EXPERIMENTAL PROTOCOL TO ANALYZE THE EFFECTS OF ADJUSTMENTS ON A MANUAL WHEELCHAIR
: A PILOT STUDY

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INTRODUCTION

Some studies related to the analysis of the propulsion cycle - a cycle containing a contact phase of the hand on the hand rim followed by a phase without contact - note that the propulsion techniques vary according to the handicap level and the moving rolling resistances, Newsam, G.J. et al., (1999). Two model types are suggested : one for the upper limb only, Wu, H.W. et al., (1999), and one for the upper limb and back, Rodgers, M.M. et al., (2000). In this last model, the back is defined as a single segment. At first, we propose the construction of a kinematic analysis model in 3 dimensions, including the upper limb and a multi segmentation of the back, and in addition the development of a postural ergonometer. From a Motion Analysis system, the upper limb and back kinematics are then calculated during a propulsion cycle, realised on this ergonometer.

METHODS

The development of a specific ergonometer (Fig1) allows to study the influence of the subject’s posture while propulsion. This ergonometer is composed of a seat independent of the rear wheels. The seating plate and the back of the seat are adjustable in length. This seat can also be adjusted in height and slope. As it is independent, we can vary its position with respect to the rear wheels axis. An adjustable magnetic resistance is used to slow down the rear wheels.

The three-dimensional coordinates of the 22 markers, glued over anatomical landmarks, are recorded at 60 Hz sampling rate, using a Motion Analysis system (Santa Rosa, California). The marker locations on the upper limb have been selected in order to affix a reference frame on each body segment (sternum, clavicula, humerus, radius-cubitus, hand). The back is segmented in 10 parts (pelvis, 3 lumbar, 5 dorsal, 1 cervical). The 3D model is built up from experimental data collected on wheelchair users. Each subject have been tested 1 minute by experimental condition, at a rate of 1 Hz imposed with a metronome. We propose to study 18 (3*3*2) situations:

- 3 conditions vary the seat slope with respect to the anterior-posterior axis : the seat parallel to the axis, the seat tilted so that the legs can touch the trunk, an intermediate tilt.
- 3 conditions vary the seat positioning with respect to the rear wheels axis, taking into account the overall length of the arm, Hughes C.J. et al., (1992).
- 2 conditions vary the rolling resistance level.

RESULTS AND DISCUSSION

The calculation of the angular variations of each degree of freedom of the 3D model permits to quantify and locate the technique variations when the resistance increases according to the position of the seat with respect to the axis of the rear wheels, but also according to the slope of the seat. For each test, we analyzed three representative cycles. The preliminary results show that the subjects mobilize differently the back segments to help themselves when the resistances increase, but do not modify or little the movement of the upper limb.

This pilot study led to building a 3 dimensions kinematic model including the upper limb and the back for the analysis of the propulsion in manual wheelchair. This model allows detecting the parameters modified by the subject to adapt its propulsion skill according to the experimental conditions. Moreover, this study made us develop a postural ergonometer to examine and modify resistances to advance the seat positioning adjustments.

REFERENCES


Figure (1): The paraplegia subject, positioned on the postural ergonometer, is equipped with markers which 3D trajectories are collected using a Motion Analysis system.