage associated with ACL ligaments by focusing on refining the technique. Fitts and Posner proposed three stages of learning: cognitive, communication, and automation. Cognitive phase refers to the informed endeavor of the subject to perform the skill, which needs considerable attention. Communication phase refers to the time that the person begins to acquire basic motor patterns and more attention is paid to other aspects of implementation while performing the skill. After extensive training, the practitioner achieves automatic mode which is characterized by smooth movements and apparently without effort. The movements are precise, very stable, and are effectively produced. At this stage (automation), the skill is performed more automatically and performing movement requires little or no attention (32). Research on motor learning set the guidelines that external focus on attention has beneficial effects in a way that first, it accelerates the learning process or shortens the first step of learning, which is done by facilitating the automatic movement. Secondly, the external focus of attention produces effective and efficient movement patterns (33).

Exercises used in this research were based on two key components of ACL damage prevention of balanced and plyometrics exercises (11). New feedback exercises show that the focus of attention could change from the internal to the external with a simple change in the instructions. Educational instructions with an external focus of attention do not require any special equipment and it can be utilized for several athletes at the same time. Training with simple instructions is the best because the

feedback exercise methods with complex instructions prevent motor movement learning.

Conclusion

The results of this study showed that eight weeks of feedback exercises have a positive effect on maximum torque of knee abduction and motion performance and do not affect the maximum knee valgus angle. Feedback exercises cause a positive change in thigh abduction torque. Since the abduction power of the thigh is one of the risk factors for ACL damage, the effectiveness of feedback exercises on the power of thigh abduction can be considered as an important finding in the ACL damage prevention program. On the other hand, feedback exercises with externally focused attention increased motor performance of subjects in this study. Therefore, for coaches and athletes it is suggested to take advantage of feedback exercises during training sessions to prevent ACL damage and to increase athletes' performance.

Further, the maximum effect size observed was related to the maximum torque of the thigh abduction and Lee's three steps jump which reflects the higher level of effect of feedback exercises on these variables. On the other hand, considering the exercises used in this research has led to improved hopping test scores and this test is considered as the criteria used in various stages for return to the sport, it is recommended that coaches and sports pathologists use these exercises to return to exercise at the appropriate stages.

Acknowledgment

The current study was based on the dissertation of Mr. Hadi Abbas Zadeh Ghanati (M.A student of Pathology and Corrective Movements) working under the guidance of Dr. Amir Letafat Kar and the advice of Dr. Ali Abbasi. The authors of this article hereby express their thanks and gratitude towards the officials of the Biomechanics Laboratory and Corrective Movements of Kharazmi University of Tehran, Research Institute for Physical Education and Sports Sciences, and the collaboration of all the people who participated in this study.

Conflict of interest:

None

Funding support:

This project had supported financially by Sina trauma and surgery research center, Tehran University of Medical Sciences.

Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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