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Relationship between physical characteristics and competitive performance of under-12 and 14-year-old elite boy and girl tennis players

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Abstract

Introduction. The role of physical abilities in modern tennis is gradually increasing, and gathering accurate information about the relationship between the physical abilities and competition performance of tennis players may help us objectively judge the role of physical abilities in competition performance, and create the possibility of forming optimal conditional training programmes. Aim of Study. The aim of the research was: 1) to examine the relationship between competition performance (player's place on the ranking list) and conditional abilities in the under-12 and -14-year-old elite boy and girl tennis players; and 2) to make suggestions – on the basis of gathered data – for the characteristics of physical training of players at this age. Material and Methods. Altogether 80 elite junior tennis players took part in the study. Eleven field tests were used to assess their physical ability: hexagon test; 5 m run; standing long jump; overhead medicine ball toss; overhead ball throw; speed of the serve; push-ups in 30 s; 5 × 10 m shuttle run; spider run; sit and reach; and shoulder turning with a stick. Results. A correlation with the position on the rankings could be found in the standing long jump (r = –0.54), 5 m run (r = 0.51), speed of serve (r = –0.52) and in push-ups in 30 seconds (r = –0.45) in the under-12-year-old girls; and in the standing long jump (r= –0.63), push-ups in 30 seconds (r = –0.58), and 5 × 10 m shuttle run (r = –0.56) in the under-14-year-old girls. However, there was no correlation between the physical characteristics and competition performance of the under-12 and-14-year-old-boy players. Conclusions. The results verified the statement that the competition performance of under-12 and -14-year-old tennis players cannot be characterized either with some physical variables, as tennis is a tactically and technically dominant ball game requiring open skills, and differentiation in conditional training according to gender already at this age is necessary.

KEYWORDS: tennis, conditional ability, competitive performance, field test.

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What is already known on this topic?
Researchers could not find any or only a very slight correlation between the physical abilities and competition performance of tennis players aged 8-12. As far as physical abilities of the older junior players are concerned, it showed a stronger correlation with the competition performance.

Introduction

Tennis performance is influenced by extremely complex factors. To examine the importance and weight of these factors, they have to be considered one by one. This paper focuses on the conditional abilities of under-12 and -14-year-old elite boy and girl tennis players, as the speed of play has been increased for this age thanks to the appearance of modern equipment (tennis rackets, tennis strings, shoes and balls) and surfaces (hard and carpet courts), which has also resulted in greater physical demands of junior tennis players.

Several researchers have studied the importance of motor abilities in the competition performance of junior

tennis players [1-7]. The summarized results showed that a zero or weak correlation was found between the physical abilities and competition performance in players aged 8-12. However, in older junior players, a correlation was found in the linear sprint, agility, explosive power of the trunk (upper body), explosive strength of the lower limbs, core strength of the trunk, hand-eye coordination, dynamic balance, aerobic endurance, flexibility, and maximal handgrip strength of the dominant arm with the players' competition performance. Furthermore, it is a widely accepted opinion that a high-level of conditional abilities in professional players provides a basis for successful and long-lasting competition performance [8-9].

Aim of Study

The role of physical abilities in modern tennis is gradually increasing, thus gathering of accurate information about the relationship between the physical abilities and competition performance of tennis players may help us to objectively assess the role of physical abilities in competition performance and create the possibility of forming an optimal conditional training programme. The completion of these types of studies is of utmost importance in under-12 and -14-year-old junior tennis players as they are still at the beginning of their careers and in intense growth and maturing phases, so physical training executed on the basis of appropriate information may help them avoid injuries and achieve long-lasting, successful competition performance.

Therefore, the aim of the research was: 1) to examine the relationship between competition performance (player's place on the ranking list) and conditional abilities in the under-12 and -14-year-old elite boy and girl tennis players; and 2) to make suggestions – using the gathered data – regarding the specialities of physically training players at this age.

Material and Methods

The sample was made up of those under-12 and -14-year-old elite tennis players who were ranked among the top 40 in their respective age groups. The classifications for the age groups were made according to the national tournament guidelines of the Hungarian Tennis Federation. Participants were chosen randomly with the stratified sampling method, and altogether 80 persons (20 boys and 20 girls from each sex and age group) took part in the survey. The sampling represented all the best Hungarian tennis players (aged 11–14) who had three to five years of tennis competition experience in international and national tennis tournaments. They played 40-70 matches per year. Their average ages were: 11.56 ± 0.38 (boys under 12); 11.61 ± 0.36 (girls under 12); 13.33 ± 0.61 (boys under 14); and 13.39 ± 0.55 (girls under 14).

