

Comparison of the Activity of the Gluteus Medius According to the Angles of Inclination of a Treadmill with Vertical Load

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Abstract. [Purpose] The purpose of this study was to compare the muscle activity of the gluteus medius according to treadmill inclination during gait with a vertical load on a treadmill. [Methods] Sixteen healthy subjects were recruited for this study. The subjects walked on a treadmill at inclination angles of 0, 5, and 10 degrees. [Results] Muscle activity of the gluteus medius increased at 5° compared to 0° treadmill inclination, though the difference was not significant. On the other hand, gluteus medius muscle activity significantly decreased in treadmill walking at an inclination of 10° compared to 5°. [Conclusion] Selective strengthening exercises using a 5° treadmill angle could be useful for patients experiencing gluteus medius weakness.

Key words: Vertical load, Gait, Gluteus medius

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INTRODUCTION

For smooth rhythmical alternating shifts, the muscle strength of the lower extremities is essential, and the improvement of the strength of these muscles is very effective at improving balance, speed, and distance during walking¹⁾. In particular, among the muscles of the lower extremities, the hip abductor plays an important role in maintaining the balance of the lower extremities in standing positions, in taking a step forward, and in adjusting strides. During single-leg stance in the gait cycle, since the entire weight of the lower extremity is supported by only one foot, the activities of the gluteus medius and the gluteus minimus, which are active in the single-leg stance phase, are very important²⁾. Patients with weakened gluteus medius cannot support their weight during the mid-stance phase, and, they tilt the pelvis toward the other side of their body. As a result, the pelvis on the other side of the body lowers, showing a Trendelenburg sign. Additionally, Fredericson et al.³⁾ reported that hip joint adduction and internal rotation might increase due to weakness of the gluteus medius, resulting in iliotibial band syndrome. Therefore, selective exercises for the gluteus medius, which plays a primary role in hip joint stability, are necessary for rehabilitation of the musculoskeletal system of the waist and lower extremities. Moreover, controlling

the unnecessary movements that occur during the exercises is recognized as being important during exercise therapy. For instance, the use of a pelvic compression belt during hip abduction in a side-lying position is a good method for preventing compensatory actions, including the reduction of the activation of the quadratus lumborum while activating the gluteus medius⁴⁾. Lee⁵⁾ also reported that walking on flat land with a vertical load equal to 1% of the body weight was effective for selective activation of the gluteus medius. Although various methods for selective reinforcement of the muscle strength of the gluteus medius have been studied recently, no study has been conducted regarding the angles of walking surface inclination. Walking on inclined planes not only occurs commonly in daily living, but it can also be a means of vertical migration that can replace stairs⁶⁾. Additionally, it requires more balance ability and postural control ability compared to walking on flat land⁷⁾. Therefore, diverse angles of inclination were used in this study, and the effect of inclination on the degree of activation of the gluteus medius during walking with a load of 1% of body weight was studied.

SUBJECTS AND METHODS

This study was conducted with 16 healthy young female subjects who had no functional disorders of their musculoskeletal system or nervous system, and could walk normally. The subjects voluntarily participated in the experiment after being given an explanation of the experimental method. All processes used in this study were harmless to the human body, and all subjects read and signed a written consent form. The subjects' mean age was 20.4 years,

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Table 1. Comparison of gluteus medius muscle activity with inclination (unit: %RVC)

	0°	5°	10°
GM*	777.28±449.53	864.68±503.90	662.30±444.00 [†]

*p<0.05, Mean±SD, GM: gluteus medius, VL: vertical load, [†]significant difference between 5° and 10° (p<0.05)

their mean height was 163.37 cm, and their mean weight was 55.8 kg.

