STUDIA UBB EDUCATIO ARTIS GYMN., LXIII, 3, 2018, pp. 29 - 40
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.63(3).21

PERFORMANCE-STRUCTURE ANALYSIS OF ELITE JUNIOR BOY TENNIS PLAYERS

DOBOS KÁROLY[1]

ABSTRACT. Introduction: Extremely complex factors lie behind sport performance in tennis. In order to evaluate the importance and weight of these factors, it is important to examine them each by each. **Objective:** The aim of the research was to examine the performance-structures lying behind the physical performance of elite junior boy tennis players and to analyse the relationship between the calendar year and physical variables. **Method:** Altogether 80 elite junior boy tennis players participated in the research. Their average age was 14.30±2.22 years. Eleven different field tests were applied. **Results:** Correlations were found between the calendar year age and all the physical variables, the 5-meter linear run and the agility, the explosive strength of the leg, the 5-meter sprint and the agility. The speed of serve showed correlation with the dominant-side upper limb, the upper body and the explosive strength of the leg. Furthermore, there was a correlation between the shoulder flexibility and the flexibility of the lower limb, the flexibility of the lower leg, the explosive strength of the leg and the agility, the flexibility of the shoulder and the speed of serve. **Conclusions:** A differentiation in the conditioning training of elite junior boy tennis players is recommended based on their age, from the age of 11, together with the joint developmental trainings of explosive strength and flexibility, agility and explosive strength of the leg, the improving of explosive strength in the lower and upper limbs, and the use of 5 meter linear run and the athletic throws as a means of training.

Key-words: *tennis, conditioning abilities, performance-structure, correlation*

[1] *Department of Combat Sports, University of Physical Education, Budapest, Hungary*
Corresponding Author: doboskaresztenisz@gmail.com

Introduction – Objective

Extremely complex factors lie behind sport performance. In order to evaluate the importance and weight of these factors, it is important to examine them. The author focused on conditional abilities in this research, as tennis movements are such a series of special motor performances, the level of which greatly influence short-term and long-range competition performance. Furthermore, due to the appearance of modern equipment and playing surfaces in tennis, the speed of play is becoming faster, thus the physical requirements of the game in the case of a professional player have increased considerably. In the author's opinion this statement is true for elite junior players as well, who are still at the beginning of their career owing to their age; their biological state of development lags behind those of adults, which presents itself in their technical and tactical repertoire and their movement dynamics. However, considering their competition system (competing all year round, playing on different playing surfaces) and the increasing number of excellently trained opponents, they show similarities to professional adult tennis players. Thus the level of physical ability is of decisive importance as well.

Several researches have studied the conditional abilities of elite junior boy tennis players with field tests (Baiget et al., 2013; Filipčič & Filipčič, 2005 a, b; Filipčič et al., 2010; Girard & Millet, 2009; Kramer et al., 20017; Meckel et al., 2015; Roetert et al., 1992, 1996; Unierzyski, 1994). A great part of the researches was focussed on putting the relationship between competition performance and conditional abilities into the forefront. They did not deal much with an analysis of the performance structures, which lie in the background of physical performance. But the opening up of a relation system between the physical variables cannot be looked at as a side-issue, as the level of trainedness is not only determined by the level of each component, but the relationship among the components, that is to say, the structure of characteristics (Nádori, 2005). A further interesting question is the analysis of calendar year age and the relationship among physical variables in the field tests, as junior tennis players have to compete in age categories based on their calendar year of birth.

This is why the aim of this research was to analyse the performance structure of elite junior boy tennis players which underlies their physical performance, based on the field tests. Furthermore, the relationship between calendar year age and physical variables was also analysed. Another aim was to provide suggestions regarding the physical preparation characteristics of junior elite boy tennis players, based on the expected results of the research.

Methods

Participants

The sample for the research included the best Hungarian boy tennis players of the 12-, 14-, 16- and 18-year-old age categories, who are among the top forty best players on the ranking list in their age categories. Sampling in the given age category was carried out with the stratified random sample; thus, 20 boys were measured in each age category. The total number of the tested players was 80 (N=80) and their average age was 14.30±2.22 years. The sample represented the total population of the best Hungarian junior boy tennis players. They had three to seven years of competition experience and played 40-70 decisive matches annually.

