



Original Article

The effect of hip abductor exercise on muscle strength and trunk stability after an injury of the lower extremities

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Abstract. [Purpose] The gluteus medius, a hip abductor, controls femoral movement and stabilizes the pelvis during lower extremity mobilization. [Subjects] This study enrolled 24 subjects into control and experimental groups. [Methods] This randomized controlled study included patients who underwent arthroscopy after meniscus injury and started a rehabilitative exercise program 8 weeks after surgery. Subjects were divided into the experimental gluteus medius resistance exercise group (n=12) and the control group (n=12). The study investigated muscle strength and balance of the flexors, extensors, and abductors of the knee for 8 weeks. [Results] Strengths of knee extensors in patients who underwent rehabilitative exercise for 8 weeks were measured. Strength of the knee extensors of the experimental and control groups increased by 40% and 31%, respectively; strength of the hip flexors of the experimental and control groups increased by 31% and 18%, respectively. Strength of the hip joint muscles showed a 40% increase in the experimental group and a 14% increase in the control group. However, there was a significant difference (18%) in muscle strength of the hip abductors between the groups. Measurements of trunk lateral flexion showed a difference within a group, but no intergroup difference was found. [Conclusion] This study investigated the effect of hip abductor exercise on muscular strength and trunk stability in patients with a meniscus injury.

Key words: Gluteus medius, Trunk lateral flexion, Arthroscopy

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INTRODUCTION

Injuries of the anterior cruciate ligament and meniscus, the most typical injuries of the knee joint, make up a large proportion of cases¹⁾. A knee joint injury may lead to injury of the ankle, as well as the hip joint²⁾. The hip abductor is a muscle that plays an important kinesiological role in humans for standing on the feet and ambulating³⁾. The gluteus medius muscle controls movements of the femur and stabilizes the pelvis during mobilization of the lower extremities⁴⁾. The results of a study of muscular strength of the hip joint after a knee joint injury revealed that isometric muscle strength of the hip abductor, adductor, flexor, and extensor of an operated leg decreased by 12% to 25% in comparison with that of a leg that had not been operated on²⁾. The hip abductor muscles play an important biomechanical role in humans, and are an essential pivotal point in mobilization of body weight. A weakening of the hip joint has an effect on a closed mechanism by applying a suitable force through the sacroiliac joint. Such weakening may cause impairment in deep core muscles, such as the multifidus. Patients with weakened hip abductor muscles need a mobilization strategy to counteract such weakening. The induction of compensatory movements of the waist, the hip joint, and the knee joint require a suitable muscular kinetic strategy⁵⁾. A weakening of the gluteus maximus or the external rotator muscle of the hip joint increases the stress on the tibiofibular articulation, and increases the risk of injury to the anterior cruciate ligament (ACL)⁶⁾. Supplementary study on the gluteus

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maximus or the external rotator muscles is necessary. If the hip abductor muscles play the role of kinesiological control of the tibiofibular articulation in a forward facing position, these muscle groups would not show a significant difference in strength between the genders⁷⁾.

Researchers suggest that the role of the gluteus medius muscle is important in the kinesiological control of the hip joint, which has a great variety of directivities⁸⁾. Intermediate and posterior fibers of the gluteus medius muscle, in an open chain, play the role of abduction and external rotation of the hip joint⁹⁾. Theoretically, the centrifugal contraction of these fibers, which occurs during the period of the deceleration phase of closed chain activities, controls the abduction of the hip joint, and the scope of joint activities of internal rotation. If the strength of the gluteus medius becomes inadequate and weak during landing, the angle of abduction of the hip joint and that of external rotation increases. Thus, the torque of the tibiofibular articulation increases and an ACL sprain may occur.

A study by Wong¹⁰⁾ asserted that the movement of trunk lateral flexion could be achieved by lateral lumbar flexion, ipsilateral abduction of the hip joint, and contralateral adduction of the hip joint. On the basis of such movements, the author emphasized the importance of the relationship of mobility between the lumbar spine and the hip joint in understanding low back pain. The present study attempts to investigate the effect of exercise of the hip abductor on muscular strength and trunk stability of the lower extremities in patients with an injury of the lower extremities.

