

The Effects of Different Indoor and Outdoor Cycling Environments on Lower Limb Muscle Activation

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Abstract

This study investigates the effects of different indoor and outdoor cycling environments on lower limb muscle activation. Eighteen female participants performed both indoor and outdoor cycling while a wireless electromyography (EMG) system recorded muscle activation in the rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius of the dominant leg. The outdoor route included downhill, flat, and uphill sections, while the indoor setup matched the outdoor gradients and resistance levels. A paired-sample t-test compared muscle activation between conditions. Results showed that rectus femoris and gastrocnemius activation was significantly higher during indoor cycling. These findings suggest that cycling environment influences muscle activation, particularly in the rectus femoris and gastrocnemius, which may have implications for training strategies and performance optimization.

Keywords

Bike; downhill; flat; uphill



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1 Introduction

Cyclists often incorporate indoor cycling as part of their training regimen to enhance outdoor cycling performance (Shao, Tsai, Lin, Shiang, & Chen, 2023). Previous studies have found that indoor and outdoor cycling do not affect lower limb kinematics (Neumeister & Litzenberger, 2021). However, differences exist between indoor and outdoor cycling environments, which may influence lower limb muscle activation. Therefore, this study aims to examine the effects of different cycling environments on lower limb muscle activation.

2 Material and Methods

2.1 Participants

Eighteen female participants (mean height: 163.3 ± 4.8 cm, mean weight: 57.9 ± 7.2 kg, mean age: 20.5 ± 0.8 years) were recruited for this study.

2.2 Equipment

A wireless electromyography (EMG) system was used to measure muscle activation in the dominant leg, specifically the rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius (Wei-Chi, Tse-Fu, Yin-Shin, & Chia-Hsiang, 2019), during both indoor and outdoor cycling. The outdoor cycling route included downhill, flat, and uphill sections, while the indoor cycling setup was adjusted to match the outdoor gradients and resistance levels.

2.3 Standardized Seating Position

The participants maintained a standardized cycling posture, with the knee flexed at 30° when the right foot reached the bottom dead center and the trunk inclined at approximately 45° relative to the horizontal.

2.4 Experimental Procedure

Participants were first positioned according to a standardized seating setup. EMG electrodes were placed on the muscle bellies of the rectus femoris, biceps femoris, tibialis anterior, and gastrocnemius. To normalize EMG signals, each participant completed a 15-second maximal voluntary contraction (MVC) sprint, followed by a 10-minute rest period. The main cycling trials consisted of two conditions—indoor and outdoor cycling—administered in a randomized sequence. During both conditions, participants cycled at a consistent workload of 150 watts and maintained a cadence of 90 revolutions per minute (rpm).

2.5 Data processing

The EMG signals underwent band-pass filtering between 10 and 500 Hz, followed by full-wave rectification. Afterward, a 6 Hz low-pass filter was applied to smooth the data. Finally, all EMG values were normalized based on each participant's maximum voluntary contraction (MVC).

2.6 Statistical Analysis

A paired-sample t-test was conducted to compare lower limb muscle activation between indoor and outdoor cycling conditions, with the significance level set at $\alpha = .05$.

3 Results

The results indicated that muscle activation of the rectus femoris and gastrocnemius was significantly higher during indoor cycling compared to outdoor cycling ($p < .05$). However, no significant differences were observed in the activation of the biceps femoris and tibialis anterior between the two conditions ($p > .05$).

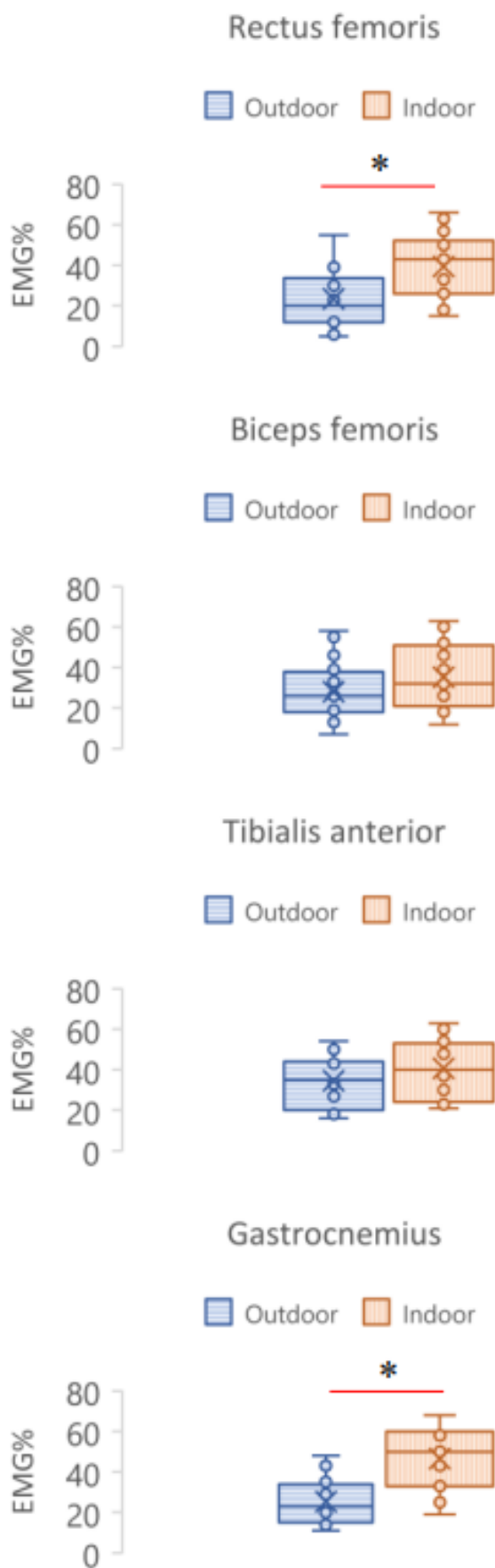


Figure 1. The different cycling environments on lower limb muscle activation.

4 Discussion

The results of this study indicate that indoor and outdoor cycling influence lower limb muscle activation. Additionally, past research has shown that there are differences in power output between indoor and outdoor cycling (Lipski, Spindler, Hesselink, Myers, & Sanders, 2022). Therefore, the results of indoor cycling may not be directly applicable to actual riding conditions.

5 Practical Applications

Understanding how different cycling environments affect lower limb muscle activation can help coaches, athletes, and rehabilitation professionals optimize training and performance outcomes. The significantly higher activation of the rectus femoris and gastrocnemius muscles during indoor cycling suggests that indoor setups may place greater demands on certain muscle groups.

This information can be used to design targeted training programs that either simulate outdoor conditions more accurately or purposefully emphasize specific muscle activation. Furthermore, when transitioning between indoor and outdoor cycling, athletes and practitioners should be aware of these neuromuscular differences to minimize injury risk and ensure performance consistency. For rehabilitation, indoor cycling may offer controlled settings for strengthening specific lower limb muscles before returning to outdoor cycling.

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

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