Feasibility of a New Ergometer Capable of Tilting the Pedaling Plane for Target-Specific Rehabilitation

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INTRODUCTION: The pedaling motion of conventional bicycle ergometers is limited to the sagittal plane, thereby lacking effective facilitation of synergistic muscles in the coronal or axial plane. To address this limitation, we developed a novel Tilted-Plane Ergometer that allows for the alteration of pedaling motion by tilting the pedaling plane and adjusting the pedal orientation. The purpose of this study was to conduct a preliminary investigation to determine whether adjusted pedaling trajectories and pedal positions can indeed alter the recruitment patterns of lower limb muscles.

METHODS: The study involved four task configurations: neutral (NEU) same as the conventional stationary bike, abduction pedaling plane with pedal eversion and internal rotation (ABE), abduction pedaling plane with pedal inversion and external rotation (ABI), and adduction pedaling plane with pedal inversion (ADI). Data were collected from 28 able-bodied participants using surface electromyography (EMG) sensors placed on 12 lower limb muscles. Signal processing techniques were employed to normalize the time trace data, allowing for qualitative analysis of recruitment patterns. The ratio of mean EMG values during entire pedaling cycles, compared to the NEU, was calculated for statistical analysis. Repeated measures analysis of variance with a Bonferroni post-hoc test was used for the analysis.

RESULTS: The ABE configuration showed distinct peaks of activation for the Gluteus Medius (Gmed) during both the power and recovery phases, while the Tensor Fascia Lata (TFL) exhibited a gradual increase with a high peak solely in the recovery phase. Furthermore, the ABE condition demonstrated a significant shift in the recruitment pattern of the Biceps Femoris lateral head compared to the NEU condition, with increased activation from the latter power phase to early recovery phase. Statistical analysis indicated significant recruitment of Gmed and TFL in the ABE condition ($p<0.001$), while the ADI condition showed increased activation of the hip adductor ($p=0.026$). Additionally, the ADI condition led to increased activity in the medial hamstring ($p=0.006$) and below-knee muscles ($p<0.05$), whereas a significant decrease in activity was observed in both the Vastus Medialis and Lateralis ($p<0.001$).

DISCUSSION AND CONCLUSION:

The findings of this study indicate that tilting the pedaling plane or adjusting the pedal orientation can result in altered muscle recruitment patterns and intensity. This suggests the potential for implementing targeted rehabilitation approaches for patients with lower limb dysfunction. However, further studies are necessary to investigate the clinical effects of the device on patients in order to validate its efficacy and practical application in rehabilitation settings.