# EFFECTS OF DIFFERENT CRUTCH TYPES AND ARM DOMINANCE ON SHOULDER JOINT KINETICS DURING THREE POINT SWING THROUGH GAIT

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## INTRODUCTION

Injury to the lower extremity is one of the leading causes of hospital admissions in young adults in the United States [1]. Assistive walking devices (AWDs) reduce the burden on lower extremity joints by transferring the load to the upper extremities. Axillary (AC) and spring-loaded crutches (SLC) are two such AWDs often prescribed. A previous study has shown that while using AWDs, 3-point swing through gait is not symmetrical with respect of load sharing on the upper body [2]. It has been reported that upper extremity joints are subjected to 44.4% of body weight during crutch stance [3], it becomes essential to measure the amount of burden acting on the joint. Thus, in order to use the crutches for long term and minimize injury, it will be advisable to discover which type of crutch would reduce the burden on the shoulder joint.

As hand dominance plays a big role in ADL [4] it is necessary to analyze its effects on biomechanics of shoulder joint during a strenuous activity like crutch walking. A developed understanding of shoulder joint kinetics during crutch walking would be imperative in the possible reduction or prevention of overuse shoulder injuries.

The purpose of this study was to determine the effects of hand dominance and crutch type on the shoulder joint vertical ground reaction force (VGRF), resultant joint moment (RJM) and joint power

## METHODS

Ten healthy adult participants (29.1 ± 9.0 years), with prior experience in crutch walking, volunteered for the study after IRB approval. Participants were fitted with the crutches of their height and sufficient practice time was given. All the participants had to complete trials on both the crutches and were asked to walk in 3-point swing through gait pattern.

49 retroreflective markers were placed on the body to model it as a rigid body. Ground reaction forces (GRF) on the feet and crutches were collected using 4 force plates (AMTI OR-6) while video data were captured from 8 digital camcorders (Panasonic AG-DVC20). Subsequent marker tracking and processing was done using Kwon3D Motion Analysis Suite Version 4.1 (Visol, Inc., Seoul, Korea; version XP 4.1). The upper extremity joint moments were computed through the inverse dynamics procedure using the crutch GRF data and the motion data. The joint moment data were normalized to the body mass.

Peak crutch VGRF, the peak joint moments and joint power for the dominant and non-dominant shoulder joints were used as the dependent variables. Repeated measures ANOVA with Bonferroni correction was applied to test for significance. The significance level was set at $\alpha = 0.05$ and all analyses were performed with SPSS for Windows (SPSS Inc., Chicago, IL; version 14.0).

## RESULTS

The results show no significant effect of type of crutches and arm dominance on peak VGRF (Table 1). Peak RJM showed a significant interaction effect of crutch type and arm dominance (Table 1). Dominant RJM increased by 45% & 36% on spring-loaded and axillary crutches, respectively. There was a significant crutch effect for non-dominant side. Peak eccentric work rate was compared and was significantly decreased between the two sides with non-dominant being reduced by 41.13% (Table 1). Even though there was no significant crutch effect, the dominant side showed 35% and 48% greater peak

eccentric work rate as compared to non-dominant side, during axillary and spring-loaded crutch respectively.

## DISCUSSION

Though the participants were found to take uniform weight on their shoulder joints, the RJMs and eccentric work rate for dominant side for both crutches was significantly greater. This difference was larger on SLC then AC. This shows that even though participants were experienced users, there is a discrepancy in the technique of using crutches. As VGRF was not statistically significant, moment arms in sagittal plane for RJM were tested for significance and it was found that except for dominant side on both the crutches, moment arm for all other condition was significantly different. Results show that spring-loaded crutches cause greater disparity in load distribution and subsequent muscle work rate between dominant and non-dominant sides. This was confirmed by the participants who found using axillary crutches more stable than spring-loaded crutches.

Previous study [7], has found out an average reduction of 2.9% to 4.4% in VGRF, which is higher than what was found in the current study. This might be because the participants were healthy elderly and might not be relying on the poles to reduce their joint loads. Even though there is a difference in the data, overall trend shows that greater reduction in lower extremity joint loads, and lower upper extremity joint moments with T-pole as compared to hiking poles.

## REFERENCES


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**Table 1:** VGRF, RJM and eccentric power measured for axillary and spring-loaded crutch.

| | | VGRF | RJM | Power |
|---|---|---|---|---|
| Axillary | N-D Shoulder | 4.96 (0.31) | 0.44 (0.11)$^{\S\dagger}$ | 36.98 (12.13)$^{\S}$ |
| | D Shoulder | 5.03 (0.38) | 0.69 (0.11)$^{\S}$ | 56.47 (8.01)$^{\S}$ |
| SLC | N-D Shoulder | 5.07 (0.33) | 0.38 (0.15) $^{\S\dagger}$ | 29.89 (7.98)$^{\S}$ |
| | D Shoulder | 5.17 (0.63) | 0.68 (0.15) $^{\S}$ | 57.14 (9.49)$^{\S}$ |

Note: $^{\S}$ Significant ($p < .05$) side effect. $^{\dagger}$ Significant ($p < .05$) crutch effect.