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Glenohumeral joint muscles strength of the young tennis players

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ABSTRACT

Zuša A, Lanka J, Čupriks L. Glenohumeral joint muscles strength of the young tennis players. *J. Hum. Sport Exerc.* Vol. 7, No. Proc1, pp. S8-S16, 2012. This paper consists from two parts. First is small theoretic review about shoulder and upper arm kinematics, biodynamics in forehand and serve strokes. Second is dedicated to study young tennis players' glenohumeral joint muscles strength peak torque, analyzing an asymmetry level of dominant and nondominant side. Five 11 years old girls, weight 42.6 kg (± 5.1), height 157,8 cm (± 5,8) have participated in study. Tests performed with use of Technogym's isokinetic device REV-9000. Mode of the testing – isometric muscle contraction. Verbal and visual feedbacks were utilized to increase the motivation of the subjects. Based on the results of this testing we created individual shoulder joint muscular strength models, that reflects peak torque of right and left shoulder flexion and extension, shoulder abduction and adduction, shoulder internal and external rotation.
Key words: FOREHAND GROUNDSTROKE, SERVE, ISOKINETIC DEVICE, PEAK TORQUE, ASYMMETRY.

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INTRODUCTION

Tennis, as type of sport, has a lot of technical elements, which are based on dominant arm work, other body segments as well as nondominant arm performing support and compensatory functions. This observation allows to assume, that tennis is an asymmetric sport. Because of this the study of tennis - specific mechanical load influence on tennis player locomotors system is interesting from the point of view of scientific and practical coaching work. This theme is relevant nowadays especially due to popularity of early specialization in children. Children start attending tennis specialized training and take part in mini-tennis competitions at age of 4 – 5. The basic technical element which training begins from is a forehand stroke (groundstroke performed by dominant arm). According to the research data (e.g. Скородумова, 1994) it was discovered that: in men, the forehand strokes are 40-55 % on fast surfaces (hard courts) and 57% on slow surfaces in average per match out of total amount of strokes performed; in women it is 55-60 % on fast and 37-45 % on slow surfaces in average per match out of total amount of strokes performed.

Shoulder is one of most important and basic joint in tennis players' body, it is on 5th position in stroke's production chain (Bahamonde & Knudson, 2003; Kopsic, 2002). The glenohumeral joint provides freedom of motion in all directions for the upper extremity as a whole. Stability in certain positions is obtained by the coordinated action of muscles (Kendall et al., 2005). The shoulder is a spheroid or ball-and-socket joint, but the socket is small and shallow, allowing ball-shaped head of the humerus to move freely. This allows it to be the most mobile joint in the body, providing the largest range of motion, but on the same time it is least stable joint. The extremely mobile shoulder joint is therefore naturally unstable (Kendall et al., 2005; Roberts et al., 2010; Roetert & Kovacs, 2011).

Each stroke in tennis performed by the shoulder and scapular muscles, maintaining a balanced musculature is vital to the stability of this region. As a result, shoulder injuries are very common in tennis. Tennis technique elements require explosive movement patterns and highly intensive maximal-effort concentric and eccentric muscular work. The largest range of motion in shoulder joint requires groundstrokes and serves. Forehand groundstroke and serve in tennis are considered as basic and more effective in tennis game, these two strokes are performed only by dominant arm. In groundstroke we can observe a combination of shoulder motion in different directions: abduction and external rotation in backswing, abduction and internal rotation in forward swing. The tennis serve is more complex: abduction and external rotation during the backswing, with scapular retraction and depression into the loading phase. From the loading phase, scapular elevation, abduction, and shoulder extension move the arm toward contact. Internal rotation, shoulder extension, and adduction complete the follow-through (Roetert & Kovacs, 2011).

The shoulder and upper arm muscles, which realize different phases of groundstroke and serve, are largely responsible for the development and deceleration of racquet velocity. Forehand groundstroke consists from preparation, acceleration and follow-through phases. The following shoulder and upper arm muscles participate in stroke realizing (Reid et al., 2003):

> I phase – preparation – we can observe the shoulder and upper arm rotation (transverse plane), which realize concentric contraction of middle and posterior deltoid, latissimus dorsi, infraspinatus, teres minor, wrist extensors and eccentric contraction of anterior deltoid, pectoralis major, subscapularis muscle.

II phase – acceleration - upper arm horizontal movement, which realize concentric contraction of anterior deltoid, subscapularis, biceps, pectoralis major muscle. And upper arm internal rotation - concentric contraction of latissimus dorsi, pectoralis major, subscapularis muscle.

III phase – follow-through - deceleration of upper arm/racquet, which realize eccentric contraction of infraspinatus, teres minor, posterior deltoid, rhomboid, serratus anterior, trapezius, triceps, wrist extensors.

Serve stroke consists from cooking, acceleration and follow-through phases (Reid et al., 2003):

I phase – cooking – action of arm motion, which realize concentric contraction of infraspinatus/teres minor, supraspinatus, biceps, serratus anterior, wrist extensors and eccentric contraction subscapularis, pectoralis major.

