Effect of Tire Type on Manual Wheelchair Propulsion Kinematics in Persons with Spinal Cord Injury. Andrew Kwarciak, MS, (Kessler Foundation Research Center, West Orange, NJ), Mathew Yarossi, BS, Arvind Ramanujam, MS, Sue Ann Sisto, PT, PhD, Gail Forrest, PhD, Trevor Dyson-Hudson, MD

Objective: To determine the effect of tire type on upper body kinematics and stroke patterns during manual wheelchair propulsion in persons with spinal cord injury (SCI). **Design:** Cross-sectional study. **Setting:** Biomechanics laboratory at a clinical research center. **Participants:** 8 men with SCI (4 with tetraplegia; 4 with paraplegia) who use a manual wheelchair. **Interventions:** Participants propelled their own wheelchair on a dynamometer at a self-selected speed using 5 different wheelchair tires. The tires, in order of increasing rolling resistance, were: 1) low-profile pneumatic; 2) full-profile pneumatic; 3) low-profile solid; 4) full-profile solid insert; and 5) full-profile solid. Tires were randomized to minimize order-effect. **Main Outcome Measures:** Mean peak angles and range of motion (ROM) for the trunk (sagittal plane), shoulder (transverse plane), and elbow (sagittal plane), and hand marker trajectories. **Results:** As tire rolling resistance increased, participants demonstrated an increase in peak trunk flexion (148.8%) and a decrease in peak trunk extension, resulting in a more forward leaning trunk position. Peak shoulder internal rotation increased >20% and peak elbow extension increased, particularly for the paraplegia group (17.8%), resulting in increased elbow ROM. Only 3 of the 8 participants changed stroke pattern across the tires; however, all participants reduced the length of their hand trajectory as tire rolling resistance increased. **Conclusions:** Tire type influences wheelchair propulsion biomechanics in persons with SCI. Biomechanical adaptations to increased tire rolling resistance are similar to those experienced when propelling uphill or over surfaces of increased resistance (e.g. carpeting). Propelling wheelchair tires with high rolling resistance may increase biomechanical demands on persons with SCI. **Key Words:** Wheelchairs; Biomechanics; Rehabilitation

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Influence of Tire Type on Perceived Exertion and Temporal Characteristics of Wheelchair Propulsion. **Andrew Kwarciak, MS, (Kessler Medical Rehabilitation Research and Education Center, West Orange, NJ), Mathew Yarossi, BS, Arvind Ramanujam, MS, Trevor Dyson-Hudson, MD, Sue Ann Sisto, PT, PhD**

Objective: To determine the influence of 5 different tires on self-selected wheel speed, push frequency, and perceived exertion. **Design:** Cross-sectional, controlled study. **Setting:** Motion analysis laboratory. **Interventions:** Not applicable. **Participants:** Four individuals with paraplegia. **Main Outcome Measures:** Hand trajectories, wheel speed, and Borg Scale ratings of perceived exertion during wheelchair propulsion at a self-selected speed for 5 different tires (low-profile, high pressure [100 pounds/inch^2] pneumatic; low-profile, airless solid; full-profile, low-pressure [75 pounds/inch^2] pneumatic; full-profile with solid insert; full-profile, airless solid). **Results:** Hand trajectories and wheel speed were used to determine push frequency in units of pushes per meter. Within profile, the low-pressure pneumatic tire resulted in significantly ($p \leq .029$) higher wheel speed and lower push frequency than the solid airless tires. For the low-profile tires, the high-pressure pneumatic resulted in higher wheel speed ($p = .032$) and lower push frequency. Borg Scale ratings demonstrated similar trends. For each profile, the pneumatic tires were rated easier than the solid airless tires. **Conclusions:** The pneumatic tires were more functionally advantageous and could impose a smaller risk of overuse injury to the upper limb. Clinicians and users should consider the affect of tire type on wheel speed, push frequency, and perceived exertion when selecting a tire for everyday use. **Key Words:** Wheelchairs; Biomechanics; Rehabilitation

INFLUENCE OF TIRE TYPE ON PERCEIVED EXERTION & TEMPORAL CHARACTERISTICS OF WHEELCHAIR PROPULSION

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Background

One of the most influential components to efficient wheelchair propulsion is the rear tire. The rear tires play a key role in determining the rolling resistance of the wheelchair. To meet the wide range of user needs, many different types of tires are available. Tires are typically pneumatic or solid, and come in a variety of pressures and profiles. Studies have shown that pneumatic tires have less rolling resistance than solid tires; and that a low-profile, high pressure pneumatic tire can provide the lowest amount of rolling resistance [1,2,3]. Although previous studies on wheelchair tires are conclusive, it is unclear how different tires, with different rolling resistances, influence manual wheelchair propulsion.

