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A COMPARISON OF ANAEROBIC PERFORMANCE OF SUB-ELITE TENNIS AND BADMINTON PLAYERS

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Abstract:
This study was carried out to determine the anaerobic properties of the sub-elite badminton and tennis players and to make comparison whether there is a difference between two racket sports in terms of anaerobic performance or not. 13 badminton players (7 male, 6 female) (Age: 20.30±1.65; Height:171.42±7.62; Weight:64.68±10.42) and 10 tennis players (5 male, 5 female) (Age: 19.50 ± 0.84; Height:171.58±6.31; Weight:62.21±9.85) who have been training 2 days a week for averagely 3 years took part in this study voluntarily. Participants' body composition, isokinetic leg strength, isometric handgrip strength, vertical jump, Illinois agility, and Wingate anaerobic test were measured. SPSS 22.0 used for data analysis, being a non-parametric test, Mann-Whitney U test was conducted in comparison of two groups. At the end of performance measurements, right and left handgrip strengths were found 39.91 kg.f and 37.89 kg.f at badminton players; 43.58 kg.f, 41.49 kg.f at tennis players, respectively. At isokinetic extensor and flexor leg muscle strengths were measured 186.83 Nm, 107.93 Nm and 168.61 Nm, 112.43 Nm and as for hamstring/quadriceps (H:Q) ratio: 0.58, 0.66. As for Wingate anaerobic strength test, peak power (PP) values at sub-elite badminton and tennis players were respectively measured as 646.96 W, 694.23 W; relative peak power (RPP) value 10.11 W kg^{-1}, 10.35 W kg^{-1}; average power (AP) value 7.21 W kg^{-1}, 7.39 W kg^{1}. vertical jump was respectively detected as 48.13 cm and 46.03 cm, agility test 17.38 sec and 17.37 sec. The difference between these parameters belonging to two groups was found statistically significant only at H:Q ratio (p=0.22), wasn't found significant at other parameters. Consequently, statistically significant difference wasn't found between anaerobic performance values of sub-elite badminton and tennis players except for the H:Q ratio. This result showed us that players at sub-elite level have similar anaerobic performances even if these two racket sports have different court sizes, different durations, different racket weights, different hitting techniques.

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Keywords: badminton, tennis, anaerobic performance, isokinetic leg strength, Wingate anaerobic test, Illinois agility test

1. Introduction

Badminton is a high intensity and intermittent branch of sports including a mix of strength, speed, power, agility, flexibility and technical skill (Lees, 2003; Phomsoupha & Laffaye, 2015). During the match, agility skills such as lunge, jumps, fast arm movements and explosive muscle activation are constantly repeated while attacking with racket. As well as leg muscles are important at badminton players because of this (Andersen et al., 2007; Phomsoupha & Laffaye, 2015), flexible hamstring and hip adductors are necessary for agility. Compared with tennis, movements at wrist are more than shoulder joint at badminton during rallies (Reilly et al., 1990). Especially high level badminton is a long and tiring sport consisting of intermittent activities including short rest periods and high density activities and matches at competition level can last between 40-60 minutes (Andersen et al., 2007; Phomsoupha & Laffaye, 2015). Studies have detected that badminton players provide 60-70% of their energies as aerobic, 30% of it as anaerobic during the game (Andersen et al., 2007), and lactate level during matches are average 5mmol or lower (Manrique & González-Badillo, 2003; Chen et al., 2011).

There are various studies on elite, sub-elite, child, young or adult badminton players. VO^2max levels and aerobic performances, lactate levels and interceding energy systems (Manrique & González-Badillo, 2003; Faude et al., 2007), badminton specific field tests (Chin et al., 1995; Wonisch et al., 2003; Ooi et al., 2009), biomechanical analyses (Mei et al., 2017), anthropometric and physical fitness levels (Phomsoupha & Laffaye, 2015) have been studied at badminton players in these studies.

