The effect of sitting trunk posture on three-dimensional scapular kinematics
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Introduction: Previous research had studied the three-dimensional kinematics of the scapula bone (McQuade, et al, 1995 &1998; Ludewig, et al., 2000; Lukasiewicz, et,1999;Ozaki, 1989). External loads applied to the humerus during elevation had been shown to reduce the movement of the scapula (McQuade, et al 1998). Impingement pathology generally resulted in decreased posterior tipping of the scapula during elevation of the humerus (Lukasiewicz, et al, 1999; Ludewig, et al, 2000). Conflicting findings have been reported regarding the effect of posture on scapular positions (Greenfield, et al,1995; Kebaetse, et al 1999). Several of these earlier studies determined scapular movement with the arms held in different static positions (Lukasiewicz, et al,1999; McQuade, et al, 1995; Kebaetse, et al, 1999; Greenfield, et al, 1995). The isometric muscular contraction required to hold these static positions will significantly alter the positions of the scapula. The findings of these studies are thus not truly representative of scapular kinematics during a dynamic task (McQuade, et al, 1998). There is thus a strong need to examine the effects of posture on scapular kinematics. The purpose of this study was to dynamically assess the effect of thoracic trunk posture on scapular kinematics during humeral elevation.

Methods: Sixteen adult volunteers participated in this study (age = 21.6 ± 3.92 years; 12 female, 4 male; height = 165.06 ± 5.36cm; weight = 51.75 ± 4.46kg). Subjects who reported a history of shoulder pathology or were currently experiencing shoulder pain were excluded from the study. Real-time three-dimensional positions and orientations of the thorax, humerus and scapula were collected using the Fastrak electromagnetic device (Polhemus, Colchester, VT). Electromagnetic receivers were attached inferior to the sternum (distal to the sternal notch), acromion process and humerus (via a thermoplastic cuff mould). Angular orientation accuracy has been reported to be within 1.3° (McQuade, et al,1998), and error due to skin motion artifact of this method has been reported to be reasonable (RMS error =2.0°-9.4°) when humeral elevation is less than 120° (McQuade,et al, 1998; Karduna,et al, in press).

Subjects performed humeral elevation along the scapular plane (30° - 45° anterior to the coronal plane) while sitting in an upright posture. Neutral reference position data of the shoulder complex was recorded prior to each elevation trial. Subjects were instructed to lift their arm to full elevation. Speed of movement was controlled by a standardized, count of eight. Three trials of the movements were performed. Subjects were then instructed to “slouch down” as far as they could and the procedures were repeated with the subjects in a slouched (increased thoracic kyphosis) posture.

The orientations of the scapular and humeral sensors with respect to the sternal sensor were determined. Three-dimensional orientations of the scapula and humerus in the starting positions of the upright and slouched postures, and three-dimensional anatomical movements of the scapula and glenohumeral joints in the two postures were derived from the orientation information using the Joint Coordinate System method described by Grood and Suntay (Grood, et al,1983). Scapular upward and downward rotations were defined as rotations about its anterior-posterior axis. Anterior and posterior tipping was defined as rotations about the mediolateral axis with anterior tipping being movement of the inferior angle of the scapula away from the thorax. Rotation about the superoinferior axis was defined as medial and lateral rotation with posterior movement of the vertebral border of the scapula being medial rotation.

Correlation of multiple coefficients and root mean-square-error were used to assess intrasubject trial-to-trial differences. Multivariate Analysis of Variance (MANOVA) was performed to compare the differences between the upright and slouched postures in the scapular and humeral orientations. These comparisons were made in the starting positions and at 30°, 60° and 90° of humeral elevation.
Results & Discussion

Reliability

Correlation of multiple coefficients ranged from 0.9 to 0.95 and the root mean square error from 0.84° to 1.5°. This suggested that the measurements were sufficiently reliable for the purpose of this study. This finding is in agreement with previous studies (Ludewig, et al 2000; McQuade, et al 1998). The method is simple, easy and inexpensive and therefore has the potential of being used for everyday clinical practice.

Starting positions

The slouched starting position demonstrated significantly increased scapular anterior tip, upward and medial rotation and more glenohumeral medial rotation when compared to the upright starting position (p<0.05) (Table 1).

