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Scapular kinematics during transfers in manual wheelchair users with and without shoulder impingement

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Abstract

Background. Scapular function during humeral elevation has been reported in groups with and without shoulder impingement pathology. To date, no one has assessed scapular kinematics during upper extremity loaded tasks that manual wheelchair users must perform on a daily basis. Therefore, the objective of this study was to compare scapular kinematics and muscle activation patterns during two different wheelchair transfers in groups of manual wheelchair users with and without shoulder impingement.

Methods. A case controlled study of manual wheelchair users, with and without shoulder impingement was performed. Twenty-three male manual wheelchair users (13 without shoulder impingement, 10 with shoulder impingement) performed transfers toward the involved or dominant limb (lead limb transfer) and away from the instrumented limb (trail limb transfer). Position and orientation measures of the thorax, scapula and humerus were obtained using an electromagnetic tracking system. Muscle activity data were collected using telemetered electromyography. Each subject performed three trials of wheelchair transfers to each side.

Findings. Manual wheelchair users with impingement performed transfers with reduced thoracic flexion, increased scapular internal rotation, and increased humeral internal rotation as compared to those without impingement. Differences were found between the tasks in the scapular motions and EMG amplitude. Trail limb transfer presented with reduced scapular upward rotation and posterior tip as compared to the lead limb transfer task. Increased muscle activity for the lower trapezius and serratus anterior muscles was demonstrated in the trail limb transfer.

Interpretation. This study provides the first kinematic description of scapular kinematics during transfer tasks. Shoulder impingement and direction of transfer does affect transfer task performance in manual wheelchair users. Scapular kinematics and muscle patterns during transfers may predispose manual wheelchair users to the development of shoulder pathology.

Keywords: Wheelchair; Biomechanics; Shoulder Impingement

1. Introduction

It has been estimated that between 1.4 and 1.6 million individuals in the United States have disabilities that require the use of a wheelchair (Morrison, 1996; LaPlante et al., 1997). Disability groups including spinal cord injury (SCI), lower limb amputation, stroke, multiple sclerosis, rheumatoid arthritis, spina bifida, poliomyelitis, and hip fracture as well as other groups are represented in the population of manual wheelchair users (MWCU).

Manual wheelchair users depend on their upper extremities for mobility, transfers, pressure relief and a variety of other daily functional activities. Several studies have reported the incidence and prevalence of

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shoulder pain and specific pathology in MWCU (Soderberg, 1986; Subbarao et al., 1995; Finley and Rodgers, 2004). In one study, 60% (33 of 52) of MWCU reported experiencing shoulder pain since the initiation of wheelchair use (Finley and Rodgers, 2004). In stark contrast, it has been estimated that only 4.7% of the general population report regularly experiencing shoulder pain (Public Health Service, 1979).

Shoulder impingement syndrome has been reported to be the most commonly occurring pathology in the manual wheelchair population (Finley and Rodgers, 2004; Bayley et al., 1987). Scapular upward rotation and posterior tipping elevate the anterior and lateral aspects of the acromion, the sites of shoulder impingement (Flatow et al., 1994; Poppen and Walker, 1976). Modest changes in scapular function lead to a reduction in this space, possibly increasing the potential for pathology (Ludewig and Cook, 2000). Alterations in scapular kinematics (increased internal rotation, reduced posterior tipping) and muscle activation patterns (increased upper and lower trapezius activity) have been reported to occur in individuals with shoulder impingement (Ludewig and Cook, 2000; Lukasiewicz et al., 1999).

Differences have been shown in muscle activation patterns of the leading limb (arm reaching to new surface) and the trailing limb (arm behind during move to new location) transfers performed by persons with SCI (Perry et al., 1996). While scapular movement patterns and scapulothoracic muscle function have been reported in open chain (non-weight bearing) humeral elevation in groups with and without shoulder impingement pathology (Ludewig and Cook, 2000), no one has assessed the scapula during upper extremity loaded tasks that individuals who use a wheelchair must perform on a daily basis. Therefore, the purpose of this research was to compare scapular kinematics and muscle function during the performance of transfers in groups of MWCU with and without shoulder impingement. It was hypothesized that (1) MWCU with shoulder impingement would demonstrate different scapular kinematics and muscle activity compared to MWCU without the pathology and (2) muscle activation patterns would be different between the two transfer tasks.

2. Methods

2.1. Subjects

After reading and providing informed consent, as approved by the University of Maryland, Baltimore Institutional Review Board, subjects completed a participant information questionnaire that provided information on the subject's age, nature of the disability, duration of wheelchair use, general activity level, and a self-reported medical history. All subjects underwent a clinical shoulder evaluation including range of motion, strength, and special tests for joint integrity and the presence of shoulder impingement.

Evaluations were performed by one experienced physical therapist with findings reviewed by a physician experienced in patient populations with shoulder pathologies. Subjects were included in the control, non-impingement group if they were negative for all of the impingement criteria tests and subjectively reported that shoulder function was painfree. Subjects were classified as having impingement if they demonstrated positive findings for a minimum of four of the following six criteria: Neer sign (Neer, 1983), Hawkins sign (Hawkins and Kennedy, 1980), pain in the anterolateral shoulder (Clarnette and Miniaci, 1998), painful arc of motion (60°–120°) in the scapular plane (Clarnette and Miniaci, 1998), tenderness to palpation of rotator cuff tendons in region of greater tuberosity, acromion or rotator cuff tendons, pain with resisted isometric abduction. Subjects were excluded from participating in either group if they presented with reproduction of symptoms with a cervical screening test, radicular symptoms of numbness and tingling in the upper extremity, scapular plane humeral elevation less than 130°, history of fracture, dislocation or surgery of the glenohumeral or acromioclavicular joint, upper extremity impairment such as extensive weakness due to spinal cord injury or nerve degeneration, or spasticity, or poor trunk control.

Both medical professionals confirmed each subject's inclusion in the experimental (impingement) or control (non-impingement) group. A total of 23 male MWCU participated in this study, 10 in the impingement group. The disabilities present in the sample were intentionally diverse to represent the general wheelchair user population. Table 1 provides the demographic information of the subjects, by group.

2.2. Instrumentation

Kinematics were collected using an electromagnetic tracking system (Ascension Technology Co, Burlington, VT, USA) and interfaced with the Motion Monitor™ software system (Innovative Sports Training, Chicago, IL, USA) consisting of electromagnetic sensors. Sensors were attached via double-sided adhesive to the manubrium of the sternum, humerus, flat surface of the acromion, and forearm. This method of using surface markers for scapular tracking has been validated against invasive bone markers (Karduna et al., 2001). The average motion pattern of each surface method was similar to that measured by the invasive technique, especially below 120° of elevation (Karduna et al., 2001). This system has a manufacturer reported accuracy of 8.0 mm/1.0° with the transmitter at a distance of 3 meters. Metallic distortion was minimized by system metal