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Anatomical glenohumeral internal rotation deficit and symmetric rotational strength in male and female young beach volleyball players

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ABSTRACT

Beach volleyball is a sport with a high demand of shoulder structures that may lead to adaptations in range of motion (ROM) and strength like in other overhead sports. Despite of these possible alterations, no study evaluated the shoulder adaptations in young beach volleyball athletes. The aim of this study was to compare the bilateral ROM and rotation strength in the shoulders of young beach volleyball players. Goniometric passive shoulder ROM of motion and isometric rotational strength were evaluated in 19 male and 14 female asymptomatic athletes. External and internal ROM, total rotation motion, glenohumeral internal rotation deficit (GIRD), external rotation and internal rotation strength, bilateral deficits and external rotation to internal rotation ratio were measured. The statistical analysis included paired Student's *t*-test and analysis of variance with repeated measures. Significantly lower dominant GIRD was found in both groups ($p < 0.05$), but only 6 athletes presented pathological GIRD. For strength variables, no significant differences for external or internal rotation were evident. Young beach volleyball athletes present symmetric rotational strength and shoulder ROM rotational adaptations that can be considered as anatomical. These results indicate that young practitioners of beach volleyball are subject to moderate adaptations compared to those reported for other overhead sports.

1. Introduction

Volleyball is one of the most popular sport in the world and a number of studies have been published about injuries, muscle strength and range of motion (ROM) patterns in indoor athletes (Forthomme et al., 2013; Hadzic et al., 2014; Martelli et al., 2013; Schwab and Blanch, 2009; Verhagen et al., 2004). More recently there has been an increasing interest in beach volleyball due to the fact that it became an Olympic sport in 1996, and still now few studies have focused on those athletes (Bahr and Reeser, 2003; Lajtai et al., 2009; Lajtai et al., 2012; Monteleone et al., 2014).

Studies evaluating beach volleyball demonstrated that athletes present with shoulder injuries (Aagaard et al., 1997; Bahr and Reeser, 2003), infraspinatus muscle atrophy (Lajtai et al., 2009; Lajtai et al., 2012), high prevalence of calcific tendinopathy of rotator cuff (Monteleone et al., 2014) and unrecognized decreased strength of external rotation along with unspecific shoulder pain (Lajtai et al., 2009). These findings corroborate that shoulder structures have high overload demands in beach volleyball (Lajtai et al., 2009).

Consistent literature demonstrates that overhead sports lead to alterations in shoulder ROM and strength and may be a contributing factor to shoulder injuries (Saccol et al., 2010; Manske et al., 2013; Wilk et al., 2011, 2012). This has been already evaluated in volleyball athletes (Martelli et al., 2013; Reeser et al., 2010; Schwab and Blanch, 2009), however only one study with beach volleyball is available (Lajtai et al., 2009). Lajtai et al. (2009) found greater external rotation and less internal rotation motion in the throwing shoulder of beach volleyball athletes (Lajtai et al., 2009).

The reduction of internal rotation motion of the throwing shoulder is defined as glenohumeral internal rotation deficit (GIRD) and is related to multiple factors such as osseous adaptation, musculotendious and capsular tightness (Burkhart et al., 2003). Recently some authors reported that not all loss in the internal rotation of overhead athletes is pathologic, some of them are just a physiologic adaptation to the overhead throw (Manske et al., 2013). Individuals with less than 18° of GIRD and corresponding symmetry of total range of motion within 5° of

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the uninvolved side are considered anatomic GIRD, while a pathological GIRD represents athletes with values beyond that amount (Burkhart et al., 2003; Manske et al., 2013). Athletes with a pathological GIRD may be at risk for shoulder injuries and a normative data profile of healthy beach volleyball athletes is an important consideration to be established since it can assist clinicians in interpreting ROM measurements and risk in this population.

Strength of the rotator cuff muscles of the shoulder is also essential to the dynamic stabilization of this naturally unstable joint. A balance must exist between the strength of the internal rotator muscles, which are widely worked in throwing actions, and the external rotator muscles that decelerate this movement (Wilk et al., 2009). The external to internal rotation strength ratio typically ranges between 66–75%, with the external rotators being at least 2/3 the strength of the internal rotators in order to provide muscular balance (Ellenbecker and Davies, 2000). To our knowledge, no studies have been carried out with beach volleyball athletes regarding strength ratios and that is another variable to be considered in the development of overhead sports shoulder injuries (Edouard et al., 2013; James et al., 2014).

Although a few studies investigated rotator cuff strength and ROM in indoor volleyball athletes (Gozlan et al., 2006; Martelli et al., 2013; Reeser et al., 2010; Schwab and Blanch, 2009; Witvrouw et al., 2000), only two studies have been carried out with adult professional beach volleyball athletes (Lajtai et al., 2009; Lajtai et al., 2012). Considering the repetitive load on the throwing shoulder and the role of these variables as modifiable risk factors for overuse shoulder injuries in volleyball (James et al., 2014), the aim of the present study was to compare the ROM and rotation strength in the dominant and non-dominant shoulders of young male and female beach volleyball athletes. This normative data of shoulder ROM and rotation strength will be useful for prevention and rehabilitation of beach volleyball athletes.

