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Effect of Eccentric Exercises of Hip Adductor muscles on Strength and Performance of Lower Limbs among Male Taekwondo Players Suffering From Lower Limb Injuries

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ABSTRACT

Groin strain is a prevalent sports related injury. This type of muscle strain can occur as a result of severe physical activity in people who lack sufficient preparedness. There are many muscles in hip and pelvis area which are responsible for movements of the pelvis joint in different motor plates. Some times as a result of an impact or severe physical activity, these muscles are over stretched and muscle strain phenomenon occurs consequently. Those pelvis muscles which are more than others prone to straining include the adductor muscles of hip. The main objective of the present study is investigation of effects of eccentric exercises for hip adductor muscles on lower limbs' strength and performance among male taekwondo players suffering from lower limb injuries. The population of this study includes the entire male Taekwondo players of Tehran during 2015. Among the target population, a number of 30 individuals were selected as the sample of the study through a purposive sampling method. Afterwards, using a random assignment method, the sample was divided into two groups of control and experimental. Conditions for participating in the study included having at least a two year experience of playing Taekwondo for three times a week in addition to being aged between 16-20 years. Prior to performance of the intervening program (hip adductor muscles strengthening program), subjects passed the eccentric and concentric hip adductor muscles test using a dynamometer and Isokinetic. They also passed the lower limb movement performance test by taking part in vertical jump test, one-foot single jump distance, one-foot triple jumps distance, stairway leap running time, sweep running time and one foot squatting test. Intervention included performance of eccentric exercises using a strap for strengthening hip adductor muscles for a period of eight weeks. 48 hours after execution of intervention program, the subjects have taken lower limbs strength and performance tests as they had taken their pre-test. Descriptive statistics have been used for describing and organizing data obtained from posttest and pretest. In term of inferential statistics, the Co-variance analysis was applied. In case of significance of average differences in Covariance test, the LSD post hoc test would be applied. It is noteworthy to mention that the entire statistical operations were performed using the SPSS software v.23. Findings of the study have shown that eight weeks of eccentric exercises of hip adductor muscles lead to improvement of concentric and eccentric strength of hip muscles as well as improvement of movement performance of lower limbs among male Taekwondo players suffering from groin strain. As a result, performing eccentric exercises is recommended for people suffering from groin injuries.

Keywords: Eccentric Exercises, Hip Adductor Muscles, Strength, Motion Range, Lower Limbs Performance, Male Taekwondo Players, Lower Limb

INTRODUCTION

Taekwondo is considered as a modern martial art. It is based on high strength kicks and speed as well. Its main emphasis is on maintaining physical distance with the opponent and designing and using techniques for driving the opponent back. This special style has differentiated Taekwondo from all other martial sports in the globe. In Taekwondo, a special importance is given to hip muscles and lower limbs [1]. Most Taekwondo related injuries are occurred during matches rather than exercises. Most prevalent types of these injuries include tearing or bruises in different parts of the body. Injuries of hip muscles, ankle sprain, knee injuries and broken bones are respectively highly prevalent in this sport. It has been reported that these injuries are most evident in athletes weighting between 65 to 75 kilograms. As the most important muscle group involved in success of Taekwondo athletes, lower limbs must be strengthened. Scientific findings indicate that for an athlete, having a suitable performance depends on sound performance of the neuromuscular system of the lower limbs [2].In this regard improvement of neuromuscular abilities is the most effective factor on joints of lower limbs including the knee [3]. Previous studies have shown that there are some special exercises which may have positive effects on improvement of neuromuscular and sensor motor abilities and generally, on performance of lower limbs [4]. Hip joint muscles play a crucial role in terms of motional activities. Activity of these muscles is crucially important in terms of manner of performance and maintaining the alignment of lower limbs in addition to stability of the body and pelvis during closed-chain activities. Muscles of this area act as a connecting link in kinetic chain and transfer forces from lower limbs to pelvis, spinal cord and vice versa [5]. It is believed that strength of hip joint muscles is closely related to lower limb injuries, backache and patella-femoral pain among athletes. In addition, weakness of hip joint muscles makes individuals prone to knee pain, iliotibial band friction syndrome and leg injuries such as internal tibia stress syndrome especially in repetitive and severe moves [6]. There are many studies which point to the role of external extender and rotator muscles of hips muscles as basics of maintaining the alignment of lower limbs in lateral and frontal plates as well as having impacts on prevention from injuries. Evaluating the strength of hip muscles can prove effective in prevention of injuries and rehabilitation upon occurrence of injuries among athletes [7]. Through Electromyography during different kinetic activities, several studies have been performed regarding the performance and role of adductor muscles. In addition, a certain number of applied studies have reported maximal muscle performance electromyography in longus Adductor in swing phase of walking during an open kinetic chain [8]. After performing a kick, compared to the signal intensity related to Adductor Magnus, a greater change occurs in signal intensity of Adductor Longus in the leg performing the kick. Simultaneously the opposite of this situation occurs for the standing leg [9]. However, two recent studies have revealed inconsistent information regarding increased activity in Adductor Longus both in Open chain exercises [10] and closed chain exercises [11]. Since these studies have not considered the Adductor Magnus, no comparison was made between the former and latter.