Tennis turned into an intermittent sport necessitating speed, agility, explosive power and medium-high aerobic capacity from a technical/tactical game basing on style and fineness (Kovacs, 2007; Fernandez-Fernandez et al., 2009). Tennis is a branch of sports in which there are rallies that points are scored in less than 10 seconds while sometimes there are matches lasting up to 5 hours. Technique, tactic, physical and physiological properties identify the success at high level tennis (Kovacs, 2007). As in the other sport branches, strength is significant for both reducing injuries and for performing fast hittings to the ball. While handgrip strength is necessary to be able to perform optimum hittings to the ball (Kovacs, 2006), strength of knee extensor muscles provide a huge impulse which is transferred from kinetical chain during serving and ground hittings, too (Ellenbecker & Roetert, 2000). Energy obtained anaerobically at tennis is about 32%; however, this system intercedes as 95% during hitting to the ball. While blood lactate levels are between 1.8-2.8 mmol·L (Lees, 2003; Botton, 2011), they increase up to 8 mmol during high intensity matches (Fernandez-Fernandez et al., 2009).

There exist lots of studies on tennis which is one of the most popular sports in the world. The studies are generally about child, adolescent, adult, sub-elite and elite level tennis players' body compositions and physiological profiles, injuries (Vodak et al., 1980;

Ellenbecker & Roetert, 2000; Sanchez-Munoz et al., 2007; Martinez-Rodriguez et al., 2014), and biomechanics of tennis (Elliott, 2006).

While there are comparisons between tennis players and other racket sports or comparisons of badminton and tennis players' anthropometric profile (Raschka & Schmidt, 2013), heart rates (Docherty, 1982) in the literature, no comparison has been encountered on anaerobic performances of tennis and badminton players. As known, these two racket sports require strength, agility, muscular endurance, cardiorespiratory endurance and eye-hand coordination. Yet, the size of the platform on which both racket sports are played, weight of the racket used, weight and speed of the ball, rally periods and total duration of the game differ (Reilly et al., 1990). Correspondingly, even if they show similar aerobic performance properties, it's thought that differences may exist on their anaerobic performances.

Purpose of this study is to identify the anaerobic properties of sub-elite level racket athletes playing at badminton or tennis teams of university and to compare whether there are differences between two racket sports in terms of anaerobic performance or not.

2. Material and Method

2.1. Participants

13 badminton players (7 male, 6 female) and 10 tennis players (5 male, 5 female) at sub-elite level who are at university badminton and tennis teams and have been training 2 days a week for averagely 3 years took part in this study voluntarily. 30 racket athletes were included in the study but measurements of 7 participants hitched because of various reasons and performance values of 23 participants in total were considered. All the subjects were informed about the study protocol, the risks of tests, and their rights according to the Declaration of Helsinki.

2.2. Measurements

The measurements lasted for 3 days. Participants taken to measurements in random turns were put through body composition and isokinetic leg strength measurement on the 1st day, vertical jump, Illinois Agility Test and isometric handgrip strength measurement on the 2nd day and Wingate Bicycle test on the 3rd day. All the measurements were carried out between 10-12 a.m.

2.2.1. Body Composition Measurement

After height measurement was performed (SECA, Germany), bioelectric impedance method (Tanita-BC 418 MA) was used for identification of body composition and weight, body mass index (BMI kg/m^2), body fat percentage (BF %) and fat-free mass (FFM) were noted down.

2.2.2. Vertical Jump Test

The vertical jump height was measured using a jump timing mat (Just Jump System, Probotics, Inc., Huntsville, AL) that calculated jump from the time in air of the participants. After "single jump" mode was set, the participant stepped up onto the jumping mat and twisted the knees 90 degrees. She/he jumped once in force with the command and fell on the mat again. The measurement was performed three times and highest value was noted down in cm.

2.2.3. Illinois Agility Test

Cones were placed in the center of the field which is 10 m in length and 5 m in wide. Firstly, the participants were ensured to do trial in accordance with the test procedure and then real test score was recorded with chronometer (Heang et al., 2012).

2.2.4. Wingate Anaerobic Power Test

The test was conducted on computer connected bicycle ergometer (Monark Ergomedics 894 E, Pike Byke, Finland). The participants were given detailed information about the test pre-test and they were ensured to warm-up 5 min in 60-70 W workload. The load corresponding with the 7.5% of the participants' weights was detected and placed into scale of the bicycle. The participants were allowed to pedal with empty load for 5 sec to let them accelerate. After the detected load was given to the pedal, they were requested to pedal in maximal speed for 30 sec after the test started and to keep this speed till the test ends. The participants were motivated verbally during the test. This test was applied once and PP, RPP, and AP parameters were considered.

