

DESIGN OF A NOVEL ANKLE JOINT FOR AN AFO FOR INDIVIDUALS WITH DROP-FOOT EVALUATED ON ABLE-BODIED SUBJECTS

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ABSTRACT

A common impairment of individuals post-stroke is drop-foot, a unilateral neurological deficit that prevents dorsiflexion, making it difficult to lift the toes to provide foot clearance during walking. Drop-foot is commonly treated orthotically; the prescribed ankle foot orthosis (AFO) limits ankle plantar flexion of the affected limb during swing, thereby preventing drop-foot. However, restricted ankle motion introduces additional gait pathologies during ambulation over level ground, pathologies that may be exacerbated on sloped surfaces and variable terrain. The goal of this study was to design a mechanical ankle joint integrated within an articulated thermoplastic AFO to permit enhanced motion during stance while preventing drop-foot. The research hypotheses are that this new orthotic ankle joint will improve temporal measures, ankle range of motion, and spatiotemporal symmetry between the lower extremities during stance and swing, while minimizing drop-foot and the compensatory mechanism of excessive knee flexion compared to a conventional design of joint for a post-stroke population. The intent of this preliminary study is to confirm readiness to proceed to post-stroke subject testing by demonstrating that the novel design is as efficacious as the conventional design in minimizing excess plantarflexion during swing and that the study protocol and test parameters are appropriate and feasible.

Comparative gait analyses were conducted on three able-bodied subjects. Trials included level, inclined, and declined walking on an instrumented split belt treadmill. The testing protocol included motion capture to characterize lower extremity joint kinematics. Walking trials were conducted to investigate two orthotic test conditions: 1) an articulated AFO with a double action ankle joint (conventional), and 2) the same AFO incorporating the novel ankle joint. Spatial and temporal symmetry, knee and ankle range of motion in the sagittal plane for the orthotic limb, and survey responses were compared for each orthotic condition to test the research hypotheses and evaluate the efficacy of the novel joint to treat drop-foot over three types of terrain. The treadmill walking trials demonstrated increased walking speed, ankle range of motion during stance, and spatiotemporal symmetry during both stance and swing for the novel ankle joint relative to the conventional orthotic ankle joint. Ongoing work includes overground walking trials for these able-bodied subjects as well as the recruitment of post-stroke individuals with drop-foot for whom treadmill and overground walking trials will also be conducted.

Keywords: orthosis, AFO, drop-foot, stroke patients

INTRODUCTION

After a stroke event, individuals commonly experience hemiplegia, which manifests as drop-foot, or the inability to actively lift the toes or dorsiflex the ankle [1]. This impairment limits the individual's walking ability, increasing their risk of tripping or adapting compensatory pathologic gait (e.g., prolonged stance on the non-paretic limb, decreased walking speed, increased knee flexion on the AFO side) [1]–[4]. Ankle foot orthoses (AFOs) are commonly prescribed to improve walking ability post-stroke.

AFOs are designed to provide stability and/or minimize pathologic motion of the foot and ankle; the structure and materials may vary to address specific treatment objectives. Articulated AFOs (custom thermoplastic molded footplate and calf sections linked by a mechanical ankle joint) are frequently prescribed to increase ankle range of motion (ROM) and enhance comfort while decreasing energy consumption relative to solid, non-articulated AFOs [5]–[7]. The level of plantar and dorsiflexion resistance or assistance is controlled through the orthotic ankle joint.