The Impact of Eccentric Exercises of Hip Adductor Muscles on Motion Range and Performance of Lower Limbs among Male Taekwondo Players Suffering From Lower Limb Injuries

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Abstract: The purpose of the present study is to investigate the impacts of eccentric exercises of hip adductor muscles on motion range and performance of lower limbs among male Taekwondo players suffering from lower limb injuries. The population of the study includes the entire male Taekwondo players of Tehran during 2015. Among the population, a number of 30 individuals were selected as the sample of the study through purposive sampling method. Furthermore, the sample was divided into two 15 individuals groups namely as control and experimental groups. Prior to initiation of evaluations, subjects had signed the privacy policy papers for taking part in the experiment and next, their personal information was collected. Each person was individually provided with general debriefings regarding the manner of performance of tests. Conditions for participation in study also included having at least a two year experience of playing Taekwondo for three times a week and being aged between 16 to 20 years. Prior to execution of intervention program (hip adductor muscles strengthening program) subjects had been subjected to tests measuring motion range of abduction and external rotation of hip using a Goniometer as well as kinetic performance of lower limbs through 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. 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 will lead to improvement of motion range of hip abduction and external rotation 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.

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1. Introduction

A field of sports which is to a great degree prone to occurrence of muscular injuries is Taekwondo. Taekwondo is in fact a Korean martial art and an Olympics sport as well. This field of sports has the most athletes than all other martial arts throughout the world. Taekwondo players boost kicks of high speed and power which are concentrated mainly on head and torso of the opponent. Kick in Taekwondo require intense involvement of expanding and bending muscles of knee and hip. In this regard, kinetic chain of expanding muscles of knee and hip is considered as the most important element of success in these hits (Machadou et al. 2010). Discussing different types of forces which have emerged upon altered movements of the lower limbs (such as kicking in Taekwondo matches) is a factor of realization of a better performance in Taekwondo matches. Results of some of studies regarding the relation between muscular strength and injuries of lower limbs have shown that, people suffering from these injuries actually suffer from having a more unstable support surface for countering the forces evolving from lower limbs. In fact, this issue makes them prone to injuries. Most injuries occurred in Taekwondo take place during matches rather than exercises. Most prevalent types of these injuries include tearing or soreness in different parts of the body. Injuries of hip muscles, ankle twist, knee injuries and bone breakings are respectively the most prevalent injuries of Taekwondo. It has been reported that these injuries have been most prevalent among athletes of weight range of 65 to 75 kilograms. Strengthening the lower limbs as the most important muscle group involved in success of Taekwondo

athletes is highly important. Considering these explanations, it can be assumed that weakness of hip adductor muscles increases the potential for injuries of hip groin and joint area. This in turn indicates the importance of muscular strengthening of these areas towards prevention of injuries. Hip joint adductor muscles include the adductor Magnus, adductor longus, and adductor Brevis, Pectineus and Gracilis. The main adductor of hip is the adductor longus. Although that all these muscles are called adductors, but each of these muscles can have different functions as well. Adductors are essential for both conditions of closed chain (E.g. the situation of standing leg with consideration for surrounding forces resulting from gravity) and open chain (E.g. the process of kicking during which in case of lack of axial pressure, the movement occurs through the limb).

Obvious differences have been reported regarding the performance of adductor longus and adductor magnus. Mostly, the activity level of the adductor longus has been debated during closed chain and open chain exercises. The main function of this muscle is adduction of the body of hip bone (Moore and Dally, 2006). During a taekwondo player's kick, hip adductor muscles undergo a great deal of pressure. Eccentric strengthening of these muscles can probably lead to improvement of these muscles' endurance against tensile stresses resulting from kicking. In addition, according to previous studies, strengthening the hip adductor muscles leads to increased pressure distribution and absorption of forces resulting from sudden tensions.. 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). 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; lower limbs are mostly considered by researchers as a result of being exposed to different types of 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 (bridge et al. 2010).

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.