The experiment began after having the subjects had walked freely on treadmill for five minutes so that their usual gait patterns could be observed. The speed was set to 2 km/h, which is a normal person's average walking speed. To determine the activity of the left gluteus medius, the degree of contraction of the gluteus medius during single support by the left foot was measured using electromyography. To eliminate order effects, the angles of inclination of the treadmill were randomly provided, and sufficient rests was provided between sets to minimize fatigue. In this study, a vertical load corresponding to 1% of body weight, which was measured with an electronic scale, was placed bilaterally 3 cm above the upper part of the lateral malleolus. Muscle activity of the gluteus medius was measured by MP36 (Biopac System Inc., USA). Treadmills (PRECOR c964i, USA) with inclinations that could be automatically adjusted were used. The data collected in this study were analyzed using SPSS version 19.0 for Windows. Repeated one-way ANOVA was used to compare the degrees of contraction of the gluteus medius between different angles of inclination. The Bonferroni correction was used as the post hoc test to examine differences between the groups. The significance level was chosen as 0.05

RESULTS

During walking on a treadmill, the muscle activity values of the gluteus medius at 0° and 5° were 777.28±449.53 and 864.68±503.90. Therefore, the muscle activity of the gluteus medius increased at the angle of inclination of 5°. However, the difference was not significant. The value of contraction at 10° was 662.30±444.00 a significant decrease from 5° (p<0.05). There was no statistically significant difference between 0° and 10° (p<0.05; Table 1).

DISCUSSION

In normal gait, the gluteus medius shows its maximum contractile force during mid-stance, in the single-leg stance phase. In the single-leg stance phase, the gluteus medius contracts efferently to restrict or decelerate the descent of the pelvis toward the swing phase side⁸. Selective reinforce training of the gluteus medius is helpful for improving the stability of the lower extremities and the trunk while minimizing compensatory actions⁴. Additionally, it can reduce the action of the quadratus lumborum, due to the weakening of the gluteus medius to prevent lateral tilting of the pelvis⁹. This study used various angles of inclination with 1% body weight to examine the effects of inclination on the degree of activation of the gluteus medius, to determine if the angle

of inclination could be usefully used for selective activation of the gluteus medius. The activity of the gluteus medius was higher at 5° than at 0° inclination, but the difference was not significant. However, the activity at 10° was significantly lower than that of 5° inclination (p<0.05). Therefore, although the gluteus medius is activated more when the angle of inclination is increased, than when walking on flat land, the application of excessively large angles of inclination decreases rather than increases the activation of the gluteus medius. This might occur because the angle of inclination has been increased excessively, inducing compensatory actions in other parts of the body, rather than activating the gluteus medius. The movements that appear when an agonist that moves a certain joint is weak, in which the agonist is replaced by a congener, or the agonist is over-activated, are called compensation movements, and these movements need to be controlled for accuracy of movement¹⁰. A previous study indicated that when the last swing phase is connected to the initial stance phase during walking on an ascending slope, the flexion of the hip joint and the knee joint increases¹¹. Walking on a slope requires more force to control the movements of the lower extremities when the slope of the ground increases. For example, a study conducted by Han¹² reported that while ascending stairs or slopes, the muscle activities of the medial gastrocnemius and the tibialis anterior increased. Additionally, in an analysis of the muscle activity of the trunk muscles and the quadriceps, Kim¹³ reported that the muscle activity of the quadriceps increased as the angle of inclination increased. The gluteus medius muscle regulated the pelvis of subjects at loads corresponding to 1% of their weight. However, when the load on the lower extremity during the swing phase was increased to 2% of the subject's weight, in addition to the gluteus medius muscle regulating the pelvis, the external oblique abdominal muscle and the internal oblique abdominal muscle acted together to stabilize the trunk and to raise the lower extremities¹⁴. The fact that the activity of the gluteus medius increased at 5° inclination compared to 0°, in the present study, means that appropriate angles are effective for selective activation of the gluteus medius. Therefore, for patients with weakened gluteus medius, engaging in gait training at angles of inclination of approximately 5° with 1% body weight should be helpful for selectively reinforcing the gluteus medius while simultaneously preventing compensation movements. Additionally, an inclination angle of 5° is more appropriate than no inclination or excessively large angles.

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