BIOMECHANICS OF THE FLEXRIM LOW IMPACT WHEELCHAIR HANDRIM

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INTRODUCTION

Handrims are the primary interface by which a wheelchair user controls the wheelchair. The standard handrim is anodized aluminum and relatively slippery. As a result, the user must grip it tight to keep their hand from slipping. A vinyl-coated handrim provides increased friction so the user does not have to grip as much. Because the vinyl coating is a heat insulator, it can burn the hand when braking downhill. However, its benefits to propulsion are important to take advantage of, since decreasing physical demand on the wheelchair user may serve to delay or prevent the development of upper extremity repetitive stress injuries.

In a study of 9 wheelchair users pushing on a treadmill set to a range of grade conditions, we found the use of a vinyl-coated handrim resulted in a 9% average decrease in metabolic demand during propulsion [1]. In a similar study of 25 wheelchair users, we found subjects tended to push with an average of 10% more power during the push [2]. As a result users spent less time pushing and more time coasting. However, this increased push intensity also resulted in a higher rate of loading in the radial direction, which has been associated with incidence of repetitive stress injuries. Use of a compliant handrim has been shown to reduce the rate of loading during propulsion [3]. The FlexRim is a new handrim that incorporates a high friction grip surface with a compliant interface to reduce impact loading (Figure 1). The outer rim is uncoated, so the FlexRim preserves the ability to brake downhill. The purpose of this study was to assess the biomechanics of the FlexRim during propulsion.

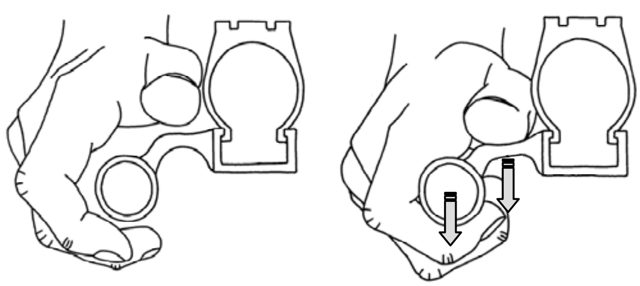

Figure 1: The FlexRim has a high friction compliant interface for the hand that is designed to improve grip and reduce impact loading during propulsion.

METHODS

Full-time manual wheelchair users were recruited to participate in this study. Subjects were asked to propel their wheelchair (with instrumented wheels) on a treadmill using one of either the FlexRim handrim or the standard handrim. Handrim order was randomized. Subjects propelled at predetermined self-selected (comfortable) speeds for 35 pushes on level, 30 pushes at 3 degrees, and finally 25 pushes at 6 degrees. Kinetic and kinematic measures were made continuously over each handrim trial. The last 20 pushes from each grade condition were used in the analysis. For each push analyzed, target temporal and kinetic characteristics were determined and averaged over the entire 60-push set. Biomechanical metrics were then compared between the handrim conditions using a paired samples t-test and determined to be statistically significant for $p<0.05$.

RESULTS AND DISCUSSION

Twenty-five (25) subjects, with an average of 17 years of wheelchair experience (sd=11) participated in the study. The resulting temporal and kinetic biomechanical measures are given in Table 1. The magnitude and rate of loading radially into the handrim (Fr, dFr/dt) were maintained due to the compliance of the FlexRim. The axial moment (Ma) and moment generated by the hand (Mh) were both found to be significantly higher, by 15.5% and 27.8% respectively for the FlexRim. The FlexRim did not affect push frequency. Similar to the vinyl-coated handrim, use of the FlexRim resulted in improvements in the ratio of time spent pushing to coasting, as well as in the amount of power generated during the push. The FlexRim resulted in a 13.2% increase in the average power generated, even greater than that found for the vinyl-coated handrim in an earlier study [2].

CONCLUSIONS

Improving the ergonomics of wheelchair propulsion is important as it may serve to delay or prevent the development of repetitive stress injuries. The FlexRim low impact handrim was found to result in dramatically improved power generation during the push without the adverse effects found for the vinyl-coated handrim. Longitudinal studies of injury development will be necessary to evaluate the long-term injury prevention potential of the FlexRim.

REFERENCES

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Table 1: Biomechanical results for the standard and FlexRim handrims. Bold values represent statistically significant differences.

Handrim	Max Fr (N)	Max dFr/dt (N/s)	Avg Ma (Nm)	Avg Mh (Nm)	Push Freq (Hz)	Push/Coast Time Ratio	Power/Push (W)
Standard	69.4 ± 21.2	1357 ± 370	10.2 ± 2.8	2.7 ± 1.4	1.02 ±0.19	0.29 ± 0.06	15.7 ± 5.5
FlexRim	68.4 ± 19.1	1353 ± 269	**11.8 ± 2.3**	**3.5 ± 1.3**	1.03 ±0.20	**0.31 ± 0.06**	**17.8 ± 5.3**