A KINETIC EVALUATION OF A NOVEL FOREARM CRUTCH DESIGN

Megan MacGillivray1,2, Ranita Manocha3, Bonita Sawatzky2,4
1Department of Rehabilitation Sciences, University of British Columbia, Vancouver, Canada, megank84@interchange.ubc.ca
2International Collaboration on Repair Discoveries, Vancouver, Canada
3Faculty of Medicine, University of British Columbia, Vancouver, Canada
4Department of Orthopaedics, University of British Columbia, Vancouver, Canada

INTRODUCTION
The forearm crutch enhances control during gait for individuals with mobility impairments [1]. Although forearm crutches have been used by individuals with long-term and short-term disabilities for centuries, there has been relatively little change in design compared to advancements in other forms of assistive devices.

Forearm crutches have evolved in an attempt to minimize the physical impact of crutch walking. Various adaptations have been made including incorporating a dynamic mechanism in the crutch to absorb impact. A new crutch design has been developed with a shock system to reduce the impact of crutch loading. It is thought that the dynamic mechanism decreases loading impact which will transfer to joints, thereby minimizing joint forces. The new dynamic shaft includes a urethane polymer which absorbs and returns energy. The new forearm crutch has also been developed with a ball-and-socket joint at the crutch foot. Other innovative highlights of the newly designed crutch include a lightweight carbon design and an ergonomically designed hand pad.

Despite the novel crutch design, it is uncertain how these new developments alter the biomechanics of forearm crutch gait. Therefore, the objective of this research is to determine the kinetic impact of two different models of the novel crutch design (one with the dynamic shaft and the other without) and determine how these models compare to a Traditional commercially available forearm crutch.

METHODS
Participants: Thirteen able-bodied individuals (5 males and 8 females) participated in this study.

Procedure: Three different crutches were compared: the SideStix™ Discovery (no shock with a Fetterman™ footpad), the SideStix™ Boundless (shock with a rotating footpad) and a Traditional model (typically sold in pharmacies).
Two force plates were used to measure ground reaction forces during the swing phase of swing-through gait. Participants walked approximately 6 meters crossing over the force plates. Data collection occurred until the participant landed with the left and right crutches on the corresponding forceplates for 5 trials. The force plates were sampled at 1000 Hz and data were low-pass filtered with a cut-off frequency of 50Hz using a fourth-order Butterworth filter.

Data Analysis: Peak force and impulse for the three-dimensional ground reaction forces were normalized to body weight and converted to units of percent body weight. Velocities were calculated for each trial. Each participant’s data was averaged across the 5 trials. Statistics were performed on the averaged data from all 13 able-bodied participants. A repeated measures ANOVA was used to determine differences between crutch types. Data from the left and right sides were combined for statistics involving peak force, impulse and time spent in the body swing-through phase. Bonferroni pairwise comparisons were used to determine which conditions were different when crutch type was significant.

RESULTS
Peak Force: There was a significant difference in peak values for braking and propulsive forces between crutch types (F=13.240, p<0.001). The Boundless crutch demonstrated a significantly smaller peak braking force compared to the Discovery model (p=0.009) and the Traditional model (p=0.001) according to a Bonferonni pairwise comparison. The Boundless crutch demonstrated significantly greater propulsive force than the Discovery model (p=0.008) and the Traditional model (p<0.001) according to a Bonferonni pairwise comparison. There were no differences in either peak vertical force between the three crutch types (F=2.804, p=0.07) or in peak medial-lateral force between the three crutch types (F=0.027, p=0.973).

Impulse: There was a significant difference in vertical impulse between crutch types (F=5.724, p=0.006). The Boundless crutch had a significantly smaller impulse compared to the Traditional model according to a Bonferonni pairwise comparison (p=0.013). There was no difference in medial-lateral impulse between the three crutch types (F=1.530, p=0.058).

DISCUSSION & CONCLUSIONS
Implementing a shock absorption system may provide some benefit to a forearm crutch user. Our study revealed a 17% relative reduction in peak braking force, a 7% increase in peak propulsive force, and a 3% decrease in vertical impulse, in able-bodied participants, for the Boundless crutch (containing a shock system) compared to the Traditional model (typically sold in pharmacies). Future research should examine what physiological impact these differences may have on joint loading and energy expenditure.

REFERENCES

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