Findings of several studies have revealed that among indices of physical readiness and wellbeing, in general strength is more than all other indexes subjected to sports pathology debates. In fact human body's alignment and performance is highly affected by strength. Lack of balance in muscle strength results in interrupted body alignment and makes the body prone to unconventional stresses on joints and other tissues as well [12]. Strength training specialists are aware of importance of exercises for those muscle groups which produce reverse actions around a joint (such as benders, expanders, adductors and abductor muscles) [13].

During a Taekwondo players kick, adductor muscles undergo a great deal of tensile strain. Eccentric strengthening of this muscle group can probably increase tolerance of these muscles against tensile strains resulted from kicking. In addition, according to literature of the subject, strengthening the adductor muscles increases tension distribution and absorption of forces resulting from sudden tension (during kicking) at the moving head of these muscles in tendon tissue. In this regard, strengthening the adductor muscles can probably result in reduction of tension on tendons of adductor muscle group. It also can prevent injuries resulting from overusing and severe tearing and several different tendon injuries. Strengthening the adductor muscles using a rubber band can be applied in sport rehabilitation. This type of muscle strengthening is an effective traditional method. Since while strengthening the muscles using a rubber band, the athletes' muscles are forced to endure the elastic force of the band during their return move; recently this method has absorbed a great deal of attention in terms of eccentric muscle strengthening. In order to make the most optimal use of this method, the pace of movement during the individual's eccentric opposition can be very slower than concentric strengthening in this method. However, there are only a few other researches regarding effectiveness of strengthening of adductor muscles of hip through using rubber bands (Jensen, Holmische, Bend holm Zebus, Andersen and Shoreberg. Lower limbs are among those parts of the body which are usually considered by researchers as a result of being exposed to different injuries. Many times these limbs develop

problems either on their own or in group with other parts of the body. A major issue for lower limbs is muscle weakness. The most prevalent engaged muscles include the Hamstrings, quadriceps and hip adductors. Injuries of hip muscles are usually complicated and early diagnosis of them is a key to adequate treatment. These injuries are usually hard to diagnose and treat. On the other hand, lack of prevention programs and suitable diagnosis indices help these injuries become chronic. These injuries are of high prevalence. In fact, in 68 percent of the cases, the main causes of groin pains were resulted from hip adductor injury [1].

Hip joint and groin injuries are the most prevalent sport injuries. In this regard, almost 0.20 of the entire sports injuries are related to these injuries. Adductor muscles injuries are the second prevalent injuries threatening the hip area in a way that it includes 0.60 of the entire these injuries. One program for strengthening the lower limbs which has been considered widely is hip adductor muscles strengthening. In this regard, several researchers have reported that by making use of hip adductor muscles exercises, up to 79% of the injured athletes have been able to obtain their pre-injury ability level. In addition, considering the fact that the hip muscles are very crucial for performance and manner of alignment of lower limbs during sports activities and that weakness of these muscles pays a very important role in occurrence of injuries; and also with respect to the necessity for further investigation of the special role of hip adductor muscles in terms of performance of lower limbs, the present study was aimed at investigation of effects of eccentric exercises of hip adductor muscles on strength and performance of lower limbs among male taekwondo players suffering from lower limb injuries.

