OPEN ACCESS

Journal of Science & Cycling
Breakthroughs in Cycling & Triathlon Sciences

Conference Abstract

Science and Cycling Conference, Lille 2025

Effects of Different Inclines on Lower Limb Muscle Activation During Cycling

Yung-Hsiu Tseng [1], Wei-Lun Yen [1], Kung-I Chen [1], Hsin-Huan Wang [2], Zi-Jun Lin [2], Chia-Yi Lu [2], Wei-Chi Tasi [3,4], and Chia-Hsiang Chen [2,*]

Received: 2 March 2025 **Accepted:** 14 March 2025 **Published:** 19 November 2025

1 Department of Recreational Sport & Health Promotion, National Pingtung University of Science and Technology, Pingtung, Taiwan

2 Office of Physical Education, National Pingtung University of Science and Technology, Pingtung, Taiwan

3 Medicine Department, Zuoying Armed Forces General Hospital, Kaohsiung, Taiwan

4 Office of Superintendent, Gangshan Branch of Kaohsiung Armed Forces General Hospital, Kaohsiung, Taiwan

Correspondence

Chia-Hsiang Chen

Affiliation Office of Physical Education, National Pingtung University of Science and Technology, Pingtung, Taiwan

doof75125@gmail.com

Abstract

This study aimed to examine the effects of different inclines on lower limb muscle activation during cycling. Twelve university students (mean height: 170.6 ± 3.5 cm, mean weight: 67.8 ± 7.1 kg, mean age: 20.5 ± 0.4 years) participated in the study. Muscle activation of the rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius were measured using a DELSYS electromyography (EMG) system. A smart bicycle posture adjustment system was utilized to modify seat tube angles and handlebar positions. Participants completed cycling trials at three incline conditions—flat (0°), uphill (+5°), and downhill (-5°)—while maintaining a workload of 100 W and a cadence of 90 rpm. Repeated measures ANOVA was performed to analyze differences in muscle activation across inclines. The results indicated that rectus femoris, biceps femoris, and gastrocnemius activation was significantly higher during uphill cycling compared to flat and downhill conditions. Additionally, activation of these muscles was greater on flat terrain than during downhill cycling, whereas tibialis anterior activation did not differ significantly across inclines. These findings suggest that even a 5° change in incline alters lower limb muscle activation patterns, providing valuable insights for cycling training and biomechanics research.

Keywords

uphill; downhill; bike; cycling training

1 Introduction

Cycling routes typically involve various terrains, with the most common being flat roads, uphill slopes, and downhill slopes. Previous studies have reported that different inclines lead to varying levels of muscle activation (Brown, Kautz, & Dairaghi, 1996). Furthermore, research has shown that when cycling uphill, riders tend to shift their bodies forward on the saddle or lean their trunks forward to ensure sufficient rear-wheel traction while maintaining front-wheel contact with the ground (Fonda & Šarabon, 2012). This postural adjustment affects lower limb muscle force production during uphill cycling (Duc, Bertucci, Pernin, & Grappe, 2008; Enoka, 2008) and increases lower limb muscle utilization. However, most previous studies have focused on uphill cycling, with limited research evaluating all terrain conditions collectively. Therefore, this study aims to compare lower limb muscle activation across different cycling inclines, specifically flat terrain, uphill, and downhill.

2 Material and Methods

2.1 Participants

This study aimed to recruit 12 university students (mean height: 170.6 ± 3.5 cm, mean weight: 67.8 ± 7.1 kg, mean age: 20.5 ± 0.4 years) who regularly engaged in cycling (at least three times per week for a minimum of one hour per session). All participants were free from cardiovascular diseases and had no musculoskeletal injuries in the past year.

2.2 Equipment

2.2.1 Electromyography (EMG) System

A DELSYS EMG system was used to record muscle activity at a sampling rate of 2000 Hz. This surface EMG system employs a high-impedance (15 GΩ) preamplifier (CMRR 130 dB at 60 Hz, gain 100), with a frequency range of 0–4000 Hz and a cutoff frequency of -3 dB. Before electrode placement, the skin was shaved and cleaned with alcohol. The following muscles were monitored: rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius.

2.2.2 Smart Bicycle Posture Adjustment System

A computer-controlled bicycle posture adjustment system (GIANT DCF, Giant Manufacturing Co. Ltd., TWN) was used to modify seat tube angles and handlebar positions (Figure 1).

Figure 1. The smart bicycle posture adjustment system

2.3 Experimental Procedure

Participants were first set up in a standardized seating position, with the saddle height adjusted such that the knee flexion angle was 30° when the pedal was at the bottom dead center, and the trunk was flexed at a 45° angle relative to the horizontal plane. EMG electrodes were then attached to the muscle bellies of the rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius. Participants performed a 15-second maximal voluntary contraction (MVC) sprint for EMG normalization, followed by a 10-minute rest period before the formal trials. The cycling protocol involved three different inclines (flat: 0°, uphill: +5°, downhill: -5°) performed in a randomized order. Participants cycled at a workload of 100 W with a cadence of 90 rpm.

2.4 Data Processing

EMG signals were band-pass filtered (10–500 Hz), full-wave rectified, and smoothed using a low-pass filter at 6 Hz. EMG data were then normalized to the MVC values.

2.5 Statistical Analysis

A repeated-measures analysis of variance (ANOVA) was conducted to examine the effects of incline on rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius muscle activation. The significance level was set at $\alpha = .05$.

