INTRODUCTION

Wheelchairs are the primary mobility device for individuals having difficulty with ambulatory activities [1]. In the U.S. it is estimated that 3.3 million people used a wheelchair in 2010 [2], of which 90% used manual wheelchairs (MWs) [3]. However, MWs often lead to reduced independent function and quality of life [4]. Furthermore, shoulder pain and injuries are commonly associated with MW propulsion [5]. Geared manual wheelchairs (GMWs) may be a promising alternative that reduces the biomechanical demands of the shoulder needed for MW propulsion while maximizing function. However, there is limited scientific evidence supporting the benefits of GMW mobility.

The purpose of this study is to compare the glenohumeral (GH) joint dynamics and shoulder flexors electromyography (EMG) during geared and standard MW propulsion. It is hypothesized that using GMWs will decrease glenohumeral joint range of motion and shoulder muscle activity.

METHODS

Six able-bodied individuals, 4 females and 2 males, ages 18-30, were recruited for this study. This study was approved by the University of Wisconsin-Milwaukee Institutional Review Board (IRB). An acclimation period (30 minutes) was provided to the participants to familiarize themselves with wheelchair propulsion techniques. Subjects were instrumented with 27 reflective markers on the upper body and surface electrodes on the anterior deltoid and pectoralis major muscles. Maximum voluntary contractions (MVCs) were performed against manual resistance for the targeted muscles [6]. Subjects were asked to propel both standard and geared MWs on a level, carpeted floor, to simulate the home environment. A Breezy MW (Sunrise Medical LLC.) was used with both its standard wheels and Easy Push (IntelliWheels, Inc.) geared wheels (gear ratio of 1:1.6). Motion analysis data was collected using a 14 camera, three-dimensional (3-D) Vicon T-series motion capture system (120 Hz). A custom inverse dynamics model was used to calculate the 3-D upper extremity (UE) joint dynamics [7]. Delsys Trigno wireless surface electrodes were used to record EMG data (2040 Hz) All recorded EMG signals were rectified and their root mean square (RMS) were normalized by their associated MVC. Normalized EMG was used to determine onset, offset [8], peak time, peak EMG and integrated EMG during a wheelchair stroke cycle using Matlab (The Mathworks, Inc.) software. Statistical analyses were completed with IBM SPSS software using a paired samples t-test (p = 0.05 significance level).

RESULTS AND DISCUSSION

EMG onset and offset, burst duration, peak time, peak EMG and integrated EMG were calculated for three trials of the wheelchair stroke cycle for five subjects. The results of a representative subject are shown in Figure 1. Peak EMG of pectoralis and anterior deltoid decreased by an average of 7% and 8% during GMW propulsion, but they were not statistically significant. Pectoralis burst duration throughout one stroke cycle decreased by 24% (p=0.038) with geared wheels, and integrated EMG for pectoralis and anterior deltoid decreased by 36% and 21%, respectively, but was not statistically significant. When normalized by the distance travelled per stroke cycle, both burst duration and integrated EMG were not significantly different between the two wheel types.
which may potentially prevent associated UE pathologies. Further investigation is underway with a larger population of able-bodied persons and persons with spinal cord injury. The results from this study will help us determine the types of mobility tasks and populations of users for which GMWs are beneficial. Ultimately, this work will lead to new multi-gearled wheel designs for manual wheelchairs.

**REFERENCES**


**ACKNOWLEDGEMENTS**

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**Table 1:** Glenohumeral joint mean ranges of motion and standard deviations during a wheelchair stroke cycle.

<table>
<thead>
<tr>
<th>Wheel Type</th>
<th>Geared Wheels</th>
<th>Standard Wheels</th>
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<tbody>
<tr>
<td>Plane</td>
<td>Sagittal</td>
<td>Coronal</td>
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<tr>
<td>GH Joint Angle</td>
<td>60.7 ± 8.7</td>
<td>16.1 ± 4.4</td>
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