Performance components of junior tennis players

Abstract of PhD Thesis

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1. Introduction

There are extremely complex factors lying behind tennis performance. The fact-finding, exact identification, presenting of differences among tennis players and between genders are not only interesting and challenging task but are fundamentals of successful coaching (Dobos et al 2009, Dobos 2011b). In possession of the gained information the coach can get to know those determining performance components which play emphasized role in tennis performance, and in formation of quality and gender differences. Thus he/she can identify important viewpoints and areas to develop, and can judge beneficial (positive) and unfavourable (negative) qualities.

Starting point of my dissertation was given by these considerations as in my opinion only conscious development based on objective observation and measurements might lead to the desired result; to training an athlete to an extremely high level performance. In my doctoral thesis I am focusing on motor abilities, physical, anthropometric and psychical qualities of junior tennis players, and on technique and technological areas of racket applied by them during the game.

2. Aims

My primary aim was to get answers for the following questions:

What correlations competition performance of elite junior tennis players show with motor performance in different field tests, and with assertiveness in relation to genders**?**

What is the correlation structure of motor abilities? What characteristics and gender differences do motor abilities, anthropometric features, assertiveness, technical qualities of tennis and technological structure of rackets show?

My aim was to give methodological viewpoints and practical material to the coaches and PE teachers preparing or coaching elite junior tennis players.

2.1. Hypotheses

1. I suppose that competition performance of elite junior girl and boy tennis players shows significant correlation with motor performance of different field tests.

2. I suppose that motor competition performance of elite junior boy tennis players in the field test shows a significantly higher compared to girls, except for flexibility test, where girls have better performance.

3. I suppose that in elite junior girl and boy tennis players

   a) results of 5 m run test show significant correlation with performance of multidirectional speed tests;

   b) results of multidirectional speed tests show significant correlation with each other;

   c) reactive strength of lower extremities show correlation with performance in multidirectional speed and in 5 m run;

   d) maximal post-impact ball speed of the flat serve shows significant correlation with reactive strength of lower and upper extremities and active mobility of shoulder joints;

   e) results of standing long jump, overhand ball throw and overhead medicine ball throw tests show significant correlation with each other;

   f) reactive strength-endurance of upper extremities show significant correlation with maximal post-impact ball speed of the flat serve in both gender;

4. I suppose that maximum hand grip force of dominant arm in both gender does not, but the explosiveness of their hand grip force shows significant correlation with maximal post-impact ball speed of the flat serve;

5. a) I suppose that maximum hand grip force and explosiveness of dominant arm in both elite girl and boy tennis players are significantly higher than the non-dominant one.

b) I suppose that maximal hand grip force and explosiveness of dominant and non-dominant arms are significantly higher in boy, than in girl tennis players.

6. a) I suppose that anthropometric features of dominant arm in elite girl and boy junior tennis players show significantly higher values than that of the non-dominant one.

b) I do not expect significant differences of anthropometric features in relation to lower extremities

c) I suppose that difference patterns of anthropometric features in elite junior boy and girl tennis players differ from those of non-athlete girls and boys.

7. a) I suppose that number of girls taller than 180 cm and boys taller than 190 cm is negligible and that is valid for the assessed data as well.

b) I suppose that current and expected height data of elite junior boy tennis players is significantly greater than those of the girls, while in relation to somatotype my expectations are open.

c) I suppose that data assessing expected height of elite junior tennis players is significantly lagging behind actual height of professional tennis players.

8. a) I suppose that competition performance of elite junior girl and boy tennis players shows significant correlation with assertiveness.

b) I suppose that assertiveness of elite junior girl and boy tennis players do not show significant difference compared to each other

9. a) I suppose that an important part of elite junior girl and boy tennis players is right-handed and use half-western grip in forehand stroke.

b) In case of basic backhand stroke I expect dominance of the two-handed one, but I have no expectations in relation to the grip.

10. I suppose that technological parameters of racket used by elite junior girls significantly differ from those used by boys.

3. Methods

3.1. Tested people

Sample of my test relations between motor abilities and competition performance, gender differences in abilities and relation structure (correlations) of motor abilities was given by the U12, U14, U16 and U18 age-category Hungarian junior elite girl and boy tennis players (n=160). Sampling was carried out with stratified random process in both genders. Two groups were formed: 80 girls (aged 14.66) and 80 boys (aged 14.30).

