Physiologic Comparison of Yamaha JWII Power Assisted and Traditional Manual Wheelchair Propulsion

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Abstract

- For people having difficulties with propulsion, tradition electric power wheelchairs are of neither desired nor necessary. Power assisted manual wheelchairs were developed as a solution. In order to compare the metabolic demand of traditional and power assisted propulsion, random order clinical trials were performed. Physiologic characteristics were recorded while ten subjects propelled with and without the Yamaha JWII power assisted hubs on a dynamometer with selected speeds and resistances. Significantly lower ($p<.05$) values were found in both oxygen ventilation and heart rate when propelling the JWII. The significantly reduced physiologic demand of power assisted wheelchair propulsion facilitates longer maintenance of higher speed.

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Objective

To evaluate the difference between the physiologic demand when propelling a traditional manual wheelchair vs. the Yamaha JWII power assisted pushrim activated wheelchair hubs.

To quantify some of the advantages of power assisted propulsion.

Background

- People in transitional status between manual and powered wheelchairs
- Individuals with upper extremity injuries
- Aging population

Electric wheelchairs are not always good solutions (their size, weight, price, psychological reasons)

Alternative methods of propulsion (e.g. arm cranks, power assistance) -> Yamaha JWII.

Yamaha JWII

Ni-MH Battery

Quickie frame, foldable or rigid

Pushrim activated propulsion

Background (cont'd)

- Physiologic measurements have been widely used to evaluate differences in wheelchair design.
  - Smith 1983 - arm cranks,
  - Hilbers 1987 - wheelchair design,
  - van der Woude 1993 - lever mechanisms.
- Decreased physiologic demand --> delayed fatigue --> ability to propel longer distance, higher speed, more varied terrain.

Subjects

- 4 female and 6 male full-time MWUs (Age 33.7+/-9.7 years, height 174+/-3.3 cm, weight 68+/- 3.2 kg)
- 9 individuals T2-9 SCI, one MS.
- All gave their written consent.

Methods

- Subjects propelled their own manual chair, and a Quickie GPV equipped with JWII hubs on a computer controlled dynamometer
- 3 different resistances (normal, slight and moderate)
- 2 speeds: 0.9 m/s (all resistances), and 1.8 m/s (only normal and slight resistances)
- Random order trials, 3 minutes of data recorded.

Methods (cont'd)

Computer controlled dynamometer

	Power (Watts)	
	Without Yamaha	*With Yamaha*
2m/h, normal resistance	9	10
2m/h, slight resistance	11	14
2m/h, moderate resistance	11	15
4m/h, normal resistance	20	23
4m/h, slight resistance	25	29

Average power applied to the dynamometer rollers (calculated from motor torque and motor speeds measured at the dynamometer during the trials)

Methods (cont'd)

- Sensormedics Metabolic Measurement Cart: Oxygen consumption. (VO_2)
- Polar heart rate monitor: Heart Rate (HR)
- Last minute of each trial analyzed.
- SPSS, SAS used. Wilcoxon Signed Rank Test (data not normally distributed), and mixed model analysis.

Results

- VO_2 mean and peak values were significantly lower in all 5 conditions.
- HR was significantly lower in 3 of 5 trials.
- When using the mixed model, both HR and VO_2 mean and peak were significantly lower for JWII at faster speeds regardless of the resistance.

Results of metabolic testing.

MEAN VALUES	VO_2			HR		
	Mean ± SD JWII	*Mean ± SD without JWII*	*P*	*Mean ± SD with JWII*	*Mean ± SD wi JWII*	*P*
1.8 m/s, normal resistance	7.8 ± 1.6	10.8 ± 2.8	0.022	113 ± 23	129 ± 27	0.059
1.8 m/s, slight resistance	8.0 ± 1.4	13.0 ± 2.8	0.005	111 ± 20	134 ± 24	0.005
0.9 m/s, normal resistance	5.5 ± 0.8	6.9 ± 1.2	0.005	95 ± 16	105 ± 20	0.022
0.9 m/s, slight resistance	5.9 ± 1.0	7.3 ± 1.5	0.005	98 ± 21	106 ± 19	0.066
0.9 m/s, moderate resistance	5.9 ± 1.3	7.5 ± 1.8	0.005	100 ± 19	106 ± 24	0.037

Discussion

- Physiological demand *is* significantly smaller with JWII.
- Easier to achieve and maintain higher speed with JWII --> Power larger --> effect size of the results is even larger.
- At 0.9m/s, little difference in VO_2 and HR at various resistances. (may be insufficient difference in resistance levels)
- The higher the speed --> the greater the difference in metabolic demand. This is because power is added proportionally to the user's input + at lower speeds subjects felt more comfortable propelling their own chair.

Conclusion

- Data proved that power assistance decreases physiologic demand in most conditions.
- JWII most advantageous when travelling long distances, e.g. outdoors.
- Benefits:
  - aging
  - people in transitional status
  - some individuals who currently use powered wheelchairs
  - most manual wheelchair users.

Future work

- Further research needed to analyze the usability of JWII in “real life” setting, as well as to compare the various power assisted wheelchairs.