

# PEAK SHOULDER KINETICS AND KINEMATICS IN DURING WHEELCHAIR PROPULSION

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## INTRODUCTION

Thirty-two to 74% of wheelchair users (WCU) are reported to experience shoulder pain. Rapid application of propulsive forces (Robertson, 1996), loading of joints in extreme positions (Veeger, 1998), and fatigue (Rodgers, 1994) have all been implicated as potential mechanisms of upper extremity pathology. It has been shown that individuals who propel with more trunk flexion have greater shoulder joint excursion, and utilize trunk excursion to assist the upper extremities in generating propulsive forces and moments, especially when fatigued (Rodgers, 2000). Additionally, it has been suggested that these individuals may be more at risk for shoulder injury.

In previous work, the magnitude of the propulsive moment was not found to be different between trunk styles<sup>3</sup>. However, the shoulder joint angle when peak moments occurred was not assessed. The purpose of this study was to determine shoulder angle when peak propulsive moments occur in groups with differing propulsion styles and in the fatigued state. It was hypothesized that shoulder angle when peak moments occurred would be different with differing propulsion styles and with fatigue.

## METHODS

Fourteen individuals (12 = M, 2 = F) who used a manual wheelchair for at least 50% of

home and community mobility served as subjects. The subjects' diagnoses included spinal cord injury (T4-T9 = 3, T12-L1 = 7), spina bifida (2), cerebral palsy (1), other (1). Refer to Table 1 for further demographic information of the subjects.

**Table 1:** Subject characteristics

<b>Age (yrs)</b>	37.8 ± 9.8
<b>Height (cm)</b>	169.9 ± 13.7
<b>Weight (kg)</b>	81.6 ± 13.6
<b>Years in WC</b>	9.9 ± 4.9

Following medical screening, propulsion mechanics were measured at a standard velocity of 3 km/hr during a submaximal exercise test to exhaustion (defined as volitional inability to sustain the designated velocity). Load for the fatigue test corresponded to 60% of the maximal load achieved during the graded maximal exercise test on the wheelchair ergometer. The wheelchair ergometer was instrumented with a PY-6 six-component force/torque transducer (Bertec Corp, Worthington, OH) in the wheel hub to detect handrim forces (Fx, Fy, Fz) and moments (Mx, My, Mz). Orientation of the x-y-z transducer coordinates was tangential (forward+), radial (up+) and medial-lateral (out of the wheel+), respectively. Kinetic data were collected at 360 Hz. A potentiometer monitored the angular position of the wheel, transducer, and handrim assembly. Kinematic data were collected at 60Hz using video cameras and the data acquisition

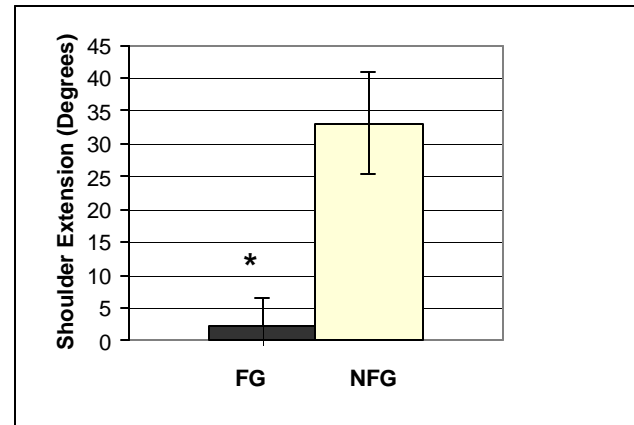
system (Peak Performance Tech., Colorado Springs, CO). Joint kinetics were calculated using a 3-D, linked segment, inverse dynamics model.

Right upper extremity joint kinematics and kinetics were averaged over three cycles (contact to contact). The timing of peak handrim and joint forces and moments were normalized to total cycle time. Shoulder joint angles at the time corresponding to the peak handrim propulsive moment (Mz) and peak shoulder Mz were determined.

Subjects were classified by propulsion style. The flexion group (FG) had peak trunk flexion angles less than 90° during contact when fresh or fatigued (n = 9). All others were classified as non-flexors (NFG, n = 5). Repeated Measures Analysis of Variance ( $p \leq 0.05$ ) was used to compare peak handrim Mz and shoulder flexion moments (Mz), and time of peak moments, at the fresh and fatigued states, within and between flexion groups.

## RESULTS AND DISCUSSION

Handrim Mz ( $21.5 \pm 8.8$  Nm) was significantly smaller ( $p \leq 0.05$ ) than shoulder Mz ( $60.3 \pm 38.7$  Nm). Differences in shoulder angles were found between groups (Figure 1). The NFG was in a position of greater shoulder extension when peak handrim and shoulder Mz occurred (Figure 1). No difference in timing of the peak torque was found between the handrim and shoulder. Fatigue did not change the magnitude or timing of handrim or shoulder Mz nor the shoulder angle at the time peak moment occurred. Application of peak moments in extreme positions has been suggested as a potential mechanism of injury. In the current study, both groups applied similar magnitudes of handrim and shoulder Mz, but they were applied in very different shoulder positions.



**Figure 1:** Shoulder angle ( $\bar{x} \pm \text{SEM}$ ) at time of peak Mz are illustrated for the flexor group (FG) and non-flexor group (NFG).

\* ( $p \leq 0.05$ )

## SUMMARY

People who propel a wheelchair in a more upright trunk posture have a more extended shoulder position when maximal handrim and shoulder Mz occur as compared to a trunk flexion style. Whether this difference predisposes one of the groups to potential injury requires further investigation. Fatigue does not appear to alter the magnitude, or timing of the peak handrim or shoulder Mz.

## REFERENCES

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