JOINT WORKSPACE OF SHOUDLER AND ELBOW ASSOCIATED WITH VARIOUS AXIS POSITIONS DURING MANUAL WHEELCHAIR PROPULSION

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INTRODUCTION

Manual wheelchair propulsion is the primary source of mobility for many persons with disabilities. The user's position relative to the drive wheel has been recognized as an important factor affecting propulsion efficiency [1, 2]. Currently, many wheelchairs provide the ability to adjust the position of the drive-wheel. To justify the effectiveness of this design feature, it is necessary to document the relationship between a user's propulsion performance and the axis position. Therefore, the purpose of this study was to investigate wheelchair users' shoulder and elbow joint workspace associated with various wheel axis positions.

METHODS

Ten persons with disabilities who use manual wheelchairs voluntarily served as subjects for this study. Detailed data for the subjects are presented in Table 1. A wheelchair with adjustable axis positions was used. Six positions including various vertical and horizontal positions were tested (Figure 1). A Zebris ultrasonic motion analysis system was used to measure each subject's upper extremity motion. ANOVA with post-hoc multiple comparisons were used to examine the differences of upper extremity motion among the six positions.

RESULTS AND DISCUSSION

The results showed that different axle position did not significantly affect ($P>0.05$) temporal parameters of push time and recovery time. High and backward axle positions resulted in increasing shoulder initial extension angle. In comparison with low axle positions, high axle positions produced significantly larger shoulder and elbow joint ranges of motion ($p<0.05$). High axle positions also produced larger efficient joint workspace than lower axle positions (Table 2).

Table1. Subject information

Anthropometric data	Mean	SD
Age; years	33.67	8.03
Height; cm	166.92	7.39
Weight; Kg	66.00	7.79
Years of disability; year	15.50	14.63
Years of using wheelchair; year	5.50	5.78
Arm length; cm	53.71	2.73
Trunk length; cm	59.39	2.78
Thigh length; cm	42.71	3.19

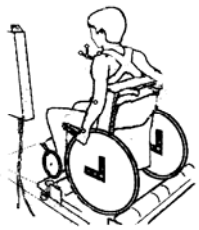

Figure1. Experimental configuration

CONCLUSIONS

The location of the drive-wheel axis determined performance of manual propulsion [3, 4]. This finding provides valuable information for guiding adjustments of the wheel-axis position relative to a user's upper body. An initial shoulder extension angle of 45 degrees and larger shoulder and elbow advantageous joint workspace could be considered adjustment principles. Adjusting the axis upwards and backwards might increase shoulder initial extension angle. Furthermore, adjusting axis height might increase efficient joint workspace.

REFERENCES

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Table2. kinematics parameters associated with various wheel-axis positions

Parameters		Axel position					
		LB	LM	LF	HB	HM	HF
Temporal	Push; sec (%cycle)	0.43±0.08 (35.3±4.2)	0.46±0.07 (36.9±3.4)	0.46±0.09 (38.4±3.5)	0.42±0.08 (35.3±3.5)	0.43±0.08 (36.6±5.2)	4.09±0.10 (39.1±4.8)
	Recovery; sec(% cycle)	0.79±0.10 (60.9±4.8)	0.80±0.07 (63.4±5.2)	0.76±0.11 (64.7±3.5)	0.79±0.10 (62.0±3.8)	0.76±0.12 (62.2±3.4)	0.79±0.17 (64.7±4.2)
Initial position	Extension; deg	$47.4±2.5^{A}$	$43.7±8.1^{B}$	$32.8±11.2^{B}$	$54.7±8.3^{A}$	$49.5±11.8^{A}$	$40.0±10.5^{B}$
Joint ROM	Sef ROM;deg	$41.6±10.1^{A}$	$42.7±10.5^{A}$	$38.8±6.2^{A}$	$56.3±12.1^{B}$	$51.9±12.4^{B}$	$52.8±9.1^{B}$
	Eef ROM; deg	$18.1±4.6^{A}$	$18.7±7.1^{A}$	$15.4±8.4^{A}$	$35.7±8.1^{B}$	$33.7±6.0^{B}$	$33.6±6.2^{B}$
	Joint workspace; rad^2	$0.066±0.017^{A}$	$0.065±0.013^{A}$	$0.045±0.017^{A}$	$0.232±0.026^{B}$	$0.259±0.037^{B}$	$0.187±0.022^{A}$

LB is wheel axis at low backward position; LM is wheel axis at low middle position; LF is wheel axis at low forward position; HB is wheel axis at high backward position; HM is wheel axis at high middle position and HF is wheel axis at high forward position. All values are mean ± SD. Sef and Eef ROM represents shoulder and elbow range of motion in the direction of extension and flexion, respectively. Mean with the same letter for post-hoc grouping are not significantly different ($p>0.05$). Mean with different letter are significantly different ($p<0.05$).