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Original Article

The effect of hip joint muscle exercise on muscle strength and balance in the knee joint after meniscal injury

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Abstract. [Purpose] This study aimed to evaluate the effect of hip muscle strengthening on muscle strength and balance in the knee joint after a meniscal injury. [Subjects and Methods] This randomized control study enrolled 24 patients who had undergone arthroscopic treatment after a meniscal injury and began a rehabilitative exercise program 8 weeks after surgery. Subjects were divided into 2 groups of 12 subjects each: gluteus medius resistance exercise group and control group. This study investigated muscle strength and balance in the knee joint flexor, extensor, and abductor during an 8-week period. [Results] Measurements of knee extensor muscle strength revealed no significant difference between the control group and the experimental group. Measurements of abductor muscle strength, however, identified a significant difference between the 2 groups. The groups did not differ significantly with regard to balance measurements. [Conclusion] The results of this study suggest that this subject should be approached in light of the correlation between the hip abductor and injury to the lower extremities.

Key words: Meniscus, Gluteus medius, Balance

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INTRODUCTION

The prevalence of knee joint injury and disease has increased as a result of the increasing frequency of injury due to various leisure, industrial, and traffic accidents[1)]. The knee joint is both one of the larger joints of the body and the most complex joint. The most typical knee joint injuries involve the anterior cruciate ligament and meniscus, which comprise large proportions of the joint[2)]. The meniscus plays multiple very diverse and important functions in a normal knee joint[3)]. These functions include joint cartilage lubrication, reduction of friction, reduction of compression stress on the knee joint, and stability of the joint during exercise[4)]. A knee joint injury may lead to both ankle and hip joint injuries[5)]. The results of a study of hip joint muscle strength after knee joint injury revealed decreases of 12–25% in the isometric muscle strength of the abductor, adductor, flexor, and extensor of the operated leg, compared to these values in the unoperated contralateral leg[5)]. Decreased hip abductor muscle strength reduces proximal control of the hip joint and thereby causes a decrease in knee exercise dynamics. In addition, the relationship between chronic knee injury and hip abductor strength signifies that endurance of the musculature also plays an essential role in myoneural control of the knee. A lower extremity fatigue protocol was shown to induce changes in the dynamics of strength generation, proprioception, coordination, and landing exercise[6)]. Cale[7)] reported that patients with an increased hip abductor peak torque exhibited decreased peak knee joint displacement through proximal hip joint control. These findings suggest that the decline in muscle strength after knee joint surgery is not limited to the flexor and extensor muscles of the knee joint, but may lead to a further loss of muscle strength[8)]. The abductor muscles play important kinesiologic roles in standing on feet and ambulation in humans[9)]. Among these, the gluteus medius muscle controls movements of the femur and stabilizes the pelvis during mobilization of the lower extremities[10)]. Strengthening

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exercises targeting the gluteus medius muscle were shown to improve movement in the lower extremities, prevent injuries, and reduce pain[10]. Hence, studies of the hip abductor have recently being emphasized in the treatment and prevention of injuries of the lower extremities[11].

Notwithstanding the focus on strengthening hip muscles after meniscal injury, this study was accordingly intended to investigate the effect of hip muscle strengthening on knee joint muscle strength and balance after meniscal injury.

SUBJECTS AND METHODS

This study included 24 patients who had undergone arthroscopic treatment for a diagnosed meniscal injury and subsequently completed rehabilitative exercise therapy at the M-training center and G hospital, located in the City of U, during an 8-week period from January to March 2014. These 24 subjects, who understood the intent of this study and volunteered to participate, were divided into 2 groups: 1) the control group (CG), and 2) the experimental group that practiced gluteus medius resistance exercises (GREG). All participants understood the purpose of this study and provided written informed consent prior to participation in accordance with the ethical principles of the Declaration of Helsinki.

As suggested by the studies of Gobbi[12] and Heckmann[13], the program of rehabilitative exercise after meniscal injury was revised and reinforced to fit the scope of this study. The exercise program was conducted in 3 steps: warm-up, main training, and cool-down. This exercise program was implemented in 4 sets that were repeated 12 times at a maximum muscle strength of 70%. The program was performed 3 times per week for 8 weeks (Tables 1 and 2).

An isometric muscle strength device (*ISO-Check*; Digimax Messtechnik, Hamm, Germany) was used to measure muscle strength in the lower extremities. This isometric muscle strength device measured both the maximum and mean muscle strength. Patients were asked to sit on the device and attached the fixed strip to their chest. The muscle strength was measured in the knee flexor, extensor, and abductor to prevent compensation of the upper extremities. Nm was the unit of measurement. An isometric strength test was used to test the muscle strength. Isometric strength tests were performed at a 45° angle for the hip flexor and extensor, and at a 90° angle for the hip abductor.

