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Original article

Comparison of shoulder rotation range of motion in professional tennis players with and without history of shoulder pain

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ABSTRACT

A glenohumeral internal rotation deficit of the dominant shoulder relative to the non-dominant shoulder (GIRD) is considered a risk factor for shoulder injury in overhead athletes. The aim of this study was to investigate whether professional tennis players with a history of self-reported shoulder pain show differences in rotation range of motion (ROM) of the dominant and non-dominant shoulder compared to asymptomatic controls. Forty-seven professional tennis players belonging to the Association of Tennis Professionals World Tour took part in the study: 19 with shoulder pain history and 28 without. Passive shoulder ROM was measured using a process of photography and software calculation of angles. The dominant shoulder had reduced internal rotation (IR) ROM and total rotation ROM, and increased external rotation (ER) ROM compared to the non-dominant side. These differences did not correlate significantly with years of tennis practice, years of professional play, nor the players' age. However, glenohumeral rotation ROMs correlated negatively with the duration of tennis practice and players' age. Although tennis players with shoulder pain history showed less IR ROM in both shoulders compared with the no-pain group, no significant differences between groups were found for ER ROM, side-to-side ROM asymmetries, years of tennis practice or years of professional play. In professional tennis players, limited IR ROM rather than a GIRD, seems to be associated with shoulder pain history, duration of tennis practice and the players' age, when compared to a similar cohort with no history of shoulder pain.

1. Introduction

Shoulder injuries are the most frequent type of upper extremity injury in professional tennis players with an incidence between 25 and 47.7% (Kibler and Safran, 2000, 2005; Pluim et al., 2006) and most being due to mechanical overload and/or repetitive mechanisms (Silva et al., 2003; Torres and Gomes, 2009). The literature describes several anatomical and mechanical adaptations which may be associated with increased risk of shoulder injury in overhead athletes, including strength imbalance between the agonist/antagonist muscles of the glenohumeral joint (Stanley et al., 2004; Niederbracht et al., 2008; Saccol et al., 2010), scapular dyskinesis (Kibler, 1998; Struyf et al., 2011), and asymmetries between the dominant and non-dominant shoulders in rotational passive range of motion (ROM), i.e., higher glenohumeral external rotation (ER) (Ellenbecker et al., 1996; Kibler et al., 1996), lower glenohumeral internal rotation (IR) (Chandler et al., 1990; Ellenbecker et al., 1996; Kibler et al., 1996; Burkhart et al., 2003; Vad et al., 2003; Schmidt-Wiethoff et al., 2004; Stanley et al., 2004; Torres and Gomes, 2009; Hjelm et al., 2012) and lower total arc of motion (TAM: the sum of internal and external rotation) of the dominant shoulder (Myers et al., 2006; Wilk et al., 2011). These differences between glenohumeral shoulder ROMs have been observed in comparison with control groups. In this way, Schmidt-Wiethoff et al. (2004) found that professional tennis players shown lower IR (43.8° ± 11°) and higher ER (89.1° ± 13.7°) in the dominant shoulder than a control group (IR: 61.6° ± 8.1°; ER: 85.4° ± 7.6°).

The difference in IR between the dominant and non-dominant sides, which is referred to as glenohumeral internal rotation deficit (GIRD) of the dominant shoulder, has been shown to affect shoulder stability (McCann and Bigliani, 1994; Tyler et al., 2000), potentially resulting in rotator cuff impingement and tears of the labrum (Burkhart et al., 2000; Ticker et al., 2000; Gerber et al., 2003), and has therefore been proposed as a criteria for the implementation of prevention (Gerber et al., 2003; Torres and Gomes, 2009) and rehabilitation programs (Cools et al., 2008; Ellenbecker and Cools, 2010) in tennis players. The current

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recommendation for defining a GIRD is a 20° difference in IR between the dominant and non-dominant glenohumeral joints (Kibler et al., 2012). However, GIRDs of as little as 11° and 18° have been associated with shoulder injury in baseball players (Myers et al., 2006; Wilk et al., 2011).

Although differences in glenohumeral rotation ROM between the dominant and non-dominant side have been observed in throwing (Thomas et al., 2010; Wilk et al., 2011) and racquet sports (Chandler et al., 1990; Kibler et al., 1996; Ellenbecker et al., 1996, 2002; Schmidt-Wiethoff et al., 2004; Torres and Gomes, 2009), few studies have analyzed the relationship between side-to-side asymmetries in rotation ROM and the history of shoulder pain in tennis players (Kibler, 1998; Schmidt-Wiethoff et al., 2004; Hjelm et al., 2012). In that previous studies have focused on young tennis players (Hjelm et al., 2012) or recreational athletes (Stanley et al., 2004), their shoulders may not yet have reached full muscular development nor been subjected to the high demands of elite competition. Therefore, further research analyzing the relation between the GIRD and the risk of injury in elite tennis players is needed.

