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THREE-DIMENSIONAL SCAPULAR KINEMATICS IN SUBJECTS WITH ISOLATED ACROMIOCLAVICULAR OSTEOARTHRITIS AND ASSOCIATED WITH ROTATOR CUFF DYSFUNCTION IN TWO PLANES OF HUMERAL ELEVATION

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SUMMARY
This study described the 3-D scapular kinematics in two planes (sagittal and scapular) of arm elevation in subjects with isolated acromioclavicular joint osteoarthritis (ACO) and associated with rotator cuff dysfunction (ACO+RCD). Seventy four subjects, divided in three groups, took part in this study. The pain and function were assessed with the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. The kinematic data were collected using electromagnetic surface sensors, and motions for scapulothoracic (ST) were described. Groups with ACO and ACO+RCD presented higher DASH than the asymptomatic healthy subjects. Group with isolated ACO showed more internal rotation than subjects with ACO+RCD and asymptomatic healthy, and in the sagittal plane, greater internal rotation. Subjects with ACO+RCD showed increased upward rotation than subjects with isolated ACO and asymptomatic healthy. Overall, greater posterior tilt was seen in sagittal plane. Therefore, ACO and ACO+RCD seem to cause alterations in scapula kinematics.

INTRODUCTION
The acromioclavicular (AC) joint is one of the most common sources of shoulder pain [1], as it can present early degenerative changes [1,2]. AC joint pathology can occur in isolation, but it is often associated with shoulder impingement or rotator cuff dysfunction [2].

Subjects with shoulder impingement have showed decreased scapulothoracic posterior tilt and upward rotation, and greater scapulothoracic internal rotation [3] as compared to asymptomatic subjects, and differences among the humerothoracic planes of elevation were found in healthy subjects [4]. Considering the lack of studies on shoulder kinematics in subjects with AC osteoarthritis, investigations on this topic can afford new perspectives of evaluation and treatment.

The purpose of this study was to describe the three-dimensional scapular kinematics in two planes (sagittal and scapular) of arm elevation in subjects with isolated osteoarthritis AC joint, subjects with osteoarthritis AC joint associated with rotator cuff dysfunction, and asymptomatic and healthy subjects.

METHODS
The study included 74 subjects divided in three groups: group 1 composed of subjects with isolated AC joint osteoarthritis (ACO) (15 men, 8 women; 42.78±11.74 years; 75.21±14.17 kg; 1.72±0.12 m); group 2 composed of subjects with ACO associated with rotator cuff dysfunction (ACO + RCD) (13 men, 12 women; 49.16±8.69 years; 70.18±9.67 kg; 1.66±0.10 m); and group 3 composed of asymptomatic healthy subjects (13 men, 13 women; 45.81±8.68 years; 66.27±9.32 kg; 1.66±0.08 m). All of them gave their written informed consent to participate in this study.

Pain and function were assessed with the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. The maximum questionnaire score is 100, which indicates the worst possible condition.

Three-dimensional motion data were collected using the Flock of Birds electromagnetic tracking system (Ascension Technology, Burlington, VT) integrated with MotionMonitor software (Innovative Sports Training, Chicago, Ill, USA). The sensors were attached to the sternum, acromion of the scapula, and to a thermoplastic cuff secured to the distal humerus to track humeral motion.

Anatomical coordinate systems were established for each segment by palpating and digitizing anatomical landmarks as per the International Society of Biomechanics recommended protocol [5]. The subjects completed 3 repetitions of arm elevation in the sagittal plane and 3 repetitions in the scapular plane guided by a flat plane surface, at a speed that took 4 seconds for each repetition. The order of the plane to be evaluated was randomly chosen. The symptomatic shoulder was evaluated in subjects with ACO, and the shoulder for the asymptomatic healthy subjects was randomly chosen.

Motions for scapulothoracic (ST) were described as internal/external rotation, upward/downward rotation and

anterior/posterior tilt. DASH scores were analyzed with a 1-way ANOVA with group (ACO, ACO+RCD, asymptomatic healthy subjects) as the main factor. For each scapular rotation, a 3-way ANOVA was used with groups (ACO, ACO+RCD, asymptomatic healthy subjects), elevation plane (sagittal and scapular), and elevation angle (30°, 60°, 90° and 120° of humerothoracic elevation) as main factors. In the presence of significant interactions, Tukey post-hoc test was employed. The significance level of 5% was adopted.

RESULTS AND DISCUSSION

Groups 1 and 2 presented higher ($P<0.05$) DASH scores (31.62±21.09 and 38.59±16.08, respectively) when compared to group 3 (1.02±2.10).