2.2.5. Isokinetic Leg Strength Measurement

The participants warmed-up on treadmill for 10 min in 6 km/h speed and performed stretching exercise for their leg muscles before strength measurement was performed with Biodex system 3 dynamometer. After the device's kit was set the way that dominant leg's knee joint angle as 90 degrees and the device was calibrated, test was performed in 60 degrees/second (°/s) with 5 sets by applying Con-Con test protocol. Extensor and flexor muscles' peak torque values (Nm) and agonist/antagonist ratio were evaluated at the end of the test performed.

2.2.6. Handgrip Strength Measurement

Digital hand dynamometer (Grip-D, Takei, Japan) was used for the determination of the isometric handgrip strengths of the participants. The dynamometer in hand was gripped by applying maximal force on standing upright position without twisting the elbow and without touching the hand to the body. The measurement was performed 3 times and best value was noted down.

2.3. Analysis of Data

Arithmetic mean and standard deviation (SD) of the data obtained in the study was calculated by using SPSS 22.0. A non-parametric test Mann-Whitney U test was used in comparison of two groups and confidence interval was considered as 0.05.

3. Results

Physical and anthropometric measurements of tennis and badminton players participated in the study are shown in the Table 1. BF values of the badminton players were detected as 17.56%, 13.93% for tennis players; and FFM values as 53.37 kg and 54.36, respectively.

Table 1: Physical and Anthropometric Parameters of Badminton Players and Tennis Players

Parameters	Badminton (13)	Tennis (10)
	Mean ± SD	*Mean ± SD*
Age (yr)	20.30 ± 1.65	19.50±0.84
Height (cm)	171.42±7.62	171.58±6.31
Weight (kg)	64.68±10.42	62.21±9.85
BMI (kg/m²)	21.92±2.64	20.96±2.44
BF (%)	17.56±6.19	13.93±5.6
FFM (kg)	53.37±9.80	54.36±9.70

Isokinetic leg strength measurement and Wingate anaerobic power test results are seen in Table 2. Leg extensor and flexor muscle strength measured with isokinetic dynamometer are 186.83 Nm, 107.93 Nm in badminton players and 168.61 Nm, 112.43 Nm in tennis players respectively. But these differences were not statistically significant between two groups. The differences of H:Q ratios are statistically significant between two groups (p=0.22). When Wingate anaerobic power test results were analyzed, PP values on sub-elite badminton and tennis players were measured as 646.96 W, 694.23 W; RPP values as 10.11 W kg^{-1}, 10.35 W kg^{-1}; AP values as 7.21 W kg^{-1}, 7.39 W kg^{-1}. The difference between these parameters belonging to two groups was not found statistically significant.

Table 2: Isokinetic Leg Strength (60 °/s) and
Wingate Anaerobic Test Values of Badminton and Tennis Players

Parameters	Badminton (13)	Tennis (10)	
	Mean ± SD	*Mean ± SD*	p
Isokinetic Extensor Strength (Nm)	*186.83* ±47.84	168.61±*52.21*	.420
Isokinetic Flexor Strength (Nm)	107.93±27.46	112.43±*35.83*	.877
Relative Extensor Strength (Nm.kg⁻¹)	2.87±0.45	2.67±0.65	.404
Relative Flexor Strength (Nm.kg⁻¹)	1.67±0.33	1.78 ±0.46	.518
H:Q Ratio	0.58±*0.09*	*0.66 ± 0.06*	***.022****
Wingate PP (W)	*646.96 ± 203.17*	694.23±246.23	.692
Wingate RPP (W kg⁻¹)	*10.11 ± 2.58*	*10.35 ± 2.51*	.843
Wingate AP (W kg⁻¹)	*7.21 ± 1.60*	*7.39 ± 1.48*	.692

