The Effect of a Vertical Load on Gluteus Medius Activity and Gait Characteristics during Walking

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Abstract. [Purpose] The present study examined the activity and the gait characteristics of the gluteus medius and the trunk stability muscles during the stance phase of gait on level ground when a vertical load corresponding to 0%, 1%, or 2% of body weight was placed on the lower extremities during the swing phase of the gait. [Methods] The subjects were 40 young males aged between 21 and 30 years. The vertical load, corresponding to 0%, 1%, 2% of weight, which was measured with an electronic scale, was placed bilaterally 3 cm above from the upper part of the lateral malleous. Electrodes were symmetrically attached to the gluteus medius, erector spinae, external oblique, and internal oblique muscles. [Results] There were significant differences in the activities of the left gluteus medius, bilateral external oblique, and right internal oblique muscles among the vertical loads of 0%, 1%, and 2% during gait. [Conclusion] Increases in vertical load were accompanied by changes in the activities of the internal and external oblique abdominal muscles to ensure the stability of the trunk under the different loads. Gait was only possible with the activity of the gluteus medius muscle and the trunk muscles resisting the different vertical loads rather than activating other muscles of the lower extremities in terms of energy efficiency.

Key words: Vertical load, Gait, Gluteus medius

INTRODUCTION

Dysfunction or weakness of the gluteus medius is related to diverse musculoskeletal diseases, including lumbar pain1, 2). The height of the hip joint is different in a person with lumbar pain, and radiating pain around the hip joint is due to weakness in the gluteus medius3). In a study of the ability to perform wall squat, pelvic drop, and wall press exercises to strengthen the gluteus medius, the muscle activity was highest during the wall press2). Samantha et al.4) conducted a lunge, single leg squat, and step up and over study and observed that gluteus medius activity was highest during the single leg squat. Lee et al.5) placed a vertical load on the lower extremities during the swing phase of gait and observed changes in the activity of the gluteus medius during the stance phase. They noted that the muscle activity increased when a vertical load weighing 0.5 kg was placed on the lower extremities during the swing phase and that the muscle activity decreased when a 1 kg load was used in place of the 0.5 kg load. In another study, strengthening of the gluteus medius muscle improved the movement of the lower extremities, preventing injury, and possibly decreased pain6).

The present study examined the activity and the gait characteristics of the gluteus medius and the trunk stability muscles during the stance phase of gait on level ground when a vertical load corresponding to 0%, 1%, or 2% of body weight was placed on the lower extremities during the swing phase of gait. The exercise methods used in the study can easily be performed in everyday life to selectively strengthen the gluteus medius.

SUBJECTS AND METHODS

The subjects were 40 young male university students aged between 21 and 30 years. The procedures of this study were harmless to the human body. All subjects read and signed a written consent form. In this study, a vertical load corresponding to 0%, 1%, or 2% of body weight, which was measured with an electronic scale, was placed bilaterally 3 cm above the upper part of the lateral malleous. The order of the load was decided randomly, and the load was affixed to each subject prior to the measurement. The gait test was conducted using an electromyography (EMG) pad. Five steps were taken, and after discarding the data of the first and last cycles, the average of the remaining three cycles were calculated. Sufficient exercise for natural gait was conducted. The measurements were made three times, and the average values were calculated. A wireless surface EMG TeleMyo 2400T (Noraxon Co., USA) was used to obtain the EMG values. The electrodes were symmetrically attached to the gluteus medius, erector spinae, external oblique, and internal oblique muscles7).

The activities of the bilateral gluteus medius, erector spi-
nae, external oblique, and internal oblique were compared among and within the different breathing patterns. One-way analysis of variance was used to examine the muscle activity of the lower extremities during the stance phase. As a post hoc test, the least significant difference was used. For the data analysis, SPSS version 18.0 was used. The significance level was chosen as 0.05.

RESULTS

There were significant differences in the activities of the left gluteus medius, bilateral external oblique, and right internal oblique during gait with vertical loads of 0%, 1%, and 2% of body weight (Table 1).