44 players (age category of 16 and 18) formed the group to test maximum hand grip force of dominant and non-dominant arms, the features, gender differences, explosiveness of hand grip force, and correlations among maximum hand grip force, explosiveness of hand grip force and maximal post-impact ball speed of the flat serve. Sampling was carried out with the so called expert method, when the best players are selected into the given groups. I created 2 groups from them: one girl (22 persons, aged 16.83) and one boy (22 persons, aged 16.18).

The sample for testing anthropometric variables, assertiveness, dominant arm, type of backhand stroke, grips, and gender differences in technological features of the used rackets and the relationship between assertiveness and competition performance were given by the Hungarian elite junior tennis players of age-category 16-18 (n=80). I also used the stratified random sampling method in this case. To fulfil viewpoints of testing I formed two groups: a girl (n=40, aged 16.41) and a boy (n=40, aged 15.92). Furthermore I also involved non-athlete students aged between 16 and 18 (girls (n=20, aged 16.19) and boys (n=20, aged 16.26)) for the asymmetry research, and professional women (n=40, aged 27.87) and men (n=40, aged 28.82) tennis players into the expected body height test. Altogether 120 extra persons were involved.

3.2. Testing methods

11 standardized field tests were applied to show correlation between motor abilities and competition performance, gender differences in motor abilities, and relation structure (correlations) of motor abilities, considering literary data, researches and considerations (Eurofit 1993, Tsigilis et al 2002, Quinn and Reid 2003, Nádori et al 2005, Roetert and Ellenbecker 2007, Augustsson et al 2009, Ulbricht et al 2013, Fernandez-

Fernandez et al 2014, 2015, Váczi 2015b, Tékus 2015b, Dobos and Nagykáldi 2017b, Huggins et al 2017, Dobos 2018b). I also applied the competition performance elaborated and used (for longer period) by the Hungarian Tennis Association. It represented the average of points received for won matches.

2 laboratory tests and 1 field test were used to find correlations between maximum hand grip forces, explosiveness of hand grip force and maximal post-impact ball speed of the flat serve. To measure assertiveness the standardized questionnaire of Nagykáldi (2002) and Nagykáldi et al (2013) was applied, and to determine the grip types and technological features of rackets the protocol of Miller and Messner (2003), Crespo and Reid (2009), and Bollettieri (2010) was used, while the measurement of anthropometric features of tennis players and non-athlete students, to detect their calendric and biological age, the somatotypes of tennis players and their current and expected body height, were carried out with the standard protocol of Conrad 1963; Mészáros and Mohácsi 1987, Carter and Heath 1990; Mészáros 1990 a, b, c). All of them were carried out with the help of qualified measuring staff.

3.3. Means used in measurement

I applied the following equipment: OXA starter infra-gate of 0.01 s accuracy, a Casio hand watch, a ± 2 km/h accuracy Stalker ATS II speed-measuring radar instrument, new, 53-56 g weight and 6.5cm diameter „Slazenger ultravis" tennis balls, 1 kg stuffed ball, 80 g small ball (diameter 8 cm**),** cm accuracy measuring tape, 1.5 m long measuring tape of cm division, a 32 cm high and 45 cm wide measuring box, Dyna-8 FMS type force dynamometer and 1 g accuracy Radwag WLC 6/F1/ R type digital scale.

For measuring circumference values, mm accuracy Cescorf metal measuring tape, while a Holtain caliper was used for measuring width of elbow and knee and a Sieber-Hegner hip compress was used to measure shoulder width, chest width and depth. Body mass was measured by 0.1 accuracy Beurer digital scale. Body height was measured with the mm accuracy Sieber-Hegner anthropometer and to measure skinfolds, a Lange-type caliper was used.

3.4. Statistical analysis

First the distribution of data was measured with Shapiro-Wilk-W test. In case of normal distribution the given basic statistic variables were based on average and scatter, while in case of non-normal distribution the basic statistical indices of variables were given by the median and quartile range.

The current and expected body height, grips, dominant hand, frequency of backhand strokes were also given in percentage (percentile) and numbers of person were also published.