Regarding groin injuries, weakness in hip adductor muscles has been revealed to be the most important risk factor for these injuries. It seems that strengthening this muscle group can be considered as a preventing factor from groin injuries. Also with respect to the necessity for further investigation of the special role of hip adductor muscles in terms of performance and injuries of lower limbs, the present study was aimed at investigation of effects of eccentric exercises of hip adductor muscles on motion range and performance of lower limbs among male taekwondo players suffering from lower limb injuries.

2. 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), Prior to execution of intervention program (hip adductor muscles strengthening program) subjects had been

subjected to tests measuring motion range of abduction and external rotation of hip using a Goniometer as well as kinetic performance of lower limbs through 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.

3. 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

Average+-SD	variable	number	group
86/1±67/18	age	15	Eccentric exercises
48/6±73/170	height		
14/11±93/69	weight		
87/3±20/29	age	15	control
52/5±06/161	height		
88/9±66/65	weight		

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

Eccentric exercises of hip adductor muscles are effective on motion range of lower limbs among male Taekwondo players suffering from groin strain

Investigating the effects of eccentric exercises of hip adductor muscles on hip abduction motion range.

Table 2. On-way covariance analysis for investigation of effectiveness of eccentric exercises on hip abduction motion range

Observed strength	Impact value	Sig.	F	Average squares	F.D	Sum of squares	Source of changes	variable
138/0	019/0	041/0	632/0	524/1	1	485/1	pretest	Hip abduction
671/0	168/0	014/0	524/2	415/6	1	695/11	group	
				365/1	29	365/82	error	
					45	1325	total	

As you can see in table 2, 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 motion range of hip abduction.

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 hip abduction

Sig.	S.D	Average differences	Group 2	Group 1	variable
*002/0	695/0	415/3-	control	Eccentric exercises	Hip abduction

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

Discussing the effects of hip adductor muscles' eccentric exercises on hip external rotation motion range

Table 4. On-way covariance analysis for investigation of effectiveness of eccentric exercises on motion range of hip external rotation

Observed strength	Impact value	Sig.	F	Average squares	F.D	Sum of squares	Source of changes	variable
152/0	020/0	044/0	248/0	356/1	1	114/1	pretest	Hip external rotation
745/0	221/0	002/0	362/2	484/4	1	253/16	group	
				362/2	29	928/60	error	
					30	1284	total	

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 motion range of hip external rotation.

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 hip external rotation

Sig.	S.D	Average differences	Group 2	Group 1	variable
*018/0	488/0	225/3-	control	Eccentric exercises	Hip external rotation

As you can see in above table, the difference between the two groups is significant. Therefore the second hypothesis of the study stating that eccentric exercises are effective on motion range of hip abduction and external rotation is approved.

Eccentric exercises of hip adductor muscles are effective on kinetic performance of lower limbs among male Taekwondo players suffering from lower limb injuries

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

Observed strength	Impact value	Sig.	F	Average squares	F.D	Sum of squares	Source of changes	variable
138/0	068/0	033/0	258/0	847/2	1	148/1	pretest	Vertical jumping
710/0	172/0	*009/0	363/3	365/6	1	248/12	group	
				485/1	29	365/15	error	
					45	1894	total	

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

Sig.	S.D	Average differences	Group 2	Group 1	variable
*039/0	365/0	885/2	control	Eccentric exercises	Vertical jumping

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

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

Observed strength	Impact value	Sig.	F	Average squares	F.D	Sum of squares	Source of changes	variable
149/0	030/0	011/0	995/0	874/1	1	115/1	pretest	One-foot single jump
612/0	169/0	001/0	989/2	354/3	1	362/15	group	
				629/2	29	928/35	error	
					30	3625	total	

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

Sig.	S.D	Average differences	Group 2	Group 1	variable
*038/0	669/0	978/2-	control	Eccentric exercises	One-foot single-jump

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

Observed strength	Impact value	Sig.	F	Average squares	F.D	Sum of squares	Source of changes	variable
156/0	068/0	035/0	584/0	748/2	1	145/1	pretest	Three one-foot jumps
691/0	174/0	044/0	487/3	629/4	1	524/14	group	
				185/3	29	958/37	error	
					30	3518	total	

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

Sig.	S.D	Average differences	Group 2	Group 1	variable
*001/0	584/0	487/3	control	Eccentric exercises	Three one-foot jumps