Before the survey, the participants were informed both orally and in writing about the process of the test. The players could participate in these tests only with a valid medical certification and their parents' declaration of agreement. The ethical norms of the research were in harmony with the principles formulated in the Declaration of Helsinki [10].

Eleven different types of field-tests (Table 1) were applied to study the fitness levels of tennis players based on

Table 1. Selected motor ability tests

Code	Exercise Test	Variables
H	Hexagon [s]	Agility and coordination
R5	5-meter run [s]	Acceleration and quick first step
SLJ	Standing long jump [m]	Explosive power of the legs
OMBT	Overhead medicine 1 kg ball throw [m]	Neuromuscular power of the body and explosive power of the upper body
OLBT	Overhand 80 g little ball throw [m]	Explosive power of the dominant shoulder and arm, neuromuscular power of the body
SERV	Serve speed [km/h]	Neuromuscular power of the body
PU30	Push ups in 30 s (freq.)	Power endurance of the upper body
SH5 × 10	5 × 10-meter shuttle run [s]	Linear directional agility (change of direction speed)
SR	Spider run [s]	Multidirectional tennis-specific agility (change of direction speed)
STR	Sit and reach [cm]	Flexibility of the hamstring and trunk muscles
STS	Shoulder turning with stick [cm]	Shoulder flexibility

Table 2. Basic statistics of elite boy and girl tennis players in the under 12 and 14-year-old age group N 80

Variable	U 12 girl N 20		U 12 boy N 20		U 14 girl N 20		U 14 boy N 20	
	M	R	M	R	M	R	M	R
H	11.90	1.81	14.25	4.75	11.87	1.28	11.31	1.67
R5	1.33	0.11	1.27	0.08	1.27	0.1	1.26	0.1
SLJ	1.59	0.15	1.79	0.21	1.78	0.28	1.87	0.29
OMBT	7.66	1.62	7.8	1.15	9.77	2.22	10.74	3.62
OLBT	22.75	7.09	31.95	4.56	29.46	5.68	37.41	11.45
SERV	115.50	15.00	126.50	14.00	139.00	14.50	154.50	24.00
PU30	9.00	6.5	15.50	6.00	7.5	10.75	18.75	6.25
SH5 × 10	21.04	1.40	20.09	1.27	19.69	0.92	19.89	1.00
SR	22.50	1.87	21.10	1.44	20.54	1.64	20.65	1.34
STR	20.50	11.50	14.25	4.75	20.75	12.00	14.75	13.50
STS	67.50	20.00	67.50	20.00	70.00	15.00	8.00	22.50

H – hexagon; R5 – 5 meter run; SLJ – standing long jump; OMBT – overhead medicine ball throw; OLBT – overhead little ball throw; SERV – serve speed; PU30 – push ups in 30 s; SH5×10 meter shuttle run; SR – spider run; STR – sit and reach; STS – shoulder turning with stick; CV – criterion variable; M – median; R – range.

literary data and research [8-9, 11-14]. They were used as these field-tests are well-known, simple and most of them model the specific physical demands required by tennis very well compared to laboratory examinations (such as treadmill tests and isokinetic strength measurements).

Measurements were carried out indoors before the peak season (main competition period). The players had to execute the tests in a given order, in proper clothing (tennis shoes for a clay court, a pair of comfortable shorts, tennis shirt), on the same day, during late morning hours, and after a 15-minute standard warm-up. No intense physical activity was performed by the participants 24 hours prior to the test, and they had to consume high-energy foods two hours before. Four players were tested during a session, and their order was decided in advance.

The order of the tests was as follows: hexagon; 5 m-run; standing long jump; overhead medicine ball toss; ball throw; serve; push-ups in 30 s; 5 × 10 m shuttle run; spider run; sit and reach; and shoulder turning with stick. Before each test, a "trial" activity was carried out, excluding the serve, in which they could execute 20 "warm-up" serves. The players had three trials in the 5 m-run, standing long jump, overhead medicine ball toss and ball throw, eight for the serve, two in the hexagon, and only one in the sit-and-reach, shoulder turning with stick, 5 × 10 m shuttle run, spider run, and push-ups in 30 s. After the warm-up and between the tests there were four-minute rests, between the trials, one-minute rests, and between the serves, twenty-second rests. For the measurement of the speed of serve, the players used their own rackets.