Before the survey the participants were informed both in oral and in written forms about the testing procedure. All players had a medical certification and declaration of agreement from their parents. The experimental design was approved by the Ethical Committee of Public Health Division of the Budapest Government Office (permission # 7878/2014), and was in harmony with the principles of the Helsinki declaration (Harriss & Atkinson, 2011).

Table 1. The selected motor ability tests

CODE	NAME OF THE VARIABLE	DIMENSIONS ASSESSED
H	Hexagon (.01 s)	Agility and coordination
R5	5-meter run (.01 s)	Acceleration and quick first step
SLJ	Standing long jump (m)	Explosive strength of the legs
OMBT	Overhead medicine ball throw -1kg (m)	Neuromuscular power of the body and explosive strength of the upper body
OLBT	Overhand little ball throw-80 g (m)	Explosive strength 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.)	Explosive strength endurance of the upper body
SH5x10	5x10-meter shuttle run (.01 s)	Linear directional agility (change of direction speed)
SR	Spider run (.01 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	Shoulder flexibility

Eleven different field tests were applied to assess the fitness level of the tennis players considering the data in the special literature, and the researches and suggestions (Eurofit, 1993; Fernandez-Fernandez, Ulbricht & Ferrauti, 2014; Quinn & Reid, 2003; Nádori et al., 2005; Roetert & Ellenbecker, 2007; Ulbricht, Fernandez-Fernandez & Ferrauti, 2013). The reasons why they were used is as follows: they are well-known and simple; and a great part of them (the majority of them) well models the tennis-specific physical demands and technical components compared to the general laboratory tests. Besides these, they fulfil the criteria of the primary and secondary tests.

Testing was done indoors, before the main competition season. The items of the test had to be executed in the late morning hours after the pre-determined fifteen-minute standard warm-up in proper clothing (tennis shoes for clay court, comfortable shorts, T-shirt). The tennis players had no intensive physical activity 24 hours prior to testing. Four players were tested at the same time, and their order was predetermined.

The order of testing was as follows: hexagon test; 5-meter run; standing long jump; overhead medicine ball throw; overhand small ball throw; serve; and push-ups in 30 seconds; 5x10-meter shuttle run; spider run; sit and reach; shoulder turning with stick. Before each test one attempt was given, except for the serve, in which case they had a chance to execute 20 warm-up services. Players were allowed three attempts before the 5-meter run, standing long jump, overhead medicine ball throw and overhand small ball throw; eight for serving; two attempts for the hexagon run; and only one for sit and reach, shoulder turning with stick, and 5x10-meter shuttle and spider run. For the push ups they had 30 seconds to reach their best result. In terms of rest, after the warm up and between the tests they had four minutes, between the attempts one minute, and in the measuring of the speed of serve, only a 20 second rest. Players used their own rackets during the testing of their serves. “Calibrated” measuring instruments were used during testing: a GUR-1 type measurer was used for the 5-meter sprint and 5x10-mter runs; a Casio hand stop watch, with an accuracy of 0.01 seconds, was used for the hexagon and spider run; a measuring tape with 1 mm of accuracy was used in measuring the explosive strength of the upper body and the dominant arm when throwing a stuffed (1 kilo) and a small (103 gram, diameter 8 cm) ball; the “Stalker ATS II” serve speed measurer of 1 km/h accuracy was used for measuring the speed of serve executed with 53-56 gram weight and 6.5 cm diameter “Slazinger ultravis”-type tennis balls; and a 1.5-meter-long stick with 1 cm grading and a 45 cm high and 30x45 cm large measuring box was used for the flexibility tests. Only one person did the measuring of the tests.

Statistical analyses

First, the scatter of the data was elaborated with the Shapiro-Wilk W test. One part of the data did not complete the requirements of the normal scatter, thus, the basic statistical indices were given based on the median and quartile range (Table 2). In measuring the correlation, the non-parametric Spearman rank-correlation method was used. The statistical analysis of the data was carried out with SPSS 13.0 software.