DISCUSSION

Lee et al. investigated changes in the activity of the gluteus medius muscle during the stance phase by placing a vertical load on the lower extremities during the swing phase. They noted that when a vertical load of 0.5 kg was placed on the lower extremities during the swing phase, the muscle activity increased compared to gait with no load, and that muscle activity with a 1 kg load decreased compared to that during gait with a 0.5 kg load. This study also compared the activity of the gluteus medius muscle during the stance phase when a 1 kg load corresponding to 1% body weight was placed on the lower extremities during the swing phase. We found that the gluteus medius muscle was significantly higher during 1% vertical load gait compared to 0% vertical load gait. The muscle activity during gait with the 2% vertical load was higher than during gait with the 0% vertical load, but lower than during the gait with the 1% vertical load. However, there was no significant difference in the gluteus medius activity between the 1% vertical load and the 2% vertical load. This result suggests that the activity of the gluteus medius muscle does not increase in proportion to the increase in the vertical load. In contrast, the activities of the internal and external oblique abdominal muscles significantly increased during gait with the 2% vertical load compared to gait with the 0% and 1% vertical loads. The external oblique abdominal muscle plays a role in the bending of the trunk, when it acts bilaterally. In the present study, the action of the external oblique abdominal muscle was significantly different between gait with the 0% and 2% vertical loads. During gait with the 0% and 1% vertical load, the activity of the gluteus medius muscle may have been more significant than that of the external oblique abdominal muscle, enabling gait with a vertical load on the lower extremities. However, under the 2% vertical load, providing a vertical load that was possibly greater than the muscle strength needed to move the gluteus medius muscle, may have forced the alignment of the trunk to the right in order to maintain gait, making the bilateral external oblique abdominal muscle act as trunk flexors, moving the trunk anteriorly.

When the external oblique abdominal muscle and the internal oblique abdominal muscle contract as individual muscles, the external oblique abdominal muscle acts as a rotator muscle on the opposite side of the trunk. Simultaneously, the internal oblique abdominal muscle acts in the same direction as the trunk. However, when the two muscles act together, the distance between one shoulder and the iliac crest on the opposite side decreases. In the present study, the right internal oblique abdominal muscle showed significant activity differences between gait with the 0% and 2% loads. When the left lower extremity was in the stance phase and the right extremity was in the maximal stance phase, the right internal oblique abdominal muscle and the right external oblique abdominal muscle acted together. Thus, 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 extremities. The gluteus medius muscle, which contracts simultaneously with the external oblique abdominal muscle and the internal oblique abdominal muscle, is a postural muscle that is necessary for stability when raising the heels during gait; it also regulates the pelvis in relation to the movement of the lower limbs.

The activation of the gluteus medius was accompanied

Table 1. Comparison of muscle activations of various vertical loads (unit: %RVC)

|       | 0%          | 1%          | 2%          |
|-------|-------------|-------------|-------------|
| GM*   | Left 483.74 ± 48.70 | 706.97 ± 67.75† | 597.88 ± 48.70 |
|       | Right 340.58 ± 41.21 | 329.40 ± 36.58 | 365.91 ± 43.51 |
| ES    | Left 345.39 ± 33.88 | 357.18 ± 37.63 | 361.48 ± 37.56 |
|       | Right 344.04 ± 27.35 | 358.18 ± 31.27 | 373.27 ± 33.17 |
| EO*   | Left 211.53 ± 13.14 | 221.89 ± 15.67 | 265.65 ± 19.40‡ |
|       | Right 216.79 ± 14.21 | 222.87 ± 18.36 | 276.51 ± 21.94‡ |
| IO*   | Left 192.74 ± 16.20 | 181.95 ± 9.46 | 213.81 ± 16.91 |
|       | Right 176.76 ± 13.82 | 190.38 ± 10.17 | 221.34 ± 14.29‡ |

*p<0.05, Mean ± SE, GM: gluteus medius, ES: erector spinae, EO: external oblique, IO: internal oblique, VL: vertical load

†significant difference between 0% and 1% (p<0.05), ‡significant difference between 1% and 2% (p<0.05), †significant difference between 0% and 2% (p<0.05).
by changes in the activity of the internal oblique abdominal muscle and the external oblique abdominal muscle to ensure the stability of the trunk under the different conditions of gait at the various vertical loads. Gait was only possible with the activity of the gluteus medius muscle and the trunk muscles resisting the different vertical loads rather than activating other muscles of the lower extremities in terms of energy efficiency.

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