MECHANICAL LOAD IN THE SHOULDER DURING WHEELCHAIR-RELATED ACTIVITIES

S. van Drongelen[1], L.H.V. van der Woude[1], T.W.J. Janssen[1,3], E. Angenot[3], E.K.J. Chadwick[2], H.E.J. Veeger[1,2]
[1] Institute for Fundamental and Clinical Human Movement Sciences, Faculty of Human Movement Sciences, Vrije Universiteit Amsterdam, s.vandrongelen@fbw.vu.nl
[2] Man Machine Systems and Control group, Department of Mechanical Engineering, Delft University of Technology
[3] Rehabilitation Center Amsterdam, Amsterdam

INTRODUCTION

The upper extremities are at serious risk in hand rim wheelchair users. Several researchers (Curtis et al., 1999, Pentland & Twomey, 1994) have shown that upper-extremity complaints frequently occur within the wheelchair user population. This is likely related to wheelchair propulsion, but possibly even more to other wheelchair related tasks such as transfers and weight relief lifts.
One of the factors that may contribute to these complains is the high mechanical load on the shoulder joints. Research has shown that the mechanical load on the shoulder during propulsion on a wheelchair-ergometer (Veeger et al., 2002) is considerable and possibly harmful, but is not as high as the load reported for other daily life activities such as coming from sit to stand in able-bodied individuals (Anglin et al., 2000. It is therefore suggested that wheelchair-related daily activities can result in higher peak mechanical loads on (especially) the shoulder compared to mere wheelchair propulsion. Physiological research on people with a spinal cord injury has shown that activities such as making a transfer provoked high levels of strain (Janssen et al., 1994). The effect of paralysis of shoulder and thorax muscles on the mechanical load could be substantial but has not been quantified yet.

The aim of this study is to quantify the internal mechanical load on the shoulder during wheelchair-related activities for a group of able-bodied subjects and to collect data for future comparison with subjects with a spinal cord injury.

METHODS

Six able-bodied male subjects (body mass: 81.7 ± 11.3 kg) participated on a voluntary basis. All subjects performed 11 tasks, including others wheelchair propulsion (0.83 m/s), and weight relief lifting (figure 1). Three-dimensional (3D) kinematics of the thorax, scapula, humerus, forearm and hand were measured with a 50-Hz digital video. A 6-degrees of freedom instrumented wheel (figure 2) measured 3D forces and moments. Position and force data were used as input for the Delft Shoulder and Elbow Model (Helm, 1997), which calculates muscle forces and joint reaction forces.

RESULTS AND DISCUSSION

Preliminary data show that peak mechanical loads (joint reaction forces) during wheelchair propulsion at normal velocity were between 600 and 800 N. The loads in the present study were comparable to values calculated by Veeger et al. (2002) for propulsion on a wheelchair ergometer.

Figure 1: Subject performing a relief lift

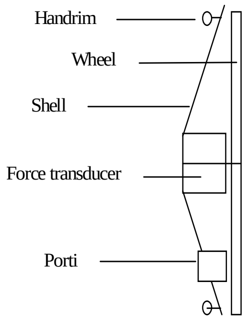

Figure 2: Schematic drawing of the instrumented wheel (frontal plane)

Peak joint reaction forces during the performance of a weight relief lift were over 1200 N. This value is comparable to the contact forces calculated by Anglin et al., (1997) who reported contact forces exceeding 1500 N during activities such as getting up and sitting down into a chair, and lifting a box. The model also calculates the joint reaction forces in the acromioclavicular and sternoclavicular joints. For wheelchair propulsion the peak reaction forces in the acromioclavicular and sternoclavicular joint were both approximately 140 N and for weight relief lifting approximately 620 and 415 N. It is expected that for subjects with a spinal cord injury the mechanical load can be notably higher due to 1. the complete absence of active support from the legs, 2. compensatory muscle activity in the remaining muscle groups after muscle paralysis and 3. a possibly higher body mass. Mechanical load during wheelchair related activities is 50% higher than during normal wheelchair propulsion. These high loads might be a risk factor for overuse of the upper extremity joint, which would be in line with epidemiological data (Pentland & Twomey, 1994). Also, these high loads might be related to local peak muscle forces and thus be indicative for the larger risk for soft tissue trauma.

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