INTRODUCTION

Inman et al (1944) initially analyzed scapulohumeral rhythm and suggested that normal rhythm is fixed and that the ratio of glenohumeral and scapulothoracic motion is almost 2.0. However, we hypothesized that the scapulohumeral rhythm of a healthy person is not fixed with different conditions of motion. In this study, the effect of motion velocity on scapulohumeral rhythm was studied to evaluate the components of shoulder motion under conditions of the most simplified motions.

METHODS

Nineteen shoulders of 10 healthy volunteers (all men, 24-30 years of age) were examined. Bilateral upper arms were abducted or adducted symmetrically in the scapular plane to avoid spinal movement. Shoulder motions were observed using an image intensifier combined with a video system. High definition 1024 x 1024 matrix images at high-speed 7.5 frames per second were displayed dynamically on the films without blurring. Fluoroscopy was done with each subject standing on the platform facing the fluoroscopic table at an angle of 30 deg. anterior to the frontal plane so that the plane of abduction was parallel to the plane of the radiograph. Each frame was digitized to measure the arm (A), glenohumeral (GH), and scapulothoracic (ST) angles. The ΔGH/ΔST ratio was calculated from the gain of GH and ST angle from one frame to the next in abduction, and was also calculated from the decrease in GH and ST angle from a frame to the next in adduction. The effects of two types of motion velocity on scapulohumeral rhythm were studied: high- and low-speed motion consisted of 2 and 4 seconds per cycle from abduction to adduction, respectively. Each motion was performed three times to confirm its uniformity.

RESULTS

Velocity of scapulohumeral motion

One cycle of abduction to adduction required an average of 1.94 seconds (1.90 ~ 1.94 sec.) at high speed, and 4.10 sec. (3.54 ~ 4.66 sec.) at low speed.

Stability of the scapulohumeral motions and findings of scapulohumeral rhythms

Representative movement patterns of A, GH, and ST during three sets of abduction and adduction at low speed are shown in Figure 1-a. The three graphs show that scapulohumeral motion is stable. Figure 1-b shows changes in GH/ST ratios at low speed, where the ratios were fixed and almost 2.3 at an abduction angle during abduction or adduction of over 40 degrees. These results agree with the findings of Inman et al (1944) and other investigators (Doody, 1970; Poppen, 1976; Bagg, 1988).

DISCUSSION

After Codman described the scapulohumeral motion during abduction in 1934, many studies followed. Inman et al's study (1944) showed that the GH/ST ratio is stable and almost 2.0 during abduction or adduction. Other reports also suggested that the ratios were fixed and scapulohumeral rhythm followed a specific pattern. All previous studies examined changes in scapulohumeral positions under static conditions. Our results differ because we conducted our study under dynamic movement conditions, that was made possible by the use of a high-resolution digital video system. We found that scapulohumeral rhythms were not fixed, but varied according to motion velocity.
Glenohumeral muscles including the supraspinatus and deltoid muscles have the advantage of rapidly gaining a range of motion in abduction because they have short moment arms, compared with the scapular rotator muscles that have long moment arms. The effect of motion velocity upon the scapulohumeral rhythm has not been studied, but our results may be based on this principle.

Bilateral scapulohumeral rhythms differed considerably at high speed despite a constant velocity of the movement, muscle power and weight of the arm. The rhythms may be regulated not only biomechanically but neurophysiologically. Voluntary movement is generally an expression of the motor program in the central nerve system and the program is imprinted through integration and training. Scapulohumeral motion consists of glenohumeral and scapulothoracic portions and scapulohumeral rhythm is regulated according to the exquisite balance of glenohumeral and scapulothoracic motions. Disrupting the balance may disorder the rhythm and may leads to disorders of the shoulder joint.

**SUMMARY**

The effect of motion velocity of the upper arm on the scapulohumeral rhythm was studied to evaluate the diversity of shoulder motion. Nineteen shoulders of 10 normal persons (all males, 24 - 30 years of age) were analyzed using an image intensifier and a high-resolution digital video system. High and low speed motion consisted of 2 and 4 seconds per one cycle, respectively, from abduction to adduction in the scapular plane. Glenohumeral and scapulothoracic ratios were fixed with low speed and these results agree with the findings of Inman et al (1944) and other researchers. Ratios at high speed were not fixed and significantly differed from the results at low speed. Ratios were high at the beginning of abduction or adduction, then decreased according to the arm movement. In conclusion, glenohumeral motion at high speed was more dominant at the beginning of abduction or adduction beyond a set phase, then becomes less dominant according to the arm movement, compared with the motion at low speed.

**REFERENCES**


**Table 1**

<table>
<thead>
<tr>
<th>Angle</th>
<th>GH/ST Ratio</th>
<th>GH/ST Ratio</th>
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</thead>
<tbody>
<tr>
<td>60º</td>
<td>2.36</td>
<td>0.20</td>
</tr>
<tr>
<td>150º</td>
<td>0.11</td>
<td>2.31</td>
</tr>
<tr>
<td>150º</td>
<td>2.91</td>
<td>0.13*</td>
</tr>
<tr>
<td>60º</td>
<td>1.67</td>
<td>0.14*</td>
</tr>
</tbody>
</table>

*: p<0.05
GH=Glenohumeral angle
ST=Scapulothoracic angle
ABD=Abduction
ADD=Adduction

Fig 1a-b: Changes in glenohumeral and scapulothoracic ratios of Participant 1 at low speed during (A) abduction and (B) adduction are shown. The vertical axis shows the value of glenohumeral angle and the horizontal axis shows the abduction angle.

Fig 2a-b: Changes in glenohumeral and scapulothoracic ratios of Participant 2 at low speed during (A) abduction and (B) adduction are shown.

Fig 3a-b: Changes in glenohumeral and scapulothoracic ratios of Participant 3 at low speed during (A) abduction and (B) adduction are shown.

Fig 4a-b: Changes in glenohumeral and scapulothoracic ratios of Participant 1 at high speed during (A) abduction and (B) adduction are shown.

Fig 5a-b: Changes in glenohumeral and scapulothoracic ratios of Participant 2 at high speed during (A) abduction and (B) adduction are shown.

Fig 6a-b: Changes in glenohumeral and scapulothoracic ratios of Participant 3 at high speed during (A) abduction and (B) adduction are shown.