WRIST ELECTROMYOGRAPHY AND KINEMATICS WHEN PROPELLING STANDARD, COMPLIANT, AND POWER-ASSISTED PUSHRIM WHEELCHAIRS: A PILOT STUDY

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INTRODUCTION

Alternative modes of manual wheelchair (WC) propulsion offer a way to reduce demands on the upper extremities [1]. A compliant pushrim can reduce the impact forces on the hands during the push-phase of propulsion [2]. A pushrim-activated power-assisted WC (PAPAW) that applies power to the hub at each push requires less effort [3] than standard unassisted WC. While the demands on the upper extremities when propelling on a standard WC are well documented [4], measurement of muscle activity allows us to determine the muscular demands when propelling with alternative modes of WC propulsion. The purpose of this pilot study was to document the electromyographic activity of the wrist muscles and range of motion of the wrist joint when propelling a standard and two alternative pushrim designs. We hypothesized that these alternative pushrim designs can reduce the demands on the wrist musculature during manual WC propulsion.

METHODS

A non-disabled adult male served as a subject for this preliminary study. He read and signed an IRB approved informed consent form before participating. The subject propelled a Standard pushrim, a compliant pushrim design (FlexRim) [1], and a PAPAW (i-GLIDE™) [2] design positioned on a stationary custom wheelchair ergometer [4]. Data were recorded at a self-selected free and fast propulsion speed (level ground simulation) and at a simulated 8% grade. Switches were taped to the right palm to determine the push and recovery phase timing. Wrist muscle activity was documented with bipolar, fine-wire electrodes inserted into the flexor digitorum sublimis (FDS), flexor carpi radialis (FCR), extensor carpi radialis longus (ECRL), extensor digitorum communis (EDC), opponens pollicis (OP), flexor pollicis brevis (FPB), supinator (SUP), and pronator teres (PT) muscles. EMG signals were transmitted via a co-axial cable and digitized (2500Hz) using a data collection computer. The EMG data were full wave rectified and integrated over 0.01sec interval. The EMG values during propulsion were normalized by the highest 1 second of activity obtained in a maximal effort manual muscle test for each muscle (%MAX). The average integrated EMG was determined at each 1% of the propulsion cycle. Three-dimensional motion of the right upper extremity and trunk was recorded (50Hz) during each 10-sec propulsion trial using a Vicon (Oxford Metrix) motion analysis system. Wrist joint kinematics was calculated from the recorded data using an Euler/Cardan rotation sequence.

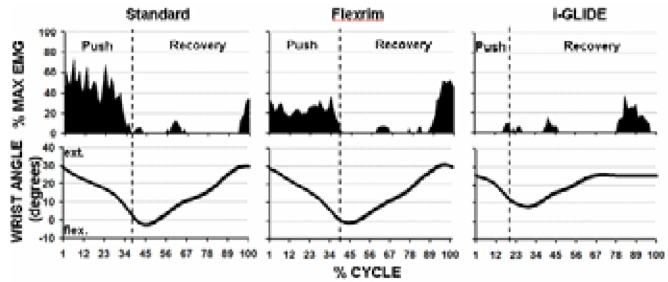

Figure 1: FDS activity during push and recovery phase of graded propulsion with a Standard, Flexrim, and i-GLIDE

RESULTS AND DISCUSSION

Five muscles had their primary activity during the push phase while three muscles were primarily active during recovery. Intensities of these muscles increased primarily in the fast and graded propulsion with Standard and FlexRim but remained low with the i-GLIDE (Table 1), particularly in the graded propulsion (Figure 1). All push-phase muscles had an onset late in recovery. Intensities of these muscles were highest primarily in the Standard. Intensities of the grip muscles (OP, FPB, and FDS) were less in the FlexRim than Standard during free and fast propulsions. During graded propulsion, the push-phase time was 52% less (42 vs. 20% cycle) for the i-GLIDE compared to Standard and FlexRim. In the graded propulsion, the push-phase flexion/extension range of motion in the i-GLIDE was 57% less (31 vs. 13degrees) than Standard and 52% less (13 vs. 28degrees) than the FlexRim (Figure 1). The lower EMG, reduced push phase timing and range of motion is indicative of reduced muscular demands. Use of alternative WC pushrim designs has the potential to benefit WC users, particularly when propelling in more demanding terrains. Assessment of wrist demands in everyday WC users remains as future work.

REFERENCES

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	Mean Push-Phase EMG (%MAX)															Mean Recovery-Phase EMG (%MAX)								
	FDS			EDC			OP			FPB			SUP			PT			ECRL			FCR		
	fr	ft	gr	fr	ft	gr	fr	ft	gr	fr	ft	gr	fr	ft	gr	fr	ft	gr	fr	ft	gr	fr	ft	gr
Standard	13	33	37	7	10	21	27	44	64	8	18	28	15	25	60	1	15	16	0	6	12	1	7	10
FlexRim	6	6	21	2	9	13	9	29	68	1	4	29	8	29	33	3	21	14	4	8	4	0	6	5
i-GLIDE™	1	13	1	11	2	1	12	11	4	0	4	0	9	7	6	3	15	1	2	7	19	0	1	0

Table 1: Mean EMG intensities of the push and recovery phase muscles during free(fr), fast(ft), and graded (gr) propulsion.