Instruments used included the GUR-1 electric timer (with the accuracy of 0.01 s) for the 5 m and 5 × 10 m shuttle run, and for the hexagon and spider run, the Casio stop watch (with the accuracy of 0.01 s) was used. During the overhead medicine ball toss and overhead ball throw tests, a one-kilogram stuffed ball and a 103-gram small ball (8 cm in diameter) were used. For the measurement of serve speed, the "Stalker ATS II" serve speed measurer (with the accuracy of 1 km/h) was used; in addition, 53-56 gram and 6.5 diameter "Slazenger Ultra Vis" balls were used. The tests were carried out on an indoor clay court certified by the Hungarian Tennis Federation according to Hungarian and international rules and regulations, at a temperature of 15-25° C. Neither the measuring equipment, nor the persons carrying out the work were changed in the repeated examinations.

First, the distribution of the data was checked with the Shapiro-Wilk W test. One part of the data did not complete the requirements of normal distribution, thus, the basic statistical indices were given based on the median and quartile range (Table 2). After that, the relationships between physical abilities and competition performance were analysed (Table 3). In measuring the

Table 3. Spearman's rank correlation coefficients of physical performance with competitive performance (player's place on the ranking list) N: 80

Category	Variable										
	H	R5	SLJ	OMBT	OLBT	SERV	PU30	SH5×10	SR	STR	STS
U 12 boy	–0.001	–0.21	0.08	0.26	0.14	0.08	0.12	0.02	0.11	0.03	0.18
U 12 girl	–0.24	0.51†	–0.54†	–0.37	–0.43	–0.52†	–0.45†	–0.04	–0.04	–0.03	–0.23
U 14 girl	0.37	0.17	–0.63‡	–0.04	–0.34	–0.09	–0.58†	0.56‡	0.4	–0.04	0.19
U 14 boy	0.32	0.26	–0.20	–0.09	–0.22	0.09	–0.13	0.35	0.36	0.42	0.06

H – hexagon; R5 – 5 meter run; SLJ – standing long jump; OMBT – overhead medicine ball throw; OLBT – overhead little ball throw; SERV – serve speed; PU30 – push ups in 30 s; SH5×10 meter shuttle run; SR – spider run; STR – sit and reach; STS – shoulder turning with a stick ;†$p < 0.05$ ‡$p < 0.005$.

correlation, the Spearman-type rank-correlation method was used. The level of significance was determined at $p < 0.05$. The statistical analysis of the data was carried out with SPSS 12.0 software.

Test description

Hexagon [12-13]: The start is from the basic standing position with a signal from the centre of the hexagon. The player jumps out and in at every side of the hexagon on both legs, clockwise. The exercise ends after three completed "circles". During the execution, the player must not touch the lines of the hexagon, and the order of the jumps has to be kept. The aim is to finish the test within the shortest time possible. The measurements are performed to the hundredth of a second.

5-m run [12]: After a signal the start is from a basic standing position behind the line. The aim is to cover a precisely measured 5 m distance (in hundredths of a second).

Standing long jump [12, 13]: The player stands behind the take-off line. The toes must not touch the line. After gaining momentum with knee-flexion and an arm-swing at the same time, the player executes a forward jump on both feet. During the drive phase, the athlete's feet have to be in full contact with the ground. The aim is to reach the highest possible distance measured in meters.

Overhead medicine ball toss [12, 14]: The player stands behind the throwing line in a forward straddle with the ball held above the head with two hands. After gaining momentum, the medicine ball is tossed with a two-hand overhead throw. During the execution and after releasing it, the tennis player's feet must not touch the throwing line and must not cross it. The aim is to throw it as far as possible; the throw is measured in meters.

Overhead ball throw [13]: The tennis player stands in a forward straddle position behind the throwing line; the ball is held in the dominant arm, in front of the thigh. After gaining momentum, the ball is thrown with a one-hand overhand throw. During the execution of the throw and the release of the ball, the player's foot must not touch or cross the throwing line. The aim is throw the ball as far as possible, which is measured in meters.

