BIOMECHANICAL STUDY
OF MANUAL WHEELCHAIR PROPULSION
OF ELDERLY SUBJECTS

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Introduction:

The use of a manual wheelchair (MWC) needs an intensive utilisation of the upper limb joints [5, 6, 10, 11], especially the shoulder girdle [5]. Although the elderly widely use the MWC, the MWC researches are focused on young and sports users [1-6, 8-21], especially paraplegic subjects who are customed to their wheelchair since a long time. Therefore, the presented research is concentrated on the biomechanical aspects of the MWC propulsion of elderly patients.

Material:

Four devices, recording synchronised data, were used:

1) The figure 1 shows the computer-controlled wheelchair ergometer, allowing the simulation of the MWC propulsion. A speedometer, included into the rollers, allowed the recording of the angular speed of the wheels. It is shown on a part of the figure 1.

2) Each wheel of the MWC is mounted with a torque-meter. The gauges let the recording of the torque due to circumferential forces (anterior-posterior tangential forces) on both the handrim.

3) An electromagnetic goniometer (Fastrack®) records the positions of the upper limb and trunk. The recording frequency was 20 Hz. The system of references used is shown in the figure 2. Due to the Fastrack specifications, it has not been possible to respect the ISB recommendations concerning the axis directions: the vertical axis was
denominated Z, positive downward. The horizontal axis Y was positive medialward and the sagittal axis X was positive in the direction of propulsion, as usually recommended.

4) A surface EMG recorder (Myodata\textsuperscript{(R)}, 12 bit, sampling frequency 2048 Hz, maximal bandwidth 800 Hz and a recording duration of 2 min 47 s for a storage capacity of 4 Mb) explores the electrical activity of muscles.

All data are processed by the mean of a program (Visual Designer\textsuperscript{(R)}, specially adapted to our purpose, which permits the standardisation of the performed tests (Fig. 3).

**Methods:**

Eight subjects have been selected, with the following criteria: age above 60, no heart problems and a recent use of the MWC, mean duration of use 8 months. Anthropometric measures and complete questionnaire were collected for each subject. The four goniometer sensors were placed as follows: middle of the posterior side of the wrist, lateral epicondyle of the elbow, acromion and spinal process of the C7 vertebra. The eight surface EMG sensors were placed upon the following muscles: Brachioradialis; Biceps and Triceps Brachii; Anterior, Posterior and Lateral Deltoideus; Transversalis Trapezius and Pectoralis Major. The skin preparation and the placement of the EMG sensors followed the usual recommendations given in the literature [7]. All sensors placements are shown in the figure 4.
The patients started to push the MWC at a stable and self selected velocity. When the heart rate was stabilised, the recording was launched. Each test was divided into three trials, having one minute as duration and separated by a rest interval, to minimise the fatigue.

**Results & Discussion:**

The main results were the following:
The velocity (0.07 to 0.16 m.s\(^{-1}\)) was lower than found in the literature [5, 6, 11, 20] concerning young subjects (0.55 to 2.35 m.s\(^{-1}\)). The maximum torque was comprised between 5 and 14 N.m\(^{-1}\), in comparison with 19 to 34 N.m\(^{-1}\) recorded for young MWC users [16]. The comparison between the left and the right side of the subjects, expresses the difficulty of the coordination of the upper limbs. Despite the visual feedback (computer screen) of the speed, the elderly subjects had a main difficulty to equal the left and right torque [3].

The technique of the propulsion of the MWC is also different from elderly to young subjects [1]: the tested subjects have the habit to push from top to the anterior part of the handrim [2] instead of pulling from the posterior to the anterior part. The pushing angle of elderly subjects was never higher than 30 degrees. This angle is lower than the one found in the literature, which is a mean of 90 degrees concerning young MWC users [13, 15, 21]. Nevertheless, the displacement of both the acromion and C7 vertebra was very small, identical to those found in the papers. (Fig. 5).
The duration of the propulsive phases was at least 50 % of the total MWC propulsion cycle instead of 33 % for young subjects [12, 16, 17].

The EMG study was in accordance with the results reported in the literature [15, 21]: most of the muscles activity is devoted to a stabilisation of the gleno-humeral joint. The figure 6 shows the muscles coordination as follows: during the pushing phase, all studied muscles have an activity except the three parts of the Deltoideus. Two muscles are active to shift the upper limb forward: Pectoralis Major (antepulsion and adduction of the gleno-humeral joint), Triceps Brachii (extension of the elbow). The Brachioradialis, the Biceps Brachii and the Transversalis Trapezius, seem to be used as stabilisers: respectively elbow joint, gleno-humeral joint and scapula [8, 14, 17].
Fig. 6: Muscles co-ordination
(A: Beginning of the pushing phase; B: End of the pushing phase)
Conclusion:

The intensive use of the MWC displays shoulders pain for both elderly and young subjects [4, 18, 19]. The presented study is a preliminary work to further investigation to improve the design of the MWC, according to the propulsion cycle and the morphology of each subject. The tests, with a second population of patients suffering pain, are in progress. The standardisation of the behaviour of such a population is the main problem: unstable velocity and fatigue phenomenon.

References:


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