EVALUATION OF THE MECHANICS OF AMBULATION WITH STANDARD AND SPRING-LOADED CRUTCHES

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INTRODUCTION

Many long-term crutch users prefer axillary (underarm) crutches over elbow crutches because they find that axillary crutches offer increased stability and control during gait. Walking with axillary crutches can be problematic, however, because of complications known to be associated with their sustained use, including crutch palsy and denervation (Raikin and Froimson, 1997; Subramony, 1989). One potential means for modifying injurious forces transmitted between the ground and the body is to fit the crutches with spring-loaded tips.

Pariziale and Daniels (1989) found decreases in both initial and maximum force at the handgrips when using spring-loaded crutches when compared to standard crutches. Shoup (1980) instrumented standard and spring-loaded crutches with strain gauges in order to estimate impact forces, anecdotally reporting reduced forces in some subjects. Neither of these studies considered ground reaction forces or their variation with time throughout the gait cycle.

The purpose of this study was to investigate differences in ground reaction force, impulse, initial rate of force rise, and spatiotemporal variables between standard and spring-loaded crutches.

We hypothesized that use of the spring-loaded crutches will produce lower peak forces, lower impulses, and lower initial rates of force rise than those found for standard crutches. Additionally, we predicted that walking with spring-loaded crutches causes the user to take a longer stride than would be taken with standard crutches because of a potentially enhanced push-off provided by the springs (Shoup, 1980).

METHODS

Ten healthy females no known musculo-skeletal problems (21-28 yrs; 167.6-175.3 cm; 54.5–72.7 kg) volunteered as subjects. None had used any type of walking aid within the last six months. All procedures were approved by the Institutional Review Board of The Pennsylvania State University.

Two pairs of standard axillary crutches (Sunrise Medical Guardian Red Dot; Carlsbad, CA) were used. One pair was unaltered, but the other was modified by the addition of helical compression springs (22400 N/m) into the shafts near the crutch tips.

All data were collected in the Biomechanics Laboratory at Penn State University. Five reflective markers were placed on the left crutch and seventeen reflective markers were placed on the crutch user. The motion of the markers was monitored using a 6-camera Eagle motion analysis system (Motion Analysis Corporation; Santa Rosa, CA).

Each subject practiced for 15 minutes with each pair of crutches prior to data collection. Subjects were asked to perform ten good trials with each crutch pair by walking over
the force plate with a single-support swing-through crutch gait at self-selected walking speed. A trial was acceptable if the left crutch struck the force plate and the subject cleared the plate without striking it again with the crutch or either foot.

One-way ANCOVAs (α = 0.05) with repeated measures were performed with average walking velocity as a random covariate to investigate the effect of crutch type on each outcome variable of interest.

RESULTS AND DISCUSSION

Of the spatiotemporal measures examined, significant differences between crutch types were found only for the period of crutch stance phase and the duration for one gait cycle. Both were slightly longer for the spring crutches than for the standard crutches. Our hypothesis that the stride length would be increased when using the spring crutches was not supported.

Contrary to our expectations, the maximum ground reaction forces were slightly higher for spring crutch trials than the standard crutch trials, perhaps due to “bottoming out” of the spring. The maximum rate of force rise over any 10 ms interval was significantly lower for the spring crutch than for the standard crutch (Fig. 1). Lower rates of force rise indicate that during the loading phase, forces are transmitted to the crutch user’s body more slowly which may lessen the risk of overuse injury.

The total impulse over the first 50, 100, and 200 ms were all lower for the spring-loaded crutches than for the standard crutches (Fig. 2). These lower impulses may indicate that the spring crutches are less likely than standard crutches to cause injury.

SUMMARY/CONCLUSIONS

The lower rates of force rise and lower impulses during the loading phase indicate that spring crutches may reduce skeletal loads and muscle forces, thus lessening the risk of injury during crutch walking.

![Figure 1](image1.png)

**Figure 1:** The maximum rate of force rise over a 10 ms interval was lower (p<0.0001) for the spring crutches.

![Figure 2](image2.png)

**Figure 2:** The total impulse over the first 100 ms was lower (p<0.0001) for the spring crutches than for the standard crutches.

REFERENCES


ACKNOWLEDGEMENT

This work was supported by NSF BES-0134217.