***P<0.05**

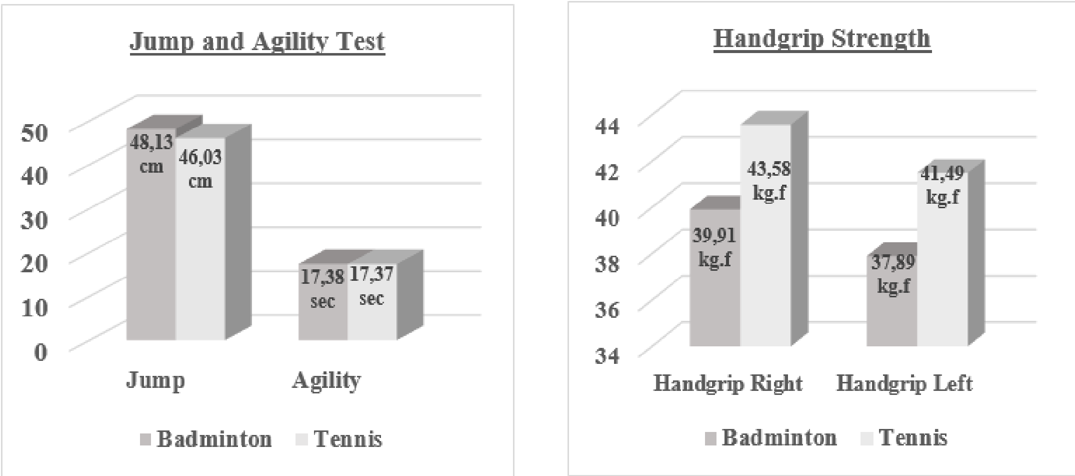

Figure 1: Vertical Jump, Agility, and Handgrip Strength Measurement Results of the Badminton and Tennis Players

Vertical Jump, agility, and handgrip strength test results are seen in Figure1. Jump test was detected as 48.13 cm and 46.03 cm in badminton and tennis players respectively and agility test as 17.38 sec and 17.37 sec. While badminton players are 2 cm better in jump height, two groups have almost similar results in agility test. The differences between these parameters belonging to two groups were not found statistically significant. Right and left handgrip strengths were measured as 39.91 kg.f and 37.89 kg.f in badminton players respectively; as 43.58 kg.f, and 41.49 kg.f in tennis players. The differences in handgrip strengths between two groups were not statistically significant.

4. Discussion

A combination of aerobic and anaerobic condition, speed, power, agility, flexibility, strength, perception of motion, technical skill, awareness and control is necessary for racket sports such as tennis and badminton (Lees, 2003). In this study carried out on sub-elite level badminton and tennis sports with a purpose to compare the anaerobic performance values by detecting, the anthropometric measurements and body composition values of the participants are shown in Table 1. Having similar height, weight and BMIs, badminton and tennis players' BF% is seen to have differences. BF% values of badminton players were examined in many studies and BF was found average 12.85% in elite male badminton players, 10.15% in sub-elite male badminton players and 14.11% in sub-elite female badminton players (Phomsoupha & Laffaye, 2015). BF% was found 17.56% in badminton players and 13.93% in tennis players in this study. BF of female tennis players is reported as 10-15% in literature and as 8-18% for male tennis players (Roetert & Ellenbecker, 2007). In a study conducted to compare the somatotypes of elite badminton and tennis players, they found BF as 10.8% in male badminton players and as 11.1% in male tennis players. Arm and leg ratios of badminton players were reported shorter and their bodies taller than tennis players (Raschka & Schmidt, 2013). A statistical comparison was not carried out on body composition parameters in this study.

In lots of sports such as racket sports, handball, baseball, weightlifting, in which there is gripping of the object and use of strength, adequate gripping strength is necessary for preventing injuries and catching optimal performance (Roetert & Ellenbecker, 2007; Cronin et al., 2017). In most of court sports, high torque and rotational speed during arm motion at shoulder, arm and wrist are desired features (Cronin et al., 2017). The strength generated during serving and volley in tennis is more than other racket sports (Reilly et al., 1990). Unlike other sport branches, non-dominant hand is also used during most volleys in tennis. Vodak et al. (1980) detected dominant and non-dominant handgrip strengths to be higher in middle aged tennis players than active persons in the same age (Vodak et al., 1980). Both dominant and non-dominant handgrip strengths of the tennis players were found approximately 4 kg.f more than badminton players in this study, however this difference was not statistically significant. This may be due to the fact that, the racket used in the tennis is heavier and more strength is applied to be able to throw the ball to a farther point because of the larger court.

