

DESIGN AND OPTIMIZATION OF VARIABLE STIFFNESS ANKLE FOOT ORTHOSES VIA FINITE ELEMENT ANALYSIS

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ABSTRACT

Ankle foot orthoses (AFOs) are commonly prescribed assistive devices which help amend pathologic walking patterns for neurologically impaired individuals. Adjusting an AFO's stiffness is a common tuning parameter for producing better clinical outcomes. However, current standard of care AFOs vary stiffness by modifying the trimline between heel and malleolus. Once stiffness is set, it is difficult to reverse the stiffness level because the modification is irreversible. There are commercially available AFOs with adjustable stiffness, however, their stiffness is only manually adjusted with the patient in a static position. This makes comparing musculotendon operating length with AFO stiffness challenging using standard visual methods. Therefore, the goal of this study is to develop an AFO with dynamically adjustable stiffness, using cantilever beam bending mechanics about different support positions. We used finite element analysis, via ANSYS, to calculate stiffness for varying cross-sectional dimensions and support positions on the beam, derived from known motion of the AFO during walking. This study shows that the illustrated AFO module design provides a variable range of stiffness, though the stiffness levels are lower than desired. Therefore, further testing and revision of the AFO module design is necessary to achieve the desired results.

Keywords: Variable Stiffness, Ankle Foot Orthoses, Finite Element Analysis

INTRODUCTION

Excessive muscle activation is common for neurologically impaired individuals, leading to atypical walking patterns[1,2]. Increased activation of the gastrocnemius during walking causes the muscle to shorten and tighten. As the gastrocnemius spans both the knee and ankle joints, shortening of the muscle causes excessive knee flexion and ankle plantarflexion during gait[3]. If this pathologic gait pattern is left untreated, it can cause secondary joint issues as well as further develop pathologic muscle characteristics.

Ankle foot orthoses (AFOs) are commonly prescribed to patients to improve pathologic walking patterns. A common tuning parameter for AFOs is dorsiflexion stiffness. Previous research has shown the appropriate dorsiflexion resistance can increase the operating length of the gastrocnemius, resulting in improved knee extension and ankle dorsiflexion during walking[3,4]. This suggests an optimally tuned AFO can aid rehabilitation in daily life. However, it is extremely challenging to prescribe the optimal stiffness level that maximizes muscle stretch due to an inability to tune AFO stiffness during dynamic tasks. The