SUBJECTS AND METHODS

This study enrolled 24 subjects divided into two groups: the control group (CG) with 12 subjects, and the experimental gluteus medius resistance exercise group (GREG) with 12 subjects. In the CG, mean age was 40.1 ± 14.4 years, mean height was 172.8 ± 6.1 cm, and mean weight was 73.3 ± 10.9 kg. In the 12 male subjects in the experimental GREG, mean age was 38.7 ± 12.4 years, mean height was 173.8 ± 4.8 cm, and mean weight was 74.3 ± 9.0 kg. There were no significant differences in the general characteristics of subjects between these two groups ($p > 0.05$). All participants understood the purpose of this study and provided written informed consent prior to participation, in accordance with the ethical standards of the Declaration of Helsinki.

A device (ISO-Check, Germany) was used to measure the isometric muscle strength of the lower extremities. The ISO-Check device measures maximum and mean muscle strength. Patients were asked to sit on the device and use the fixed strip to attach the device to the chest. The mean muscle strengths of the knee flexor, extensor, and abductor were measured for 10 minutes in each direction to prevent compensation by the upper extremities. Nm is the unit of measurement.

A skin-surface device for the measurement of spinal range of motion, the SpinalMouse[®] (Idiag, Voletschwil, Switzerland), was utilized to measure the kinetic angle and flexibility of vertebral segments in the sagittal and frontal planes. It has shown satisfactory correlations and a high reliability coefficient (0.96) in functional radiology, as well as in comparative research^{11, 12)}. Spinal curvature on the first attempt was measured during relaxed standing by gliding the device manually down the back along the lateral aspect of the spinal processes from the 7th cervical vertebra to the 3rd sacral vertebra. Spinal curvature on the second attempt was also measured in the same way in full flexion of the trunk. Flexibility of the thoracic vertebrae was examined using the data collected from subjects before and after the exercise¹³⁾.

As suggested in studies by Gobbi¹⁴⁾ and Heckmann¹⁵⁾, the program for rehabilitative exercise after a meniscus injury was revised and reinforced to fit the scope of this study. The exercise program was carried out in 3 steps: warm-up, main training, and cool-down. This exercise program was implemented in 4 sets, repeated 12 times at 70% of maximum muscle strength. The entire duration of exercise was 60 minutes, performed 3 times a week for 8 weeks.

SPSS for Windows S12.0 was used for statistical analysis of the data. General characteristics of subjects and all variables of the two groups were computed and expressed as a mean \pm standard deviation. A paired t-test was used for muscle strength of the knee joint and hip abductor, and for verification of differences in balancing capacity within each group, before and after exercise. An independent t-test was used for the intergroup analysis of muscle strength of the knee and hip joint, and for verification of differences in balancing capacity. A p-value of 0.05 or less was considered statistically significant.

RESULTS

In this study, muscle strengths of the knee flexors in the CG before and after exercise were 70.7 ± 30.4 and 84.0 ± 29.7 , respectively, while those of the experimental GREG were 69.0 ± 20.2 and 90.7 ± 27.2 , respectively. The data showed a significant increase after the exercise within a group. However, there was no significant difference in muscle strength between these two groups. Muscle strengths of the knee extensor in the control group before and after the exercise were 96.9 ± 42.6 and 127.9 ± 42.1 , respectively, while those of the experimental GREG were 99.6 ± 48.2 and 140.1 ± 42.1 , respectively. Muscle strength significantly increased after the exercise within a group. However, there was no significant difference in muscle strength between these two groups. Muscle strengths of the hip abductor of the CG before and after the exercise were 60.2 ± 10.3 and 69.0 ± 11.6 , respectively, while those of the experimental GREG were 58.0 ± 14.8 and 81.8 ± 16.3 , respectively. The muscle strength significantly increased after the exercise within each group ($p < 0.05$). There was a significant difference in muscle strength between these two groups. In this study, the extents of trunk lateral bending on the side of an injured leg in the CG before and after exercise were 25.2 ± 10.2 and 27.5 ± 9.8 , respectively, while those of the experimental GREG were

