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Original Article

Flexibility of internal and external glenohumeral rotation of junior female tennis players and its correlation with performance ranking

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Abstract. [Purpose] The purpose of this study was to compare the internal and external rotation of the dominant and nondominant shoulders of adolescent female tennis players. The correlation between the shoulder rotation range of motion and the player's ranking was also analyzed. [Subjects and Methods] Twenty-one female junior tennis players who were 13 to 18 years old participated in this study. A standard goniometer was used to measure the internal and external rotation of both glenohumeral joints. The difference in internal and external rotation was calculated as the glenohumeral rotation deficit. The year-end ranking of each player was obtained from the Chinese Taipei Tennis Association. [Results] The internal rotation of the dominant shoulder was significantly smaller than that of the nondominant shoulder. Moreover, player ranking was significantly and negatively correlated with the internal rotation range of motion of both shoulders. On the other hand, the correlations of the internal and external rotation ranges of motion with the age, height, and weight were not significant. [Conclusion] The flexibility of the glenohumeral internal rotation is smaller in the dominant shoulder than of the nondominant shoulder in these junior female tennis players. Flexibility of the glenohumeral internal rotation may be a factor affecting performance in junior female tennis players.
Key words: Shoulder tightness, Adolescent, Racket sport

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INTRODUCTION

Playing a game of tennis requires the tennis players to possess excellent physical fitness including such things as strength, speed, flexibility, agility, and power[1, 2)]. Among these fitness related factors, shoulder joint flexibility is important for athletes repeatedly executing over-shoulder motions. Changes in the strength and range of motion of shoulder rotation have been reported in young tennis and baseball players[3, 4)], and they have been generally characterized by a decrease in internal rotation range of motion (ROM) and increase in external rotation in the dominant shoulder. To generate a powerful stroke, tennis players need to transfer forces from the ground up, through the kinetic chain consisting of a series of movements of limbs and joints, before hitting the ball[5)]. The glenohumeral joint of the dominant shoulder plays a vital role in the preparation, acceleration, and follow-through phases of a tennis stroke. A greater range of glenohumeral rotation in the dominant shoulder may be beneficial for tennis players[6)], since it has been shown that internal glenohumeral rotation is a major contributor to

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the mean linear velocity of racket speed[7].

Lack of flexibility in the shoulder might not only deteriorate performance but also increase the injury risk. Repetitive and stressful protraction of the dominant shoulder during tennis serves and swings often lead to tightness and compromise the internal rotation ROM of the dominant shoulder, in comparison with the nondominant side. The bilateral difference or asymmetry in rotation can be explained as an adaptation of the posterior shoulder musculature and soft tissues[8]. Shoulder injuries are frequently seen in the upper extremity in tennis players[9], and decrease of internal rotation in the dominant shoulder is correlated with shoulder pain[10]. Measurements of shoulder rotation ROM have therefore been recommended in the athletic conditioning of tennis players[11] to maintain fit shoulder rotation and also reduce the risk of shoulder injury[12].

Since healthy glenohumeral rotation may be beneficial to the biomechanics of the tennis stroke and prevention of shoulder injury, the junior tennis players in particular need periodic surveillance of shoulder flexibility with the aim of assisting in the training of junior female tennis players in Taiwan, this study was performed to evaluate the shoulder rotation of these players in terms of whether a bilateral difference in shoulder rotation was present and to determine the correlation between shoulder rotation and performance ranking. The results could be helpful for their training and future development.

SUBJECTS AND METHODS

Twenty-one female junior tennis players participated in this study. The athletes' physical characteristics and year-end rankings are listed in Table 1. They were free of severe upper extremity injury in the three months prior to measurement. The Chang Jung Christian University ethics review board approved this study, which complied with the Declaration of Helsinki principles. All the players signed informed consent forms prior to participation. Moreover, the measurement data were given to the players individually for training adjustment. The U18 year-end ranking of each player was obtained from the Chinese Taipei Tennis Association. According to the rules of ranking, players needed to compete in U18 games to earn points for ranking determination, and players younger than 18 years old were allowed to compete in U18 games.

