Correlation between Wrist Biomechanics and Median Nerve Health Parameters in Manual Wheelchair Users

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INTRODUCTION
Carpal tunnel syndrome (CTS) is a major public health problem in the United States, with as many as 3 million individuals suffering from its symptoms and complications [1], such as pain, tingling, numbness, and weakness in the hands and wrists. One population struck particularly hard by CTS is manual wheelchair users (MWUs). The prevalence of CTS in this population is between 49% and 73% [2-5]. CTS is poorly tolerated by this population because they rely on their arms for mobility, transfers and activities of daily living. Multiple cross-sectional studies have investigated CTS prevalence in MWUs and very few have looked at the relationship between wrist biomechanics and CTS [6]. The results have implicated that the prevalence of CTS increased with the duration of paralysis and certain biomechanical parameters; however, long-term studies have yet to be conducted. The objective of the present study was to investigate wrist biomechanical variables, to compare the changes in these variables along with quantified changes in median nerve health at two time-points, and to examine any possible correlation at each time point.

METHODS
33 manual wheelchair users with a spinal cord injury (SCI) were recruited and tested at two visits. Visits ranged from a minimum of 23 months to 101 months apart; mean time between visits was 53.8±24.9 months. During each visit, the subjects underwent bilateral nerve conduction studies (NCS) on the median and ulnar nerves [7]. Wrist kinematics variables were measured in manual wheelchair users during wheelchair propulsion [8]. An Optotrak motion analysis system was used to track the position of infrared markers placed on bony landmarks of the upper extremity. Kinetics data was also recorded using SmartWheel as the subjects propelled their wheelchairs at two speeds. Upper extremity joint angles and wrist joint forces and moments during wheelchair propulsion were calculated using inverse dynamic methods [9].

RESULTS
The changes in NCS parameters from visit 1 to visit 2 were not statistically significant; however, trends which may represent deteriorating median nerve health were noted in our analysis. Mean median nerve sensory and motor latencies increased from the first visit to the second one; likewise, mean median motor amplitude decreased during the same period of time. Particularly, between visits 1 and 2, women demonstrated significant median nerve deterioration in their dominant hands when compared to men, including significant increases in motor latency and sensory latency. The results of the correlational analyses demonstrated that maximum radial deviation had a significant negative correlation with the median sensory amplitude and a significant positive correlation with the median motor latency at the 2nd visit (Figure 1).

Figure 1: The correlations between maximum radial deviation and the median sensory amplitude and motor latency in the follow-up visit.
Significant differences were also found between maximum forces and maximum moments in dominant hands of female subjects who previously showed significant median nerve deterioration [8]. Our analyses also showed that maximum abduction force had a significant positive correlation with the median motor latency and maximum flexion moment had a significant positive correlation with the median sensory latency (Figure 2).

![Graph](image)

**Figure 2:** The positive correlations between (a) maximum abduction force and median motor latency, and (b) maximum flexion moment and median sensory latency in dominant hands of female subjects at the second visit.

**CONCLUSIONS**

By performing nerve conduction studies and biomechanical testing at two time-points, we attempted to link subject NCS findings and biomechanics variables at baseline and follow-up visits. Radial deviation’s negative correlation with sensory amplitude and positive correlation with motor latency suggested that greater radial deviation during wheelchair propulsion could be associated with higher risk of median nerve injury. In addition, positive correlation between wrist forces and moments and median nerve health parameters indicates a need to modify force required to propel a wheelchair in order to preserve upper limb integrity. This information can provide insight into the cause of median nerve injury and possible development of carpal tunnel syndrome in manual wheelchair users.

**ACKNOWLEDGMENTS**

This research was funded by the Department of Veterans Affairs, grant numbers: B869RA, B2290T and B3057R, OAA01 (VA Office of Academic Affiliations), the National Institutes of Health Training Rehabilitation Clinicians for Research Careers, and NIDRR grant#H133A011107. The contents of this paper do not represent the views of the Department of Veterans Affairs or the US Government.

**REFERENCES**