To derive correlations and differences of variables and differences between groups, parametric (one sample t-test, or paired sample t-test) and non-parametric, the (Mann-Whitney-type U test, the Spearman rank correlation, and the Wilcoxon tests) were applied, depending on the distribution. In both case level of significance was determined at $p < 0.05$. Statistical analysis was carried out with the SPSS 20.0 software.

4. Results

4.1. Correlation of motor abilities with competition performance

Significant correlation was found between motor performance and competition performance of elite junior girl tennis players ($p < 0.05$) in the 5 m run ($r = -0.43$), standing long jump ($r= 0.50$), overhead medicine ball throw tests ($r= 0.34$), overhand ball throw ($r= 0.49$), serve speed ($r= 0.46$), push-ups in 30 s ($r= 0.39$), 10x5 m shuttle run ($r=-0.41$), and in spider run ($r=-0.39$) tests. But no significant correlation was found in the following motor tests in girls: multi-lateral run, shoulder turn with stick, and in sit and reach ($p > 0.05$).

Motor performance of elite boy tennis players in the field tests did not show significant correlation with competition performance ($p>0.05$).

4.2. Gender differences in motor abilities

Girl tennis players showed significantly better performance only in joint mobility test ($p<0.05$). In other motor tests the boy group showed significantly better performance ($p <0.05$).

4.3. Correlation matrix of motor abilities

Performance in 5 m run test showed significant positive correlation with multidirectional (hexagon, 10x5m shuttle and spider) speed tests in both gender ($p<0.05$).

Results of tests measuring speed of multidirectional (hexagon, 10x5 m shuttle and spider runs), showed positive correlation with each other in both gender ($p<0.05$).

Reactive strength of lower extremities (in standing long jump) showed negative correlation in the multidirectional speed tests (hexagon, 10x5 m shuttle and spider) and with 5 m ($p<0.05$) run test.

Maximal post-impact ball speed of the flat serve in both gender showed positive correlation with overhead medicine ball throw and overhand ball throw and with reactive strength of lower extremities (standing long jump) and a negative one with the active mobility of shoulder joint (shoulder turn with stick ($p<0.05$).

Results of standing long jump, overhead medicine ball throw and overhand ball throws showed significant positive correlation with each other ($p<0.05$).

Reactive force-endurance of upper extremities (push-up tests in 30 s) showed significant positive correlation with maximal post-impact ball speed of the flat serve ($p<0.05$).

4.4. Correlation of maximum hand grip force of dominant arm and its explosiveness with maximal post-impact ball speed of the flat serve

Positive significant correlation was found between explosiveness of hand grip force of dominant arm and maximal post-impact ball speed of the flat serve in both genders (girls: $r= 0.49$ and boys $r= 0.54$, $p<0.05$)

In contrast there was no significant correlation found between maximal hand grip force of the dominant arm and maximal post-impact ball speed of the flat serve in either genders ($p> 0.05$).

4.5. Differences in maximum hand grip force of dominant and non-dominant arm and their force explosiveness, and gender differences

Significant differences were found between maximum hand grip force and its explosiveness in both genders for the advantage of dominant arm ($p<0.05$). Maximum

hand grip force and its explosiveness in boys were significantly greater than that of the girls in both arms ($p<0.05$).

4.6. Anthropometric feature results of elite junior boy and girl tennis players and non-athlete boy and girl students

I have found significant differences in anthropometric features of dominant and non-dominant arms of elite junior girl and boy tennis players for the advantage of dominant side ($p<0,05$). But no significant difference was found in lower extremities ($p>0.05$).

Significant difference was found in circumference of contracted upper arm, forearm, wrist and hand for the advantage of dominant side ($p<0.05$) in non-athlete girls. Circumference of lower leg on the right-side showed significantly greater values than the left ones ($p<0.05$). I could not find significant differences in circumference of upper arm, in elbow width and other circumference and width features ($p>0.05$).

In case of non-athlete boys I found significant difference in circumference of contracted upper arm and hand of dominant (more skilful) and non-dominant arm for the advantage of dominant one ($p<0.05$). As far as lower extremities are concerned, circumference of right thigh, knee width and circumference of lower leg were significantly greater than those of the left one ($p<0.05$). No significant differences were found in the other anthropometric variables ($p>0.05$).

4.7. Somatotype, current and expected body height of elite junior girl and boy tennis players and their gender differences

Averages of tested elite junior girl and boy tennis players' somatotype components (4.7-3.75-2.63) were in the meso-endomorph category, while that of the boys was in the ecto-mesomorph (2.7-3.99-3.67) ones.