Strength generation in tennis occurs by transferring ground reaction forces upward from legs and to the tennis racket in the end (Kovacs, 2006). Hitting the badminton ball does not necessitate acute muscle strength like hitting the tennis ball. Though, world ranking badminton players' leg strengths were seen to be high (Reilly et al., 1990). In this study, extensor muscle strength is seen to exist more in badminton players. Similar results are reported in youngsters in literature too (Cren Chiminazzo et al., 2012). Flexor muscle strength was found lower in badminton players than tennis players. Correspondingly, H:Q ratio was also calculated lower. In this study, relative extensor strength was found as 2.87 $Nm.Kg^{-1}$ and relative flexor strength as 1.67 $Nm.Kg^{-1}$. And in literature, they were found as 3.42 $Nm.Kg^{-1}$ and 1.89 $Nm.Kg^{-1}$ (Chin, et al., 1995) and 3.69 $Nm.Kg^{-1}$ and 1.86 $Nm.Kg^{-1}$ (Andersen et al., 2007) respectively in elite badminton players.

When two groups were compared, this difference between both flexor and extensor muscle strengths was not seen significant, however the difference between H:Q ratio was statistically significant (p=0.22). H:Q ratio's being under 60% poses a risk for hamstring muscles. Ellenbecker et al (2007) detected H:Q ratio between 59-67% in the isokinetic leg strength measurement in tennis players between the ages 16-21. This ratio was stated as 63% in undergraduate female tennis players in another study (Kraemer et al., 1995). Cren Chiminazzo et al. (2012) detected H:Q ratio as 56.6% in young male badminton players and as 51% in females between the ages 25-20.

When the athletes' Wingate anaerobic power test results in this study were analyzed, tennis players are seen to have higher anaerobic power. RPP for per kg was found as 10.35 W kg^{-1} in tennis players, as 10.11 W kg^{-1} in badminton players and AP value as 7.39 W kg^{-1} in tennis players, as 7.21 W kg^{-1} in badminton players. Wee et al. (2017) also found RPP as 10.61 W kg^{-1} and AP as 7.80 W kg^{-1} in undergraduate male badminton players. In another study, RPP was measured as 16.27 W kg^{-1} in young male tennis players, as 14.82 W kg^{-1} in females and AP as 11.17 W kg^{-1} in male tennis players, as 9.34 W kg^{-1} in females (Simpson, 2017). No study comparing Wingate anaerobic power performances of badminton and tennis players was encountered in the literature. Studies are generally carried out on a single branch or in the way comparing these racket sports with the other sports.

Score of the vertical jump test which is one of the anaerobic tests was found averagely 2 cm higher in badminton players than tennis players. Yet, this difference was not statistically significant. Knee extensor strength's, which is related with jumping, being higher in badminton players in this study suggests us that it also causes the jump performance to turn up higher. While the jump height of tennis players was measured as 46 cm in this study, it was measured as 41.1 cm in male tennis players (Fernandez-Fernandez et al., 2015) and as 41.5 cm in elite male badminton players in the literature (Ooi et al., 2009).

Agility is the ability to make fast and effective changes in the speed and direction of the motion. Agility is generally accepted as a significant feature for most of sports which require a fast and effective change of direction, planned or suddenly. Especially, it is also one of the factors designating success in tennis and badminton sports (Fernandez-Fernandez et al., 2009; Sekulic et al., 2017). In this study, the score in the agility test was similar in tennis players and badminton players. Similar results exist in literature, too. While agility score was found as 17.66 sec in undergraduate male badminton players (Wee et al., 2017), Illinois agility test result was found as 19.38 sec in young tennis players who have been training tennis for 8 years.

In conclusion, the other anaerobic performance parameters, except for extensor muscle strength and jump performance, showed up higher in tennis players. But, a statistically significant difference was only found in H:Q value in favor of tennis players. As in all branches of sports, detection of elite or sub-elite level athletes' anaerobic performances and finding out the similarities and differences between them by comparing will help in directing the trainings in racket sports, too. This study's being limited to players in university team caused the participants to be low in number. By keeping this number high, carrying out the measurements of players only in one gender and making comparisons by detecting their performances in other racket sports such as table tennis, crossminton, squash, in the following studies, will ensure clearer identification of anaerobic profiles of sub-elite level racket sports.

Conflicts of interest

The authors declare that there are no conflicts of interest.

About the Authors

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