MATERIAL AND METHODS

The population of this study includes the entire male Taekwondo players of Tehran during 2015. Among the target population, a number of 30 individuals were selected as the sample of study through a purposive sampling method. Further, the sample was randomly divided into two groups namely as control and experimental group. Conditions for participation in the study included having experience of playing Taekwondo for at least two years and three times a week and being aged in the range of 16-20. Prior to execution of the intervention program (adductor muscles strengthening program), subjects passed the eccentric and concentric hip adductor muscles test using a dynamometer and Isokinetic. They also passed the lower limb movement performance test by taking part in vertical jump test, one-foot single jump distance, one-foot triple jumps distance, stairway leap running time, sweep running time and one foot squatting test. Intervention included performance of eccentric exercises using a strap for strengthening hip adductor muscles for 8 weeks. 48 hours after execution of intervention program, the subjects have taken lower limbs strength and performance tests as they had taken their pre-test. Descriptive statistics have been used for describing and organizing data obtained from posttest and pretest. In term of inferential statistics, the Co-variance analysis was applied. Fist we have tried to control the hypotheses of our study. In this regard, normality of data distributions was evaluated through application of Kolmogorov-Smirnoff test and also the Levin's homogeneity of variances test was used for testing the assumed homogeneity of variances.In term of inferential statistics, the Co-variance analysis was applied. In case of significance of average differences in Covariance test, the LSD post hoc test would be applied. It is noteworthy to mention that the entire statistical operations were performed using the SPSS software v.23.

RESULTS

Characteristics related to age, height and weight of subjects are reviewed in table 1.

Table 1: anthropometric characteristics of the control and experimental group subjects; average and standard deviation

group	number	variable	Average+-SD
Eccentric exercises	15	age	18.67±1.86
		height	170.73±6.48
		weight	69.93±11.14
control	15	age	29.20±3.87
		height	161.06±5.52
		weight	65.66±9.88

Information provided in table 1 indicates the average values of age, weight and height for subjects of each group.

Investigating the effect of eccentric exercises of hip adductor muscles on eccentric strength of these muscles

Table 2: on-way covariance analysis for investigation of effectiveness of eccentric exercises on eccentric strength of hip muscles

variable	Source of changes	Sum of squares	F.D	Average squares	F	Sig.	Impact value	Observed strength
Eccentric strength	pretest	1.153	1	1.153	0.632	0.524	0.016	0.121
	group	12.775	1	6.338	3.499	0.040	0.152	0.619
	error	71.194	29	1.825				
	total	1029	45					

As you can see in table 2, the pretest has indicated a significant value of larger than 0.05. This means that pretest selected was not suitable, however no interference was occurred in results of the co-variance test and the results are correct. On this basis, we have concluded that eccentric exercises have had a significant impact on eccentric strength of adductor muscles of hip.

With respect to statistical significance of results of the co-variance test and for investigating the differences between two groups, the post hoc test of LSD was applied and its results have been shown in table 3.

Table 3: results of LSD post hoc test for investigation of differences between averages obtained from two groups in terms of eccentric strength

variable	Group 1	Group 2	Average differences	S.D	Sig.
Eccentric strength	Eccentric exercises	control	-4.181	0.496	0.001*

As you can see in above table, the difference between the two groups is significant.

Investigating the effect of eccentric exercises of hip adductor muscles on concentric strength of these muscles

Table 4: on-way covariance analysis for investigation of effectiveness of eccentric exercises on concentric strength of hip muscles

variable	Source of changes	Sum of squares	F.D	Average squares	F	Sig.	Impact value	Observed strength
concentric strength	pretest	1.254	1	1.317	0.336	0.022	0.018	0.138
	group	15.348	1	3.695	2.658	0.011	0.214	0.702
	error	60.365	29	2.147				
	total	1698	30					

As you can see in table 4, the pretest has indicated a significant value of smaller than 0.05. This means that pretest selected was suitable on this basis; we have concluded that eccentric exercises have had a significant impact on eccentric strength of adductor muscles of hip.