Average current body height values of elite junior girl tennis players was 168.34 cm ($p<0.05$). As far as frequency is concerned, 2 persons (5%) were under 160 cm, 21 (52.5%) between 160 and 170 cm, 15 (37.5%) between 170 and 180 cm, 2 (5%) between 180 and 190 cm.

Current height averages of elite boy tennis players was 177.68 cm. 4 person (10%) was between 160-170 cm, 20 (50%) between 170-180 cm, 15 (37%) between 180-190 cm and 1 (2.5%) over 190 cm. Current body height of elite junior boy tennis players is significantly higher than that of the girls. ($p<0.05$).

It can be made probable, that body height of 2 person (5%) in elite junior girl tennis players will be under 160 cm, 20 (50%) between 160-170 cm, 16 (40%) between 170-180 cm, and 2 (5%) over 180 cm in the future. The assessed average body will be 169.99 cm.

It can be made probable, that expected body height of 16 person (40%) of elite junior boy tennis players will be between 170-180 cm, 22 (55%) between 180-190 cm, and 2 (5%) over 190 cm in the future. The assessed average body height will be 181.15 cm.

The expected body height of boys was significantly greater than that of the girl ones ($p<0.05$).

Significant differences were found between body height of professional women players and expected height of elite junior girl tennis players for the professional ones. ($p<0.05$).

Current body height of professional men tennis players was also significantly bigger than data of expected height elite boy tennis players ($p<0.05$).

4.8. Relationship of assertiveness with competition performance and gender differences

Significant positive correlation was found between competition performance and assertiveness in elite junior girl tennis players ($r= 0.48$, $p<0.05$). But no significant correlation was found in boys ($p>0.05$).

It is the same in elite junior girl and boy tennis players: No significant correlation was found in assertiveness ($p>0.05$) between them.

4.9. Results of dominant arm, backhand stroke-type, applied handgrip and technical parameter of racket tests in elite junior girl and boy tennis players

95% (38 persons) of the girls were right-handed and 5% (2) left-handed. In case of boys frequency of right-handedness was 92.5% (37), while 7.5% (3) were left-handed.

65% of girls (26) used semi-western and 35% (14) eastern-type racket hold in forehand stroke, while 72.5% of boys (29) applied semi-western forehand and 25% (10) the eastern one. 1 person (2.5%) applied the western-type forehand grip.

As far as backhand groundstrokes are concerned: 55 % (22) of girls used the traditional two-hand backhand stroke, and 40% (16) the modern two-hand racket one. Rate of traditional and modern two-hand racket grip in boys is 37.5% (15) and 40% (16). A further 2.5% (1) used extreme two-hand grip. A 2.5% (1) of the girls used the eastern, 2.5%, (1) used the half-western one-hand racket grip. In case of boys 17.5% (7) applied the one-hand eastern backhand, and 2.5% (1) the one-hand half-western racket grip.

As for as backhand is concerned, frequency of using two-hand stroke is 95% (38) in girls and 80% (32) in boys. 5% (2) of the girls and 20% (8) of the boys used one-hand backhand stroke.

Elite junior girl tennis players used significantly larger head size, more stiffness, shorter and lighter rackets of wider frame and less weight of swing, than boys. ($p<0.05$).

5. Conclusion

It is without doubt that spreading of modern equipment and court surfaces, tennis game is becoming faster in elite junior tennis players, as a consequence of which physical, technical and morphological demands have extremely increased. As a result of it, these players have to fight against growing number of excellently trained opponents. Besides, we can talk about all-year-round competitions already in this age-category. Stemming from it, in the background of performance of junior tennis players extremely complex factors can be found. To open up importance and weight of these factors, it is important to assess them each by each. This way we can increase effectiveness of work, carried out during trainings, can give fundamentals of long-lasting high-level competition performance and proper selection.