A standard goniometer (Economy Jamar® Transparent Plastic Goniometers, Patterson Medical Holdings, Inc., USA) was used to measure the internal and external rotation of dominant and nondominant shoulder. Each was measured twice, and the average of the two measurements was used for statistical analysis[13].

Internal rotation was measured by asking the subject to lie in a supine position, abduct the shoulder at 90°, and flex the elbow at 90°, with her forearm perpendicular to the floor and fingers pointing at the ceiling. The center of the goniometer was aimed at the lateral side of the humeral head, and its fixed arm was held parallel to the central line of the forearm. To begin measurement, the subject was asked to voluntarily rotate the shoulder joint to move the forearm internally towards the pelvis until the shoulder joint tightened. The mobile arm of the goniometer was then adjusted to be parallel to the central line of the forearm. The range of motion was read as the internal rotation.

External rotation was measured by starting in the same position as above, but the subject was instead asked to rotate the forearm externally towards the head until the shoulder joint tightened. The mobile arm of the goniometer was then adjusted to be parallel to the central line of the forearm, and the external rotation was read.

The difference between shoulders was calculated by subtracting the measurement (in degree) of the nondominant shoulder from that of the dominant shoulder. The data were subjected to descriptive analysis, paired t-tests and the Spearman rank correlation analysis by using PASW Statistics (18.0), and the significance level α was set at 0.05.

RESULTS

The data for internal and external rotations of both shoulders are shown in Table 2. The values for the dominant shoulder were lower than those for the nondominant shoulder. However, only internal rotation was significantly different between shoulders.

The Spearman's rank correlation coefficients for the correlations between glenohumeral rotations and player ranking, age, height, weight, and BMI are shown in Table 3. Only the values for internal rotation of the two shoulders were significantly correlated with ranking.

DISCUSSION

This study showed that both the internal and external rotation of the dominant shoulder were smaller than those of the nondominant shoulder; however, only the difference in internal rotation was significant. Moreover, the internal rotation range of motion of both shoulders was significantly and negatively correlated with the U18 ranking of the players; that is the more flexible internal rotation was, the more matches were won and the higher the ranking achieved by the player in the year.

Age, level of skill, and tennis-related physical fitness are factors that may influence a player's performance. However, studies focused on determinants of performance ranking in tennis players are rare. A previous study reported that performance and ranking of junior players was correlated with dexterity evaluated by the hexagon test[14]. A study of junior male players, on the other hand, indicated that the player's ranking was correlated with speed and vertical jump[15]. It should be noted that glenohumeral rotation was not evaluated in these two studies. The present study indicates that besides speed, power, and

Table 1. Physical characteristics and year-end ranking of the participants (n=21)

	Mean ± SD	Range
Age (years)	14.9 ± 1.5	12.8–17.4
Height (cm)	164.1 ± 6.1	155–180
Weight (kg)	57.6 ± 8.3	45.0–75.1
BMI (kg/m^2)	21.4 ± 2.6	18.4–29.0
Ranking	26.2 ± 22.8	2–76

BMI: body mass index

Table 2. Internal and external rotation of the dominant and nondominant shoulders (n=21)

	Dominant shoulder	Nondominant shoulder	Difference
Internal rotation (degrees)	59.2 ± 10.0	64.0 ± 11.7*	−4.8 ± 9.0
External rotation (degrees)	96.2 ± 10.4	98.7 ± 11.3	−2.5 ± 10.3

*p<0.05

Table 3. Spearman's rank correlation coefficients for the correlations between the glenohumeral rotations and player ranking and physical characteristics (n=21)

	Internal rotation			External rotation		
	Dominant	Nondominant	Difference	Dominant	Nondominant	Difference
Ranking	−0.552**	−0.588**	−0.093	−0.015	−0.121	−0.259
Age (years)	0.075	0.239	0.099	0.004	−0.101	−0.118
Height (cm)	0.009	0.226	0.380	−0.093	−0.089	−0.123
Weight (kg)	0.208	0.421	0.327	−0.233	−0.037	0.062
BMI (kg/m^2)	0.245	0.385	0.179	−0.300	−0.002	0.180

**p<0.01

agility, the range of internal glenohumeral rotation may be a factor that relates to performance of female junior tennis players.