Serve [9]: In this test the player executes eight flat serves onto a 150 × 60 cm target area located in the service court in the corner nearer to the T-line. Right-handed players serve from the right, and left-handed players from the left. The radar measuring the speed is located in the centre, four meters behind the baseline, at a height identical to the contact point of service. The player is instructed to execute the serve with maximal speed. Only correctly executed serves and the speed of those balls which landed in the target area are measured. The recording is in km/h.

Push-ups in 30 s [13]: The player executes arm flexion and extension from a shoulder-width push-up position, in such a way that a 12-cm high object located on the ground has to be touched by the chest. The aim is to do as many arm-flexions and extensions (push-ups) within 30 seconds as possible. Only correctly executed push-ups are recorded.

5-10 m shuttle run [11]: The athlete stands in a starting position behind the starting line. At a signal they run to the line 5 m away, cross it with both feet, turn and run back; this has to be repeated four more times. During the task the tennis player must not use the sliding technique. The aim is to execute the exercise within the shortest possible time, and is measured in hundredths of a second.

Spider run [14]: The player stands in a basic position in the middle behind the baseline. Starting at the signal, they have to collect five balls located in different parts of the court, one by one in a pre-determined order, and put

them onto a 30-45 cm quadrangle-shaped area drawn just behind the centre part of the baseline. The player can only run forward, but he can use the sliding technique. The aim is to execute the test within the shortest possible time, measured in hundredths of a second.

Sit and reach [11, 14]: The player is in an L-seat position with the soles firmly supported against the measuring box, and the fingers are positioned on the ruler located on the inner side of the upper surface of the box. Then, leaning forward, they try to push the ruler as far forward as they can. The knees must not be flexed during the execution. The results are recorded in centimetres.

Shoulder turn with a stick [13]: The athlete stands in a basic position and grips the one-meter-long stick (marked at each centimetre) in a front middle arm position, then moves it through a high to low back arm position without bending the arm and releasing the stick or without sliding it. The stick has to be raised back to the starting position along the same path. The aim is proper execution with the narrowest possible grip length. The result is recorded in centimetres.

Ranking: The actual position of the player in the given age group on the official junior ranking list of the Hungarian Tennis Federation.

Results

The correlation coefficients of physical performance with player's place on the ranking list are showed in Table 3. The standing long jump (r = –0.54), 5 m run (r = 0.51), speed of serve (r = –0.52) and push-ups in 30 s (r = –0.45) showed a correlation with the player's place on the ranking list in the under-12 elite girls. The standing long jump (r = –0.63), push-ups in 30 seconds (r = –0.58) and 5 × 10 m shuttle run (r = 0.56) showed a correlation with the rankings in the under-14 elite girls. But the physical performance of the under-12 and -14 boys did not show a correlation with their position on the ranking list.

Discussion

Physical maturity, anthropometric characteristics and physiological and psychical features of players influence their technical and tactical repertoire, playing style and movement dynamics during the play. Furthermore, the speed of maturation and growth show individual and sex variability [15-16]. In spite of this, more or less regularity can be observed in children's growth and development [15]. The study results indicate that girls reach the peak of their growth much earlier than boys [16]. Their biological maturation occurs earlier, thus their relative physical growth is more advanced, and beside this they reach the maximum of their physical growth much earlier as well [17]. This is why girls' physical abilities play a more emphasized role in their tennis performance.

The results obtained for the under-12 and -14 boys can be explained with a lack of relative physical development. In other words, the accurate hits owing to technical knowledge and disciplined tactical solutions are those which are crucial for competition performance of boys at this age. Physical abilities are less stressed.

The performance results of under-12 elite girl tennis players in the 5 m run showed a correlation with their positions on the ranking list, and thus with their competition performance (r = 0.51). The speed of the hits at this age lags far behind the speed of adult players; still, the first fast step and the ability to speed up in a short distance is an essential condition of the quick and successful solving of special game situations. The 5 m linear sprint reflects well the initiation of this first movement. Girard and Millet [3] found a correlation between the 5m run and competition performance in 13-14-year-old boy tennis players.

It is well-known that serving does not have such a dominant role in the play of junior girls as in boys, independent of age group. However, the speed of serves in under-12 junior elite girl tennis players showed a correlation with their competition performance (r = –0.52). The reason for this could be that the serve hit with greater speed allows a shorter preparation time for the receiving player. Faster serves increase the chances of the server and decrease the chances of the receiver of gaining points as the movements of the receiver have to be matched to the parameters of the ball's trajectory within a very short time; this is a huge challenge for players at this age. The preparation time is 1200 milliseconds in the case of a 117 km/hour average second serve, which decreases to 900 milliseconds with a 160 km/hour first serve. This time it further decreases by about 200 milliseconds in the case of play on a hard-cover court [18]. It must not be forgotten that the speed of serve is only one factor (besides reliability, accuracy, spin and speed) determining the quality of the hit.