II phase – acceleration - upper arm elevation and forward movement - which realize concentric contraction of subscapularis, pectoralis major, anterior deltoid, triceps. And shoulder internal rotation - concentric contraction of latissimus dorsi, subscapularis, pectoralis major muscle.

III phase – follow-through - eccentric contraction of infraspinatus, teres minor, serratus anterior, trapezius, rhomboids, wrist extensors, forearm supinators.

Aim of our research work was to perform a study of the shoulder joint muscles' strength of the young tennis players.

MATERIAL AND METHODS

Five right handed 11 years old girls, weight 42.6 kg (± 5.1), height 157.8 cm (± 5.8), who played tennis more than 3 years and participated in Latvian Tennis Federation official competitions in U-12 age group, have participated in tests performed with use of Technogym's isokinetic device REV-9000. This machine is one of commonly used strength-testing devices, is practice adopted and is widely used for clinical studies. Isokinetic device tests the muscular strength capabilities, it allows to stabilize and position the tested tennis player, isolates required joint for testing on required physiological parameters (Davies et al., 2000; Robertson et al., 2004). System is computer controlled and includes a gravity correction option.

Before the testing subjects performed a general warm-up for about 15 min. In given test the testing mode consisted from specific joint warm up 60 s, after followed 6 x 3 s isometric muscle work (fixed joint angular position, with resistance 600 Nm and fixed speed at 0°/s) with 20 s passive rest and after 60 s cool down continuous passive motions. Verbal and visual feedbacks were utilized to increase the motivation of the subjects. Our study was accepted by Latvian Academy Sport Education ethics commission.

RESULTS

First testing exercise was shoulder flexion and extension in supine position (Figure 1). Movement performed in the sagittal plane. The rotational axis shifts medially to the acromion when the arm was in the rest position. The arm was completely extended in the neutral position. Range of motion for specific warm up and cool down was 0°-180°. Isometric muscle contractions 6 x 3 s with 20 s passive rest, fixed joint angular position at 100°, fixed resistance was 600 Nm, speed 0°/s. The test results are presented in Table 1.

Figure 1. *Shoulder flexion and extension testing exercise.*

Table 1. *Shoulder flexion and extension testing results.*

	Shoulder flexion		**Shoulder extensión**	
Subjects Nr.	Right	Left	Right	Left
1	30.11	31.24	26.72	24.09
2	55.7	54.57	34.63	30.11
3	39.52	35	28.23	24.09
4	37.64	39.52	27.47	19.57
5	37.26	38.77	21.83	27.1

Average group testing results for right shoulder flexion are 40.04 Nm (± 8.04), for extension are 27.78 Nm (± 4.58). For left shoulder flexion average group testing results are 39.82 Nm (± 8.76), for extension 24.99 Nm (±3.93).

Second testing exercise was shoulder abduction and adduction in horizontal plane, in supine position (Figure 2). The rotation axis starts at the claveolar acromion and runs parallel to the longitudinal axis of the trunk. Range of motion for specific warm up and cool down was 0°-140° (adduction 30°, abduction 110°). Isometric muscle contractions 6 x 3 s with 20 s passive rest, fixed joint angular position at 60°, fixed resistance was 600 Nm, speed 0°/s. The results are presented in Table 2.

Figure 2. *Shoulder adduction and abduction testing exercise.*

Table 2. *Shoulder adduction and abduction testing results.*

	Shoulder abduction		Shoulder adduction	
Subjects Nr.	Right	Left	Right	Left
1	15.81	14.68	21.83	14.68
2	24.84	25.22	24.84	29.73
3	25.22	24.46	25.22	27.85
4	21.45	18.82	22.58	21.45
5	26.35	28.23	29.36	27.85

Average group testing results for right shoulder adduction are 24.77 Nm (± 2.95), for abduction are 22.73 Nm (± 7.84). For left shoulder adduction average group testing results are 24.31 Nm (± 6.23) for abduction are 22.28 Nm (± 5.44).

Third testing exercise was shoulder internal and external rotation, in sitting position with shoulder flexed by 90° and abducted to 85° (Figure 3). The rotation axis is along the humerus. Intra/extra rotation testing is most commonly used for glenohumeral joint testing in tennis players (Ellenbecker & Roetert, 2000). Range of motion for specific warm up and cool down was 0°-135°. Isometric muscle contractions 6 x 3 s with 20 s passive rest, fixed joint angular position at 25°, fixed resistance was 600 Nm, speed 0°/s. Detailed results are presented in Table 3.

