IS SYNCHRONOUS HANDCYCLING LESS STRAINING THAN HANDRIM WHEELCHAIR PROPULSION?

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INTRODUCTION

The upper extremities - especially the shoulders - are at serious risk for overuse in handrim wheelchair users. It has been shown that upper extremity complaints frequently occur within the wheelchair user population [1]. However, physical activity and an active lifestyle are important to maintain general fitness and to prevent long term health problems. Because handrim wheelchair propulsion has been shown to be an inefficient and mechanically straining form of ambulation [2], alternative propulsion mechanisms have been developed and studied. The handcycle has been proven to be an energetically more efficient and less straining alternative to the wheelchair [3]. However, the magnitude of the mechanical load of handcycling has not been subject of report. Due to the fact that the external power output needed for propulsion is produced with a considerably larger muscle mass, the mechanical load of handcycling on the upper extremity is believed to be lower.

Purpose of this study is to determine the mechanical load, expressed as mean and peak glenohumeral reaction forces, during synchronous handcycling. Further, the load will be compared to the load of handrim wheelchair propulsion under similar conditions to evaluate the assumption that handcycling is the mechanically least straining form of ambulation of the two.

METHODS

Ten able-bodied male subjects participated on a voluntary basis. All subjects propelled a handcycle at three different speeds (5, 6 and 7 km/h) for one minute. Power output was kept constant at 35 W by means of a pulley system for all conditions [4]. Three-dimensional kinematics of the thorax, scapula, humerus, forearm and hand were recorded with a 6-camera infrared system (Qualisys, Sweden) at 100Hz. External forces applied to the handgrip of the handcycle were measured by a custom made system (VU University Amsterdam, the Netherlands), which included a 6-degrees of freedom force sensor. Position and force data of five complete cycles were resampled to 50Hz and used as input for the Delft Shoulder and Elbow Model [5]. The model contains a glenohumeral contact force constraint that requires the force to be directed within the glenoid surface. To compare results with previous work [2], muscle forces were calculated using the stress cost function in which the sum of the squared muscle stresses is minimized. The calculated glenohumeral contact force was studied as the output variable.

RESULTS AND DISCUSSION

Preliminary results of one subject showed a mean glenohumeral contact force of 296 ± 23 N over the 5 cycles (Figure 1). The peak glenohumeral contact force was 680 ± 26 N.

Veeger et al., [2] found peak glenohumeral forces up to 1400 N for propelling the wheelchair at 20 W at 5 km/h. The peak glenohumeral contact forces in the present study are considerably lower while the external power output was much higher (35 vs. 20 W). The peak forces can be compared to propelling a wheelchair at 10 W at 3 km/h. The lower load might not only be due to the larger muscle mass involved in the force production, but also due to a more favorable moment arm of the propulsion force relative to the shoulder. Further, the mechanical load might be lower because in handcycling force can be applied over the whole cycle. Further studies on force direction and muscle activity are needed to confirm this.

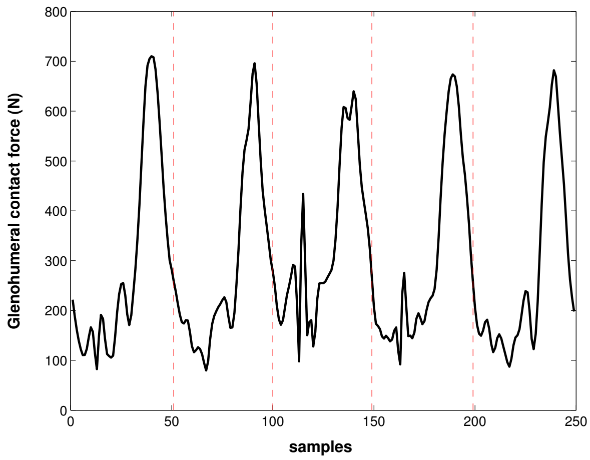

Figure 1: Glenohumeral contact force for 5 consecutive cycles. Dotted lines represent the start of a new cycle (crank horizontal and pointing towards the subject).

CONCLUSIONS

Based on these preliminary results the synchronous handcycling can be considered a good alternative for wheelchair propulsion. The lower mechanical load of handcycling reduces the risks on overuse injuries at the shoulder; therefore the use of the handcycle should be stimulated.

REFERENCES

1. Pentland WE, *Paraplegia*. **32**:211-218, 1994.
2. Veeger HEJ, et al., *Clin Biomech*. **17**:211-218, 2002.
3. Dallmeijer AJ, et al., *Spinal Cord*. **42**:91-98, 2004.
4. van der Woude LHV, et al., *Clin J Sport Med*. **4**:14-24, 1994.
5. van der Helm FCT. *J Biomech*. **27**:551-69, 1994.