THE EFFECT OF WRIST RESTRAINTS ON WHEELING BIOMECHANICS

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INTRODUCTION

High intracarpal pressures created by hyperextension of the wrist and repetitive high force stresses during wheelchair propulsion are suggested causes of median nerve dysfunction at the wrist/hand (Burnham & Steadward, 1994; Gellman et al., 1988; Aljure et al., 1985). An injury survey of 116 wheelchair basketball players found that the wrist and hand were the most common site of injury (Burnham, Higgins & Steadward, 1994). Prevalence of carpal tunnel syndrome has been found to range between 10% and 67% in wheelchair dependent individuals (Burnham & Steadward, 1994; Davidoff et al., 1991; Gellman et al., 1988; Tun & Upton, 1988; Aljure et al., 1985). A previous investigation (Burnham, Chan, Hazlett, Laskin & Steadward, 1994) found that wearing a foam-padded glove did not reduce wheeling induced median nerve conduction block and it was hypothesized that either the type of glove used did not provide adequate extrinsic protection to the median nerve or, alternatively, that the position of extreme wrist extension during wheelchair propulsion was the major cause of median nerve dysfunction. A better padded glove, a splint to reduce wrist extension, or a combination of both may provide greater protection to the median nerve. Such intervention, however, would not be acceptable if the wheeling mechanics became awkward or slow. The purpose of this investigation, therefore, was to assess whether various forms of hand/wrist protection (visco-elastic padded glove, wrist splint, glove and splint combined) could effectively reduce the hyperextension seen at the wrist during wheelchair propulsion, thus potentially reducing the conditions predisposing to carpal tunnel syndrome. In addition, the various forms of hand/wrist protection and their effects on wheeling mechanics were evaluated.

METHODS

The wheeling performances of thirteen subjects with prior wheeling experience were recorded using two SVHS Reporter Panasonic AG-450 videocameras. The cameras were positioned to obtain a front and side view of the subject and wheelchair. Reflective markers were placed on the joint centers of each subject at the shoulder and elbow, on the styloid processes of the radius and ulna, and on the distal ends of the 2nd and 5th metacarpals of the right limb. Each subject propelled a standard wheelchair basketball chair mounted to a set of wheelchair rollers under four different conditions: i) no protection, ii) visco-elastic padded glove, iii) wrist splint, and iv) glove and splint together. The glove ("Vibra-glove", Chatanooga Group Inc.) allowed free wrist motion and contained a visco-elastic material sewn into the palm overlying the carpal tunnel region. The splint (Hammerline Dorsal Splint) wrapped around the palmar aspect of the metacarpal joints and had a padded metal bar extending along the dorsal wrist. The design of splint was intended to immobilize the wrist, but did not provide padding over the carpal tunnel region. The combined glove and splint was created to pad the carpal tunnel, and at the same time immobilize the wrist. Under each of the conditions, subjects were videotaped as they wheeled for fifteen seconds both at their average and maximum wheeling speeds.

Twelve points surrounding the activity space were filmed prior to testing and later utilized for calibration. The direct linear transformation method (Abdel-Aziz and Karara, 1971), incorporated into the Ariel Performance Analysis System. was used for three-dimensional coordinate data reconstruction, followed by smoothing of the data using a cubic spline. Synchronization between the two views was achieved using an externally triggered LED visible to both cameras. Three-dimensional joint angular displacement-time histories for the elbow and wrist were determined using the 3D coordinate data and the dot product identity. A relative measure of wheeling speed was determined using the roller wheel's angular displacement while the subject was wheeling.

Each subject was analyzed on at least two complete wheeling cycles under all four wrist conditions. Wrist and elbow angles and joint range of motions were determined. Data were analyzed using an one way ANOVA followed by Scheffe post hoc comparisons at the .05 level of significance.

RESULTS

No significant differences were found between the conditions for the elbow angle, however significant differences were revealed for the wrist extension and wrist range of motion angles (Table 1). Both splint conditions (splint, glove & splint) were significantly different from the non-restraint conditions (no protection, glove). Wrist extension was significantly less under both splint conditions. No significant differences were found between the conditions for maximum wheeling speed.

TABLE 1

The Effect of Various Types of Hand Protection on Selected Kinematic Parameters During Wheelchair Propulsion

	Elbow			Wrist		
Type of Hand Protection	Max Flexion (deg)	Min Flexion (deg)	ROM (deg)	Max Extension (deg)	Min Extension (deg)	ROM (deg)
No Protection	86.6 (31.7)	26.3 (16.1)	65.8 (20.0)	42.7 (17.1)	10.8 (8.8)	34.8 (9.2)
Glove	97.7 (12.8)	30.3 (15.9)	67.7 (21.0)	44.6 (8.1)	12.0 (8.6)	32.6 (8.3)
Splint	97.7 (15.2)	32.6 (17.1)	65.2 (19.9)	*33.0 (10.3)	17.5 (9.6)	*15.5 (4.6)
Glove & Splint	97.2 (11.5)	30.7 (17.6)	66.4 (18.3)	*29.9 (10.2)	11.7 (8.4)	*18.2 (8.2)

* = $p < .05$

CONCLUSIONS

Within the limitations of this study, it can be concluded that the wrist restraints significantly reduced wrist extension during wheeling and that the restraints did not significantly affect wheeling mechanics as suggested by the consistent elbow-angle time histories and wheeling speeds.

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