That is why I found it necessary to carry out researches among junior players the focal point of which was diversity. I studied the motor, anthropometric, assertiveness

(fighting ability), technical and technological aspects of the topic. Results of my opening up correlations between competition performance and field tests of motor abilities showed that except for hexagon and flexibility tests in elite girl tennis players it verified, while in case of boys it did not justify at all the earlier findings of international researchers (Filipčič and Filipčič 2005 a, b, Girard and Millet 2009, Filipčič et al 2010, Meckel et al 2015, Ulbricht et al 2016, Kremer et al 2017). **That is why, my first hypothesis (Hypothesis 1) was only partially verified.**

Correlation values well reflected the statement according to which successful performance cannot be characterized only by one or by a few decisive motor variables. Tennis is a tactically and technically dominated ball game, in which physical abilities give only one segment of performance complexity. Furthermore, those elite girl junior tennis players, motor abilities of whom is of higher value, can fight more successfully against challenges of higher overload. So to say, thanks to their physical abilities they can vindicate their tactical ideas more effectively on the court. In contrast to boys, in whom motor differences are smaller in the elite age category. That is why higher level motor abilities in boys do not mean a significantly higher chance of victory. Besides all these I think that boy tennis players can play more tactical and more combinative play than their girl mates. The latter ones may choose simpler solutions, in the success of which their motor abilities can play a better, more outstanding role. That is why, I would put a greater stress on developing motor abilities besides technical training during the preparation of girl tennis players.

Performances in field tests, except for hexagon and flexibility ones, showed acceptable correlation with competition performance in girls. So in my opinion, they can give suitable point of reference to process of measuring motor abilities of elite junior girl tennis players. Majority of these field tests – as opposed to laboratory ones -, well-model those special motor patterns, motor abilities and metabolic processes, which characterize the sport. Besides, they are relatively simple and cost effective. That is why I suggest the use of them.

The basic demand of right preparation is that coach should be aware of the gender features of physical conditioning. In the test measuring gender differences of motor abilities (hexagon, 5m run, standing long jump, overhead medicine ball throw tests, overhand ball throw, serve speed, push-ups in 30s, 10x5m shuttle run, spider run) they

were the boy tennis players who had better results. But in flexibility tests (shoulder turn with stick, sit and reach test), they were the girls who had better results. **Hypothesis 2 was verified.**

From the results the followings can be deducted: in the process of conditioning elite junior tennis players' differentiation of genders in conditional training is necessary. I would approach motor ability development in the pre-adolescence period in both gender from the technical side and would apply basic weight training exercises using own weight. Taking into consideration the biological age. I would put stress on individual development of elderly girls, and on combining trainings using weight and plyometric exercises. In case of boys I would apply the maximum and explosive strength training with lifting weight (jerk, snatch). And I would handle flexibility development as a priority, especially in boys.

Opening-up relation systems among motor abilities cannot be looked upon as a non-useful thing. Analysis of performance structure cannot be avoided, either, as level of trainedness is not determined only by level of each component, but by the relationship existing among them; the structure of its characteristics. (Nádori et al 2005). My research that ability of speeding up within a short distance and the first quick step (5m run) showed significant correlation with multidirectional speed (hexagon, 10x5m shuttle run, spider run) has verified in both gender.

Performances in multi-directional (hexagon, 10x5 m shuttle and spider run) speed tests showed significant correlation with each other. Tests measuring reactive strength of lower extremities (standing long jump) showed significant correlation with multidirectional speed (hexagon, 10x5 m shuttle and spider run) and speeding up within a short-distance, and the fast first step (5 m run). Maximal post-impact ball speed of the flat serve (serve speed) showed significant correlation with reactive strength of upper and lower extremities (standing long jump, overhead medicine ball and overhand ball throw). Maximal post-impact ball speed of the flat serve (serve speed) and active mobility of shoulder joint (shoulder turn with stick) also showed a significant correlation coincidence. Reactive force-endurance (push-ups in 30 s) showed significant correlation with maximal post-impact ball speed of the flat serve. Performances of tests measuring reactive strength (standing long jump, overhead medicine ball and overhand ball throw) showed significant correlation with each other. **Based on all these I can declare that my Hypotheses 3a,**

b, c, d, e, and f have been verified. As an extra, these results supported findings of previous earlier researches. (Weber et al 2007, Roetert and Kovacs 2011, Asadi 2012, Fernandez-Fernandez et al 2015, Dobos and Tóth 2021, Dobos et al 2022).