The activity (contribution) and importance of the muscles in the lower limbs to the hit are often underestimated and not taken into consideration. The data show that the explosive strength of the lower limbs in under-12 and -14 junior elite girl players showed a correlation with their competition performance (r = –0.54; r = –0.63). The contact of the foot with the ground creates the so-called starting force, which provides the basis of each tennis hit [19-21]. Besides the feet are needed in moving around the court as well. Some authors found

a relationship between the explosive strength of the leg and sprints covering different lengths [22-23] and the explosive strength of running speed accompanying direction change [24-25]. This is why improvement of the explosive strength in the lower limbs is of key importance already at this age as the movement material of the sport is decisively characterised by the start and runs. Thus a tennis player, who is able to exert explosive strength, is able to move fast on the court and execute hits with an appropriate speed. The obtained results support the results of Girard and Millet [3], who found a correlation between the explosive strength of the lower limbs of the player and the position on the ranking list (competition performance) in 13-14-year-old elite boy tennis players.

The data showed that the explosive strength endurance of the shoulder joint and the arm showed a correlation with competition performance ($r = –0.45$; $r = –0.63$). In tennis, the explosive strength of the upper limbs is as important as those of the lower ones. The pectoralis, the collar bone, and the muscles executing the hit show a great activity in executing different technical elements: forehand and backhand groundstroke and serve [26-28]. Tennis involves a great, repeated and unbalanced load on the upper body of junior players already at this age. Matches may last for hours, during which players execute several hundred strokes. This is why explosive strength endurance has to be developed to maintain the level of players' hitting quality as well as to avoid injury. Stress must be put on the symmetrical strengthening of the dominant and non-dominant parts of the body. This is especially important in the studied age-group as these tennis players are still in the phase of intense bone and muscle development and at the beginning of their sporting careers. Roetert et al. [6] found a correlation between push-ups and competition performance in junior tennis players aged 13 to 15.

The linear agility (5 × 10 m shuttle run) test showed a correlation ($r = 0.56$) in the under-14 elite girl tennis players with their competition performance. The development of competitive tennis has resulted in the speeding up of play thanks to modern equipment, facilities and training methods, which can be observed in the play of junior tennis players, independent of their age and sex. Professional players cover an average of four meters between hits, and the maximal distance covered was between eight and twelve meters [29]. Thus, professional tennis players rarely reach the maximum of their running speed, which is why they rarely show the traditional acceleration technique. According to the author, this statement is true for the junior players as well, with the difference being that their movement intensity is essentially lower. This is why the ability that allows the players to speed up and stop within an extremely short distance is of vital importance. It is important to mention that mostly sideward movements dominate in tennis, but these forward runs create the basis for the sideward moves [30]. Meckel et al. [4] and Roetert et al. [5-6] also confirmed the role of agility in the competition performance of junior players.

Conclusions

Correlations were found between the performance of some physical tests (5 m runs, speed of serve, push-ups in 30 seconds, standing long jump and 5 × 10 m shuttle run) and the player's position on the ranking list (competition performance) in elite under-12 and -14 girl tennis players. In contrast, no correlation was found between position on the ranking list and performance in the physical test in the elite under-12 and -14 boy tennis players.

The correlation values show that competition performance in tennis in the under-12 and -14 age groups cannot be characterized either by only some physical variables, as tennis is a tactical and technically dominant ball game requiring open skills. However junior tennis players belonging to this age group have to compete against an increasing number of excellently trained opponents, considering whole-year competitions, already at the junior level in tennis. This is why a high level of conditional abilities creates the basis for successful competing without injuries. Furthermore, the relative physical maturation of girls at this age is much more advanced than that of boys, thus the physical abilities in their competition performance play a greater role. As a result, it is necessary to differentiate according to gender conditional trainings already at this age.

What this study adds?

Studies on correlations between physical ability and competitive performance have documented differences in elite under-12 and -14 girl and boys tennis players. It is suggested there is a differentiation in conditional training according to gender already at this age.

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