The 3-way ANOVA for ST internal/external rotation revealed main effect of groups ($P<0.05$) and elevation planes ($P<0.05$). Figure 1 shows the ST internal/external rotation for all groups in both planes. Subjects with ACO showed more internal rotation than subjects with ACO+RCD and asymptomatic healthy subjects ($P<0.05$). Overall, in the sagittal plane, subjects from all of the groups showed increased internal rotation than in the scapular plane ($P<0.05$).

The increased ST internal rotation presented in the sagittal plane, more evident in subjects with isolated ACO, can be a causative factor to greater compression in AC joint contributing to degeneration in this joint.

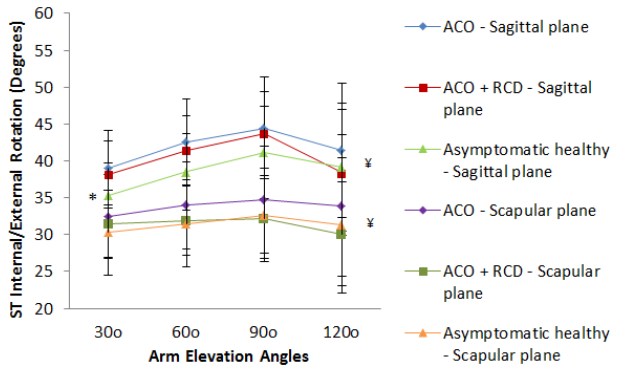

Figure 1: Scapulothoracic (ST) internal/external rotation (y axis) for arm elevation in sagittal plane and scapular plane (x axis). Internal rotation: more positive.
Notes: *: difference between planes, ¥: ACO ≠ ACO+RCD and asymptomatic.

The 3-way ANOVA for upward/downward rotation revealed interaction between groups and elevation angles ($P<0.05$). According to Figure 2, subjects with ACO+RCD showed more upward rotation than subjects with ACO at 30° of humerothoracic elevation ($P<0.05$). Subjects with ACO+RCD also presented more upward rotation than subjects with isolated ACO and asymptomatic healthy subjects at 60° and 90° of humerothoracic elevation ($P<0.05$). Subjects with ACO and ACO+RCD showed increased upward rotation when compared to asymptomatic healthy subjects at 120° of humerothoracic elevation ($P<0.05$).

The increased ST upward rotation presented by subjects with ACO+RCD may represent compensatory responses as an attempt to reduce pain and possibly direct impingement of the shoulder [6].

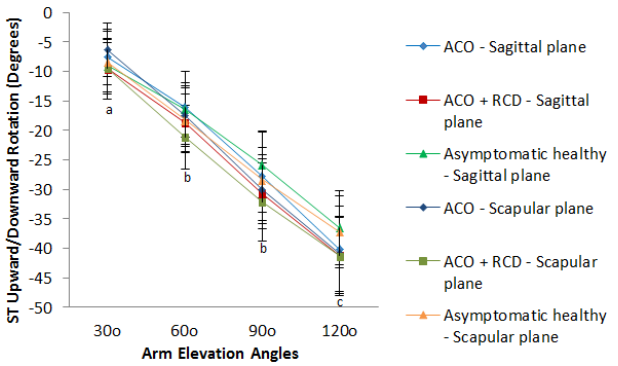

Figure 2: Scapulothoracic (ST) upward/downward rotation (y axis) for arm elevation in sagittal plane and scapular plane (x axis). Upward rotation: more negative.
Notes: a: ACO+RCD ≠ ACO, b: ACO+RCD ≠ ACO and asymptomatic, c: ACO and ACO+RCD ≠ asymptomatic.

The 3-way ANOVA for ST anterior/posterior tilt revealed main effect of plane of elevation ($P<0.05$). More posterior tilt was demonstrated in the sagittal plane when compared to the scapular plane ($P<0.05$).

The increased ST posterior tilt contrasts with the findings previously reported [4], which did not find differences between elevation planes for ST tilting. However, this result can be interpreted as a positive effect as it increases subacromial space [6]. One possible reason for not finding differences between groups for ST anterior/posterior tilt can be the high variability of our data.

CONCLUSIONS

In conclusion, subjects with isolated ACO showed increased ST internal rotation and subjects with ACO + RCD showed increased ST upward rotation. The planes of elevation seem to cause alterations in scapula kinematics, especially for ST internal rotation and posterior tilt. However, more studies are necessary to verify if these alterations are associated to changes in muscle activation.

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