Based on my gained results, I think that learning direction forward running and their movement patterns should precede development of running speed with multidirectional. Explosiveness of the first step, speeding-up and slowing down exercises within a short distance form part of physical preparation, during execution of which stress should be put on correct technical execution. Development of running speed in multidirectional runs (runs with direction changes) should happen with increase of reactive strength in lower extremities. I urge acquisition and use of such unilateral (overhand ball throw) and bilateral (overhead medicine ball throw) and athletic type of throws and their use as a means of training, as they aid and promote learning and perfecting motions of serve, supplemented with exercises increasing vertical reactive strength in lower extremities. Adequate interest should be put on optimal development of active movement range in shoulder joint to increase reactive strength of upper torso. Stress should be put on endurance of reactive strength in upper torso and on symmetrical strengthening of dominant and non-dominant side of the body in preparation of elite junior tennis players, as well.

Significant correlation was found between explosiveness of hand grip force of dominant arm and maximal post-impact ball speed of the flat serve speed in both gender, in opposition to maximum handgrip of dominant arm. **So my Hypothesis 4 was verified**.

In my opinion, as explosive contraction of muscles in forearm of dominant arm plays role in stabilization of racket head at contact point, aiding optimal force impact, as racket head has to get into optimal position within fraction of seconds, related to body and height of the stroke. Thanks to high level technology, more up-to-date rackets, racket patterns have appeared, which make reaching faster racket head speed in the contact point possible. That is why manoeuvring possibility of players is of key importance. Moreover, statement that explosiveness of dominant hand grip force is an important biomechanical factor seems to be realistic based on the gained data. Based on guidance of Váczi (2015b) and Gąsior et al (2018) maximum hand grip force much rather characterizes general strength state of the player, and besides, it may give punctual data to open up certain risk factors of certain injuries. That is why I suggest that besides testing maximum hand grip

force measuring explosiveness of hand grip force should be done as well during assessment and preparation of junior tennis players, as explosive force – in tennis – seems to be of utmost importance. Development of explosive force in forearm-bending muscles should get into focus, too.

Maximum hand grip force and explosiveness of the hand grip force in dominant arm were significantly greater in both gender, than in the non-dominant one. During tennis strokes dominant arm is repeatedly loaded thanks to mechanical vibration of racket (Henning et al 1992; Elliott et al 2003), torsion forces (Etherington et al 1996) and muscle contraction (Reid et al 2003). This evokes a neuromuscular adaptation in the dominant arm of the tennis player (Roetert and Kovács 2011). Deriving from it, the gained data about maximum hand grip force and explosiveness of hand grip force well describe neuromuscular adaptation of dominant arm in junior tennis players participating my research. The fact that maximum hand grip force of boy tennis players is significantly greater than that of the girls, supports results of previous researches. In case of explosiveness of hand grip force they were again the boys who showed significantly better performance. **So Hypotheses 5 a and b are verified.**

It is the nature of sport that a huge, repeated, unbalanced load on upper body results in anatomical and neuromuscular differences between upper extremities, but rate of differences is not irrelevant, as extreme asymmetry can be a performance destroying factor with hidden injury-risk. A huge asymmetry between dominant and non-dominant upper extremities of elite junior tennis players could be observed. Data enforce results of previous researches **(**Sánchez-Muňoz et al 2007, Rogowski et al 2008, and Meckel et al 2015). But no asymmetry could be found in lower extremities. Opposite to it, percentage difference values of non-athlete girls and boys were much smaller, but in anthropometric variables (in girls: circumference of upper arm and elbow-width, and in boys: circumference of upper arm, elbow width, forearm and wrist circumference) they do not show significant differences at all. Besides all these, asymmetry could be observed in their lower extremities, too. **Hypotheses 6 a, b and c were verified.**

Huge asymmetry manifested in difference of force and anthropometric features of dominant and non-dominant upper extremities can be extremely dangerous for junior tennis players, as their passive and active movement systems are still under development. It is necessary to do balancing movements (e.g. conditional exercises, strength

development) against harmful asymmetry. Rate of asymmetry in upper body is further increasing with age, and years spent with competing, as well as with number of trainings (Sanchis-Moysi et al 2010). That is why I think that decreasing one-sidedness of upper body in elite junior tennis players is of cardinal importance, as this ensures optimal muscle balance, prevents the one-sided load of the whole body frame, especially that of the spinal column, prevents overload of joints, aids execution of coordinated movement, and at the same time decreases risk of injury. So, I suggest to thrive for symmetric workout; unilateral exercises with non-dominant side, as well. Strengthening of weaker (non-dominant side) and upper extremities is as important as the lower ones. Because of asymmetrical loading of lower and upper extremities, applying of core stability trainings is also indispensable.