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

Observed strength	Impact value	Sig.	F	Average squares	F.D	Sum of squares	Source of changes	variable
157/0	030/0	336/0	847/0	874/1	1	447/2	pretest	Stairway leap running
592/0	142/0	021/0	487/3	354/3	1	996/18	group	
				658/2	29	178/36	error	
					30	2548	total	

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

Sig.	S.D	Average differences	Group 2	Group 1	variable
*016/0	584/0	695/3-	control	Eccentric exercises	Stairway leap 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 sweep running

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

Observed strength	Impact value	Sig.	F	Average squares	F.D	Sum of squares	Source of changes	variable
158/0	098/0	039/0	440/0	852/2	1	953/7	pretest	Sweep running
642/0	151/0	037/0	556/3	489/3	1	951/19	group	
				748/1	29	684/42	error	
					30	18569	total	

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
*024/0	695/0	487/2	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

Observed strength	Impact value	Sig.	F	Average squares	F.D	Sum of squares	Source of changes	variable
150/0	033/0	017/0	178/0	362/1	1	478/2	pretest	One-foot squatting
723/0	173/0	007/0	417/3	487/2	1	2547/14	group	
				4875/2	29	928/29	error	
					30	4872	total	

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

Sig.	S.D	Average differences	Group 2	Group 1	variable
*003/0	625/0	858/4	control	Eccentric exercises	One-foot squatting

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

4. Discussion and Conclusion

Movement and flexibility of soft tissues surrounding joints are highly important in terms prevention of re-occurrence of injuries (Bandi, Irain and Briggler; 1998). Reduction movement results in increased cohesion between collagen fibers. If a muscle remains inactive for a long period of time, it will lose its normal activity and as a result of structural changes in connective tissues, it becomes shorter (Bandi and Irain, 1995). If the new fibers in injured tissue are not organized in line with forces exerted on the muscle, they will be put along each other in a random fashion and then, adhere to each other as well as surrounding tissues; therefore resulting in limitation in range of activities (Bonar, Dort and Gold, 2004; Belo, 1981). Also some times the muscle becomes shorter. In this case, there no special tissue pathologies involved; rather the tendon-muscular unit becomes comparatively shorter. This issue will lead to limitation of motion range. Pathologies resulting from trauma, inflammation, edema, ischemia, bleeding, surgical cuts and burning, lead to formation of fibrous tissues which are substituted for natural connective tissues. Following these injuries, tissues lose their normal elasticity and plasticity and therefore, the muscle's overall length-tension relation alters. On the other hand, the muscle becomes weaker and the joint's motion range reduces as well. Reduced flexibility results in muscular pains, soft tissue pains and periosteum pains as well (Bandi, 1998).

There is a tight relation between limitation of hip muscles' motion range and hip adductor muscles injuries (Extrand and Gilquest, 1983). Some studies have reported that a significant relation exists between hip motion range and hip adductor muscles strain among athletes of different sports (Extrand et al, 1983; Durak, Jang, Komiac, Bowman, Petersen, Rooth et al, 2000; Ochard et al. 1997). In addition, among certain risk factors for hip adductor muscles strain it has been pointed to Limited range of motion of the hip adduction and internal and external rotation (Akstrand et al., 1983), the weakness of the adductor tendon and previous muscle damage that plays a role in re-injury (Taylor et al., 2001; Seward et al., 1993).

Athletes who suffer from reduced joint motion range are more susceptible to injuries (Morphy et al. 2003). On this basis, considering for exercises which increase the flexibility of different muscle groups is essential for exercise programs of athletes (Harvey et al, 2002). Reduced range of motion results in injuries and reduced strength of muscle as a result of altered length-tension relation in muscles(Sullivan, 2012). Although that most researches have emphasized on considering for stretching exercises in athletes' exercise programs, eccentric exercises on the other hand, not only help strengthening the muscles and obtaining the most desirable length-tension relation, but also increase the flexibility of muscles. This issue significantly reduces risk factors for muscular strain (Prosk et al, 2001; O-Sullivan, 2012; Sling et al, 2003, M. Julesence, 2004). Eccentric exercises result in sarcomerogenesis in muscles (Lin and Morgan, 1994). According to results of some previous studies, and also based on a proposed theory, production of sarcomere results in increased muscle length as well as increased length of muscular fascicules (Lim et al. 2004). Several studies have been performed regarding impacts of eccentric exercises on increased muscular flexibility and length. Among these, two researches were performed regarding Quadriceps (Belzovich et al, 2007; Rios et al. 2009), two were performed regarding Hamstrings (Nelsen and Bandi, 2004; Putsier et al, 2002) and two were also performed regarding Gastrocnemius muscle (Dolki et al. 2009; Mahio et al. 2008).