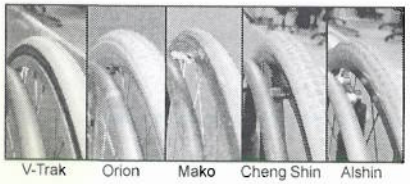
The objective of this study was to determine what effect tire type has on perceived exertion and the temporal characteristics of wheelchair propulsion, specifically wheel speed and push frequency. It was hypothesized that tires with greater resistance to propulsion will negatively affect propulsion characteristics.

Methods

Four individuals with paraplegia were asked to propel their own wheelchair on a dynamometer, using 5 different sets of tires.

Tire	Type	Profile	Mass* (kg)	Diameter (cm)	Inflation pressure (pounds/in²)
Primo V-Trak	Pneumatic	Low	0.36	59.6	100
Primo Orion	Pneumatic	Full	0.64	61.5	75
KIK Mako	Solid	Low	0.48	58.8	-
Cheng Shin	Solid insert	Full	1.16	60.9	-
Alshin	Solid	Full	0.71	60.1	-

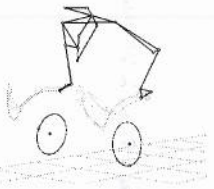
* Includes mass of tire and tube or solid insert (if applicable)



All tires were mounted to a 0.61m Sunrims SW600 wheel and attached to each wheelchair in a randomized order.

Data Collection

Reflective markers were placed on the hub and spokes of each wheel as well as on bony landmarks of the upper body. Marker trajectories were captured with a Vicon motion analysis system (Vicon, Oxford, UK) at a rate of 120Hz. For each tire condition, participants were asked to propel at a comfortable, self-selected speed for 20 seconds. Perceived exertion during the trial was rated using the BORG Scale.

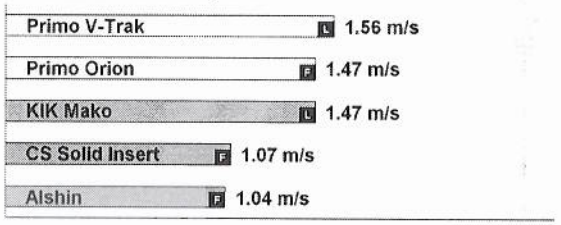


Data Analysis

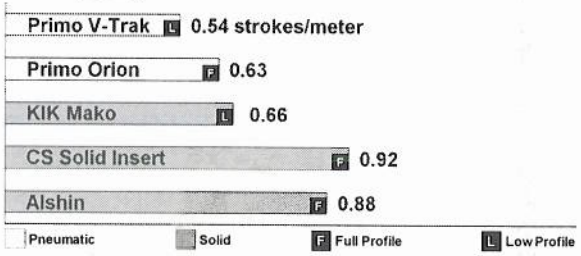
Marker trajectories on the wheel and hand, from 5 consecutive strokes, were used to calculate wheel speed and strokes per meter, a speed-normalized measure of push frequency. A one-way ANOVA was used to compare data within and across tire type and profile.

Results

Self-selected wheel speed

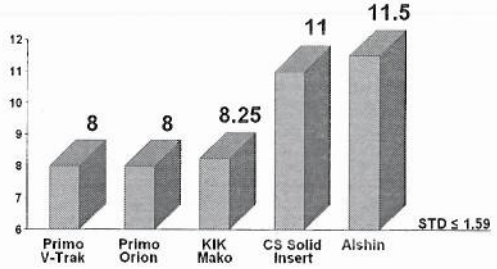


Push frequency



Results (cont.)

BORG Scale



Discussion Points

- Pneumatic tires resulted in significantly (p = .01) faster wheel speed and (p = .033) lower push frequency.
- Within profile, the Primo Orion tire had significantly (p = .005) higher wheel speed than the full-profile solid tires.
- Within tire type, the KIK Mako resulted in significantly (p = .001) higher wheel speed than the other solid airless tires.
- A larger sample size and increased degrees of freedom may have revealed more significant differences, particularly within the push frequencies.
- Borg Scale ratings demonstrated similar trends. Both within and across profile, the pneumatic tires elicited lower perceived exertions than the solid airless tires.

Conclusions

The pneumatic tires were more functionally advantageous and could impose a smaller risk of overuse injury to the upper limb. Clinicians and users should consider the affect of tire type on wheel speed, push frequency, and perceived exertion when selecting a tire for everyday use.

References

1. Sawatzky, B.J., Kim, W.O., Denison, I. (2004). The ergonomics of different tyres and tyre pressure during wheelchair propulsion. Ergonomics, 47(14), 1475-1483.
2. Gordon, J., Kauzlarich, J.J., Thanker, J.G. (1989). Tests of two new polyurethane foam wheelchair tires. JRRD, 26(1), 33-46.
3. Hoffman, M.D., Millet, G.Y., Hoch, AZ, Candau, R.B. (2003). Assessment of wheelchair drag resistance using a coasting deceleration technique. Am J Phys Med Rehabil, 880-889.