25.9±10.4 and 30.7±9.7, respectively. The extent of trunk lateral bending after the exercise significantly increased within a group. However, there was no significant difference in the extent of trunk lateral bending after the exercise between these two groups. The extents of trunk lateral bending on the normal leg side in the CG before and after the exercise were 27.5±10.3 and 28.4±9.5, respectively, while those of the experimental GREG were 28.6±10.6 and 29.8±10.6, respectively. The extent of trunk lateral bending on the normal leg side showed no significant increase after the exercise within a group.

There was no significant difference in the extent of trunk lateral bending on the normal side between these two groups ($p>0.05$).

DISCUSSION

Recent studies have focused on the importance of the muscles concurring with the corresponding muscular angle of the hip joint. In particular, these studies were largely conducted with an emphasis on the gluteus medius with a purpose of injury prevention in the lower extremities¹⁶⁾. Jacobs¹⁷⁾ reported that diminished muscular strength of the hip abductor reduces controllability of the proximal aspect of the hip joint, and causes kinesiology weakening of the knee joint. Furthermore, instability of the lumbar vertebrae is one of the significant causes of low back pain. The functional weakening of the hip abductor induces chronic lumbago and functional disability of the lower extremities¹⁸⁾. A study reported that not only pain reduction and the recovery of muscle strength but also securing of the range of joint movement are the most important tasks in order to gain stability and normal functionality of the knee joint in patients with an injury of the lower extremities¹⁹⁾. Sale²⁰⁾ reported that muscular strengthening, which occurs in the early phase of exercise for 4 to 6 weeks after an injury of the lower extremities, is attributed to neurologic adaptation. In this study, among patients who underwent a rehabilitative exercise program for 8 weeks after an injury to the lower extremities, the muscle strength of the knee extensor after exercise in the experimental group increased by 40%, while that of the control group increased by 31%. The muscle strength of the knee flexor after exercise in the experimental group increased by 31%, and that in the control group increased by 18%.

With respect to the results for the hip joint, the muscle strength of the subjects in the experimental group increased by 40%, and that of the control group increased by 14% within each group. There was a significant difference of 18% in muscle strength of the hip abductor on the injured side between these two groups. Only an exercise program of the hip joint produced a significant difference in the rehabilitation program. The results concur with those of previous studies. The Corrigan study reported that position sense decreased on the injured side and threshold levels increased after an injury of the lower extremities²¹⁾. Effective proprioceptive function prevents injuries and recovers damaged motor sensation. This is emphasized in rehabilitative processes, and proprioceptive training in the early phase of rehabilitation is recommended²²⁾. Fujisawa et al.²³⁾ reported development of the gluteus maximus muscle after carrying out a training program for improvement of muscle strength of the lower extremities. They also asserted that the development of the gluteus maximus muscle had an effect on the improvement of self-balancing capacity. The results in this study showed that there was a difference of 0.7% in balancing capacity between the experimental group and the control group before the exercise program (experiment). However, there was a difference of 12% in balancing capacity between these two groups after the exercise program (experiment). Therefore, with continuous application of the 8-week rehabilitative program, the muscle strengths and balancing capacities of the abductors of the knee and hip joints improved. These results may support those of previous investigations. However, another study was conducted on athletes to investigate the correlation between imbalance of the hip joint muscles and development of low back pain. The results of this study revealed that changes in left-and-right balancing abilities of the hip muscles were correlated with the load of body weight, form, lateral dominance, and gender, but were not correlated with the muscle strength of the abductor of the hip joint²⁴⁾.

In this study, the measured results of trunk lateral bending showed a difference within each group, but revealed no difference between these two groups. These outcomes concur with the results of previous studies, but further study on a correlation between the hip extensor and the trunk is necessary.

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