Measurement of scapulo-humeral rhythm and related factors

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Abstract
The purpose of this study was to investigate the relationship between conventional reports and to investigate factors related to scapulo-humeral rhythm using a simple method to measure scapulo-humeral rhythm. The study included 10 subjects (10 shoulders) with no disorder of or past medical history involving the shoulder joint (mean age: 25.2 ± 2.8 years). For the measurement of scapulo-humeral rhythm, subjects performed scapular plane elevation in a sitting position according to a previous study, and the distances between each landmark on the scapula and spine were measured at 0°, 30°, 60°, 90°, 120°, and 150° shoulder joint abduction angles. Furthermore, we measured factors such as scapular upward rotation angle and the wall acromial distance with the upper limb hanging downwards and the distance between the acromion and floor in a lateral position with thoracic spine rotation and evaluated their relationships with scapulo-humeral rhythm. In this study, we reported the average scapulo-humeral rhythm to be 3.12:1. Analysis of related factors showed that scapulo-humeral rhythm was positively correlated with the wall acromial distance($r = 0.64$, $p<0.05$) as well as the distance between the acromion and floor in a lateral position with thoracic spine rotation ($r = 0.78$, $p<0.05$). The study suggests that scapula malposition caused by anterior tilting of the scapula is involved in the reduction in scapular upward rotation angle related to scapulo-humeral rhythm.

【Introduction】

Optimal function of the shoulder is reliant on the coordinated movement of the scapula and the humerus. A humerus in the elevation movement of the shoulder joint and the scapular sense of cooperation are made the definition as scapulo-humeral rhythm (SHR)[1)], and it is reported that the scapular movement for the humerus moves by a constant ratio of 2:1[2)]. It is reported that the disorder of this SHR is associated with the dysfunction of shoulders such as the subacromial impingement disorder, and the like[2]. The factors that effect SHR such as decline of scapular function due to aging[3], the posture of the thoracic kyphosis rank[4], and diseases such as frozen shoulder[5] or rotator cuff injury[6] have been reported. However, there are few reports about the relationship between scapular malposition and stiffness of the scapular muscles. In addition, common, but, as for the measurement of the SHR, the studies such as X-rays or the three-dimensional motion analysis[7][8], and the like cannot measure those studies by problems such as the involvement to a body and the gap of the skin marker position, the measurement environment, and the like easily. Therefore we cannot measure SHR in many subjects using conventional methods. For the rating system of simple scapula malposition, Kibler scapula lateral slide test[9] and Diveta test[10] to measure distance from a spinal column to inferior angle of the scapula are reported as a physical therapy evaluation now, there are few reports evaluating the ratio of the SHR. Therefore in this study, we devised a procedure to evaluate SHR that can be easily performed of the shoulder scapula aspect elevation from each scapular landmark and distance between the spinal column that we could perform easily, and demanded SHR at the shoulder elevation and examined the investigation of the relationship with the conventional report and a factor related with the SHR.

【Methods】

The study included 10 shoulders of 10 healthy adults (mean age: 25.2 ± 2.8 years) with negative findings in the impingement tests by Neer and Hawkins. We explained the purpose and significance of this study to subjects and obtained their written consent. For the measurement of SHR, subjects performed scapular plane elevation in a sitting position, and the distances between each scapular landmark and the spine at 0°, 30°, 60°, 90°, 120°, and 150° shoulder joint abduction angles were measured using a carpenter's square (Fig. 1).

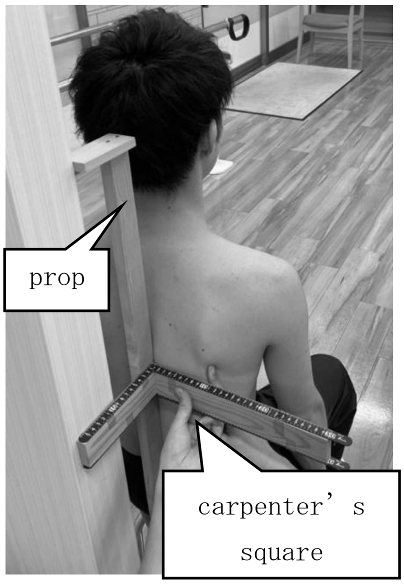

Fig. 1 Setup for measuring scapulo-humeral rhythm

The setup was carefully designed to avoid pelvic retroversion.