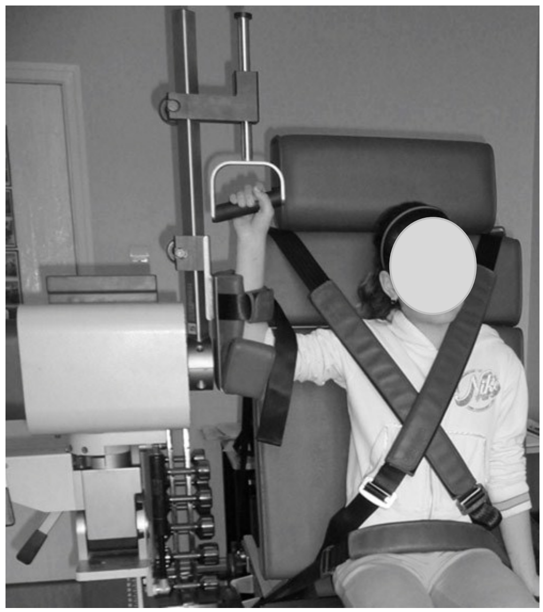

Figure 3. *Shoulder internal and external rotation testing exercise.*

Table 3. *Shoulder internal and external testing results.*

	Shoulder intra rotation		Shoulder intra rotation	
Subjects Nr.	Right	Left	Right	Left
1	19,95	11,67	10,91	9,79
2	29,73	19,57	21,45	10,91
3	26,72	20,7	18,82	9,03
4	23,71	18,44	15,81	14,3
5	28,98	22,58	13,55	12,8

Average group testing results for right shoulder internal rotation are 25.82 Nm (± 4.03), for external rotation are 16.11 Nm (±6.51). For left shoulder internal rotation average group testing results are 18.59 Nm (± 4.16) for external rotation are 11.37 Nm (± 2.17).

Shoulder flexion muscles for all subjects as well as for right and for left side showed greatest rates of peak torque. In turn the greatest right vs. left side asymmetry we can observe in internal shoulder rotators.

DISCUSSION

The only one strength parameter that we looked at was isometric peak torque in specific angle position. The results of previous studies showed positive linear relationship between serve's speed and peak torque (Signorile et al., 2005) and isometric internal/external rotation peak torque positively correlated with groundstroke and serve speed (Cohen et al., 1994).

Each testing exercise position we tried to carry out as close as possible to tennis technique. The testing formula has been carefully thought-out. Rest intervals have been 20 s, which is similar to the rest intervals between points during tennis play. In internal and external rotation testing it is recommended to fix shoulder abducted to 60°-75° (Davies et al, 2000), in sport medicine use 90° abduction angle to simulate the specific functional length-tension implications of the muscles (Bassett et al., 1990). Scientists of tennis biomechanics used high speed cinematography and founded motion at the glenohumeral joint during serves motion at cooking phase average abduction angle 83° (Elliot et al., 1986). Based on this knowledge, we chose shoulder joint abduction at 85°.

Right and left shoulder testing data we compared in percentage value. The more significant trends of right side dominance were observed in following testing exercises: shoulder extension (average results of four subjects 19.4% of right side dominance), internal rotation (group average results 29% of right side dominance), external rotation (group average results 25.4% of right side dominance).

Modern tennis is characterized as high dynamic game with explosive movements and powerful strokes. This fact is the reason why the main goal of tennis-specific fitness programs is to increase muscular power under the variety of conditions that relate to tennis performance (Reid, 2008). Undeniable is the fact, that in such complex sport as tennis, that requires high performance of most physical capacities (speed, strength, power agility, aerobic and anaerobic endurance) the improvement of strength parameters cannot provide a full success in the competition. In previous study was shown, that improvement of absolute level of strength will not produce optimal stroke speed and effectiveness. For preparing powerful stroke it's necessary to apply a high level of strength, coordination, flexibility and technique (Pugh et al., 2003; Reid, 2008).

Exist many strength increasing programs and recommendations in tennis, which include different kind of stretch-shortening cycle exercises (Kopsic, 2002; Berdejo et al., 2009), but markedly less attention has been dedicated to one of basic problem in training process – prevention of injury, especially in work with young tennis players. The locomotor system of young tennis players is in active development stage. The movements as well as postural stereotypes are not persistent. To insure the harmonic development of locomotor system, physical condition coaches need to pay more attention to applying static-dynamic exercises in training. The question of tennis specific mechanical load effect on young tennis players' locomotor system requires more detailed study.

CONCLUSIONS

Based on the results of this testing we created individual upper extremity muscular strength models. General trends of the group: shoulder flexion muscles for all subjects as well as for right and for left side showed greatest rates of peak torque. Right and left shoulder testing data we compared in percentage value. The more significant trends of right side dominance were observed in following testing exercises: internal rotation (group average results 29% of right side dominance), external rotation (group average results 25.4% of right side dominance) and shoulder extension (average results of four subjects 19.4% of right side dominance).

These data can serve as a basis for the individual shoulder muscles strength training programs. To insure the harmonic development of locomotor system, physical condition coaches need to pay more attention to applying static-dynamic exercises in training. The question of tennis specific mechanical load effect on young tennis players' locomotor system requires more detailed study.

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