Table 2. Basic statistical table of elite boy junior tennis players (N: 80)

Variable	Median	Range
H	11.12	1.99
R5	1.20	0.12
SLJ	2.00	0.41
OMBT	11.95	5.71
OLBT	42.30	15.38
SERV	161.00	38.00
PU30	21.00	11.00
SH5x10	19.28	1.76
SR	19.39	2.85
STR	15.00	9.50
STS	82.50	30.00

***Legends**: H-hexagon; R5- 5 meter run; SLJ- standing long jump; OMBT- overhead medicine ball throw; OLBT- overhand little ball throw; SERV- serve speed; PU30- push ups in 30 s; SH5x10-5x10 meter shuttle run; SR-spider run; STR-sit and reach; STS- Shoulder turning with stick.*

Results

A correlation was found between the calendar year age and all the physical variables. The 5-meter linear sprint showed a correlation with the results of the agility tests. The explosive strength of the legs showed a correlation with the 5-meter linear sprint and agility. The speed of serve correlated with the explosive strength of the dominant side upper limb, the upper body and the leg. In addition, there proved to be a correlation between the results of the agility tests.

The results of the flexibility test showed correlations with each other. The flexibility of the lower limb correlated with the explosive strength of the leg and agility. There was a correlation between the flexibility of the shoulder joint and the speed of serve as well. The explosive strength endurance of the upper limb showed a correlation with the speed of serve (Table 3).

Discussion

The correlation between physical abilities and calendar year age support the findings in the special international literature (Fernandez-Fernandez, Ulbricht & Ferrauti, 2014; Quinn & Reid, 2003; Nádori et al., 2005; Roetert & Ellenbecker, 2007). Thus, the statement that older elite junior boy tennis players play faster and move more dynamically than their younger mates, owing to their increasing physical abilities, proves to be evident.

Biological age is a better forecaster of level of physical abilities than chronological age (Mészáros, 1990; Ochi & Campbell, 2009). In spite of this, the author think that the research aimed at studying the relationship between calendar year age and conditional abilities makes sense, as the players have to compete in the age groups determined by the International Tennis Federation (ITF). The categorisation of tennis players is based not on biological, but calendar year age. Stemming from this, the competition circumstances matching the certain age categories and the condition levels of the competitors during the preparation should be emphasised.

Table 3. Correlation matrix of elite junior boy tennis players (N: 80)

V	A	H	R5	SLJ	OMBT	OLBT	SERV	PU30	SH5X10	SR	STR	STS
A	1	-0.41*	-0.75*	0.79*	0.82*	0.76*	0.84*	0.69*	-0.63*	-0.78*	-0.29*	-0.36*
H		1	0.61*	-0.53*	-0.48	-0.45	-0.47	-0.45	0.65*	0.55*	-0.28*	-0.02
R5			1	-0.86*	-0.81	-0.76	-0.75	-0.67	0.73*	0.81*	-0.39*	-0.12
SLJ				1	0.87*	0.81*	0.83*	0.77	-0.73*	-0.79*	0.44*	0.21
OMBT					1	0.86*	0.87*	0.68*	-0.68	-0.77	0.44*	0.21
OLBT						1	0.79*	0.59*	-0.65	-0.75	0.40*	0.11
SERV							1	0.68*	-0.65	-0.75	0.40*	-0.30*
PU30								1	-0.58	-0.63	0.28	-0.30
SH5x10									1	0.79*	-0.25*	-0.19
SR										1	-0.36*	-0.23
STR											1	-0.25*
STS												1

Legends: *A-age; H-hexagon; R5- 5 meter run; SLJ- standing long jump; OMBT- overhead medicine ball throw; OLBT- overhand little ball throw; SERV- serve speed; PU30- push ups in 30 s; SH5x10-5x10 meter shuttle run; SR-spider run; STR-sit and reach; STS- Shoulder turning with stick; *p<0,05.*

The flexibility of the shoulder joint showed a “negative” tendency with age. The data obtained reinforces the results of previous researches (Kibler et al., 1996; Roetert, Ellenbecker & Brown, 2000). The flexibility of the lower limb also showed a negative correlation with age. The flexibility of the shoulder joints and the lower limbs of elite junior tennis players decreases with age as a result of the repeated and one-sided loading of the upper body (deriving from the nature of the sport) due to the explosive starts, sudden stops, fast leg supports and vertical jumps characteristic of the legwork of a tennis player. This is why the development of the effectiveness of the upper body – mainly the shoulder joint – and the lower leg should be given priority in the preparation process of junior tennis players.