A Posture Med balance measurement device (Microswing 5; Haider Bioswing GmbH, Pullenreuth, Germany) was used in this study. Subjects with good balance received a score of 1,000 points, whereas those who lost balance received a score of 0 (zero). All subjects were asked to move their left and right legs one at a time while stretching out their knees for 10 s, with their eyes open. This test was repeated 3 times to obtain a mean value.

Table 1. Exercise program for the gluteus medius resistance exercise group

Level	Component	Item	Intensity	Time
Warm-up		Self stretching	30 s/2 set	5 min
		Joint mobilization	5 min	
Main-training	Resistance exercise	SLR (quadriceps femoris)	20 RM/4 sets (1–4 week) and 12 RM/4 sets (5–8 week)	40 min
		SLR (gluteus medius)		
		One leg sit-up		
		Leg curl (hamstring)		
		Calf raise		
		Toe raise		
Cool-down		Bicycle		10 min

SLR: straight leg raising, RM: repetition maximum

Table 2. Exercise program for the control group

Level	Component	Item	Intensity	Time
Warm-up		Self stretching	30 s/2 sets	10 min
		Joint mobilization	5 min	
Main-training	Resistance exercise	SLR (quadriceps femoris)	20 RM/4 sets (1–4 week) and 12 RM/4 sets (5–8 week)	40 min
		One-leg sit-up		
		Leg curl (hamstring)		
		Calf raise		
		Toe raise		
Cool-down		Bicycle		10 min

SLR: straight leg raising, RM: repetition maximum

SPSS for Windows 12.0 (IBM SPSS, Chicago, IL, USA) was used for the statistical data analysis. General characteristics of the subjects and all variables in the 2 groups were computed and expressed as means ± standard deviations. A paired t-test was used to compare muscle strength of the knee joint and hip abductor and to verify differences in the balancing capacity within each group before and after exercise. An independent t-test was used to analyze muscle strength in the knee joint and hip joint and verify differences in the balancing capacity. A p-value of ≤0.05 was considered statistically significant.

RESULTS

In this study, the muscle strengths of the knee flexor before and after exercise were 70.69 ± 30.40 Nm and 84.04 ± 29.70 Nm, respectively, in the CG, and 68.95 Nm ± 20.26 and 90.69 ± 27.24 Nm, respectively, in the GREG. A significant statistical increase after exercise was observed within each group. However, the groups did not differ significantly in terms of muscle strength of the knee flexor.

The muscle strengths of the knee extensor before and after exercise were 96.93 ± 42.56 Nm and 127.93 ± 42.14 Nm, respectively, in the CG, and 99.63 ± 48.19 Nm and 140.08 ± 42.07 Nm, respectively, in the GREG. A significant statistical increase in muscle strength of the knee extensor was observed after exercise within each group. Nevertheless, the groups did not differ significantly with regard to muscle strength of the knee extensor (Table 3).

The muscle strengths of the hip abductor before and after exercise were 60.18 ± 10.30 Nm and 69.03 ± 11.55 Nm, respectively, in the CG, and 58.00 ± 14.81 Nm and 81.76 ± 16.34 Nm, respectively, in the GREG. A significant increase in muscle strength of the hip abductor was observed after exercise within each group. In addition, the groups differed significantly with regard to muscle strength of the hip abductor ($p < 0.05$) (Tables 3 and 4).

Balance analyses revealed that the balance scores before and after exercise were 153.33 ± 271.85 and 602.50 ± 211.26, respectively, in the CG, and 154.50 ± 217.13 and 687.91 ± 136.83, respectively, in the GREG. Both groups exhibited a significant increase in balancing capacity after exercise. However, there was no significant difference in balancing capacity between these groups (Table 3).

DISCUSSION

The present focus was the muscles of the knee joint after meniscal injury. However, this study also attempted to determine the effect of hip muscle strengthening on knee joint muscle strength and balance after meniscal injury. Jacobs et al.[7] reported that a decrease in hip abductor muscle strength reduces proximal control in the hip joint, thus causing a decrease in exercise dynamics of the knee joint.

