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Original article

Comparison of elbow joint isokinetic strength and reaction times of racquet players

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Abstract. *Study Objectives:* This study aimed to compare racquet players' elbow joint isokinetic supination-pronation strength and reaction times. *Methods:* study sample consisted of a total of 48 healthy male volunteers including 12 table tennis players (TP), 12 badminton players (BP), 12 court tennis players (CP), and 12 sedentary controls (SC). Isokinetic strength bilateral elbow supination-pronation strengths were measured at two different velocities (30⁰/sand 120⁰/s) using an isokinetic dynamometer while bilateral hand movements were aurally and visually recorded using a NewTest 1000 instrument in 4 different ways to determine reaction times. *Results:* CP had higher isokinetic 30⁰/s and 120⁰/s supination right elbow and 120⁰/s left supination elbow values than BP, TP, and SC ($p<0.01$). The isokinetic 30⁰/s and 120⁰/s pronation right elbow isokinetic strength values of CP significantly differed from those of SC and TP. There were significant differences in mean visual and auditory reaction times between CP and SC ($p<0.05$). *Conclusion:* CP had higher isokinetic strength mean score than SC, BP and TP. The visual and auditory reaction times of CP were better than those of SC and similar to those of BP and TP.

Keywords: Isokinetic Strength, Isokinetic Elbow Strength, Reaction Velocity, Racquet Sports

Introduction

The elbow joint is a complex structure that provides an important function in terms of mechanical connection in the upper extremity between the shoulder, hand, and wrist. The elbow functions serve as an abutment for the hand for fine movement, for strong grip, and the forearm. Loss of elbow function can significantly affect daily life activities. For this reason, it is important to recognize the specific anatomy of the bony geometry elbow, in the joint and soft tissue structures (1). Comparing the relationship between agonist and antagonist muscles may provide information on the weaknesses of certain muscle groups. The proportional relationship of numerous muscle groups depends on speed. Dominant muscle groups are the muscle groups of choice to improve muscle performance (2). The correct movement of the hand remains at 90⁰ flexion with the elbow, while the palm up (supination) or downward (pronation) rotation depends on the orientation level. Hand rotation is possible with the rotation of the forearm and also the rotation of the upper extremity in the shoulder (3). When applied correctly, exercises can improve arm strength and muscle balance. It is generally ideal for the dominant and non-dominant arm to have equal strength. Strength exercises should focus on muscle balance and endurance. We, therefore, recommend that light weights and multiple repetitions be applied especially to the lower arm. Properly strengthened arms not only help players perform better on the court but also protect their shoulders, elbows, and wrists from injuries (4). Badminton and tennis are branches of sports where legs, arms, and upper body are completely used. Strength and endurance of the arms and body decrease

due to long stroke rallies or by the end of a match. Both stroke strength and attention are reduced, and the body shape changes (5). Racquet sports such as tennis, table tennis and badminton require a combination of physiological requirements such as speed, resistance, force, motor coordination, short-term maximal and submaximal efforts, game-based techniques and strategies, which makes racquet sports particularly difficult for different levels of players such as professionals, amateurs and beginners (6). Strokes have become even more severe in tennis sports with the development of racket and spring technology. Arm muscles in particular require more strength to protect the joints from injury. Grip, forearm strength, and muscle strength are critical for tennis players. Sufficient forearm strength and grip reduce the pressure on the joints and thus reduces the possibility of a shoulder injury. Players with weak grip and forearms try to reduce the risk of a shoulder injury (4). The reaction time (RT) is defined as a measure of the response to a stimulus. The reaction time plays an important role in our lives as practical results can lead to greater results. Factors that may affect the reaction time of a person; age, gender, left or right hand, central and environmental views, practice, fatigue, fasting, breathing cycle, personality types, exercise and includes the intelligence of the subject (7).

Though court tennis, badminton, and table tennis are similar in some respects, they differ in many aspects such as models used by players, field size, ball or feather ball speed, and so on. There are, however, few studies focusing on the necessary motor skills in these sports (8-10). Based on the above information, it is expected that the isokinetic peek force values and reaction times will differ in racket sports, as the arm and forearm work at different angles and loads. The aim of this study was to the comparison of elbow joint isokinetic strength and reaction times of racquet players.