In this study, bilateral passive ROM of glenohumeral rotation (IR, ER and TAM) was analyzed in two samples of professional tennis players: one with a history of shoulder pain and the other with no such pain history. The objectives were to quantify the differences in ROM between the dominant and non-dominant sides, and compare rotation ROM and sided differences between the two participant groups. In addition, in that previous studies suggested that the dominant shoulder's GIRD and TAM deficit may be linked to a player's age and years of tennis practice (Kibler et al., 1996), the relationship was investigated between rotation ROMs, dominant vs. non-dominant shoulder ROM differences, years of tennis practice and years of professional tennis play.

2. Methods

2.1. Participants

Forty-seven professional tennis players, belonging to the ATP (Association of Tennis Professionals) World Tour, volunteered for this study (Table 1). Forty-three players were right-hand dominant and four were left-hand dominant. All were adult males, who at the time of the study were currently competing in the ATP tour. According to the ATP, during the recording phase of this study (2011–2013), 42.5% of the participants were ranked among the top 100, while 57.5% of the remaining players ranked among the top 1000 world tennis players.

The participants' inclusion criteria were: belonging to the ATP World Tour, to be actively competing at the time of the study, to not have shoulder pain nor have taken any type of medication for the treatment of pain or musculoskeletal injuries at the time of the study, and to not have undergone shoulder surgery.

Table 1
Descriptive characteristics (mean ± standard deviation) of the professional tennis players organized by group.

	All tennis players ($N = 47$)	No pain history ($N = 28$)	Pain history ($N = 19$)	F	p
Age (years)	23.2 ± 4.9	22.2 ± 4.3	25.6 ± 3.0	3.624	0.063
Height (cm)	183.6 ± 5.0	184.1 ± 5.8	182.7 ± 3.6	0.886	0.352
Mass (kg)	77.5 ± 6.5	77.60 ± 7.6	77.5 ± 4.8	0.006	0.938
Years of tennis practice	16.2 ± 5.6	15.3 ± 5.2	17.6 ± 6.0	1.883	0.177
Years of professional play	5.9 ± 3.9	5.1 ± 3.3	7.0 ± 4.5	2.914	0.095

Written informed consent was obtained from each participant prior to testing. The experimental procedures used in this study were in accordance with the Declaration of Helsinki and were approved by the Ethic Committee of the University.

The tennis players were divided into two groups according to the following criteria: a) *Group with no pain history* (NPH group) included 28 individuals who had not experienced shoulder pain; b) *Group with pain history* (PH group) included 19 tennis players who had experienced shoulder pain that had prevented them from training and/or competing during the 14 months prior to the study. ANOVA did not show significant differences between the NPH and PH groups for age, height, mass, years of tennis practice or years professional play (Table 1).

2.2. Data collection

All data collections were performed during the pre-season months of November and December, 2011–2013. Upon the arrival of each participant, the measurement protocol was explained and demonstrated on each arm. Once the procedure was understood, measurements were performed in random order for both, dominant and non-dominant shoulder (Ellenbecker et al., 2002), and range of motion (ER and IR).

To measure passive glenohumeral rotation, each participant lay supine on a bench, with his shoulder in 90° of abduction and the elbow flexed to 90° (forearm perpendicular to the bench). From this starting position, a researcher held the participant's proximal shoulder region (i.e. clavicle and scapula) against the bench to stabilize the scapula while rotating the humerus in the glenohumeral joint to produce maximum passive ER (Fig. 1a) and IR (Fig. 1b). In both cases, glenohumeral rotation started at the perpendicular neutral position and finished upon reaching firm resistance to passive rotation. The forearm was placed and remained in a pronated position for the duration of the testing. Special attention was paid to constrain motion to pure glenohumeral rotation and minimize compensatory movements of the scapula-thoracic region during the maneuver. A photograph was taken once full ER or IR was achieved, thus capturing arm position for subsequent digitizing (Fig. 1a and b). The camera (Canon® IXUS75 digital camera, Tokyo, Japan) was secured on a tripod at the participant's elbow height, at a distance of 70 cm from the elbow, with the optical axis perpendicular to the plane of movement. Based on Almeida et al. (2012) and Wilk et al.'s study (2011), digital pictures were taken when the examiner perceived the end of the passive ROM had been reached and before the occurrence of any compensatory scapular motion. Throughout the study, the arm was positioned, and photographs digitized, by the same physiotherapist who had 15 years of clinical experience. All photographs were taken by one researcher, with 5 years' experience in this area.

In order to evaluate the reliability of the measurements, two different analyses were performed. Intra-rater reliability analysis was carried out on 94 pictures (47 participants × 2 sides), to test the examiner's ability to re-digitize the same photo twice (4 weeks apart). In addition, to assess the consistency of the entire protocol, we performed a test-retest reliability analysis of the measurements. Ten of the participants (age: 25.1 ± 4.9 years; height: 183.0 ± 4.8 cm; mass: 78.4 ± 4.8 kg) were measured a second time in a separate recording session, at least one week later.

2.3. Data analysis

In most previous studies, glenohumeral rotation has been measured using a goniometer with the participant lying supine (Kibler, 1998; Schmidt-Wiethoff et al., 2004; Hjelm et al., 2012). In this study, ROM measurements were based on photos of maximum