A WALKING CANE WITH HAPTIC BIOFEEDBACK Reduces Degenerative Loading in the Arthritic Knee

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INTRODUCTION

Osteoarthritis (OA) is the most common joint disorder and the leading cause of ambulatory disability in adults. Specifically, it is thought that at least 37% of adults over the age of 65 exhibit evidence of knee OA [1].

The knee adduction moment (KAM) is commonly used as a proxy for loading in the knee’s medial compartment – the primary indicator of knee OA progression. Of particular interest are the KAM’s peak magnitude (PKAM) and the knee adduction angular impulse (KAAI), the KAM’s time integral. Although decreasing these metrics has been shown to reduce the symptoms of knee OA [3], patients often do not know how to properly use their walking aids to achieve such results. In response to these failings, attempts have been made to quantify and improve upon conventional walking aids’ ability to ameliorate the symptoms of knee OA through reduction of degenerative knee loading predictors [2].

In order to provide patients with a practical, intuitive solution to improve cane usage techniques, we have developed a walking cane with on-board haptic biofeedback, which alerts the user when an appropriate amount of weight has been applied to the cane. We hypothesize that participants who walk with the biofeedback cane will exhibit lower knee loading metrics than those walking with a conventional cane. The goal of this project is to develop a more effective walking cane that can better slow the progression of the degenerative OA, reduce pain, delay the need for surgery, and improve mobility.

METHODS

Persons with mild to moderate knee OA who had experience using walking canes were recruited to participate. Volunteers who had knee surgery within the past year or who had trouble completing 30 minutes of continuous aided walking were excluded. After an explanation of the IRB approved protocols and patient consent, participants completed an approximately 20-meter walking trial to establish a self-selected walking speed (SSW). Next, motion capture (MoCap) markers were placed using a modified Plug-In-Gait method, for collection of the KAM using Vicon and Visual 3D software [4].

Participants completed walking trials in five conditions for data collection: 1) a conventional cane with no instruction (naïve), 2a) a conventional cane with scale training, 2b) a conventional cane with no further instruction, 3a) the haptic biofeedback cane with an explanation of the feedback mechanisms, and 3b) the haptic biofeedback cane with no further instruction. Before the b) conditions, a five-minute break was taken to test instruction retention. The order of condition-sets 2 (2a/2b) and 3 (3a/3b), were randomized, to avoid a carryover effect.

RESULTS AND DISCUSSION

KAMs were calculated in Visual3D using inverse dynamics and exported to MATLAB for analysis and plotting. The grand-mean of five participant’s KAM during the stance phase in the arthritic leg for each condition was calculated (Fig. 1).

![Knee Adduction Moment vs. Condition](image)

Figure 1. Grand-mean adduction moment of the arthritic knee during stance phase, normalized to participant bodyweight (BW) and height (Ht).

The cane with haptic biofeedback was able to improve participants’ knee loading - both the average PKAM and KAAI decreased across conditions. The conditions implementing scale training or the biofeedback cane resulted in lower loading metrics than in the first naïve condition, which had no instruction or feedback mechanisms. During condition 1 (naïve), subjects exhibited an average, normalized PKAM of 2.18 ± 0.72 N-m/(BW*Ht) which decreased to 1.66 ± 0.63 N-m/(BW*Ht) in Condition 3b (biofeedback cane). Late-stance PKAM decreased when the biofeedback cane was used in the instruction retention trial, implying familiarity with the new feedback mechanisms may yield improved results. This study is ongoing and therefore grand mean results may change as more data is added. However, similar prior studies’ results give us confidence that these trends will hold as the study progresses [2].

Improving the design and usability of common walking aids through biofeedback serves the OA population by giving them the tools to better manage their condition rather than relying on more invasive surgical treatments.

REFERENCES