EFFECT OF ACTIVE VS. PASSIVE END-RANGE DETERMINATION ON SHOULDER AXIAL ROTATION IN THROWER ATHLETES

Andrea Ribeiro[1] **& Augusto Gil Pascoal**[1]

[1]**Technical University of Lisbon, Faculty of Human Kinetics,**
CIPER-Neuromechanics Lisbon, PORTUGAL

The effect of active or passive end-range determination on shoulder axial rotation is unclear on overhead-throwing athletes. Twenty-two healthy males were equally divided into athletes and non-athletes groups and their throwing arm was tested during internal and external arm rotation and on active and passive end-range determination conditions. The humeral and scapular 3D position were recorded at the shoulder rotational end-range and compared across groups using two-way repeated-measures ANOVA. No differences were found between groups for all humeral and scapular variables. The active internal Thoracohumeral (TH) and Glenohumeral (GH) arches were significantly ($p=0.00$) higher than internal passive TH and GH. At the end-range of external rotation athletes showed a scapula less in protraction ($p=0.027$) and less in scapular posterior tilt ($p=0.00$). External passive TH and GH were significantly higher than external active TH and GH.

KEYWORDS: humeral axial rotation; end-range determination; throwing shoulder

INTRODUCTION: Overhead-throwing athletes include throwers (e.g. baseball pitchers), swimmers, water-polo, handball and volleyball players. From a functional standpoint these sports produce repetitive overhead motions, that are discontinuous and ballistic in nature, and where the throwing arm is forcefully moved forward from maximal external rotation to near maximal internal rotation, while is kept in an elevation position. This mechanical demand seems to be in the origin of the adaptive changes described on rotational range-of-motion (ROM) pattern in the throwing shoulder. This pattern favours the increased external rotation (external rotation gain) and limited internal rotation (glenohumeral internal rotation deficit), while the range of the total arc of motion (external arc plus internal arc) remains unchanged (Myers, Laudner, Pasquale, Bradley, & Lephart, 2006). Altered shoulder mobility is thought to develop secondary to adaptive structural (bones, capsule and ligaments) changes to the glenohumeral joint.

Clinical shoulder assessment often includes ROM measurement of internal and external humeral rotation recorded via goniometry by placing the patient supine or in a sitting position with the arm at 90º of abduction (Myers, et al., 2006; Yamamoto, et al., 2006). In a supine position, the arm is rotated to the internal and external end-range while kept fully supported on a table. A posterior force applied by the examiner on the coracoid process and clavicle limit scapular motion, and the arm movement is assumed restricted to the glenohumeral joint. In a sitting position, patient holds or supports his/her elbow at a side while the arm is rotating around the long axis of the humerus (Boon & Smith, 2000; Ellenbecker, Roetert, Piorkowski, & Schulz, 1996). On both ROM testing conditions, the joint end-range is determined by the examiner according with the capsular end-feel (Awan, Smith, & Boon, 2002; Barlow, Benjamin, Birt, & Hughes, 2002; Reagan, et al., 2002) scapular liftoff (Warner, Micheli, Arslanian, Kennedy, & Kennedy, 1990) or the presence of pain (Andrews & Bohannon, 1989). Some studies suggest the use of an active self end-range determination on shoulder thrower assessment in order to collect information close to the specific patterns of external and internal rotation, during the arm throwing cycle (Ellenbecker & Roetert, 2002; Hayes, Walton, Szomor, & Murrell, 2001). However, no studies to date have specifically investigated the effect of passive and active end-range (active vs. passive) measures on humeral rotational pattern and scapular position in overhead throwing athletes.

The aim of this study was to quantify the effects of the active or passive end-range determination on the external and internal rotation ROM, as well as in the scapular position, in overhead throwing athletes assessed in a sitting position.