3 Results

Repeated-measures ANOVA revealed significant differences in muscle activation across inclines for the rectus femoris ($F = 21.333$, $p = .000$), biceps femoris ($F = 28.464$, $p = .000$), tibialis anterior ($F = 3.799$, $p = .035$), and gastrocnemius ($F = 19.594$, $p = .000$). Post hoc analysis indicated that rectus femoris activation was significantly higher during uphill cycling than on flat terrain ($p = .001$) and downhill ($p = .000$). Similarly, biceps femoris ($p = .001$) and gastrocnemius ($p = .014$) activation were significantly greater uphill than on flat terrain, and both muscles showed greater activation on flat terrain than downhill (biceps femoris: $p = .007$; gastrocnemius: $p = .011$). The tibialis anterior showed no significant activation differences across inclines ($p > .05$).

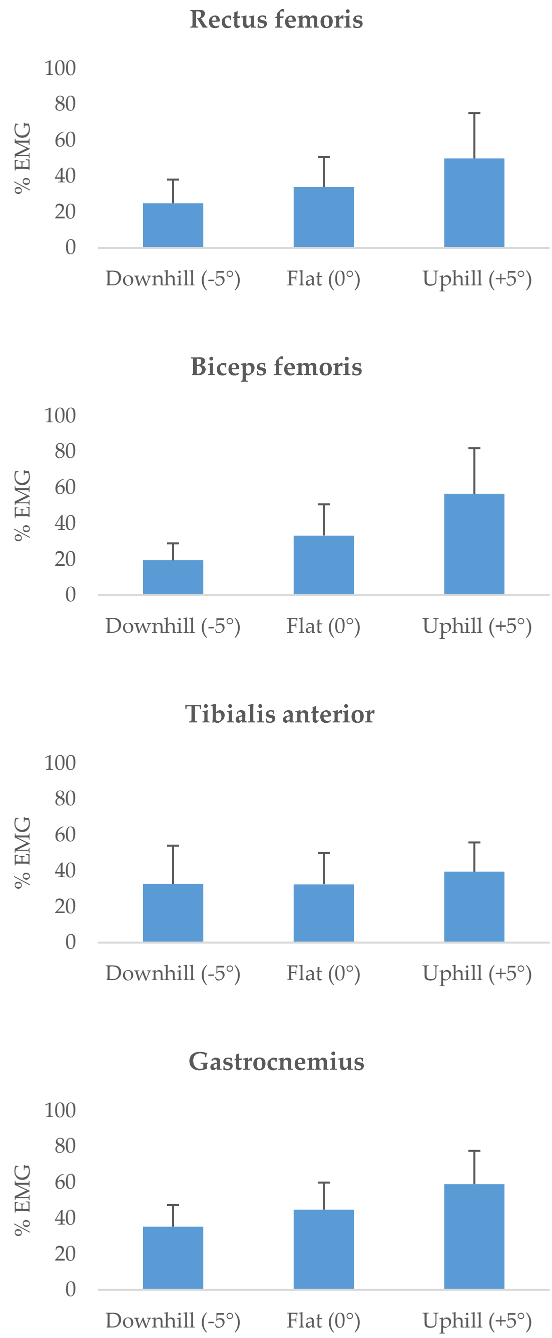

Figure 2. The different inclines on lower limb muscle activation during cycling

4 Discussion

The findings indicate that cycling incline affects the activation of the rectus femoris, biceps femoris, and gastrocnemius muscles but does not influence tibialis anterior activation. Previous research on elite cyclists has reported that different inclines influence the activation of the biceps femoris, vastus medialis, tibialis anterior, and gastrocnemius (Clarys, Alewaeters, & Zinzen, 2001; Duc et al., 2008). However, the present study found that in recreational cyclists, rectus femoris, biceps femoris, and gastrocnemius activation were influenced by incline, which differs slightly from previous findings. This discrepancy may be attributed to differences in cycling experience.

5 Conclusions

This study demonstrates that even a slight incline change of 5° can significantly affect muscle activation patterns, with potential implications for cycling performance, training optimization, and injury prevention.

Funding: This work received support from the National Science and Technology Council of Taiwan under Grant Numbers NSTC 113-2410-H-020 -004 -MY2 and NSTC 112-2622-8-003 -005 -SP

Acknowledgments: Thanks for the National Science and Technology Council of Taiwan.

Conflicts of Interest: The authors declare no conflict of interest.

References

Brown, D. A., Kautz, S., & Dairaghi, C. (1996). Muscle activity patterns altered during pedaling at different body orientations. Journal of biomechanics, 29(10), 1349-1356.

Clarys, J., Alewaeters, K., & Zinzen, E. (2001). The influence of geographic variations on the muscular activity in selected sports movements. Journal of Electromyography and Kinesiology, 11(6), 451-457.

Duc, S., Bertucci, W., Pernin, J., & Grappe, F. (2008). Muscular activity during uphill cycling: effect of slope, posture, hand grip position and constrained bicycle lateral sways. Journal of Electromyography and Kinesiology, 18(1), 116-127.

Enoka, R. M. (2008). Neuromechanics of human movement: Human kinetics.

Fonda, B., & Šarabon, N. (2012). Biomechanics and energetics of uphill cycling: A review. Kinesiology, 44(1.), 5-1.