ABSTRACT SUBMISSION

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Effects of Ankle Brace Stiffness on Post-Stroke Gait Biomechanics: A Case Report

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ABSTRACT

Understanding how the mechanical characteristics of orthoses influence gait is essential for optimizing assistive device prescription. This study investigated the biomechanical responses to two ankle braces with varying stiffness in a male post-stroke participant (67 years old, 170cm height, BMI 22.5, left hemiparesis, 101 months post-hemorrhage stroke). Three conditions were evaluated at self-selected walking speed: 1) no brace (control), 2) high-stiffness brace (HSB), and 3) low-stiffness brace (LSB). Gait data were collected using a motion capture system (Vicon, Nexus 2.15) synchronized with six force plates (AMTI). Kinematic and kinetic data were processed using OpenSim (version 4.4) and Matlab. Gait performance was quantified using double stance time, ankle range of motion, ground reaction forces (GRF), lower-limb kinematics, and the muscle co-contraction index (CCI) between soleus and tibialis anterior.

duration increased from 48% of gait cycle (control) to 51% (HSB) and 55% (LSB). Ankle kinematics demonstrated improved foot drop during the swing phase, with superior correction observed in the highstiffness condition. The minimum swing ankle angle improved from −21.72° (control) to −9.06° (HSB) and −15.13° (LSB). At end of swing, the ankle angle increased from −0.31° (control) to 1.97° with the HSB but decreased to −5.82° with the LSB. The CCI on the paretic side during the stance phase increased from 0.6578 (control) to 0.8256 with the HSB but decreased to 0.4523 with the LSB. Both braces exhibited peak assistive force during the initial swing phase, with the HSB generating a greater peak force than the LSB. GRF analysis revealed differences during late stance. During the second double stance, the average vertical GRF increased from 273.2 N (control) to 273.9 N (HSB) and 290.3 N (LSB). Peak GRF also increased from 570.9 N (control) to 595.5 N (HSB) and 612.0 N (LSB), while full-stance impulse remained similar between control and HSB (22597.4 N·%gait cycle vs 22707.0 N·%gait cycle) but notably increased under the LSB condition (24803.6 N·%gait cycle). Proximal kinematics differed between conditions, the HSB increased hip flexion during the swing phase and introduced greater knee flexion during stance. Notably, both braces improved hip hiking during gait.

These results reveal stiffness-dependent biomechanical adaptations. Unchanged double stance time suggests neither brace improved gait confidence. The HSB provided consistent foot-drop correction throughout the swing phase. The LSB improved dorsiflexion during most of the swing phase but failed to maintain sufficient control during terminal swing. Conversely, CCI analysis indicated a functional trade-off: while the stiffer brace enhanced joint stability, the softer brace reduced muscular effort and led to greater ankle pushoff. Furthermore, alterations in hip and knee kinematics revealed distinct proximal compensatory strategies.

In summary, higher brace stiffness promotes joint stabilization at the cost of increased muscular energy and compensatory strategies, whereas lower brace stiffness facilitates push-off and efficiency but provides less motor control. These findings directly link brace mechanical properties to specific functional gait outcomes, highlighting the importance of tailored stiffness in neurorehabilitation.