Assessment of Muscle Activity During Uphill Propulsion in a Wheelchair Equipped with a Anti-Rollback Module

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Abstract:

Uphill propulsion in a wheelchair is one of the most demanding and high-risk maneuvers, imposing significant strain on the musculoskeletal system. It often presents a challenge that limits the user's ability to function independently. Therefore, the development of assistive systems that enhance safety and facilitate uphill propulsion is crucial. The aim of this study was to compare the effects of different backward-locking module designs on muscular effort during uphill propulsion. The study analyzed three variants: a module with an elastic roller (EAR), a module with a rigid roller (SAR), and the absence of a locking module (NAR). The tests were conducted on a ramp with a 5° incline and a length of 6.3 m, involving a group of eight male participants. Muscular effort was assessed by analyzing several parameters, including normalized cumulative muscle load (CML), normalized muscle activity (EMGnorm), peak-to-mean EMG signal ratio, the number of pushes required to ascend the incline (np), and the average duration of the propulsion cycle (tpc). The results demonstrated that the use of a backward-locking module does not increase the muscular load and may even provide slight relief. For example, CML was reduced by 2.69% for the EAR module and 4.38% for the SAR module. Additionally, the implementation of the locking module resulted in an increase in the number of pushes, by 6.76% for the EAR module and 7.46% for the SAR module. A prolongation of the overall propulsion cycle duration (tpc) was also observed, with an increase of 30.33% for the EAR module and 13.93% for the SAR module. In conclusion, the use of a backward-locking module reduces muscular effort during uphill propulsion. This effect, combined with the module's primary function, contributes to improved comfort and safety for wheelchair users. The observed increase in propulsion cycle duration promotes smoother propulsion movements, which help minimize the risk of injuries caused by dynamic musculoskeletal strain.

Keywords:

Wheelchair, uphill propulsion, backward-locking mechanism, muscular effort, muscle activity.