Tennis players have been shown to have a greater range of internal glenohumeral rotation in their dominant shoulder[7]. Moreover, internal rotation of the upper arm is the major contributors to the mean linear velocity of racket speed[14]. Better shoulder flexibility is beneficial for increasing ball-hitting speed because a more flexible shoulder rotation may increase the contact time between the racket and the ball, giving the ball more momentum and a faster speed[1]. The glenohumeral internal rotation deficiency of the dominant shoulder seen in this study is consistent with other studies[4, 12]. It seems that the asymmetry of internal and external rotation between shoulders develops early after tennis players start to engage in training and competitions. Tennis is an over-shoulder sport that requires players to swing a racket with extreme shoulder joint motion. To generate the required momentum for hitting the ball successfully during serves, forehand stroke, and backhand strokes, a tennis player constantly place his/her shoulders under pressure. Consequently, injuries of the shoulder joint occur frequently in tennis players. Repeated injuries result in rigidity of the muscles and ligaments around the joint and thus reduce the shoulder joint ROM. It is reported that athletes who frequently perform over-shoulder motions often suffer from posterior internal impingement of the shoulder joint capsule[16]. During over-shoulder and accelerated anterior rotation of the shoulder joint, the posterior rotator cuff of the glenohumeral joint performs an eccentric contraction to stabilize the shoulder joint. As a result of long-term use or overuse, the posterior rotator cuff of the glenohumeral joint becomes vulnerable to injury, such as partial tearing of the rotator cuff muscle. Repeated injuries can lead to rigidity of these soft tissues and tightening of the joint capsule posterior to the glenohumeral joint, which in turn limits the internal rotation of the dominant shoulder, a condition known as glenohumeral internal rotation deficit (GIRD). It has been reported that tennis players who suffer from shoulder joint pain had smaller internal rotation in the dominant shoulder than those without a history of shoulder joint pain[17]. It is therefore recommended that tennis players should maintain the flexibility of their shoulder joints during training both to improve hitting of the ball and to reduce the risk of injury.

Correlations among the internal glenohumeral rotation, glenohumeral internal rotation deficit, and ages were not significant in the junior tennis players in this study. This suggests that the flexibility and asymmetry of internal rotation do not worsen with age in these female players of this present study in comparison to those of previous studies. A study of 47 adult male professional tennis players found that the internal and external rotation ROMs of the dominant shoulder were significantly and negatively correlated with years of practice (r=−0.313 and −0.239, respectively), whereas the correlation for the nondominant shoulder was somewhat stronger (−0.426 and −0.424, respectively)[17]. Similar results were also found in a study of 59 adolescent male players[10]. The inconsistency between our results and those of other studies may be due to gender difference. Flexibility is generally better in females than in males, and this may decrease the glenohumeral internal rotation deficit in female players. Besides, the hitting power of female players is lower than that of males, and therefore the musculature and soft tissues of the shoulder may suffer less impact and damage that lead to tightness of glenohumeral rotation.

Based on the present results, we suggest that coaches and physiotherapists may include shoulder stretches, such as sleeper or cross-arm posterior shoulder stretches, in athletic conditioning of adolescent tennis players to counter the possible loss of internal rotation ROM. In addition, periodic measurements of shoulder flexibility are recommended to be included in athletic conditioning for junior tennis players, since they may experience glenohumeral internal rotation deficiency early when they start to train and compete and the deficiency may affect their performance.

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