INSTRUMENTATION OF A HANDBIKE FOR BIOMECHANICAL MEASUREMENTS

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INTRODUCTION

This study presents the design of an instrumentation system to measure biomechanical parameters of a subject pedalling on a handbike. In spite that many similar devices are available for normal bikes (ergometers), nothing exists strictly dedicated to handbikes.

A handbike (Figure 1) is a device for the locomotion of disabled people with impaired legs; it has a stiff chassis and three wheels. The propulsion is applied by the handles; a bike-like transmission actuates the front wheel, which can also steer. Handcycling is a paralympic discipline.

The system is intended to determine the energetic cost of handcycling and to study biomechanical, physiological and neuromuscular parameters of this activity. Examples of applications include the determination of risk factors of handcycling, and the definition of the optimal configuration of the seat and the backrest.

METHODS

The measure of the energetic cost requires a system that can apply a controlled braking action, in order to keep the examined subject on exerting a defined cranking power.

A system, which measures the applied forces on the handles, is also needed. Forces must be measured in a vectorial way, describing magnitude and direction. All the data must be collected by a PC synchronised with the electromyography signals coming from the examined subject muscles.

THE DEVICE

The handbike is placed on a static structure (Figure 2), the wheels have been removed, the anterior shaft and its sprocket wheels have been left in place. The braking torque is generated by a brushless motor connected with a chain to one of the sprocket wheels. The motor size is based on upper body exercises power output value found in literature [1].

The innovative employment of a torque controlled brushless motor instead of a normal brake has been chosen because the measure of velocity and torque can be performed more easily and with more precision. Secondly, it makes possible the simulation of the effect of the inertia action of a flywheel that is normally employed in ergometers. The value of the simulated inertia can be changed and controlled by a PC and it is possible to adapt the system to each subject, even though its effect is negligible at steady state conditions [2]. The employment of a brushless motor permits, also, an easily generation of various braking profiles that can be used to define the characteristic of the examined subject.

For the measurements of the forces at the handles, a load cell is placed between the crankset and each handles to collects the radial and tangential components of the applied forces. An encoder measures the angular position of the crankset.

PRELIMINARY STUDY

A preliminary study has been performed on 14 Div.B (lesions T1-T10) and 6 Div.C (lesions T11-L5) at three different power levels L1, L2 and L3. The system collected several data (velocity, handle forces, $V0_2$ and VCO_2, electromyography of several muscles). Each subject selected the most comfortable posture and the elbow angle α was measured when the when crank was in 90° position (maximal arm extension during cranking). The power determining 60-70% of maximum Heart Rate was selected to test two other elbow angle $\alpha \pm 10°$.

DISCUSSION

VO_2 was influenced by posture changes only in Div.C: resulting in higher values for α-10° and α+10° compared to α position (α-10°: 23±7.5; α+10°: 22±6.9; α: 20±6.7 ml/kg·min). The increase of energy cost in Div.C for α-10° and α+10° cranking positions, without concomitant changes in force and EMG, indicates lesser efficient postures compared to the free chosen one. For Div.B, the more stable α+10° position determines even a more advantageous biomechanical condition, which is probably not spontaneously adopted by the subject for the uncomfortable sustained flexion of the head required to look forward.

CONCLUSIONS

The lack of literature about handcycling oriented the project to reach the highest possible flexibility, so it can be used for different models of handbike and different experimentation protocols. With a few modifications it could be applied to normal cycles and to wheelchairs.

Preliminary use confirms that the designed instrumentation can be conveniently used for different experimentation in sport and rehabilitation context.

Figure 1: An example of handbike.

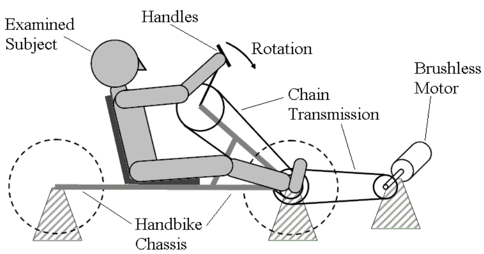

Figure 2: Sketch of the system.

REFERENCES

1. Weissland T, et al., *Eur J Appl Physiol.* **79**:230-236, 1999.
2. Fregly BJ., *Journal of Biomechanics* **29**:1559-1567, 1996.