Comparison of novel handle-based wheelchair (KURT) and traditional push rim wheelchair: Effect on muscular activity of the user

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Summary

To date more than 80% of manual wheelchair users use the traditional push rim wheelchair. However, this type of wheelchair forces the upper extremities to move in a non-physiological manner introducing excessive stress on the joints that often leads to injuries. Hence, our team developed a novel handle-based wheelchair (KURT) that is more ergonomic and reduces the probability of an injury. The aim of this study was to investigate the effect KURT has on the muscular activity of the user by comparing it with the push rim wheelchair. 15 healthy subjects propelled both a standard wheelchair and KURT in a laboratory environment following a circuit that simulated movements performed daily by wheelchair users. The results showed an overall decreased muscular activity while driving KURT. In conclusion KURT is similar in performance with a push rim propelled wheelchair but more ergonomic hence posing a very good alternative as means of transport.

Introduction

Manual wheelchairs are the most commonly used form of wheelchair propulsion since they enhance the cardiorespiratory system and general well-being of the user in contrast to motor driven ones. Among manual wheelchairs the push rim type is by far the most commonly used [1]. Even though it has benefits such as robustness, low cost, ease of manufacture, it also has a fundamental problem. During its propulsion, the user has to perform motions that are on the limits of the physiological range of motion of the upper limb joints. This often leads to injuries such as shoulder impingement syndrome and rotator cuff tears that affect millions users worldwide [2]. Inspired by this our team has developed a functional wheelchair that poses a more ergonomic alternative to the push rim type wheelchair [3] and is also suitable for daily indoor use in terms of size and maneuverability (going backwards, turning in place). The aim of this work is to investigate the effect KURT wheelchair has on the muscular activity of the user and compare it with the push rim type.

Methods

15 healthy, non-wheelchair users participated on the study. The task required the subjects to drive 3 different wheelchair configurations (KURT, push rim with small wheels and push rim with large wheels) around our laboratory room for 6 rounds (3 clockwise, 3 anti-clockwise). Data for the muscular activity were taken for the right and left biceps (BI), triceps (TRI), anterior deltoid (A_DEL), flexor radialis (FL_RA), lower trapezius (L_TRA), latissimus dorsi (LAT_DO) and pectoralis major (PEC_MA) using Trigno from Delsys (https://delsys.com/). The RMS values of the raw data were normalized against the Maximum Voluntary Contraction (MVC) and were expressed as a percentage of it for comparison between the cases.

Results and Discussion

Analysis of mean muscle activations showed a decreased muscular activity on the users when using KURT in all muscles except the R_BI, L_BI, R_FL_RA and L_LAT_DO (Figure 1). Increased activity in biceps was expected since elbow flexion is implemented for the propulsion of KURT.

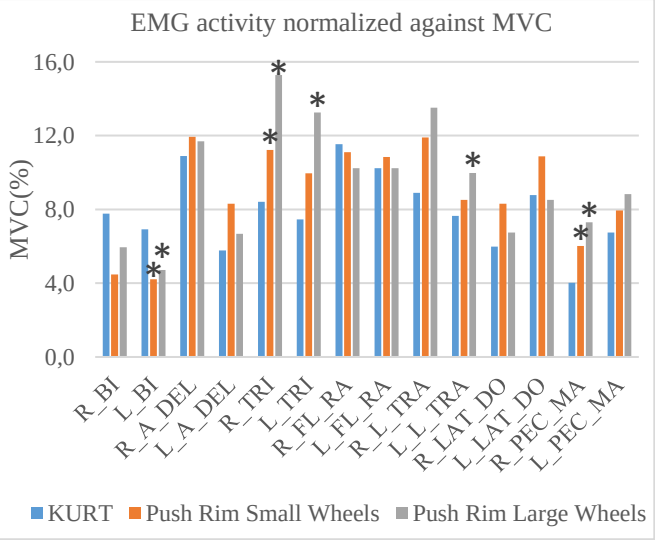

Figure 1: EMG activation for the 3 different wheelchair configurations (*=p<0.05 with Mann-Whitney U test, KURT vs Push Rim)

Conclusions

It can be concluded that the novel wheelchair proposed offers a functional and more ergonomic alternative to wheelchair users while decreasing muscle fatigue and upper limb joint injuries.

References

[1] Kaye H.S. et al. (2000) *Mobility device use in US*, **rep.14**
[2] Mason B. et al. (2020) *Clin.Reha.* **vol. 34 (1)**
[3] Puchinger M. et al. (2021). *TNSRE* **vol. 29**