Materials and Method

Participants

The study sample consisted of 48 healthy male right-lateral dominant participants including 12 table tennis players (TP), 12 badminton players (BP), 12 court tennis players (CP) and 12 sedentary controls (SC) (mean age 23.50 ± 2.62 years, mean height 178.27 ± 6.43 cm, and mean weight 74.12 ± 9.56 kg). Racquet players were selected from healthy young person's participating recreational athletes for activities at least 3 years. Participants with any drug or disability history were excluded from the study.

Experimental Design

In this study, comparison method between groups was used. The study was approved by the Clinical Research Ethics Committee of Afyon Kocatepe University (Approval No: GO 2011/KAEK-2: 2017/64). All participants signed informed consent forms before participation. Body composition (height, weight, light) and reaction measurements were performed in the Performance Laboratory of Afyon Kocatepe University Faculty of Sport Sciences. Isokinetic elbow strength measurements were performed in the Isokinetic Test Room of the Department of Physical Therapy and Rehabilitation in the Faculty of Medicine of Afyon Kocatepe University under the supervision of a specialist doctor.

Collection of Data

Measurement of Body Composition

Body heights and body weight were measured using a Seca digital scale. The participants were instructed to stand on the scale with shorts and a jersey. Measurements were performed on an empty stomach and in the morning.

Isokinetic Strength Test

Isokinetic strength measurements were carried out using an Isomed 2000 (USD) isokinetic dynamometer. Before the isokinetic test, the participants performed a 10-min warm up (jogging) followed by a 5-min arm and elbow exercise. The dynamometer was adjusted according to each participant in a sitting position. The test arm was strapped to the dynamometer while the other arm was strapped to the handle of the device to prevent it from moving during the test.

The participants performed five trials followed by five isokinetic right arm and left arm supination-pronation movements at the angular velocities of 30°/s and 120°/s as specified in the protocol. Supination and Pronation Isokinetic strength peak torque (Nm/kg) were calculated. A rest period of 60 s – or more, if needed - was permitted between each session (11). All participants reported right arm dominance.

Reaction Test

Reaction measurements visual and auditory reaction measurements of the right and left hands 5 repetitions it was measurement with the New Test 1000. The participants are placed on the chair with their hands on the table seated and responding to light stimuli given at uneven intervals has been requested. Light and auditory were given five times at different time intervals, response times to these warnings were recorded in milliseconds. The measurements were taken arithmetic averages of other response times by discarding the minimum and maximum values (12).

Statistical Analysis

Data were analyzed using SPSS version 20 (IBM Inc., Chicago, IL, USA) at the significance levels of 0.05. Normality of the distribution and homogeneity of variance were calculated with Kolmogorov-Smirnov test and Levene test. The performance of the groups was determined with One-Way ANOVA. Bonferroni test was used for post-hoc multiple comparisons. Percentage differences, which Yıldız and Kale (2018) used in theirs study (13), were calculated using the formula (Group I-Group II/Group I x100) as by Newton (14).

Results

The groups did not significantly differ by age, weight, and height ($p>0.05$). CP had significantly higher 120°/s right and left elbow supination strength mean scores than SC, TP and BP did ($p<0.01$). Also, CP had significantly higher 120°/s right and left elbow pronation strength mean scores than TP and SC did ($p<0.05$ $p<0.01$). CP had significantly higher 30°/s right elbow supination strength mean scores than the other groups ($p<0.01$). CP also had significantly higher 120°/sn^{-1} and 30°/sn^{-1}supination and pronation mean scores and isokinetic strength mean scores than the other groups (Table 3).The visual reaction time of SC differed from those of CP and BP while the auditory reaction time of SC differed only from that of CP ($p<0.05$).

CP had significantly higher 120°/s right (SC % 41.48, TP % 47.30, BP % 33.34) and left elbow (SC % 28.73, TP % 29.3 BP % 20.63) supination strength mean scores than SC, TP and BP did ($p<0.01$). CP also had significantly higher 120°/s (SC %41.07, TP % 37.75) right and left (SC % 3.92, TP % 20.87) elbow pronation strength mean scores than TP and SC did ($p<0.05$ $p<0.01$).

