Abstract for WMVC 2022

Title: A two-dimensional model to simulate the effects of ankle joint misalignments in ankle-foot-orthoses.

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Misalignment of an orthotic ankle joint with respect to the anatomical ankle joint leads to "pistoning motion" which is the relative sliding motion between a limb and its externally wearable orthosis. This pistoning motion and resulting pressure points are the cause of skin problems such as friction blisters, due to which an orthosis user experiences pain and discomfort. This work quantifies the effects of sagittal plane ankle joint misalignments in terms of relative motion between the limb and the orthosis. The proposed model also predicts pressure point locations on the limb. A 2D link segment model was developed using MATLAB (R2021b) software to simulate the relative motion between the limb and the orthosis for a functional range of ankle motion. The orthotic ankle joint was methodically misaligned with respect to the anatomical ankle joint in the Anterior-Posterior (A-P), Proximal-Distal (P-D) directions, and their combinations to simulate orthosis sliding and locate pressure points on the limb. Simulation results showed that A-P misalignments caused a significantly greater pistoning motion than P-D misalignments which agrees with previous studies. Combined misalignments (Anterior-Proximal, Anterior-Distal, Posterior-Proximal, and Posterior-Distal) were found to have a greater effect on overall relative motion between the limb and the orthosis as a result of superposition of relative motions from the A-P and P-D directions. The 2D model also predicts pressure point locations due to joint misalignment which supports the results from past literature. Simple 2D simulations presented in this work can be used to interpret the consequences of orthotic ankle joint misalignments. It further emphasizes the importance of accurate alignment of orthotic and anatomical ankle joints and provides insights for possible orthosis modification for improved user comfort. The model presents a way to study the effects of sagittal plane ankle joint misalignments for a range of ankle motion. Such a simulation-based model can be used to guide anatomical and external joint alignments in ankle foot orthoses and lower-limb exoskeleton devices.

Keywords: orthoses, ankle joint, biomechanics, exoskeleton, pistoning, misalignment