METHODS: A sample of 22 healthy subjects recruited from the community participated in this study and were divided in two groups: the athletes group (N= 11; age = 25.5 ± 5.9 years; height = 185.3 ± 7.9 cm; weight = 84.2 ± 9.3 kg) and the non-athletes group (N= 11; age = 27.4 ± 5.4 years; height = 172.7 ± 8.8 cm; weight = 73.3 ± 13.3 kg). Inclusion criteria for the athletes group was practicing overhead sports for at least 6 years. Non-athletes group included subjects that do not practice or have practiced overhead sports and do not have overhead professional activity. Subjects with a previous history of shoulder surgery or traumatic injury (e.g. dislocation, subluxation) were excluded from this study, as well as, participants with shoulder or elbow pain in the last 6 months. In a supine position with the dominant arm abducted at 90º, subjects were instructed to perform both active and passive shoulder rotation to establish the maximum range of humeral axial rotation. No allowance for scapular protraction or elevation was permitted. The scapulothoracic joint was stabilized via a posterior directed constainment force exerced by the examiner hand on the coracoid process and the anterior aspect of the acromion. This procedure replicates the one used on standard goniometry for shoulder rotation. Humeral and scapular 3D kinematic were recorded by means of an electromagnetic tracking device (Flock-of-Birds, Ascension Technology, Burlington, VT) controlled by a specific software (The Motion Monitor software, Innovative Sports Training, Chicago, IL) with a four sensors setup: the thorax sensor, firmly attached to skin over the first thoracic vertebrae (T1); the arm sensor attached by mean of a cuff just below the deltoid attachment; and the scapular sensor placed on the superior flat surface of the acromion process. A fourth sensor mounted on a hand-held stylus (±6.5cm) was used on bony landmarks digitalization in order to link sensors to the local anatomical coordinate systems (LCS) and subsequently calculated segments and joint rotations by combining the LCSs with the sensor motions. Segments LCSs and joint rotations definition were made according to the shoulder International Society of Biomecahnics and the International Shoulder Group standardization protocol (Wu, et al., 2005). The digitalization protocol was performed with the subject in a seated position, arm elevated (±90º), elbow flexed (±90º) and forearm parallel to the floor. This position was used on the definition of the neutral arm rotation position and the zero point (0º). The amplitude of arm rotation (internal or external) corresponds to the absolute value of the difference between this position and the end-range arm rotation position. Dependent variables includes humeral positions with respect to thorax (thoracohumeral angles) and to scapula (glenohumeral angles) as well as the 3D scapular position (protraction, lateral rotation and spinal tilt), recorded at the end-range of arm internal and external amplitude. A two-way repeated-measures ANOVA was used to calculate the effects of the end-range determination (passive or active), and arm rotation (internal and external) across groups (athletes and non-athletes) on dependent variables. Significant results were considered for *p* values < 0.05.

RESULTS: With respect to the internal rotation (IR), no differences were found between groups for all humeral and scapular variables. The active internal thoracohumeral (TH) and glenohumeral (GH) angles were significantly (p=0.00) higher than internal passive TH and GH. Concerning external rotation (ER), no differences were found between groups for all humeral variables but for scapular variables athletes showed less scapular posterior tilt (p=0.00) and a scapula more in retraction (p=0.027). That means a scapular position with the inferior angle of the scapula fairway from the thorax cage and simultaneously with the glenoid more oriented with the frontal plane.

External passive TH (33.7º ± 3.9º) was significantly higher (p=0.034) than external active TH (31.3 ± 4.1). On the same way external passive GH (34.5º ± 3.7º) was significantly higher (p=0.00) than external active GH (28.2º ± 4.0º).

DISCUSSION: Our findings showed that shoulder internal active ROM has higher values than passive motion. These results emphasize the importance of the end-range determination in a clinical setting, particularly on functional assessment of the thrower´s shoulder. Reports are inconsistent with regard to how end-range is determined. Some use active positioning while others use passive positioning determining capsular end-feel (Awan, et al., 2002; Barlow, et al., 2002; Reagan, et al., 2002), by scapular liftoff (Warner, et al., 1990) or by pain (Andrews & Bohannon, 1989). This aspect is crucial to understand the results from other studies that showed higher values of ROM associated to passive condition of testing (Myers, et al., 2006; Osbahr, Cannon, & Speer, 2002). Most of the studies in the literature assessed shoulder rotational ROM in supine position, and the arm at 90º abduction, like we did. Athletes presented higher internal rotation values within active motion. Concerning external rotation, passive motion showed highest values especially among non-athletes. We also found that athletes have more internal rotation than non-athletes passively or actively which is different from what we have found in literature (Dwelly, Tripp, Tripp, Eberman, & Gorin, 2009; Torres & Gomes, 2009). Considering GH, we found more active internal rotation, highest values among the athletes, but concerning external rotation passive motion is higher, and athletes are the ones that show the highest values. This could be due to shoulder osseous or soft-tissue adaptations that can result from repetitive shoulder motions (Huffman, et al., 2006; McCully, Kumar, Lazarus, & Karduna, 2005), which are common among throwing athletes. Stretching of the anterior glenohumeral capsule leads to increased external rotation at the point of late cocking and early acceleration and aids in the achievement of higher throwing velocities. Although literature (McCully, et al., 2005) refers that many throwers develop a posterior capsular contracture that limits internal rotation. We found in the athletes group more active internal rotation than on non-athletes group. Besides this no differences were found in the total arch of arm movement, even on active or passive one. Concerning scapular position at the end-range of active arm rotation, significant differences were found on scapular tilt between groups, in such a way that non-athletes showed a scapula more in a posterior tilt position. This can be due to the fact that athletes use their scapula along the throwing motion, and not only the at glenohumeral joint as the experimental setup imposed. Borich et al. (2006) found in athletes with impingement and IR deficit a greater scapular anterior tilt. In contrast we found less IR among athletes but scapular posterior tilt, although non-athletes show more shoulder internal rotation, and greater scapular posterior tilt. Besides differences found, athletes seem to show a similar behaviour in both studies.

CONCLUSION: Our findings emphasize the importance of the end-range determination in a clinical setting particularly on functional assessment of the throwers shoulder. On shoulder internal rotation the highest values of TH and GH internal angles were found when the end-range was actively determined. In contrast, the active end-range determination was associated with the lowest values of TH and GH on shoulder external rotation. No differences were found between athletes and non-athletes for all variables at internal rotation, but at external rotation athletes showed a scapula less in protraction and less in scapular posterior tilt.

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