Hamberg[14] asserted that after surgery, (1) the maximum knee extensor muscle strength recovers to the preoperative level

Table 3. Comparison of the knee flexor, knee extensor, and hip abductor strengths and balancing capacity before (pre) and after exercise (post) in the 2 study groups (unit: Nm)

	Group	Pre	Post
Knee flexor	GREG*	68.9±20.3	90.7±27.2
	CG*	70.7±30.4	84.0±29.7
Knee extensor	GREG*	99.6±48.2	140.1±42.1
	CG*	96.9±42.6	127.9±42.1
Hip abductor	GREG*	58.0±14.8	81.8±16.3
	CG*	60.2±10.3	69.0±11.5
Balancing capacity	GREG*	154.5±217.1	687.9±136.8
	CG*	153.3±271.9	602.5±211.3

*$p < 0.05$
CG: control group, GREG: gluteus medius resistance exercise group

Table 4. Comparison of the involved hip abductor strengths in the 2 study groups (unit: Nm)

	GREG	CG
Involved hip abductor	81.8±16.3	69.0±11.6

*$p < 0.05$
CG: control group, GREG: gluteus medius resistance exercise group

in 4–8 weeks, (2) the knee flexor muscle strength completely returns to the preoperative level in 6 weeks, and (3) the flexor muscle recovers strength more rapidly than does the extensor muscle.

In a study of the effect of a 6-week isometric exercise program in patients with meniscal injury, Kim et al.[15] reported a lack of a significant statistical difference between the maximum flexor and extensor muscle strengths at 60°/s. Another study reported that the implementation of a 12-week rehabilitation exercise program after anterior cruciate ligament reconstruction surgery engendered muscle strength deficits of 10.8% and 12.2% for the extensor and flexor, respectively[16]. Yet another study reported that the implementation of a 24-week rehabilitation exercise program for male soccer players yielded muscle strength deficits of 7.9% and 3.7% for the extensor and flexor, respectively[17]. These authors also reported that the same 24-week rehabilitation exercise resulted in muscle strength deficits of 17.6% and 12.5% for the extensor and flexor, respectively, in female soccer players.

The present study, which was conducted for an 8-week period after surgery, yielded the following knee flexor muscle strengths before and after exercise: 70.69 ± 30.40 Nm and 84.04 ± 29.70 Nm, respectively, for the CG and 68.95 ± 20.26 Nm and 90.69 ± 27.24 Nm, respectively, for the GREG. The knee extensor muscle strengths before and after exercise were 96.93 ± 42.56 Nm and 127.93 ± 42.14 Nm, respectively, in the CG and 99.63 ± 48.19 Nm and 140.08 ± 42.07 Nm, respectively, in the GREG. The hip abductor muscle strengths before and after exercise were 60.18 ± 10.30 Nm and 69.03 ± 11.55 Nm, respectively, in the CG and 58.00 ± 14.81 Nm and 81.76 ± 16.34 Nm, respectively, in the GREG. Statistically significant increases in strength after exercise appear to support the results of previous studies.

With respect to intergroup differences, only the before- and after-exercise hip abductor muscle strength differed significantly, with values of 69.03 ± 11.55 Nm for the CG and 81.76 ± 16.35 Nm for the GREG. This result was attributed to the fact that this part of the experiment was performed 8 weeks after surgery. The assumption is that concurrent exercises involving other muscles, in addition to the hip abductor exercises, led to a lack of significant differences in knee flexor and knee extensor strength.

The proprioceptors are perceptive receptors that transmit stimuli from the skin, muscles, tendons, and joints to the central nervous system.

These stimuli transmit information about the locations of body parts for the control of tendon and muscle activities. Proprioceptors are distributed in the Golgi tendon organ, muscle spindle, and joint receptor areas and provide input data to the central nervous system. The scientific literature indicates that proprioception and postural control are of great importance for optimal sports injury prevention[18], and proprioceptors play an important role in a patient's exercise execution[19]. Injury to the lower extremities was reported to decrease the proprioceptive (position sense) capacity in the injured area and increase the threshold value[20]. As proprioception prevents injury and restores damaged movement sensations, it is emphasized in the rehabilitative process and recommended during the early phase of rehabilitation[21]. Lee[22] revealed that comprehensive exercise of the injured lower extremities resulted in a 60% improvement in muscle strength 14 weeks after surgery relative to the preoperative strength. In the present study, the measured balance scores before and after exercise 153.33 ± 271.85 and 602.50 ± 211.26, respectively, in the CG and 154.50 ± 217.13 and 687.91 ± 136.83, respectively, in the GREG. Although these within-group increases after exercise were significant, there was no significant intergroup difference.

The results of this study revealed that weakness of the knee flexor, the knee extensor, and hip abductor after injury to the lower extremities. The intragroup hip abductor and hip abductor muscle strengths and balancing capacity increased significantly; however, no significant intergroup differences were observed. Similar results were observed for all targets of the exercise program, except for the hip abductor muscle.

