# UPPER EXTREMITY KINEMATICS OF CRUTCH-ASSISTED GAIT IN CHILDREN WITH MYELOMENINGOCELE

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## INTRODUCTION

Currently, there are limited biomechanical models for quantitative evaluation of upper extremity (UE) dynamics in children with myelomeningocele (MM). While the lower extremities have been studied extensively in MM during crutch-assisted gait (Vankoski, et al., 1997; Galli, et al., 2002; Gutierrez, et al., 2003), UE dynamics have received very limited attention (Requejo, et al., 2005). In order to study UD dynamics, a three-dimensional (3D) biomechanical model of the UEs was developed for dynamic analysis of reciprocal and swing-through Lofstrand crutch-assisted gait in children with MM.

A pediatric model that describes joint motions of the upper body during crutch-assisted gait may be a valuable tool for clinicians. The study findings may also prove useful for improving crutch prescription and in planning ambulatory rehabilitation of children with MM.

## METHODS

The UE motion model includes seven rigid body segments: 1) trunk, 2) right upper arm, 3) right forearm, 4) right hand, 5) left upper arm, 6) left forearm, and 7) left hand. Three degree-of-freedom shoulder (glenohumeral) joints and two degree-of-freedom elbow and wrist joints connect the segments. The upper extremity model incorporates ISB recommendations for modeling (Wu, et al., 2005). Eighteen markers are placed on bony landmarks of the upper body in order to determine the kinematics of the trunk, shoulders, elbows and wrists during crutch-assisted gait. To calculate the kinematics of the crutches, four markers are placed strategically. Rotations are described using Euler angles (Z-X-Y order). The trunk and crutch segments are described with reference to the lab (global) coordinate system.

Nine subjects (mean ± S.D. age: 11 ± 4 years) volunteered and gave written consent to participate in the research study. All subjects had an L3 or L4 level myelodysplasia and were ambulatory using Lofstrand crutches in both reciprocal and swing-through gait patterns. Subjects who had undergone orthopaedic surgery in the past year were excluded from the study. The subjects walked at a self-selected pace using Lofstrand crutches until five successful trials were completed with each gait pattern. A 14-camera Vicon MX system captured the marker motions.

## RESULTS AND DISCUSSION

The mean cadence, walking speed, stride length, and stance duration during reciprocal gait and swing-through gait were calculated. All temporal-spatial parameters were greater during swing-through gait compared to reciprocal gait, except stance duration (Table 1). Stride length and stance duration were found to be statistically different between gait patterns ($p<0.05$).

**Table 1:** Mean temporal-spatial parameters. *Gait patterns are significantly different ($p<0.05$)

| | **Cadence (steps/min)** | **Walking Speed (m/s)** | **Stride Length* (m)** | **Stance Duration* (s)** |
|---|---|---|---|---|
| Reciprocal | 69.55 | 0.46 | 0.77 | 0.62 |
| Swing-through | 77.36 | 0.68 | 1.00 | 0.54 |

The mean flexion/extension joint motion, for right and left sides, during reciprocal gait and swing-through gait were also determined (Figure 1). Although reciprocal and swing-through gait have distinguishable characteristics, the flexion/extension motions were similar throughout the gait cycles. Joint ranges of motion were greatest during swing-through gait. Significant differences were found in trunk and elbow ranges of motion between swing-through and reciprocal gait ($p<0.05$). Right and left elbow and wrist ranges of motion were significantly different during reciprocal gait.

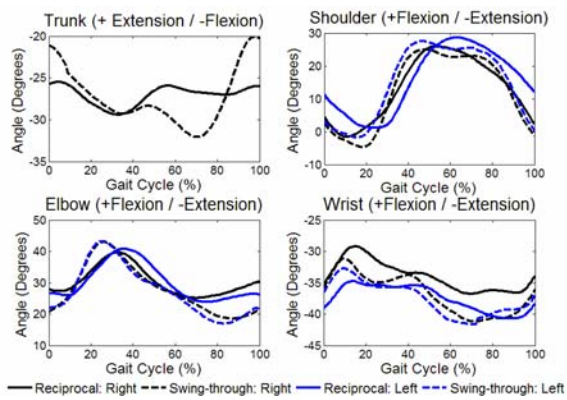


**Figure 1.** Joint kinematics during reciprocal and swing-through gait.

The model is effective in detecting significant differences in upper extremity joint motion. The model is considered to be suitable for further application to quantify upper extremity dynamics in pediatric subjects with MM. The information gained may be useful for developing injury prevention strategies, rehabilitation protocols, and/or improving the design of Lofstrand crutches.

## SUMMARY/CONCLUSIONS

The current study aids physicians in treatment planning of children with MM, which may ultimately improve quality of life. Further subject testing is currently underway, as well as, a kinetic analysis of the UE joints. Future work includes identifying correlations among dynamics and standardized outcomes assessment tools.

## REFERENCES


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