With respect to statistical significance of results of the co-variance test and for investigating the differences between two groups, the post hoc test of LSD was applied and its results have been shown in table 5.

Table 5: results of LSD post hoc test for investigation of differences between averages obtained from two groups in terms of eccentric strength

variable	Group 1	Group 2	Average differences	S.D	Sig.
Concentric strength	Eccentric exercises	control	-4.181	0.496	0.036*

As you can see in above table, the difference between the two groups is significant. In this regard it can be concluded that effectiveness of eccentric exercises on eccentric and concentric strengths of hip adductor muscles is true.

Eccentric hip muscle exercises are effective on performance of lower limbs among male Taekwondo players suffering from hip groin injury

Investigating the effects of eccentric exercises of hip adductor muscle on vertical jumping:

Table 6: one-way co-variance analysis for investigation of effectiveness of eccentric exercises on vertical jumping

variable	Source of changes	Sum of squares	F.D	Average squares	F	Sig.	Impact value	Observed strength
Vertical jumping	pretest	1.148	1	2.847	0.258	0.033	0.068	0.138
	group	12.248	1	6.365	3.365	0.009*	0.173	0.710
	error	15.365	29	1.485				
	total	1894	45					

As you can see in table 6, the pretest shows a significant value smaller than 0.05, this means that a suitable pretest was selected. On this basis, we may conclude that eccentric exercises have had a significant effect on vertical jumping.

With respect to significance of results of the co-variance test and for investigation of differences between the two groups, the LSD post hoc test was used. Results of this test are summarized in table 6.

Table 7: results of LSD post hoc test

variable	Group 1	Group 2	Average differences	S.D	Sig.
Vertical jumping	Eccentric exercises	control	2.885	0.365	0.039*

As you can see in above table, differences between experimental and control groups were significant.

Discussing the effects of eccentric exercises of hip adductor muscles on on-foot single-jump

Table 8: one-way co-variance analysis for investigation of effectiveness of eccentric exercises on one foot single jump

variable	Source of changes	Sum of squares	F.D	Average squares	F	Sig.	Impact value	Observed strength
One-foot single jump	pretest	1.115	1	1.874	0.995	0.011	0.030	0.149
	group	15.362	1	3.354	2.989	0.001	0.169	0.612
	error	35.928	29	2.629				
	total	36225	30					

As you can see in table 8, the pretest shows a significant value smaller than 0.05, this means that a suitable pretest was selected. On this basis, we may conclude that eccentric exercises have had a significant effect on one-foot single-jump.

With respect to significance of results of the co-variance test and for investigation of differences between the two groups, the LSD post hoc test was used. Results of this test are summarized in table 8.

Table 9: results of LSD post hoc test

variable	Group 1	Group 2	Average differences	S.D	Sig.
One-foot single-jump	Eccentric exercises	control	-2.978	0.669	0.038*

As you can see in above table, differences between experimental and control groups were significant.

Discussing effects of eccentric exercises of hip adductor muscles on three one-foot jumps

Table 10: one-way co-variance analysis for investigation of effectiveness of eccentric exercises on three one-foot jumps

variable	Source of changes	Sum of squares	F.D	Average squares	F	Sig.	Impact value	Observed strength
Three one-foot jumps	pretest	1.145	1	2.748	0.584	0.035	0.068	0.156
	group	14.524	1	4.629	3.487	0.044	0.174	0.691
	error	37.958	29	3.185				
	total	3518	30					

As you can see in table 10, the pretest shows a significant value smaller than 0.05, this means that a suitable pretest was selected. On this basis, we may conclude that eccentric exercises have had a significant effect on three one-foot jumps.

With respect to significance of results of the co-variance test and for investigation of differences between the two groups, the LSD post hoc test was used. Results of this test are summarized in table 10.