CP had significantly higher 30°/s right elbow supination strength mean scores than SC % 40.12, TB% 41.20, BP % 33.3 ($p<0.01$). CP had significantly higher 30°/sn right isokinetic strength pronation score than SC % 33.0, TB 31.20 and 30°/sn left pronation mean scores than SC % 27.58.

The visual reaction time of SC differed from those of CP and BP while the auditory reaction time of SC differed only from that of CP ($p<0.05$).

Discussion

This study aimed to compare table tennis players (TP), badminton players (BP), court tennis players (CP), and sedentary controls (SC) in terms of elbow joint isokinetic supination pronation strength and reaction time. According to table 1, there was no difference between the physical properties of the groups. The results showed that CP had higher 120°/s right and left elbow supination isokinetic strength than the other groups. CP also had significantly higher 120°/s right and left elbow pronation strength than TPs and SC had (Table 2). CP had higher 30°/s right elbow supination strength than the other groups, however, they had higher 30°/sn left elbow supination strength only than SC had (Table 3).

Akşit et al., (2003) reported that isokinetic strength exercises require effective and dynamic reinforcement. They stated that such biomotor abilities as

Table 1. Comparison of descriptive characteristics of groups

	Groups	N	$\bar{X}$±Sd	Min	Max	F	p
Age (Year)	Sedentary	12	23±3.06	19.00	27.00	1.077	0.369
	Court Tennis	12	24±1.88	22.00	27.00		
	Table Tennis	12	23±2.78	20.00	28.00		
	Badminton	12	23±2.61	19.00	27.00		
	Total	48	23±2.63	19.00	28.00		
Height (cm)	Sedentary	12	179±6.38	163.00	188.00	1.238	0.307
	Court Tennis	12	180±7.90	173.00	198.00		
	Table Tennis	12	175±5.38	163.00	182.00		
	Badminton	12	179±5.55	170.00	188.00		
	Total	48	178±6.43	163.00	198.00		
Weight (kg)	Sedentary	12	72.5±8.31	61.00	90.00	2.747	0.054
	Court Tennis	12	79.5±9.87	61.00	95.00		
	Table Tennis	12	69.2±9.40	60.00	85.00		
	Badminton	12	75.2±8.65	58.00	86.00		
	Total	48	74.1±9.57	58.00	95.00		

p>0.05; Sd: Standard Deviation; Min: Minimum; Max: Maximum

strength, speed, endurance, and flexibility and coordination should be improved to combine them with speed and strength, which become more and more prominent in tennis (15).Forehand stroke speed in tennis depends on not only the player's grip but also the acceleration of the spine, arm, forearm, and wrist (16). Ellenbecker (1991) conducted a study on 22 elite tennis players to investigate whether there were significant differences in strength between the dominant and non-dominant arms and to determine its relationship with the speed of tennis serves. He reported no difference between the extremities for shoulder external rotation and forearm supination in terms of shoulder extension and wrist extension. He also reported that the muscle strength of the upper extremity around the joint was high and that the dominant arm isokinetic muscle strength was dominant (17). Another study was conducted on 20 table tennis players at different levels and 12 women who had never played tennis before. In that study, six different measurements were performed to compare and evaluate the rate of supination and pronation and hand pressure strength. Elite table tennis players have the lowest pronation performance indicators of the dominant limb. The difference between the groups was observed only in the supination of the dominant arm, which may be specific for table tennis due to the use of the dominant arm. The best results for the supination of the dominant arm in table tennis are obtained by the correlation between kinesthetic difference and sport level, and this can only be observed in high-level group players who have long-term training experience (18). Turhan et al., (2003) observed the semifinal and final matches at the 2003 European Table tennis championship to analyses service, backhand spin, forehand spin, chop, forehand smash, backhand smash, counter spin, short balls, drop, backhand block, forehand block, loop, and miss. They reported that 36.8% of forehand spin strokes and 14% of backhand block strokes result in the score while 35% of forehand spin strokes and 17.6% of backhand block strokes miss, indicating that forehand spin and backhand block strokes are critical in table tennis matches (19). Elite players focus on maintaining year-round performance and avoiding

Table 2. Comparison of 120⁰/s Supination/ Pronation isokinetic strength values of racquet player groups and sedentary group