2. Methods

Beach volleyball athletes were evaluated during one of the Brazilian national tournaments organized by the National Confederation of Volleyball. All players were informed about the study during the technical meeting, which all teams were required to attend. Thirty-six beach volleyball players under 21 years of age participated in the study and were evaluated before the competition started. All athletes agreed to participate in the study on a voluntary basis and provided written informed consent according to the Universitýs Human Research Ethics Committee.

To participate in the study, the athlete must belong to the Brazilian Volleyball Confederation and be among the 50 best players in his/her category. The exclusion criteria included the presence of pain or any other symptoms (i.e. fracture, luxation, or surgery) of the shoulder or elbow that limited the time of practice over the past three months. Based on the eligibility criteria, three athletes were excluded from the study, and two groups (19 males and 14 females) were evaluated. Athletes' demographics are presented in Table 1.

For shoulder ROM evaluation, the athlete was positioned in supine, knees flexed, shoulder at 90° of abduction, elbow at 90° flexion and forearm in the neutral position. This position is often used in shoulder rotation ROM studies since it stabilizes the scapula, eliminating scapulothoracic contributions to movement (Manske et al., 2013; Schwab and Blanch, 2009; Wilk et al., 2011, 2012). For all measurements, the axis of the goniometer was positioned over the olecranon, the fixed arm remained perpendicular to the ground and the adjustable arm was aligned parallel to the ulna, with the center over the styloid process. The assessment of the external and internal rotation ROM was performed passively, with one examiner stabilizing the athlete's shoulder and the other measuring the ROM. The final ROM was measured after reaching a firm endpoint and no shoulder compensations were observed. Both passive external and internal rotations were measured with the goniometer by the same investigator.

Table 1
Descriptive characteristics of male and female young beach volleyball players. Data are presented as mean (standard deviation).

	Male athletes $n = 19$	Female athletes $n = 14$	p value
Age (years)	18.57 (1.42)	18.5 (1.09)	0.864
Mass (kg)	76.78 (7.26)	66.85 (6.08)	<0.001
Height (cm)	186.42 (7.60)	175.78 (5.27)	<0.001
Training hours of beach volleyball (per week)	21 (9.99)	20.28 (4.49)	0.810
Beach volleyball experience (years)	4.73 (2.05)	4.78 (1.76)	0.943

Total rotation motion was calculated by summing the amplitude of the internal and external rotation of each limb. GIRD measurements were calculated from the difference in internal rotation ROM between the dominant and non-dominant limbs. The pathological GIRD was considered in athletes presenting greater than 18° of internal rotation deficit and total rotation motion above 5° of the nondominant shoulder (Manske et al., 2013).

A handheld dynamometer (Microfet 2 HHD, Hoogan Health Industries, West Jordan, UT, USA) was used for the assessment of isometric external and internal rotation muscle strength. The athlete was seated in a non-height or back-adjustable wooden chair (height 42 cm, 5° of back tilt), with hips and knees flexed at 90° and torso stabilized by strapping in order to restrain the natural tendency to rotate the body during the rotator strength tests. The evaluated shoulder was maintained in adduction and neutral rotation, 90° of elbow flexion and forearm in the neutral position. The dynamometer was maintained fixed to a structure with wall support in order to avoid any interference in the stabilization (Fig. 1).

The athlete performed shoulder rotator isometric strength against the handheld dynamometer positioned 3 cm proximal to the styloid process of the radius. All athletes practiced twice in order to become familiarized with the procedure and the test was performed three times for internal rotation and external rotation with a 30 s rest between each measurement. In order to assure that the athletes understood what they asked to do, the test was first explained and then they practice it twice. If, during the test, the athlete compensated with other movements, the investigator had to eliminate this repetition and the athlete was asked to do the movement once again. This, however, did not occur often since the athletes seemed to fully understand the test and presented a great sense of self awareness of their body movements and were able to follow the instructions. Athletes performed the test in a random order and the same investigator measured all of them. The mean obtained in the three strength tests was used for analysis purposes. The variables of interest were peak isometric strength (kgf) of the internal and external rotators normalized to body weight (kg) and expressed as force (f). We calculated the external to internal rotation ratio and identified athletes with abnormal strength ratios if they had values below 0.66 or above 0.75 (Ellenbecker and Davies, 2000). Deficits between sides were also calculated using the equation $1 - \frac{Non-dominant\ strength}{Dominant\ strength}$ and expressed as percentage (Hadzic et al., 2014). Asymmetry between dominant and non-dominant side was considered when values were above 15% (Ellenbecker and Davies, 2000).

A pre-experiment reliability trial with overhead athletes ($n = 20$) was done previous to the study. The investigators reliability for ROM and strength assessment was considered good to excellent (intratester ICC values between 0.71 and 0.92) and to