Mechanical Properties of the Bi-articular Muscle of the Thigh in Pedaling Motion

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Summary

Pedaling is widely used in fitness evaluations, health programs, and rehabilitation because it is a safe aerobic exercise, even for postoperative joint patients [1]. This study examined how heel and toe contact points during pedaling affect lower limb muscle activity and pedal reaction force. The results showed that joint angles change during pedaling and that bi-articular muscles do not function as parallel links but contribute to pedaling when using only the weight of the lower limbs.

Introduction

Pedaling is low risk of falls, it is widely used as a safe exercise method. Pedaling also plays an important role in physical fitness evaluations using ergometers, exercise programs, and rehabilitation. Previous studies have primarily recognized pedaling as an aerobic exercise, suggesting that it has only a limited effect on muscle strengthening.This study aims to clarify the effects of differences in heel and toe contact points during pedaling on lower limb muscle activity and pedal reaction force. By conducting electromyographic analysis during exercise using an ergometer, we examine how the parallel link function of bi-articular muscles influences rotational movement in pedaling.

Methods

To clarify the effects of differences in heel and toe contact points during pedaling on lower limb muscle activity and pedal reaction force, we conducted motion electromyographic analysis. The pedaling posture was defined with the trunk positioned vertically, ensuring that the body's center of gravity was aligned over the saddle. The pedaling load was set at 75 W, and data were recorded over a stable one-second period at 70 rpm. Muscle activity potentials of the lower limb muscles were measured using a surface bipolar electrode method, capturing voltage changes during muscle contractions. The ten recorded muscles included the gluteus maximus, vastus medialis, vastus lateralis, medial hamstrings, lateral hamstrings, rectus femoris, lateral gastrocnemius, medial gastrocnemius, tibialis anterior, and soleus. Muscle activity was recorded using an EMG measurement system , while posture changes during pedaling were captured using a camera. EMG data were recorded using an A/D converter with a sampling rate of 1 kHz. The camera frame rate was set at 120 fps.

Results and Discussion

Since similar trends were observed in the pedaling motion of three subjects with different output points, the results of a representative subject are shown in Figure 1. In these figures, posture P1 represents the pedal position at the bottom (180°), P5 represents the position near the top (0°), and P9 represents the bottom position (180°) again. In Figure 1, during pedaling with the toes as the output point, hamstring activity was observed between postures P2–P4. Additionally, vastus lateralis, vastus medialis, and rectus femoris activity was observed between postures P6–P8. In the lower leg, medial gastrocnemius and lateral gastrocnemius activity was observed between postures P8–P2.

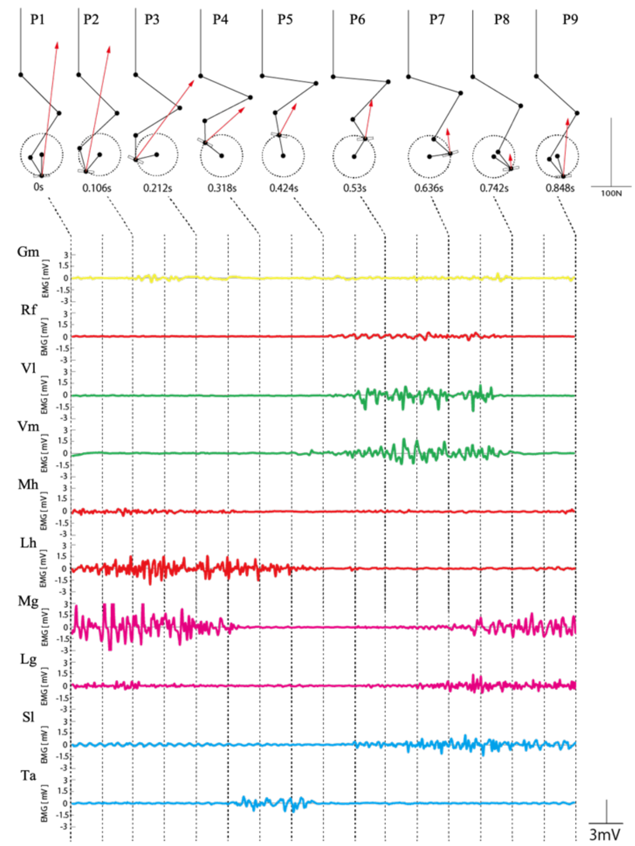

Figure 1: Electromyographic analysis of pedaling motion.

Conclusions

This study clarified the effects of different output points (toes and heels) on lower limb muscle activity and pedal reaction force during pedaling using motion electromyographic analysis. When the toes were used as the output point, significant activity was observed in the hamstrings and gastrocnemius muscles, suggesting the possibility that the gastrocnemius functions as a parallel link.

References

[1] W. Iriyama et al. (2024). *Journal of the Comprehensive Rehabilitation*, 52(9) : 965-972.