TOWARD AN UNDERSTANDING OF SHOULDER DEMANDS IN MANUAL WHEELCHAIR USERS

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INTRODUCTION

Manual wheelchair users (MWU) rely extensively on their upper extremities for mobility. As a result, MWU experience a high incidence of upper extremity pain and injury [1]. However, the direct link between wheelchair activities and upper extremity (UE) injury has not been established. The overarching goal of our research has been to determine which wheelchair tasks are most likely responsible for upper extremity pain and injury and to design training and rehabilitation programs aimed at reducing injuries.

METHODS

Over the past 15 years, our research has focused on understanding kinematic and loading mechanisms of MWU. We have progressed from ergometer based studies to the real-world environment to accurately capture the loads experienced during activities of daily living.

Our pursuits began with investigations of the effect of seat position and handrim size on handrim and intersegmental biomechanics [2-3]. These studies were performed using a marker-based motion capture system to measure 3-D UE kinematics and an instrumented handrim to measure applied forces and moments. Additionally, isometric strength production of the shoulder, elbow and wrist in MWU and matched controls was examined [4].

In more recent work, we expanded our methods for studying shoulder pain and pathology [5]. Our musculoskeletal model was changed to include a scapula segment in order to examine impingement [6] during level propulsion, ramp propulsion, and weight relief lifts. Additionally, advanced optimization modeling was applied to investigate shoulder joint contact forces and muscle force distribution [7].

Our research has now evolved from inside the laboratory into the real-world environment. This began with quantifying the differences between the demands of the traditional laboratory propulsion to that of outdoor and indoor community ambulation [8-10]. Subjects propelled on an ergometer, over level tile, level carpet, inclined carpet, and varying outdoor concrete surfaces. Symmetry, propulsion moment, power, work, and temporal variables were assessed to test the hypothesis that community ambulation differs from laboratory propulsion.

RESULTS AND DISCUSSION

The results of our earliest work dissipated concerns over seat position and muscle strength imbalances as autonomous contributors to UE injury. The lowest seat position showed improvements in timing variables, but also increased force [2]. Additionally, the UE strength of MWU was not different from matched control subjects [4].

Our modeling work has proven that there is a dramatic difference between joint loading during level propulsion (typical laboratory testing) and higher demand, real-world activities such as ramp propulsion and weight relief lifts [5,7] (Fig. 1). The scapular kinematics of MWU tasks showed detrimental postures for impingement during all tasks with an increased risk during weight relief due to more internal rotation of the humerus [6].

Comparison of laboratory and outdoor community conditions resulted in significant differences in symmetry indexes for all kinetic variables (outdoor...
> lab) and the majority of timing variables (moment shown in Fig. 2) [8]. Additionally during outdoor propulsion, greater power generation from the dominant limb occurred during more challenging conditions (Fig. 3) [10]. The presence of asymmetry among manual wheelchair users suggests data collected from one limb or averaging data collected bilaterally may lead to inaccurate interpretations of propulsion biomechanics. The greater asymmetry identified during outdoor versus laboratory conditions emphasizes the need to evaluate wheelchair biomechanics in the user’s natural environment.

The average propulsion moment and work were significantly increased from smooth level propulsion to aggregate level, and ramp conditions (Fig. 3) [10]. Effort during outdoor community wheelchair ambulation varies with demands imposed by different ground conditions. These results agree with conclusions drawn from the modeling results.

CONCLUSIONS

Our recent work has shown that there are large differences between laboratory and community ambulation in terms of handrim biomechanics and shoulder joint contact forces. To accurately capture the relationship between MWU activities and shoulder injuries, it is imperative to collect data in the wheelchair user’s natural environment. Our future work will continue to focus on characterizing wheelchair propulsion and joint loading in the real-world setting in order to provide clinically relevant injury prevention strategies and treatment recommendations.

REFERENCES

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