Ease of pushing two wheelchairs designed for low-resource settings.

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Background

A wheelchair should be appropriate for the needs of users in their own living conditions which may differ significantly in different cultural and economic settings (J. Borg & Khasnabis, 2008). Less-resourced settings where power chairs are often not available provide a unique challenge for wheelchair users who cannot self-propel (Johan Borg, Lindström, & Larsson, 2009). In North America and Europe, manual wheelchairs for children who cannot self-propel are often configured for stability rather than ease of pushing since most travel is indoors and is often only for short distances as vehicles are used for longer distance travel (American Medical Association, 1994; Sonenblum, Sprigle, & Lopez, 2012). In low-resource settings, wheelchairs are frequently pushed on uneven terrain as much of the routine of daily living may occur outdoors (Lysack, Wyss, Packer, Mulholland, & Panchal, 1999). In many low-resource countries, children with disabilities are unable to attend mainstream schools and must attend boarding schools where there are often few able-bodied assistants; children who are not able to self-propel are often assisted by friends that are less disabled who use the wheelchair as a walker.

The types of pediatric wheelchairs designed for use in less-resourced settings include the Hope Haven KidChair (H-KC), which is designed in the USA and assembled in both the USA and Guatemala and distributed globally, and the Free Wheelchair Mission Gen-2 wheelchair (F-G2) which is designed and built in the USA and distributed around the world (Pearlman et al., 2008). Free Wheelchair Mission focuses on affordability and availability. Hope Haven has focused on the seating system, and the H-KC chair has more options for cushioning and lateral support; the cost of sponsoring an H-KC chair is more than twice the cost of the F-G2 chair.

We hypothesized that a repeated measures study using able bodied subjects pushing children in these two types of wheelchairs would be able to meaningfully differentiate strengths and weaknesses in the ease of pushing the H-KC and pediatric sized F-G2 wheelchairs.

Methods

The study was completed at LeTourneau University with able bodied volunteers from the community. Teams of one child subject and one adult subject worked together to complete a set of performance tests in one type of wheelchair and then the other.

In a repeated measures study protocol, subjects completed all tests with the H-KC and the F-G2 chair. These included two six-minute timed tests, one on a track with a paved surface and the other on a track with a rough grass/soil surface; and two three-minute timed tests, one on a track ascending and descending an 8cm curb, and one in tight spaces on a figure-8 track between chairs. The order of the tests and the order of the wheelchair use were randomized. Feedback was obtained from the pusher and the wheelchair user for each test using a visual analogue scale question regarding the ease or difficulty of the test and comments were solicited. The heart rate of the pusher was obtained using PolarPro800 heart rate monitors and the physiological cost index (PCI) was calculated. Data was analyzed using repeated measures ANOVA.

Findings

Thirty-one adult able bodied teams, each consisting of an adult and child, completed the study (adults: 17M, 14F, age 33.8 ± 9.6; children: 18M, 13F, weight 30.7 ±5.6). On rough ground, smooth ground, tight spaces and curb tracks, PCI results were significantly lower for the F-G2 chair indicating a lower energy cost to a pusher propelling a child in that chair. For distance traveled during these timed tests, the two chair types were only significantly different on the curb track on which the subjects traveled significantly farther in the F-G2 chair. User feedback indicated that the wheelchair pushers and riders rated the F-G2 more highly in on all tracks except the tight spaces for which there was no significant difference in the user responses.

Discussion

This study distinguished differences in the ease of pushing the two wheelchairs. In all statistically significant differences, the F-G2 chair outperformed the H-KC chair in user feedback data, physiological cost index, and distance traveled. Compared to the F-G2 chair, the H-KC chair has smaller diameter wheels, an exceptionally short wheelbase, and a posterior center of gravity, all factors that can negatively impact rolling resistance(van der Woude, Veeger, Dallmeijer, Janssen, & Rozendaal, 2001).

Limitations of the study include the fact that those pushing the wheelchairs were not experienced in assisting children in wheelchairs and may not have known many small habits of movement that could have reduced the difficulty of rolling. This study is also limited by the very different design of the two chairs. The H-KC is designed to include postural support seating options whereas the F-G2 is not. Therefore, they are intended for disparate populations of wheelchair users. We also recognize that the ease of pushing a wheelchair in different conditions is only one small part of wheelchair function. A long term study is underway that will look at some of the other aspects of the function of these wheelchairs, including feedback from long-term wheelchair users and feedback from clinicians which will include data on the clinical impact of the seating system.

Conclusion

The F-G2 chair is significantly easier to push than the H-KC chair. In situations where the wheelchair pusher may have limited energy, or there are longer or rougher distances to travel, it would seem to us that this greater difficulty in pushing the H-KC wheelchair may significantly reduce the mobility of the wheelchair user and assistant, and in so doing may reduce the participation level of the wheelchair user.

References

American Medical Association. (1994). *Guidelines for the Use of Assistive Technology: Evaluation Referral Prescription*. Chicago, IL AMA.

Borg, J., & Khasnabis, C. (2008). Guidelines on the Provision of Manual Wheelchairs in Less-Resourced Settings. *Geneva: World Health Organization*.

Borg, J., Lindström, A., & Larsson, S. (2009). Assistive technology in developing countries: National and international responsibilities to implement the Convention on the Rights of Persons with Disabilities. *The Lancet, 374*(9704), 1863-1865.

Lysack, J. T., Wyss, U. P., Packer, T. L., Mulholland, S. J., & Panchal, V. (1999). Designing Appropriate Rehabilitation Technology: A Mobility Device for Women with Ambulatory Disabilities in India. *International Journal of Rehabilitation Research. Internationale Zeitschrift fur Rehabilitationsforschung. Revue Internationale de Recherches de Readaptation, 22*(1), 1-9.

Pearlman, J., Cooper, R. A., Krizack, M., Lindsley, A., Wu, Y., Reisinger, K. D., et al. (2008). Lower-limb Prostheses and Wheelchairs in Low-income Countries [An Overview]. *IEEE Engineering in Medicine and Biology Magazine, 27*(2), 12-22.

Sonenblum, S. E., Sprigle, S., & Lopez, R. A. (2012). Manual wheelchair use: bouts of mobility in everyday life. *Rehabilitation Research and Practice, 2012*, 1-7.

van der Woude, L., Veeger, H., Dallmeijer, A., Janssen, T., & Rozendaal, L. (2001). Biomechanics and Physiology in Active Manual Wheelchair Propulsion. *Medical Engineering & Physics, 23*(10), 713-733.