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ABSTRACTS FROM CONFERENCE PRESENTATIONS (2003 – 2005)

Shoulder EMG during manual wheelchair propulsion: The influence of seat position, terrain, and propulsion speed. Gutierrez DD, Mulroy SJ, Newsam CJ, Gronley JK, Perry J. Clinical Gait and Movement Analysis Society conference: May 2004; Lexington, KY

Introduction

Following spinal cord injury (SCI), the demands of mobility are shifted from the lower extremities to the upper extremities. Despite offering considerable independence, manual wheelchair (WC) propulsion imposes a repetitive weight-bearing demand on the upper extremities, which has been associated with a high prevalence of disabling shoulder pain.[1] In addition to the highly repetitive nature of WC propulsion, joint demands have been reported to increase by as much as 3 to 4-fold during fast and graded propulsion efforts.[2] The muscular response to the increased demands during fast and graded propulsion, however, has not been reported. The purpose of this investigation was to document the muscular response to fast and graded WC propulsion and to determine if changing the WC-user interface can reduce the muscular demands of the shoulder.

Statement of Clinical Significance

The muscles about the shoulder provide the force necessary to propel a WC and also must protect the glenohumeral joint against potentially damaging weight-bearing loads. Efforts to reduce the demands associated with manual WC propulsion are paramount to long-term glenohumeral joint integrity and functional independence in persons with SCI.

Methods

Thirteen men with SCI resulting in complete paraplegia (T3 to T12) participated in this study. WC propulsion was performed with a test wheelchair in 2 seat positions: (1) with the wheel axle aligned under the glenohumeral joint (ANTERIOR) and (2) with the seat moved 8cm posteriorly (POSTERIOR). The test WC was secured on a stationary ergometer, which simulated propulsion over level-ground and ramps. Three levels of effort were tested for each seat position: (1) level-ground FREE propulsion, (2) level-ground FAST propulsion, and (3) simulated 8% grade propulsion (GRADED). Fine-wire electromyographic (EMG) activity was recorded from 6 push phase muscles: anterior deltoid (AD), sternal pectoralis major (SPM), supraspinatus (SUP), infraspinatus (INF), lower serratus anterior (LSA), and lower trapezius (LT). EMG intensity during WC propulsion was normalized to a maximum voluntary effort (%Max). A 2x3 (seat position x propulsion condition) repeated measures analysis of variance was performed to compare EMG onset, cessation, and duration for each muscle. EMG intensity data were not normally distributed and therefore nonparametric analyses were used. The alpha-level was set at .05 after correction for multiple comparisons.

Results

Median EMG intensity during FREE propulsion was low, ranging from 0%Max (LT) to 22%Max (SPM).(Figure 1) EMG intensity increased significantly for all muscles during both FAST (25%Max to 56%Max) and GRADED propulsion (26%Max to 46%Max). There was no difference between FAST and GRADED propulsion intensity. The duration of EMG activity was significantly longer for all muscles during GRADED propulsion (37% to 53% propulsion cycle [PC]) compared with that recorded during the FREE condition (5% to 23% PC) owing to a significantly later cessation of activity (33% to 39% PC for GRADED vs. 16% to 21% PC for FREE). Additionally, AD onset occurred significantly earlier during GRADED propulsion further contributing to a longer duration. The only difference in EMG timing between FAST and FREE propulsion was a longer duration for LSA and earlier onset for AD, SPM, and INF during the FAST condition.

Changing the seat position resulted in significantly decreased EMG intensity for SPM and AD in the POSTERIOR seat position.(Figure 2) SPM decreased from 46%Max in the ANTERIOR position to 39%Max in the POSTERIOR position. AD decreased from 30%Max to 22%Max in the POSTERIOR position. AD timing, however, displayed a significantly earlier onset (85%PC vs. 89%PC) and longer duration (32%PC vs. 29%PC) in the POSTERIOR position.

Figure 1. Effect of test condition on median EMG intensity

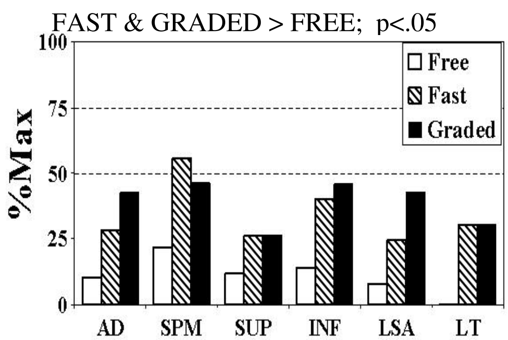
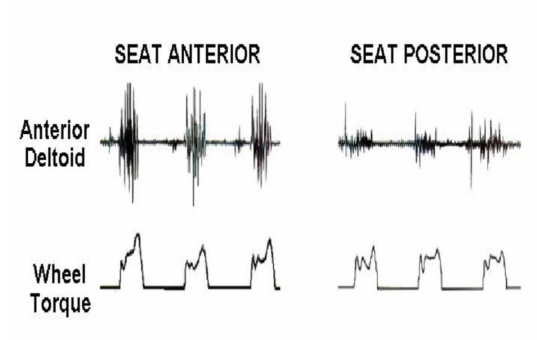


Figure 2. Effect of seat position on raw AD EMG during FREE propulsion



Discussion

During WC propulsion, there are a variety of speeds and terrains that are encountered in the community. These challenges must be met by the muscles of the upper extremity. The muscular demands of FREE propulsion were relatively low.[3] The muscular response increased considerably for both FAST and GRADED propulsion. The magnitude of EMG intensity during FAST and GRADED propulsion was consistent with the increases in shoulder forces and moments previously reported.[2] For all muscles studied, the EMG duration during GRADED propulsion was significantly longer than that of FREE. The combined effects of increased EMG intensity and duration in GRADED propulsion presents the greatest risk for fatigue.

Moving the seat POSTERIOR resulted in significantly decreased EMG intensity for the AD and SPM, two of the primary push phase muscles. Although AD demonstrated decreased EMG intensity, the duration significantly increased. Further investigation is required to determine if this places AD at risk for fatigue. Our findings suggest that moving the seat posteriorly may decrease muscle intensity and potentially prolong muscular endurance.

References

1- Sie et al., (1992) Arch Phys Med Rehabil, 73:44-48
2- Kulig et al., (1998) Clin Orthop Rel Res, 354:132-143
3- Mulroy et al., (1996) Arch Phys Med Rehabil,77:187-93

Acknowledgments

Funded by the National Institutes of Health; Grant# HD37098