<table>
<thead>
<tr>
<th>Motion</th>
<th>Starting Position</th>
<th>% Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-T Anterior/posterior tipping</td>
<td>2.5³ ± 3.2³ (anterior)</td>
<td>75.0% (12/16)</td>
</tr>
<tr>
<td>S-T MR/LR</td>
<td>-0.66³ ± 38.6³ (medial)</td>
<td>68.7% (11/16)</td>
</tr>
<tr>
<td>S-T Up/down rotation</td>
<td>4.5³ ± 5.1³ (upward)</td>
<td>93.7% (15/16)</td>
</tr>
<tr>
<td>GH MR/LR</td>
<td>-7.7³ ± 6.8³ (medial)</td>
<td>87.5% (14/16)</td>
</tr>
</tbody>
</table>

* Indicates the percentage of subjects who presented with this scapular position
† S-T = scapulothoracic; ‡ MR/LR = medial/lateral rotation; † GH = Glenohumeral

Movements of the Scapula and the Humerus in the Upright and Slouched Postures

In both postures, posterior tip, medial and upward rotations of the scapula and glenohumeral lateral rotation were observed during humeral elevation. MANOVA indicated that there were significant decreases in posterior tip (p = 0.004) and increases in method rotation (p = 0.000) when the slouched posture was adopted, but there were no significant differences in the other movement planes (p>0.05) (Figure1).

The changes in the scapular positions with the adoption of a slouched posture, as observed in the present investigation, were in general agreement with those of earlier studies (Culham, et al 1993; Ludewig, et al 1996; Ludewig, et al 2000; Kebaetse, et al 1999). Kebaetse et al (1999) also found that the slouched posture (increased thoracic kyphosis) placed the scapula in a resting position with greater medial rotation, upward rotation and anterior tip as compared with an upright posture.

Figure 1 – Comparison of scapular movements between upright and slouched posture

* Significant difference upright vs slouched posture
Thatched bars = upright posture; solid bars = slouched posture
Table 2 provides a comparison of the mean magnitude of these movements for 90° of humeral elevation as observed in the present and earlier studies. In general, the present study demonstrated smaller magnitude of scapular upward rotation and greater amount of medial rotation. The differences in the magnitude of movements might be due to biological variation and the differences in the methods of computing the anatomical angles. The computational method of Grood and Suntay was employed in this study, as it was the method currently recommended by the International Society of Biomechanics for joint motion description (Grood, et al 1983).

Table 2 Mean scapular movements with 90° of humeral elevation - a comparison of the results of the present study and those of earlier work

<table>
<thead>
<tr>
<th></th>
<th>Upright Upward rotation</th>
<th>Upright Medial rotation</th>
<th>Posterior tip</th>
<th>Slouched Upward rotation</th>
<th>Slouched Medial rotation</th>
<th>Posterior tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finley &amp; Lee</td>
<td>9.2°</td>
<td>12.4°</td>
<td>11.1°</td>
<td>8.3°</td>
<td>10.1°*</td>
<td>9.6°*</td>
</tr>
<tr>
<td>(current)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ludewig et al</td>
<td>19.0°</td>
<td>5.0°</td>
<td>6.0°</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>(1996)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kebaetse et al</td>
<td>15.0°</td>
<td>3.3°</td>
<td>11.4°</td>
<td>14.7°</td>
<td>3.0°*</td>
<td>13.5°</td>
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<tr>
<td>(1999)</td>
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* Significant difference upright vs slouched posture

The present study clearly demonstrated that the slouched posture, with increased thoracic kyphosis, would lead to decreased posterior tip and increased medial rotation of the scapula, movements associated with impingement syndrome (Ludewig, et al, 2000; Lukasiewicz et al, 1999). Therefore, it could be argued that repetitive humeral elevation in a slouched posture may lead to an increased likelihood of encroachment of the supraspinatus tendon and development of shoulder pathology.

Conclusion: The present study revealed that the adoption of a slouched posture would alter scapular kinematics. Changes in the movement patterns of the scapula may increase the likelihood of shoulder pathology. Further studies of the relationship between posture and kinematics are needed to determine the mechanisms of injury and possible preventions for shoulder disorders.

References

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