User Power Reduction in Yamaha JWII Pushrim Activated Power Assisted Wheelchair

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Yamaha JWII Pushrim Activated Power Assisted Wheelchair

Abstract

- Yamaha JWII power assisted hubs have been developed to provide a transition between manual and powered chairs. Five manual wheelchair users propelled the JWII and their own chairs with selected speeds and resistances on a dynamometer. Torque data collected from both the dynamometer and the hubs as well as the recorded metabolic data resulted in comparable power values. The JWII add power proportionally to the user's input (providing 67% of the total power) and significantly ($p=<0.05$) increases gross mechanical efficiency (17% with JWII vs. 8% with own chair). Significantly lower demand in physiologic and mechanical user power input is thus achieved while still providing some exercise to the user.

Full Citation

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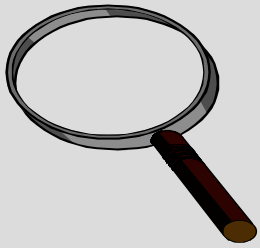
Objective

- Quantify the amount of power added by the Yamaha JWII hubs
- Evaluate the level of increase in Gross Mechanical Efficiency -->
- Quantifying some benefits of power assistance.



Background

- Upper extremity injuries + inefficiency of propulsion --> search for alternative methods (arm cranks, power assistance, etc.)

Yamaha Motor Corporation: JWII hubs.

Background (cont'd)

One measure of efficiency:

$$GME = \frac{Total\ power\ generated\ by\ the\ system\ (user + chair)}{Metabolic\ power}$$

Traditional manual propulsion:

GME = 7-15% (Veeger, 1992).

Q: What increase in GME can be achieved with power assistance?

Methods

- Subjects: 2 female and 3 male full-time MWUs (age 34.4+/-10.2, T3-9 SCI)
- Computer controlled-dynamometer: propulsion with own chair and with Quickie GP equipped with JWII hubs
- 1.8 and 0.9 m/s speed, normal, slight and moderate resistances
- Order of chairs, speeds and resistances was randomized.
- 3 minutes propulsion for each trial
- Data collection: last 30 seconds

Methods (cont'd)

- Motor speed and torque collected from dynamometer from attached sensors at 240 Hz --> these values reflect the total power applied by the system, i.e. the user and the chair.

Power (Watts)	*2 m/h normal resistance*	*2 m/h slight resistance*	*2 m/h medium resistance*	*4 m/h normal resistance*	*4 m/h slight resistance*
With Yamaha	10	16	16	25	32
With own chair	7	9	10	22	28

- Wired connection between JWII hubs and a laptop - sampling voltage at 240 Hz.
- Calibration facilitated translation of voltage to the torque applied to the pushrims.

Methods (cont'd)

- Sensormedics Metabolic Measurement Cart Oxygen consumption (VO_2), Carbon Dyoxide production (VCO_2) and Respiratory Quotient (RQ) were recorded.
- Translation to metabolic power followed the equations suggested by the manufacturer.
- Matlab, Excel and SPSS used for data analysis.
- Paired T-test used to calculate significance ($p<0.05$)

Results

- Higher speed achieved by Yamaha total power achieved is also higher.
- JWII hubs triple the user's input: 67% of total power is added by the power assistance
- GME is significantly higher with the Yamaha (17% vs. 8%).

Average results over five trials

	Total power (Watts)	*User power (Watts)*	*Phys. Power (Watts)*	*GME (%)*
Own Chair	15	15	186	8
Yamaha JWII	21	7	126	17
Significance (p)	0.009	0.006	0.000	0.010

Discussion

- Own chair: $GME_{withOwnChair} = \frac{UserPower}{PhysPower}$
- Yamaha: $GME_{withJWII} = \frac{UserPower + MotorPower}{PhysPower}$

having measured user power, the difference with JWII motor power can be calculated.

- Subjects aimed to achieve the same propulsion speed with both chairs.
- Actually achieved higher speed with Yamaha, user power dissipated by the dynamometer.
- The fact that the GME is still significantly greater means the difference is essentially even larger.

Discussion (cont'd)

Yamaha triples the user's input (adds double the amount of power applied by the user, or supplies 67% of the total power in the user+chair system.)

This proportion is consequent across speeds (0.9 or 1.8 m/s).

The higher the speed the more additional power the user gains.

Conclusion

- Increase of Gross Mechanical Efficiency
- Longer maintenance of higher speed on a more varied terrain beneficial for most manual wheelchair users.
- Eased transition between manual and electric chair, both physically and psychologically.