During the measurement, we carefully avoided lateral bending of trunk movement and pelvic retroversion rank using a prop. It prescribed the line which linked the middle point of bilateral posterior superior iliac spines from the seventh cervical vertebrae spinous process with trunk axis O and put it together to a prop and rearranged it.

We designated the medial border of the spine of the scapula as point A, the inferior angle of the scapula as point B, the intersection point of a perpendicular line from point A and a horizontal line from point B as point C, and the angle between AB and BC as θ. We measured the distances between the trunk axis and point A (OA), and the trunk axis and point B (OB); the difference between OB and OA was considered as the distance between point B and C (BC). We also calculated the distance between point A and B (AB), and cosθ was calculated using the formula (1) (Fig.2) .

$\cos\theta = BC/AB$ ・・・・(1)

Next, we determined the arc degree using the formula (2).

$\text{radian} = \cos^{-1}(\cos\theta)$ ・・・・(2)

The measured numerical values were converted into degrees using the formula (3).

$\text{degree} = \text{radian} * 180/\pi$ ・・・・(3)

After converting the values in degree into positive values, and the upward rotation angle (θ′) was calculated using the formula (4).

$\text{scapular upward rotation angle } (\theta') = 90 - \angle ABC$ ・・・・(4)

The upward rotation angle of each elevation angle was calculated using the above formula. Next, the movement of the humerus in SHR was calculated based on the change in the upward rotation angle at each elevation angle. All distances were measured twice, and the average value was used for analysis.

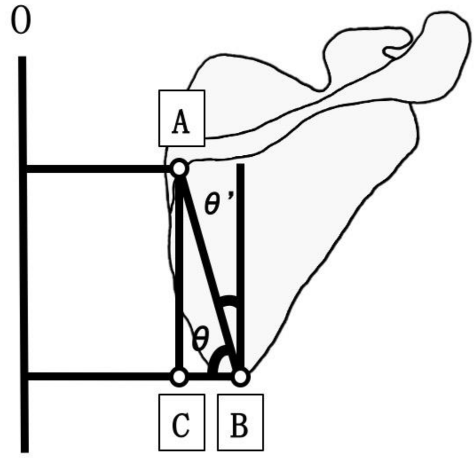

Fig.2 Analysis method

O: the human trunk axis that linked the middle point of the posterior superior iliac spine on both sides and the seventh cervical vertebra transverse process,
A: the medial border of the spine of the scapula,
B: the inferior angle of the scapula,
C: the intersection point of a perpendicular line from point A and a horizontal line from point B.

a

ICC (1, 1)	OA	OB
0°	0.99	0.99
30°	0.98	0.99
60°	0.99	0.97
90°	0.93	0.88
120°	0.93	0.89
150°	0.87	0.83

b

ICC (2, 1)	OA	OB
0°	0.99	0.99
30°	0.98	0.99
60°	0.99	0.96
90°	0.92	0.86
120°	0.92	0.89
150°	0.87	0.81

Table.1 Intraclass correlation coefficients

a: Intraclass reliability,
b: Interclass reliability,
OA: Distance from human trunk axis O to the medial border of the spine of the scapula,
OB: Distance from human trunk axis O to

the inferior angle of the scapula.

Both the intraclass and interclass reliability of this method were as high as 0.81 or higher in the intraclass correlation coefficient (Table.1).

The factors related to SHR, such as scapular upward rotation angle with the upper limb hanging downwards, the wall acromial distance[11] (WAD) in the sitting position, and the distance between the acromion and floor in a lateral position with thoracic spine rotation (TR-AFD) in the lateral decubitus position, were measured (Fig.3).For the measurement of WAD, the spinal column was in close contact with the wall in the sitting position, and the distance between the acromion posterior horn and the wall was measured in 1 cm units. For the measurement of TR-AFD, the compensation of the lumbar spine was minimum at 90° flexion of the hip joint; the shoulder girdle was passively twisted towards the dorsal side, and the distance between the posterior angle of the acromion and the bed was measured in centimeters.

The relationships between SHR and related factors were analyzed using Pearson's correlation coefficient. In addition, related factors were treated as dependent variables, whereas the changes in scapular upward rotation angle at each elevation angle were considered as explanatory variables. Multiple regression analysis was performed using a stepwise method, and the related of the extracted factors on changes in scapular upward rotation angle were investigated. All statistical analyses were performed using SPSS software version 23.0. The level of significance was set at $P<0.05$. This study was conducted according to the principles of the Declaration of Helsinki.

a b

Fig.3 Measurements of wall acromial distance and acromion floor distance with thoracic spine rotation

a: Wall acromial distance,

b: acromion floor distance when thoracic spine rotation.