Table 11: results of LSD post hoc test

variable	Group 1	Group 2	Average differences	S.D	Sig.
Three one-foot jumps	Eccentric exercises	control	3.487	0.584	0.001*

As you can see in above table, differences between experimental and control groups were significant.

Discussing the effects of eccentric exercises of hip adductor muscles on stairway leap running

Table 12: one-way co-variance analysis for investigation of effectiveness of eccentric exercises on stairway leap running

variable	Source of changes	Sum of squares	F.D	Average squares	F	Sig.	Impact value	Observed strength
Stairway leap running	pretest	2.447	1	1.874	0.847	0.336	0.030	0.157
	group	18.996	1	3.354	3.487	0.021	0.142	0.592
	error	36.178	29	2.658				
	total	2548	30					

As you can see in table 12, the pretest shows a significant value larger than 0.05, this means that a suitable pretest was not selected. However, No interference was made in terms of results of the Co-variance test. On this basis, we may conclude that eccentric exercises have had a significant effect on stairway leap running.

With respect to significance of results of the co-variance test and for investigation of differences between the two groups, the LSD post hoc test was used. Results of this test are summarized in table 12.

Table 13: results of LSD post hoc test

variable	Group 1	Group 2	Average differences	S.D	Sig.
Stairway leap running	Eccentric exercises	control	-3.695	0.584	0.016*

As you can see in above table, differences between experimental and control groups were significant.

Discussing the effects of eccentric exercises of hip adductor muscles on sweep running

Table 14: one-way co-variance analysis for investigation of effectiveness of eccentric exercises on sweep running

variable	Source of changes	Sum of squares	F.D	Average squares	F	Sig.	Impact value	Observed strength
Sweep running	pretest	7.953	1	2.852	0.440	0.039	0.098	0.158
	group	19.951	1	3.489	3.556	0.037	0.151	0.642
	error	42.684	29	1.748				
	total	18569	30					

As you can see in table 14, the pretest shows a significant value smaller than 0.05, this means that a suitable pretest was selected. On this basis, we may conclude that eccentric exercises have had a significant effect on sweep running.

With respect to significance of results of the co-variance test and for investigation of differences between the two groups, the LSD post hoc test was used. Results of this test are summarized in table 14.

Table 15: results of LSD post hoc test

Sig.	S.D	Average differences	Group 2	Group 1	variable
0.024*	0.695	2.487	control	Eccentric exercises	Sweep running

As you can see in above table, differences between experimental and control groups were significant.

Discussing the effects of eccentric exercises of hip adductor muscles on one-foot squatting

Table 16: one-way co-variance analysis for investigation of effectiveness of eccentric exercises on one-foot squatting

variable	Source of changes	Sum of squares	F.D	Average squares	F	Sig.	Impact value	Observed strength
One-foot squatting	pretest	2.478	1	1.362	0.178	0.017	0.033	0.150
	group	14.2547	1	2.487	3.417	0.007	0.173	0.723
	error	29.928	29	2.4875				
	total	4872	30					

As you can see in table 16, the pretest shows a significant value smaller than 0.05, this means that a suitable pretest was selected. On this basis, we may conclude that eccentric exercises have had a significant effect on one foot squatting.

With respect to significance of results of the co-variance test and for investigation of differences between the two groups, the LSD post hoc test was used. Results of this test are summarized in table 16.

Table 17: results of LSD post hoc test

variable	Group 1	Group 2	Average differences	S.D	Sig.
One-foot squatting	Eccentric exercises	control	4.858	0.625	0.003*

As you can see in above table, differences between experimental and control groups were significant.

DISCUSSION AND CONCLUSIONS

The mechanism of supportive effect of eccentric exercises on muscle strain is not clearly known. According to one theory, increased muscle strength increases absorption of imposed impacts on muscles. On the other hand, research has shown that eccentric exercises lead to increases tendon density and diameter which in turn, reduces the amount of stress imposed on tendons and respectively, muscle strains are healed more quickly. In addition, as a result of strengthening the muscles and tendons, resistance training prohibits muscular injuries (Cangsgrad, Ritlesder and Peterson, 2007; Cangsgrad, kuanen and Vagard, 2009; Cangsgrad, Coretherape and Larsen, 2010). Another theory implies that resistance training results in increased Collagen cords as well as diameter of muscular cords. It in fact increases tendons' and muscles' resistance against strains. The third theory suggests that as a response to eccentric exercises, muscle lengths increase and this, in turn results in maximal production of muscular torque in most optimal joint angle. This mechanism supports muscles and tendons and inhibits muscle strains.

