SHOULDER KINEMATIC PATTERNS DURING EXECUTION OF CIRCUIT RESISTANCE TRAINING IN INDIVIDUALS WITH PARAPLEGIA: A CASE SERIES

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INTRODUCTION

Following spinal cord injury (SCI), shoulder demands are radically altered as usage and upper extremity weight-bearing increase. Consequently, shoulder pain associated with impingement is common in persons with paraplegia (40% prevalence). Although little is known regarding shoulder health and injury prevention following SCI, exercise including circuit-resistance training (CRT) is encouraged in rehabilitation and community settings to promote shoulder health. Ironically, positions inherent to CRT programs may increase shoulder impingement risk, either subacromial or internal. In the able-bodied, impingement is associated with altered shoulder kinematics, including increased scapular anterior tilt (AT), downward rotation (DR), internal rotation (IR), and glenohumeral (GH) IR[1]. Previous literature supports scapular AT and GHIR as key detrimental motions for shoulder impingement [1]. These same potentially detrimental kinematic patterns may be present during the execution of CRT exercises from a wheelchair level.

The purpose of this study was twofold: 1) to critically evaluate three-dimensional (3-D) scapular and GH kinematic patterns among wheelchair-based upper extremity CRT exercises in order to determine which exercises place the shoulder at greater impingement risk and 2) to evaluate whether specific humeral modifications during execution of upper extremity CRT exercises will alter 3-D scapular and GH kinematic patterns such that shoulder impingement risk can be minimized.

METHODS

In this case-series design, three subjects with SCI at the second thoracic (T2) level or below and without shoulder pain participated. During the first session, the one repetition maximum (1-RM) was determined for five Cybex Total Access™ exercises (chest press, seated row, lat pulldown, overhead press, cabled rickshaw). During the second session, 3-D shoulder kinematic data were collected using the Flock of Birds™ electromagnetic tracking system. At each station, the subject performed one paced set of ten repetitions at 50% 1-RM in both a traditional position and a modified arm position.

Exercises were rank-ordered based on the magnitude of deviation from previously established normative data for scapular anterior tilt, internal rotation, downward rotation, and GH internal rotation [3]. Based on the magnitude of deviation at specific humerothoracic (HT) elevation angles of 45° and 60° (subacromial impingement risk) and 105° and 120° (internal impingement risk), values for each kinematic variable within one standard deviation (sd) from normative values were assigned one point, between one and two sd were assigned two points and beyond two sd were assigned three points. Comparisons between traditional and modified positions for each exercise were also assessed at selected positions of HT elevation. Differences exceeding five degrees or more of scapular or GHIR angles at these selected angles were considered a modifiable change.

RESULTS AND DISCUSSION

Three subjects (50 ± 13 years and neurologic level ranging from the fourth to twelfth thoracic level) participated. At less than 60 degrees, the risk of subacromial impingement (combined patterns of scapular AT, IR, DR, and GHIR) was greatest for
rickshaw, row or chest press, and lat pulldown. At greater than 105 degrees, the risk of internal impingement was greatest for overhead press followed by lat pulldown (Figure 1). Findings also suggest that modified arm positions can result in more favorable kinematics during the execution of CRT as demonstrated by a maximum decrease in scapular AT of 22 degrees during row and 12 degrees during chest press at 60 degrees HT elevation (Figure 2). At 105 degrees HT elevation, GHIR demonstrated a maximum decrease of 7 degrees during overhead press (Figure 2).

This study is limited to three participants. Ongoing studies include an expanded sample size and simultaneous collection of kinematic and muscle activation data during execution of CRT. Initial findings are promising that impingement risk during the execution of CRT can be reduced by modifying arm positions.

REFERENCES


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Figure 1: Scapular anterior tilt (one of four kinematic patterns) for subject one during five CRT exercises. Green boxes are ± 1sd, orange are between 1-2sd, and red are greater than 2 sd from normative data reflecting scapular positions considered least to most risk, for subacromial (45-60 degrees) or internal (105-120 degrees) impingement.

Figure 2: a) Scapular anterior tilt at 60 degrees HT Elevation and b) GH internal rotation at 105 degrees HT elevation. Asterisks indicate greater than 5 degree differences between traditional and modified positions.