【Results】

The average SHR measured in this study was 3.12±0.36:1.

In our study, SHR was positively correlated with WAD ($r = 0.64$, $p<0.05$) and TR-AFD ($r = 0.78$, $p<0.05$) (Fig. 4). However, there was no correlation between SHR and the scapular upward rotation angle with the upper limb hanging downwards. Then, the relationships between WAD and the changes in scapular upward rotation angle at each elevation angle were analyzed using multiple regression analysis. The changes in the scapular upward rotation angle at each elevation angle were analyzed using multiple regression analysis. The Changes in scapular upward rotation angle at 90° to 120° abduction were measured as the factors related to WAD ($B = 0.71$, $p<0.05$). No factor related to the changes in scapular upward rotation angle was extracted at any elevation angle ($B = 0.58$, $p>0.05$).

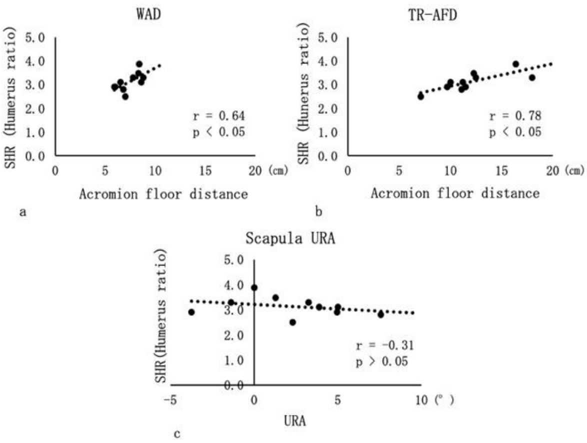

Fig.4 The Influence of related factors on scapulo-humeral rhythm

a: Relationship with WAD and the SHR,
b: relationship with TR-AFD and the SHR,
c: relationship with scapula URA and the SHR,
WAD: wall acromial distance,
TR-AFD: acromion floor distance when thoracic spine rotation,
URA: upward rotation angle,
SHR: scapulo-humeral rhythm.

【Discussion】

Previously, SHR has been reported to be between 3.2:1 and 4.3:1[8] as well as 2.89:1[12]. In this study, SHR was 3.12:1, which was similar to the previous reports using three-dimensional motion analysis. Therefore, we recommend the simple method developed in this study as one of the methods to measure SHR.

We found that SHR was positively correlated with WAD ($r = 0.64$, $p<0.05$) and TR-AFD ($r = 0.78$, $p<0.05$). WAD is one of the tools used to evaluate scapular anterior tilting[11], and TR-AFD comprehensively estimates the mobility of thoracic spine extension/rotation and scapular posterior tilting/adduction. Therefore, increasing the angle of scapular anterior tilting and decreasing the flexibility of the thoracic vertebra may increase the humeral movement ratio and decrease the scapular movement ratio in SHR. The high values of scapular malposition and TR-AFD, such as scapular anterior tilting, limit scapular posterior tilting during shoulder elevation. Furthermore, the restrictions of scapular anterior tilt and scapular posterior tilt during shoulder elevation are closely related to the stiffness of the pectoralis minor muscle[13], and it is speculated that the stiffness of the pectoralis minor muscle is related to SHR disorder.

Clinically, many diseases involving the shoulder joints, such as impingement syndrome[2)14], are associated with SHR disorder. In subacromial impingement syndrome, it has been reported that scapular upward rotation and posterior tilt angle significantly reduced at 90° abduction[15], and the changes in WAD and scapular upward rotation angle observed in this study were similar to the related angle. Therefore, it is clinically possible that mechanical stress, such as impingement, can be reduced by improving scapula malposition of the scapular anterior tilt in diseases involving the shoulder joints caused by SHR disorder.

【Limitation】

Measurement procedure of the SHR of this study is two-dimensional measurement and cannot prove a related factor and the relationship with the three-dimensional scapular movement.

【Conclusion】

Although the method described in this study is based on two-dimensional measurement, it is one of the methods that can easily measure SHR clinically. This study suggests that the scapular malposition of the scapular anterior tilt might contribute to the reduction in the change in scapular upward rotation angle in SHR.

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