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Resting scapular posture in healthy overhead throwing athletes

Andrea Ribeiro*, Augusto Gil Pascoal

Technical University of Lisbon, Faculty of Human Kinetics, Interdisciplinary Centre of Human Performance (CIPER), Neuromechanics Research Group, Estrada da Costa, Cruz Quebrada, 1495-688 Lisbon, Portugal

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ABSTRACT

Introduction: On shoulder examination, asymmetric scapular posture is often associated to abnormalities of the shoulder complex joint. However, shoulder asymmetries may also be related to adaptations to sports practice. The overhead throwing motion is a highly repetitive skilled motion performed at high velocities. Due to overuse of the dominant overhead-throwing shoulder, athletes may develop some kind of overhead throwing shoulder adaptation pattern that possibly includes scapular asymmetry at the resting position.
Purpose: To quantify the asymmetry between dominant and non-dominant resting scapular posture in 3 groups of healthy subjects (volleyball players, team-handball players and a control group).
Methods: Bilateral 3D scapular kinematics with the arm at rest was measured using a 6 degrees-of-freedom electromagnetic tracking device.
Results: In handball athletes, the dominant scapula was more in internal rotation and anteriorly tilted than in volleyball players. Between athletes and non-athletes groups, the dominant scapula was more anteriorly tilted in the athletes.
Conclusions: Clinicians should be aware that some degree of scapular asymmetry may be normal in some athletes. It should not be considered automatically as a pathological sign but rather an adaptation to sports practice and extensive use of upper limb.

1. Introduction

Scapular position and orientation at rest is one of the components of shoulder physical examination (Kibler, 1998; Burkhart et al., 2003b; Uhl et al., 2009). Alterations in scapular motion have been found in athletes (Ellenbecker et al., 1996; Torres and Gomes, 2009; Wilk et al., 2011), and are thought to affect normal scapulohumeral rhythm and shoulder artrokinematics leading to several kinds of impairments (Burkhart et al., 2003b; Uhl et al., 2009).

It is still not clear how much these scapular postural asymmetries may be related with abnormalities (Meister, 2000; Burkhart et al., 2003a, 2003b) or if they should be considered as a sport adaptation.

Devices such as digital inclinometer and tape measure have been used to quantify asymmetric scapular posture in patients with abnormalities or shoulder complaints (Downar and Sauers, 2005). However these devices can only provide a 2-dimensional image of scapular motion. A 3-dimensional (3D) image would be more valuable to understand scapular position and orientation. This could help researchers and clinicians identify the behavior of specific scapular kinematic variables that could contribute to scapular posture asymmetries.

Electromagnetic motion tracking devices allow calculation of 3D scapular positions and orientations (Wu et al., 2005). It would be important to describe and characterize scapular posture 3-dimensionally in subjects without pathology and also in athletes.

The purpose of our study was to quantify the scapular resting posture in 3 groups of healthy subjects, two groups of overhead-sports athletes (volleyball players and team-handball players), and a third group composed of non-athletes. This was measured using an electromagnetic tracking device and to determine whether these groups of overhead athletes displayed asymmetry in scapular resting posture. We hypothesized that the asymmetry would be present in the 2 groups of healthy overhead athletes from the repetitive use of the dominant shoulder. Identifying scapular asymmetry in healthy overhead athletes is important because it provides a basis for comparison with injured overhead athletes.

2. Methods

2.1. Participants

Fifteen volleyball players (age = 27.6 ± 1.6 years, height = 189.4 ± 2.7 cm, body mass index = 24.3 ± 0.5 kg/m^2; 15

* Corresponding author. Tel.: +351 967441378.
E-mail address: andrear77@gmail.com (A. Ribeiro).

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right-handed), 15 competitive team-handball players (23.8 ± 0.8 years, 185.8 ± 1.5 cm, 25.4 ± 0.5 kg/m^2; all right-handed), and 30 non-athletes (29.6 ± 1.1 years, 178.1 ± 1.2 cm, 25.0 ± 0.7 kg/m^2; 30 right-hand dominant) participated in this study. The dominant limb was identified as the arm that would be used to throw a ball or to write. Only men were recruited for this study to control possible sex differences. Those with a previous history of shoulder surgery or traumatic injury (dislocation, subluxation, or acromioclavicular joint sprain) were excluded from this study. Participants with shoulder or elbow pain within 6 months of testing also were excluded from the study.

2.2. Instrumentation

We used the Motion Monitor electromagnetic motion tracking device (Innovative Sports Training, Inc., Chicago, IL) to assess 3D scapular resting position.

The device consists of a transmitter that creates an electromagnetic field and receivers that detect the electromagnetic field emitted by the transmitter. The receivers were attached to specific body segments as described in the previous literature. The electromagnetic motion tracking device recorded the position and orientation of the receivers about the *x*-axis, *y*-axis, and *z*-axis relative to the transmitter (global coordinate system) (Meskers et al., 1998). By digitizing the anatomical landmarks with a stylus, the orientation of one body segment was calculated with respect to another. The data were collected at 100 Hz. All kinematic assessments were performed with the participants in a seated position with their arms along the body.

