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UPPER EXTREMITY KINEMATICS IN CHILDREN WITH SPINAL CORD INJURY DURING WHEELCHAIR MOBILITY

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INTRODUCTION

Manual wheelchair propulsion is highly repetitive and imposes considerable weight-bearing demands on the upper extremities (UE) [1]. Excessive joint range of motion (ROM) and propulsion in awkward postures have been associated with upper limb pain and injuries [2], which are reported in 50% of manual wheelchair users (MWU) with Spinal Cord Injury (SCI) [3]. Some MWU only experience unilateral UE pain and, since asymmetric stroke biomechanics may be a contributing factor, UE symmetry during propulsion should not be assumed [4]. In the pediatric population the musculoskeletal system is not fully developed and improper propulsive techniques can predispose children to early-onset injury. In this study, we propose a triaxial UE kinematic model to quantify and evaluate manual wheelchair mobility in children with SCI.

CLINICAL SIGNIFICANCE

A better understanding of the UE kinematics of propulsive stroke patterns will help define the biomechanical parameters associated with wheeled movement strategies and related upper limb pathologies. These data may also be beneficial to further promote injury prevention, patient education, diagnosis, and improved treatment approaches for pediatric wheelchair users.

METHODS

Our UE kinematic model is comprised of seven rigid body segments [5] and follows ISB recommendations [6]. The respective X, Y and Z –axes are directed anteriorly, superiorly, and laterally. Thirteen MWU with SCI, aged 9-25 years-old, participated in the study. Each subject propelled their wheelchair along a 15 meter walkway at a self-selected speed for multiple trials. Motion data was collected at 120 Hz using a 14 camera Vicon MX motion capture system.

RESULTS

Group mean joint angles over the wheelchair stroke cycle were characterized (Figure 1). The mean peak angles and ROMs of each joint were also computed over the stroke cycle and two sample t-tests were applied to assess asymmetry (Table 1).

DISCUSSION

Joint ROM was found to range from 13° at the wrist in the transverse plane to 72° at the shoulder in the sagittal plane. The large joint ROMs at the shoulder and elbow highlight the concern of increased demands during manual wheelchair propulsion for the pediatric user. Since inappropriate positioning and loading may lead to pain and pathology in children with SCI, it is essential to characterize UE joint dynamics during wheelchair use. Asymmetry was most significant for the shoulder in the

transverse plane. Detection of asymmetry may help improve training guidelines and propulsion techniques incorporating limb dominance effects. This model serves as a basis for developing a kinetic model of internal joint load demands. Future work includes completion of a validated kinetic model along with integrated functional outcomes measures with regard to injury.

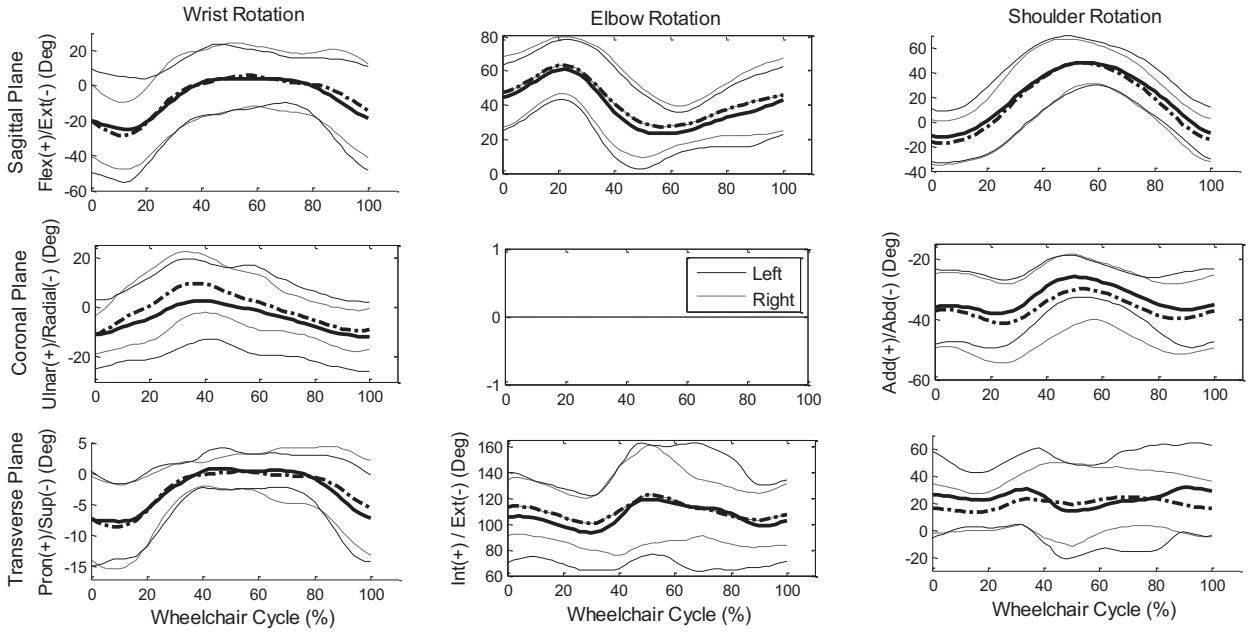

Figure 1: Mean (**bold**) and +/- 1 SD of bilateral joint kinematics for 13 subjects during the stroke cycle.

Table 1: Mean (SD) peak angles and ROM for wrists, elbows and shoulders in all planes of motion. (*, ** indicate statistically significant difference, p<0.05)

	Sagittal Plane			Coronal Plane			Transverse Plane		
Joint	Maximum Angle (deg)	Minimum Angle (deg)	ROM (deg)	Maximum Angle (deg)	Minimum Angle (deg)	ROM (deg)	Maximum Angle (deg)	Minimum Angle (deg)	ROM (deg)
RWrist	16.9 (16.4)	-36.0 (15.0)	52.9 (13.4)	14.9 (10.8)	-14.1 (7.5)	29.0 (7.2)	2.2 (2.7)	-10.6 (6.1)	12.9 (5.7)
LWrist	16.5 (19.1)	-35.5 (20.9)	52 (16.1)	11.2 (16.2)	-17.5 (12.3)	28.6 (9.1)	2.2 (3.3)	-10.7 (5.7)	12.8 (5.5)
LElbow	68.5 (18.0)	15.2 (9.7)	53.3 (15.7)	elbow coronal plane motion is constrained			143.9 (46.8)	73.5 (33.9)	70.4 (49.6)
RElbow	71.4 (17.7)	19.0 (9.5)	52.4 (18.1)				144.6 (32.2)	84.1 (16.6)	60.5 (25.9)
LShoulder	53.3 (12.9)	-16.8 (22.4)	70.1 (18.6)	-22.4 (5.9)	-43.4 (11.0)	21.0 (8.3)	51.8 (31.0)*	-8.0 (36.5)	59.8 (42.3)**
RShoulder	51.3 (14.4)	-21.4 (19.4)	72.7 (16.0)	-25.7 (8.6)	-46.8 (13.2)	21.1 (8.8)	36.5 (21.1)*	-1.3 (23.5)	37.7 (13.8)**

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DISCLOSURE STATEMENT

UWM, Shriners Hospital-Chicago and OREC have no conflicts of interest to disclose.