The results of this study suggest that this subject should be approached in light of the correlation between the hip abductor and injury to the lower extremities. Further study is needed to identify a method for ameliorating this exacerbation and a modality to allow recovery to the pre-injury exercise capacity.

REFERENCES

1) Uçar M, Koca I, Eroglu M, et al.: Evaluation of open and closed kinetic chain exercises in rehabilitation following anterior cruciate ligament reconstruction. J Phys Ther Sci, 2014, 26: 1875–1878. [Medline] [CrossRef]
2) Cho WS, Lee KC, et al.: Sports injury around knee joint. J Kor Sports Med, 2005, 23: 24–29.
3) McDermott ID: Meniscal tears. Current Orthopaedics, 2006, 20: 85–94.
4) Donald AN: Kinesiology of the Musculoskeletal System. Saint Louis: Mosby, 2004: 315–319.
5) Jaramillo J, Worrell TW, Ingersoll CD: Hip isometric strength following knee surgery. J Orthop Sports Phys Ther, 1994, 20: 160–165. [Medline] [CrossRef]
6) Griffin LY, Agel J, Albohm MJ, et al.: Noncontact anterior cruciate ligament injuries: risk factors and prevention strategies. J Am Acad Orthop Surg, 2000, 8: 141–150. [Medline]
7) Jacobs CA, Uhl TL, Mattacola CG, et al.: Hip abductor function and lower extremity landing kinematics: sex differences. J Athl Train, 2007, 42: 76–83. [Medline]

8) Judd DL, Eckhoff DG, Stevens-Lapsley JE: Muscle strength loss in the lower limb after total knee arthroplasty. Am J Phys Med Rehabil, 2012, 91: 220–226, quiz 227–230. [Medline] [CrossRef]
9) Inman VT: Functional aspects of the abductor muscles of the hip. J Bone Joint Surg Am, 1947, 29: 607–619. [Medline]
10) Fredericson M, Cookingham CL, Chaudhari AM, et al.: Hip abductor weakness in distance runners with iliotibial band syndrome. Clin J Sport Med, 2000, 10: 169–175. [Medline] [CrossRef]
11) Dwyer MK, Boudreau SN, Mattacola CG, et al.: Comparison of lower extremity kinematics and hip muscle activation during rehabilitation tasks between sexes. J Athl Train, 2010, 45: 181–190. [Medline] [CrossRef]
12) Gobbi A, Domzalski M, Pascual J, et al.: Hamstring anterior cruciate ligament reconstruction: is it necessary to sacrifice the gracilis? Arthroscopy, 2005, 21: 275–280. [Medline] [CrossRef]
13) Heckmann TP, Barber-Westin SD, Noyes FR: Meniscal repair and transplantation: indications, techniques, rehabilitation, and clinical outcome. J Orthop Sports Phys Ther, 2006, 36: 795–814. [Medline] [CrossRef]
14) Hamberg P, Gillquist J, Lysholm J, et al.: The effect of diagnostic and operative arthroscopy and open meniscectomy on muscle strength in the thigh. Am J Sports Med, 1983, 11: 289–292. [Medline] [CrossRef]
15) Kim AN, Kim YK, Won KH: Effects of Exercise rehabilitation after meniscus transplantation on muscular strength in knee joint. J Exerc Rehabil, 2010, 6: 129–137.
16) YK K: The effects of a 12-week exercise training program on ligament stability, knee function, and lysholm score after anterior cruciate ligament reconstruction. Seoul National University, 2002.
17) DY A: Effect of rehabilitative exercise on isokinetic muscle function and functional exercise performance in male and female soccer players with ACLR. Seonam University, 2013.
18) Romero-Franco N, Martínez-Amat A, Hita-Contreras F, et al.: Short-term effects of a proprioceptive training session with unstable platforms on the monopodal stabilometry of athletes. J Phys Ther Sci, 2014, 26: 45–51. [Medline] [CrossRef]
19) Neumann DA: Kinesiology of the hip: a focus on muscular actions. J Orthop Sports Phys Ther, 2010, 40: 82–94. [Medline] [CrossRef]
20) Corrigan JP, Cashman WF, Brady MP: Proprioception in the cruciate deficient knee. J Bone Joint Surg Br, 1992, 74: 247–250. [Medline]
21) Cooper RL, Taylor NF, Feller JA: A randomised controlled trial of proprioceptive and balance training after surgical reconstruction of the anterior cruciate ligament. Res Sports Med, 2005, 13: 217–230. [Medline] [CrossRef]
22) JC L: The effects of rehabilitative exercise on musculoarticular, proprioceptive functions and Lysholm score in athletes with meniscus repair. J Coaching Dev, 2006, 8: 219–227.