2.3. Procedures

All testing in the current study was performed in a biomechanics research laboratory. The purposes of the study and the technique of examination were explained to the participants, and those who agreed to participate signed an informed consent form. This study was approved by the Scientific Board of the Faculty of Human Kinetics, Technical University of Lisbon (Portugal). None of the athletes who met the inclusion criteria declined to participate.

We used 5 receivers for bilateral scapular resting position assessment, attached as follows: the spinous process of the seventh cervical vertebra, the flat portion of the acromion processes bilaterally, and the posterior midshaft of the humerus. All receivers were secured on the skin using double-sided adhesive disks, prewrap, athletic tape, and a hook-and-loop strap to minimize skin-receiver movement. The fifth receiver was attached to the stylus that was used to palpate and digitize the anatomical landmarks on the upper arm, scapula, and thorax. The anatomical landmarks digitized included the eighth thoracic vertebra, xiphoid process, seventh cervical vertebra, jugular notch, sternoclavicular joint, acromioclavicular joint, medial scapular border where it intersects with the scapular spine, inferior scapular angle, medial epicondyle, lateral epicondyle, and glenohumeral joint center. Landmarks on the humerus and scapula were digitized bilaterally. Because the glenohumeral joint center cannot be palpated, it was estimated as the point that moves least with respect to the scapula when the humerus is moved passively through several short arcs. Digitizing these anatomical landmarks on each segment allowed construction of the local coordinate system for each body segment (thorax, scapula, and humerus). Using local coordinate systems, we calculated the position and orientation of the scapula with respect to the thorax. Raw scapular kinematic data were filtered with a low-pass, 10-Hz Butterworth filter. The position and orientation data of the receivers and the digitized anatomical landmarks were used to construct local coordinate systems for the thorax, scapula, and humerus. The coordinate systems used were in accordance with recommendations from the International Shoulder Group of the International Society of Biomechanics (Wu et al., 2005). When the participant stood in an anatomical position, the coordinate system for each segment was vertical (*y*-axis), horizontal to the right (*x*-axis), and posterior (*z*-axis). Scapular orientation was determined as rotation about the *y*-axis of the scapula (internal–external rotation), rotation about the *z*-axis of the scapula (upward–downward rotation), and rotation about the *x*-axis of the scapula (anterior–posterior tilt). We used Euler angle decompositions to determine scapular and humeral orientation with respect to the thorax. The rotation sequence of the Euler angles was chosen based on the recommendation of the International Shoulder Group (Wu et al., 2005).

Each participant performed 3 continuous repetitions of bilateral full-shoulder elevation in the scapular plane (45° anterior to the frontal plane). The volunteer elevated the arm in 3 s and lowered the arm in 3 s, guided by the metronome. The participants were instructed to bring their arms to rest by their sides at the end of each repetition. This procedure allowed the volunteers to be distracted from the postural assessment, which may have helped to capture their natural posture. Bilateral resting scapular posture was measured as the scapular position and orientation when the arms were at the sides between the 3 repetitions of the elevation task. The averages of the 3 recordings for both limbs were used for analysis.

2.4. Data analysis

Between-limbs and between-groups differences in each scapular variable (upward–downward rotation, internal–external rotation, anterior–posterior tilt, protraction–retraction, and elevation–depression) were analyzed using separate within-subjects, between-subjects factor analyses of variance. Tukey HSD post hoc analysis was conducted when the interaction was significant. We performed the statistical analysis using SPSS (version 20; SPSS Inc., Chicago, IL). The level of significance was set at 0.05.

3. Results

Comparing athletes and non-athletic groups, differences were found in scapular anterior–posterior tilt concerning dominant limb ($P = 0.002$) and non-dominant limb ($P = 0.04$). 3D scapular position assessment demonstrated limb-by-group interaction for protraction–retraction ($P < 0.001$), for scapular anterior–posterior tilt ($P = 0.04$) and scapular upward–downward rotation ($P < 0.01$) (Table 1, Fig. 1).

4. Discussion

Our goal was to quantify scapular resting posture in 3 groups of healthy male subjects; volleyball players, team-handball players

Table 1
Mean (SEM) for scapular internal–external rotation; scapular anterior–posterior tilt and scapular upward–downward rotation for dominant and nondominant limbs.

	Dominant limb			Nondominant limb		
	Volleyball	Team-handball	Control	Volleyball	Team-handball	Control
Sy	24.3 (2.5)	38.3 (2.5)	32.2 (1.7)	24.4 (1.6)	22 (1.6)	24.8 (1.1)
Sz	−10.5 (0.9)	−11.8 (0.9)	−8.3 (0.6)	−12.7 (0.6)	−11.4 (0.7)	−10.6 (0.5)
Sx	1.4 (0.1)	3.1 (0.2)	1.3 (0.4)	7.4 (0.1)	7.6 (0.5)	7.6 (0.1)

Sy: Scapular internal–external rotation Sz: Scapular anterior–posterior tilt Sx: Scapular upward–downward rotation.