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Evaluation of Muscle Activity During Downhill Descent in a Wheelchair Equipped with Anti-Rollback Module

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Abstract:

The design of a manual wheelchair requires the use of the muscular system to generate friction between the upper limb and the push rims for braking. During a downhill descent, gravitational force increases energy levels, raising the risk of injury when slowing the wheelchair. The backward locking module, in addition to its primary function, introduces additional rolling resistance, which can aid in controlled descent. The study aimed to compare the effects of different backward locking module designs—featuring an elastic roller (EAR), a rigid roller (SAR), and the absence of the module (NAR)—on muscle effort during wheelchair braking on a slope. The study was conducted on a ramp with a 5° incline and a length of 6.3 meters, involving a group of eight men. Muscle effort was assessed by analyzing parameters such as normalized cumulative muscle load per second of physical activity (CML/s), normalized muscle activity (EMGnorm), and the peak-to-mean ratio (PMR) of the EMG signal. The results demonstrated that using the backward locking module during descent reduces muscular strain, as indicated by CML/s and EMGnorm analyses. For the CML/s parameter, both the EAR and SAR modules led to a 29.41% reduction in effort compared to descending without the module. Regarding EMGnorm, the EAR module reduced average muscle activity during descent by 44.44%, while the SAR module reduced it by 50%. The PMR analysis revealed that the EAR module was the most favorable, with a coefficient of 4.78, whereas the SAR module had a value of 5.43, which was higher than in the absence of the backward locking module. In conclusion, using a backward locking module reduces muscular effort during downhill descent by utilizing increased rolling resistance. The study highlights that, despite being an undesirable physical effect for the module's primary function, this additional resistance has a beneficial impact on descent. Therefore, when adjusting the clamping force of the

backward locking module, a balance should be maintained between the generated resistance and its influence on uphill effort.

Keywords:

Backward locking module, downhill descent, muscle effort, safety, braking.