Morphological, anthropometrical features (body height, somatotype) show increasing differences and characteristics in different sports. Deriving from it those physical features have appeared which are absolutely necessary to do the given sport at the highest level. That is why it is not all the same what current body height player has and what physique does it couple with. My research has justified that physical features (somatotype) of elite junior tennis players differ, while their current body height follow trends of international junior tennis players' data in both gender. As for the scatter of current and expected body height data is concerned, an important percentage of girls are in the 160-170 cm and 170-180 cm domains. In case of boys these values are in the 170-180 and 180-190 cm domains. Unfortunately, number of players in expected height category was very low in the above 180 and 190 cm domains. Current and assessed body height of boys were significantly bigger than the current and assessed body height of girls. Besides all these, data assessing their expected body height were significantly smaller than the current body height of professional tennis players. **Hypotheses 7 a, b, and c are verified.**

It is my opinion that higher mesomorph is expected beside the dominance of a relative fatness and relative slenderness in both gender. Current body height might basically influence preparation of the player in a sport, while unfavourable body shape (physique) is not modified by regular trainings. That is why I suggest monitoring of expected body height besides continuous measuring of current body height and morphological state. As achieved high-level sport performance is not only the effect of

training, but also of aware selection as well. Considering the above mentioned things it may improve international results of future generations.

The more initiative, more aggressive attitude, the fighting ability (assertiveness) of girls show correlation with competition performance. **That is why, Hypothesis 8 a could be only partly verified.** Girl and boy tennis players have similar level of assertiveness. **So, Hypothesis 8 b has been verified.** The followings can be deducted from it: both boys and girls can be well prepared for psychological demands of competitive tennis. Furthermore those girls were more successful, whose play was more initiative and aggressive. In case of boys – similar to motor abilities – their assertiveness had a smaller role in their play.

More accurate observation and preparation, more information gain and analysis about the dominant arm, different type of grips, technical elements and technological features of rackets used by players are indispensable to reach successful performance. My research justified in both genders the frequent, decisive use of half-western forehand grip and two-hand backhand stroke, in right-handed elite junior tennis players. **So, Hypotheses 9 a and b have been verified.** Up-to-date two hand backhand grips in both gender had the same frequency. Use of traditional two-hand grip in girls had a higher frequency.

Boys used larger head size, narrower and more flexible frame, significantly longer and heavier rackets of greater swing weight, than girls. **Hypothesis 10 was verified.**

Left-handed junior players have some minor advantage against right-handed ones, as they are smaller in number. This disadvantage can be well compensated with aware preparation of right-handed players. Players use such (eastern, half-western) racket grips which although suit demands of modern junior tennis, but stronger forehand spins could have been executed with the use of western type ones. Thanks to the shorter spatial and time features, ball handling, racket position, grip hold, learning and conditioning features, the use of two-hand backhand stroke is more frequent. Occurrence of tennis-elbow is smaller if they use the two-hand stroke that cannot be neglected because of development of active and passive movement system. Besides it, use of one-hand technique has reason for existence as well. Gender of player, his/her anthropometric features, motor abilities, style of play have to be considered in selection of racket, as racket has a basic influence

on characteristics (speed, spin, direction) of the ball, as well as on accuracy of stroke, and on active and passive movement system of the players.

As a summary, it can be said that all these facts and factors have influence on the trends in preparing players.

6. List of own publications

Original publications related to the topic of the dissertation:

Dobos K, Nemes G. (2004) Korszerű pedagógiai ellenőrző módszerek a teniszoktatásban. Iskolai testnevelés és sport, 23: 19-21.

Nemes G, **Dobos K,** Rigler E. (2006) Teniszmérkőzések megfigyelésének sajátos módszere. Magyar Edző, 9: 23-27.

Dobos K, Ungvári Á, Gyulai G. (2009) A Wilson próba megbízhatóságának vizsgálata. Kalokagathia, 47: 163-179.

Dobos K. (2009) Játékorientált oktatási stratégia a teniszben. Kalokagathia, 47-48: 99-126.

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