Comparison of temporal spatial characteristics and shoulder muscle activity during reverse and conventional manual wheelchair propulsion in persons with paraplegia.

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Objective: Shoulder pain following spinal cord injury is attributed to a shift in functional mobility demands to the upper limbs and negatively impacts independence, participation and quality of life[1, 2]. The repetitive superior and posterior shoulder joint forces produced during wheelchair (WC) propulsion can result in impingement of subacromial structures if unopposed owing to fatigue or weakness[3]. Further, these forces increase with fast and inclined propulsion. RoWheels® (RW), geared rear wheels that produce forward WC movement with backward rim pulling, have the potential to reverse these shoulder joint forces and utilize the larger posterior shoulder and scapular muscles.

Design/Methods: Ten males with paraplegia from SCI (AIS A, B) volunteered. Participants pushed traditional manual WCs and were free of shoulder pain (Wheelchair User's Shoulder Pain Index (WUSPI) < 12) or pathology. Right upper extremity/trunk kinematics and kinetics were collected during three conditions of ergometer propulsion: self-selected free speed reverse (pulling back on the rim) propulsion with RW, and matched-speed forward (fSW) and reverse propulsion (rSW) with standard instrumented rear wheels (Smartwheels (SW) using an analog display of propulsion speed. Electromyographic activity of ten right shoulder muscles also was recorded with indwelling wire electrodes during propulsion. Temporal spatial characteristics and EMG variables were compared across the three conditions with a repeated-measures Analysis of Variance.

Results: Mean age of participants was 39.6 years and duration of spinal cord injury was 14.5 years. Free propulsion velocity and cadence were similar during reverse propulsion (RW=70.1 +/- 10.9 meters/minute (m/min) and 67.4 +/- 26.1 pushes/minute (p/min); rSW=70.3 +/- 6.9 m/min and 68.1 +/- 14.1 p/min, respectively) compared to forward (fSW=72.0 +/- 7.8 m/min and 61.5 +/- 17.1 p/min, respectively) although push distance was slightly reduced in the rSW (1.06 ± 0.17m) vs. RW (1.16 ± 0.35m, p=.028), and fSW (1.23 ± 0.27m). Traditional push-phase muscle activity (Pectoralis Major, Anterior Deltoid, Infraspinatus) was significantly decreased with reverse propulsion (RW and rSW vs. fSW) with the largest reduction recorded in Pectoralis intensity-time-integral (16 and 36 %MMT▪sec vs. 351 %MMT▪sec, respectively, p=.001). Conversely, traditional recovery phase muscle activity (Latissmus, Rhomboideus, and Triceps, Long Head) was increased during reverse propulsion (RW and rSW vs. fSW) with the greatest increase documented in Rhomboideus (1731 and 1449 %MMT▪sec vs. 889 %MMT▪sec, respectively, p=.04).

Conclusion: The RW with alternative rear wheel technology, allows forward propulsion by pulling back on the rim using larger posterior shoulder muscles vs. traditional push-phase muscles. This may substantially protect the subacromial structures from impingement to prevent injury and pain and preserve mobility, independence, and participation for individuals living with paraplegia. The significant reduction in infraspinatus activity suggests a reduction in the superior (impinging) force. Shoulder joint forces during reverse and forward propulsion will need to be analyzed.

Support: RoWheels® Grant.

Learning Objective: Attendees will be able to describe how propulsion with RW alters shoulder muscle activity compared to traditional forward manual WC propulsion and how this alternative rear wheel could protect the shoulders and preserve mobility and independence for manual WC users.

References:

1. Kemp et al. (2011).
2. Ataoğlu et al. (2013).
3. Requejo et al. (2015).