



Original Article

The effects of standing balance in anteroposterior and mediolateral directions on knee strengthening in post-total knee replacement

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Abstract. [Purpose] The purpose of this study was to examine the association between muscle-strengthening exercises applied to the knee extensor muscles and the maintenance of standing balance in both, the anteroposterior and mediolateral directions in patients who had undergone total knee replacement. [Subjects and Methods] Thirty patients who underwent total knee replacement with bilateral artificial joints participated in this study. During the eight-week study period, the load on the knee extensors was gradually increased, and the standing balance ability was measured by differentiating the anteroposterior and mediolateral directions both, before and after the experimental period. [Results] In both, the anteroposterior and the mediolateral directions, there were statistically significant increases after the eight-week experiment, with a 29% increase in standing balance maintenance in the anteroposterior direction and a 22% increase in the mediolateral direction. [Conclusion] In patients who underwent bilateral total knee replacement, strengthening exercises applied to the knee extensor muscles with gradually increasing load positively affected standing balance in both anteroposterior and mediolateral directions.

Key words: Total knee replacement, Balance, Knee exercise

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INTRODUCTION

Total knee replacement (TKR) is frequently used for functional improvement, pain reduction, and dynamic alignment of the legs in patients with osteoarthritis (OA)¹⁾. This study examined gait patterns in an OA group that had undergone surgery six months previously and in a control OA group that had not received surgical treatment. The postoperative surgical group tried to maintain the center of gravity in movement strategies on a sagittal plane. The control group, while still in pain, maintained the center of gravity using the same movements²⁾. In a previous study, female OA patients increased strength of the knee extensor muscles through a home training program, which was helpful in increasing postural stability and decreasing the fear of falling³⁾.

A previous study of OA patients showed that the activity of the hamstring muscle was high, and that balance of muscle co-contraction through strengthening of the antagonistic quadriceps femoris muscle was important for normal weight-bearing and prevention of gradual transformation⁴⁾. Tanaka et al.⁵⁾ suggested including a change in period and frequency in a strengthening exercise program for OA patients. Muscle strength of the lower limbs and the co-activation of knee extensors and flexors was important in the early rehabilitation process after TKR surgery, with an important effect on the formation of postoperative muscle activation patterns⁶⁾.

A previous study of elderly subjects found that the quadriceps femoris muscle provided strength in major motions, such as sitting, standing, and walking. In particular, the results indicated that muscle-strengthening exercises of the knee extensors

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are important for obtaining dynamic stability in the lower limbs⁷).

The purpose of the present study was to examine the relationship between increased muscle strength and standing balance ability in both anteroposterior and mediolateral directions by applying gradually increasing loads to the knee extensor muscles of patients who underwent TKR.

SUBJECTS AND METHODS

Thirty patients less than 65 years of age who had undergone bilateral TKR for OA were included. Surgeries had been performed four to six weeks before the study. Subjects had no difficulty in standing or balancing ability caused by neurological diseases, vestibular organ involvement, or visual and sensory disorders. The subjects were able to flex the knee joint to 90° and completely extend it in passive range of motion.

The general characteristics of the subjects were as follows: age, 62.17±2.39 years; height, 160.07±4.43 cm; and weight, 64.87±5.65 kg. All patients understood the purpose of this study and provided written informed consent prior to their participation, which was in accordance with the ethical standards of the Declaration of Helsinki.

Training to strengthen the knee extensor muscles was conducted by gradually increasing loads at 0 kg, 1 kg, 2 kg, and 4 kg, excluding the weight of the legs below the knees in a sitting posture. Additional loads were attached above the ankle joint at both the medial and lateral malleoli. The exercise was conducted with flexion between zero and 90° without pain, for 10 minutes per session, twice a day for eight weeks. When muscle fatigue was felt, sufficient resting time was provided, and the exercise was resumed. Thermal therapy was applied to the extensor muscles for 20 minutes, while cold therapy was concurrently applied to the knee joints for 10 minutes. Eight weeks before and after the experiment, the My Fitness Trainer (MFT) balance measurement device (MFT, Austria) was utilized to measure the ability to maintain balance in a standing posture in both, the anteroposterior and mediolateral directions. The ankles were fixed with an elastic band in order to minimize compensation by the ankle joints.

Paired t-test was performed to compare measurements before and after the experiment. The significance level was set at $p < 0.05$. The PASW Statistics 18.0 version was utilized.

RESULTS

The results of the eight-week experiment showed that both the anteroposterior and mediolateral directions achieved statistically significant increases ($p < 0.05$). The anteroposterior direction increased by 29%, from 4.87±0.97 (mean ± SD) before the experiment to 6.27±0.91 after the experiment. The mediolateral direction increased by 22%, from 4.97±0.72 before the experiment to 6.07±0.83 after the experiment.

DISCUSSION

The purpose of this study was to examine the effects of knee extensor muscle strengthening exercise on both anteroposterior and mediolateral standing balance in patients who had undergone TKR with artificial joints for OA. A recent study reported that a knee extensor strengthening exercise program decreased pain in OA patients⁸. Takaki⁹ reported that TKR decreased knee pain, and increased movement, gait distance, and stair climbing and descending after three months, knee extensor muscle strength after six months, and range of motion after one year.

A previous study examined groups with and without ankles fixed to measure postural maintenance ability; muscle activity of the rectus femoris and gastrocnemius was increased in the group with fixed ankles. Thus, the rectus femoris, a knee extensor muscle, exhibited much activity in the maintenance of balance¹⁰. Accordingly, the present study also fixed the ankles in order to maximize the action of the knee extensor muscles and restrict ankle compensation. Balance ability was measured before and after the experiment. However, in consideration of safety, this study employed an elastic band that allowed some movement of the ankles.

In a study that applied isometric exercises in patients with mild degenerative arthritis in the knee and in healthy controls, there was little difference in the increased range of motion and the thickness of the thigh muscles; however, the decreased muscle strength restricted function in the patient group¹¹. Donna et al.⁷ noted that strengthening of the quadriceps in elderly subjects contributed to the dynamic stability of the body, with increased gait speed and stride length. The amount of linear momentum in the anteroposterior direction was also increased, but there was no significant correlation with lateral linear momentum. In the present study, there was a significant increase in the ability to maintain balance in both, the anteroposterior and mediolateral directions. However, the increase was greater in the anteroposterior direction, which supported the results of a previous study.

In conclusion, the results showed that patients who underwent TKR increased their ability to maintain standing balance in both anteroposterior and mediolateral directions according to the strengthening of the knee extensors. However, more patients showed improved ability to stand in the anteroposterior direction than in the mediolateral direction. Because the duration of the experiment was eight weeks, the effects were difficult to differentiate from those of postoperative recovery. Therefore, future research should consider safety, and should also use an improved experimental method for a shorter period.

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