Variables	Groups	n	x̄±Sd	F	p
Right Elbow 120⁰/s Pronation	Sedentary [b]	12	7.42±2.15	5.114	.004*
	Court Tennis[a]	12	12.58±6.07		
	Table Tennis[bc]	12	7.83±2.48		
	Badminton[abc]	12	8.92±2.06		
	Total	48	9.18±4.04		
Left Elbow 120⁰/s Pronation	Sedentary[b]	12	6.33±1.61	7.133	.001**
	Court Tennis[a]	12	9.58±1.97		
	Table Tennis[b]	12	7.58±1.38		
	Badmintona[b]	12	7.75±1.91		
	Total	48	7.81±2.05		
Right Elbow 120⁰/s Supination	Sedentary[b]	12	12.58±2.94	9.885	.001**
	Court Tennis[a]	12	21.50±6.14		
	Table Tennis[b]	12	11.33±6.08		
	Badminton[b]	12	14.33±4.12		
	Total	48	14.94±6.27		
Left Elbow 120⁰/s Supination	Sedentary[b]	12	9.50±2.31	8.272	.001**
	Court Tennis[a]	12	13.33±2.39		
	Table Tennis[b]	12	9.42±2.43		
	Badminton[b]	12	10.58±1.56		
	Total	48	10.71±2.66		

*p** 0.01; p* 0.05; a,b,c: Different letters indicate statistically significant differences.*

injuries, and therefore, sport-specific muscular balance is critical for them (15). Using the forearm muscles excessively leads to fatigue and a reduction in the grip strength, failing to maintain the strength of these muscles and a general decrease in sporting performance due to a reduction in neuromuscular control, proprioception accuracy and muscle strength (20). Mavvidiş et al., (2010) performed a groundstroke performance evaluation test on male and female tennis players between the ages of 12 and 15 years. They reported that participants' performance differed by age and their execution of forehand or backhand strokes, but it was not different by gender. This result indicates that the performance of young tennis players does not depend on gender but it depends on age and training on the forehand and backhand strokes (21).

Those who executed forehand strokes performed better than those who executed backhand strokes, indicating that supination strength is higher than pronation strength, hence 36.8% of forehand strokes resulted in a score. Racquet grip strength is high, and angular velocity and stroke speed depend on field conditions in tennis, and therefore they are the most important features differentiating tennis from other racquet sports. In this context, the result showing that tennis players have higher isokinetic elbow strength than sedentary controls is consistent with the literature. The performance of tennis players depends on some anthropometric characteristics. In this context, the skills transferred to the tennis ball must be converted to scores. Forehand and backhand strokes are executed in front of the net or the baseline, and the advantag-

Table 3. Comparison of 30⁰/s Supination / Pronation Isokinetic Strength Values Racquet Player Groups and Sedentary Group

Variables	Groups	n	x̄±Sd	F	p
Right Elbow 30⁰/s Pronation	Sedentary[b]	12	8.92±2.91	4.120	.012*
	Court Tennis[a]	12	13.33±4.85		
	Table Tennisb[c]	12	9.17±3.33		
	Badmintonb[a]	12	10.17±2.25		
	Total	48	10.40±3.80		
Left Elbow 30⁰/s Pronation	Sedentary[a]	12	7.50±2.65	2.195	.102
	Court Tennis[a]	12	9.67±1.61		
	Table Tennis[a]	12	8.50±1.88		
	Badminton[a]	12	8.67±2.01		
	Total	48	8.58±2.15		
Right Elbow 30⁰/s Supination	Sedentary[b]	12	13.92±3.06	16.066	.001**
	Court Tennis[a]	12	23.25±5.93		
	Table Tennis[b]	12	13.67±3.55		
	Badminton[b]	12	15.50±1.98		
	Total	48	16.58±5.47		
Left Elbow 30⁰/s Supination	Sedentary[b]	12	10.50±1.88	3.386	.026*
	Court Tennis[a]	12	14.50±4.54		
	Table Tennisa[b]	12	11.83±3.90		
	Badmintona[b]	12	11.17±2.04		
	Total	48	12.00±3.54		