Strength of hip adductor muscles in people suffering from groin injury is 18% less than healthy people. In addition, among the injured, the ratio between strength of adductor and abductor muscles is approximately 78percent. While in healthy people, this ratio is 95 percent. This indicates that a significant relation exists between strength of adductor muscles as well as ratio between strength of adductor and abductor muscles and groin injury. In fact the aforementioned factors can be suitable anticipators for groin strain injury. On this basis, with respect to results of the present study, it can be said that probably, strengthening this muscle group can play an important role in terms of

prevention of stresses on these muscles. On the other hand, the former can be a good and suitable anticipator for preventing reoccurrence of adductor muscles strain.

Lack of treatment of groin strain is usually related to lack of execution of a suitable rehabilitation program. This is because most studies have shown that massage, tension and muscular stimulation have no significant effects on improvement and treatment of groin strain. However, and eight to twelve weeks resistance training program for adductor muscles, balance exercises, strength exercises for abdominal muscles can have significant effects on treatment of adductor muscles strain.

The present study has made use of eccentric exercises in addition to rubber straps for strengthening adductor muscles among young Taekwondo players. As it was observed, these exercises have significant effects in terms of increased eccentric and concentric strengths of hip adductor muscles. In addition, as a result of having a resistance feature, these exercises have probably increased the concentric and eccentric strength of hip muscles of subjects after the period of study. According to aforementioned documents, significant increase in strength of adductor muscles can be considered as a factor of healing for strains of these muscles. On this basis, it can be said that performance of eccentric exercises using a rubber strap can be used for rehabilitation of athletes suffering from hip adductor muscle strain. With respect to previous studies and the literature of the subject, there are no other researches regarding investigation of effects of empowerment of hip adductor muscles on performance of lower limbs. In spite, only a few researches have elaborated on one-foot squatting and kinematics of lower limbs (Cashman, 2012; decker, 2013; Safari Nodehi et al. 2014). According to this information, results of the present study are consistent with results obtained by Cashman (2012), Decker (2013) and Safari Nodehi et al. (2014). On the other hand, no inconsistent studies were found in this domain.

With respect to analyses of first and second hypotheses, we have discovered that eccentric exercises have led to empowerment of hip muscles and its motion range. Since strength and flexibility are among the nine-fold factors physical readiness, therefore improving these two factors can absolutely increase the efficiency and performance of the athlete in physical activities. Also in present study, probably increased motion range and increased hip muscles strength have increased the abilities of individuals in terms of better performance in kinetic performance tests.

An obvious reality is that more powerful athletes have better performances and suffer from less frequent injuries. Walking and running require phased activity of large muscles such as surface abdominal muscles, Para spinals and muscles surrounding the hip such as the hamstrings, quadriceps and adductors. Sports activities such as jumping and running create adductor torque in hip joint. It is obvious that the more the maximal torque of this muscle group, then the individual will have a better performance in activities such as jumping and bouncing and running. Since kinetic tests applied in this study include activities such as sweep running, stairway leap running and etc. we can point to positive role of increased hip adductor muscles strength in better performance of kinetic tests more than before. According to results obtained from first hypothesis of this study, significant decreases in external rotation and abduction of hip in one-foot squatting test can be considered as a result of more opposition of hip muscles against abduction and external rotation. With respect to results of the exercise program provided by this research, effectiveness of the suggested program can be witnessed in improved kinetic performance of athletes after taking the course. It can also be concluded that eccentric exercises using a rubber band is a suitable solution free from any side-effects for improvement of injuries of hip adductor muscles. Results of the research have also shown that these exercises can be considered as a suitable and safe therapeutic method for healing injuries of hip adductor muscles as well as prevention of reoccurrence of such injuries.

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