All these researches had measured muscle length using ultrasound devices and also the range of motion was evaluated through laboratory experiments. Results of the entire researches revealed that after taking an eccentric exercise program, muscle length and motion range increase significantly. The motion range and length of the Hamstring were increased respectively for 6.9-12.79 degrees and 34%. The motion range and length of the Gastrocnemius muscle were increased respectively for 6 degrees and 1.1milimeters. The length of the Quadriceps was increased for 3.1-22% (Belzovich et al, 2007; Rios et al. 2009; Nelson et al. 2004; Putsier et al. 2002, Dalki et al, 2009, Mahio et al. 2008).

With respect to the above mentioned mechanisms, it can be concluded that eccentric exercises of hip adductor muscles approved in this research may result in increased range of motion for internal muscles of the hip. In fact results of statistical analyses approve this statement. This can take part in reduction and minimization of risk factors for adductor muscles strain and prevent these muscles from straining.

With respect to analyses performed on the literature of the subject, no researches were found to having considered for effects of strengthening the 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 (Dextran et al. 1983). 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.

References

1. Bandy WD, Irion JM. Briggler M. "The effect of static stretch and dynamic range of motion training on the flexibility of the hamstring muscles". J Orthop Sports Phys Ther, 1998, 295-300.
2. Blazevich AJ, Cannavan D, Coleman DR, et al. Infl uence of concentric and eccentric resistance training on architectural adaptation in human quadriceps muscles. J Appl Physiol 2007, 103, 1565–75.
3. Borghuis A, Lemmink K. Core stability response times and postural reactions in soccer players and nonplayers. Medicine & Science in Sports & Exercise. 2010, 43(1), 108-114.
4. Duclay J, Martin A, Duclay A, et al. Behavior of fascicles and the myotendinous junction of human medial gastrocnemius following eccentric strength training. Muscle Nerve, 2009, 39, 819–27.
5. Ekstrand J, Gillquist J. The avoidability of soccer injuries. Int J Sports Med, 1983, 4, 124–8.
6. Harvey L, Herbert R, Crosbie J. Does stretching induce lasting increases in joint ROM? A systematic review. Physiother Res Int, 2002, 7, 1–13.
7. Holmich P, Larsen K. Exercise program for prevention of groin pain in football players: a cluster-randomized trial. Scand J Med Sci Sports. 2010, 20, 814-821.
8. Jansen G, Mens M, Stam H. Diagnostic in athletes with long lasting groin pain. Scand J Med Sci Sports. 2012, 18, 679-690.
9. Lynn R, Talbot JA, Morgan DL. Differences in rat skeletal muscles after incline and decline running. J Appl Physiol 1998; 85:98–104.
10. Machado SM, Osório RAL, Silva NS, Magini M. Biomechanical analysis of the muscular power of martial arts athletes. Med Biol Eng Comput 2010; 48(6):573-7.
11. Murphy DF, Connolly DA, Beynnon BD. Risk factors for lower extremity injury: a review of the literature. Br J Sports Med, 2003, 37, 13–29.
12. O'Sullivan K, McAulifee S, DeBurca N. The effects of eccentric training on lower limb flexibility: a systematic review. Br J Sports Med, 2012, 46, 838–845.
13. Tyler TF, Campbell R, Nicholas SJ, et al. The effectiveness of a preseason exercise program on the prevention of groin strains in professional ice hockey players. Am J Sports Med. 2002, 30(5), 680–3.

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