*p** 0.01; p* 0.05; a,b,c: Different letters indicate statistically significant differences.*

es of kinanthropometry variables affect strength and energy release. Research shows that there is a strong relationship between anthropometric parameters and tennis strokes (22). The results show that the dominant arm isokinetic strength values are higher than non-dominant arm isokinetic strength values and that elbow joint muscles operate actively with multiple contractions. This result suggests that the measured muscle group is influenced by such factors as a branch, racket weight, duration of the match, the scope of the match, stroke techniques and angles, field ground, racket grip types (different grip depending on the stroke) and ball angle. The right-hand visual reaction speed of SC differed from those of CP and BP. The right hand and left-hand visual reaction speeds of CP and BP differed from those of SC while the visual reaction speed of CP differed from that of SC (Table 4).

Sarıtaş et al., (2006) compared the right hand-left hand and right foot-left reaction times of male football and tennis players. They reported that both football and tennis players had shorter right hand and right foot reaction times (23). This might be since participants were mostly right-footed or that they used the right extremity intensely or it was only due to the nature of these sports branches. Can et al., (2014) compared the reaction times of 17 male court tennis players, 18 male table tennis players, and 16 sedentary individuals between the ages of 10 and 12 years. They reported significant differences between table tennis players and the other two groups. The reaction times of table tennis players had shorter visual and auditory reaction times than court tennis players and sedentary individuals (24).

Table 4. Comparison of Reaction Times of Racquet Player Groups and Sedentary Group

Variables	Groups	N	X̄±Sd	F	p
Reaction Right Hand Visual	Sedentary[b]	12	0.22±0.04	5.514	0.003**
	Court Tennis[a]	12	0.17±0.03		
	Table Tennisa[b]	12	0.19±0.04		
	Badminton[a]	12	0.18±0.04		
	Total	48	0.19±0.04		
Reaction Left Hand Visual	Sedentary[b]	12	0.21±0.05	4.257	0.010*
	Court Tennis[a]	12	0.16±0.03		
	Table tennisa[b]	12	0.18±0.02		
	Badminton[a]	12	0.17±0.03		
	Total	48	0.18±0.04		
Reaction Right Hand Auditory	Sedentary[b]	12	0.22±0.05	3.595	0.021*
	Court Tennis[a]	12	0.16±0.02		
	Table tennisa[b]	12	0.18±0.03		
	Badmintona[b]	12	0.18±0.05		
	Total	48	0.19±0.04		
Reaction Left Hand Auditory	Sedentary[b]	12	0.21±0.05	3.974	0.014*
	Court Tennis[a]	12	0.16±0.04		
	Table Tennisa[b]	12	0.16±0.03		
	Badmintona[b]	12	0.19±0.05		
	Total	48	0.18±0.05		

*p** 0.01; p* < 0.05; a,b,c; Different letters are different and same letters are no different.*

Another research that the visual reaction times of BPs with the age-matched control group. BP group consisted of 50 badminton players aged from 18 to 22 years who engaged in badminton at least for two years and practice at least for 2-3 hours per week. The visual reaction time of the dominant and non-dominant limbs of BPs was significantly shorter than that of the control group. Badminton players is useful in improving eye-hand reaction time, muscle coordination, cognitive functions, concentration, and alertness (25). Elite and non-elite badminton players in favor of elite athletes have been reported that significant differences in the between visual and auditory (26). Bhabhor et al., (2013) compared the visual reaction time of 50 table tennis players and 159 sedentary individuals. They reported that the visual reaction times of table tennis players were significantly shorter than those of sedentary individuals (27). In our study, all racquet players (CP, TP, and BP) had significantly shorter reaction times than the sedentary group.

Conclusion

The supination isokinetic strength mean scores of all racquet players were significantly higher than their pronation isokinetic strength mean scores. The dominant arm isokinetic strength mean scores of all racquet players and the sedentary groups were significantly higher than their non-dominant arm isokinetic strength mean scores. CP had a higher elbow joint isokinetic supination strength mean score than did the

other groups did. CP and BP had shorter right-hand and left-hand visual and auditory reaction times than SC. However, all racquet player groups had similar visual and auditory reaction times. Preparing training contents by taking these differences into account will make training more balanced and reduce the risk of injury.

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Conflicts of Interest

The authors declare that there is no conflict of interest in this manuscript.

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