The 5-meter linear sprint showed a positive correlation with agility. Professional tennis players generally cover four meters between the strokes, and the maximal distance between the shots is 8-12 meters (Weber, Pieper & Exler, 2007). Thus, tennis players cannot reach the maximum of their running speed, so they rarely show their traditional acceleration running technique. According to the author this statement is also true for junior tennis players as well, with a difference: the dynamics of their movement are much smaller. This is why the ability that makes the tennis player able to speed up within a very short distance is of utmost importance. This is well modelled by the 5-meter linear sprint test. Furthermore, forward movements provide the basis for multi-directional movements (Klika, 2010). Thus, the performance shown in the 5-meter linear sprint of elite junior tennis players provides a proper basis for tennis-specific agility.

Several researchers have found correlation between the explosive strength of the lower limb and different sprint lengths (Baker & Nance, 1999; Cronin & Hansen 2005; Girard & Millet, 2009; Wisloff et al., 2004) and the explosive strength of the leg and running speed with direction-change (agility) (Asadi, 2012; Miller et al., 2006; Thomas, French & Hayes, 2009). The development of explosive strength in the lower limb is of key importance, as the majority of the legwork in tennis is characterised by explosive starts (quick first steps) and runs. So the tennis player who is able to exert explosive strength against the ground is able to move fast on the court and speed up within a short distance. The results obtained reinforced the results of the aforementioned researches in junior boy tennis players participating in our research.

The speed of the serve in elite junior tennis players showed a positive correlation with the strength of their dominant side upper limb, upper body and their legs. The results well-represent the statement that the lengthening-shortening cycle of the strokes (the so called “plyometric movement form”) is the most frequent type of contraction in tennis, as the coordination pattern of the majority of strokes is made up of these contractions. So those tennis players who can most effectively make use of their power are able to hit the ball most strongly, and they have the strongest serves. Furthermore, the explosive force-exertion manifested in the overhand little ball and overhead medicine ball throw can be well-transferred to the movement structure of the serve; this is why the application of plyometric practice throws is indispensable in initiating the proper force impact (hitting power), with a special hint to those athletic-type of throws (ball throw, two-hand heaves and putts) which aid in the learning and perfecting of technical elements in tennis. Besides all these, the development of the explosive strength of the legs is also important, as the lower limbs play a decisive role in creating hitting power. The results reinforce the suggestions in the special international literature and their research results (Dobos, 2011; Fernandez-Fernandez, Ulbricht & Ferrauti, 2014; Quinn & Reid, 2003; Roetert & Ellenbecker, 2007; Reid, Chow & Crespo, 2003).

The results of the agility tests show positive correlations among them. Agility is a complex ability, in which the running speed with direction change and the factors in relation to perception play a role (Young, James & Montgomery, 2002). In addition, the technical components of agility (special foot skills, different movement patterns, leg supports, and the movement coordination necessary for their execution) also play a determining role in agility. Based on all these results, it can be concluded that agility requiring a linear run (5x10-meter sprint) provides a suitable technical basis for agility requiring multidirectional movements (hexagon test, spider run). Furthermore, agility is an important part of the quick first step (Klika, 2010), which appears in the agility tests used by our research team, so a close correlation among the agility tests is expected.

As mentioned earlier, the explosive strength of the lower limb muscle is determinant in creating the proper hitting power and in running speed with direction changes. The flexibility of tendons is of decisive importance in the effective execution of the lengthening-shortening contraction of the muscles. The researches of Wilson, Murphy and Pryor (1994) proved that training aimed at the development of flexibility adds to an increase in elastic energy and increases the efficiency of muscle work through its lengthening and shortening contraction. So the results of the correlation of the standing long jump, the speed of serve and agility tests with the flexibility of the lower limb is not surprising, as the coordination pattern of the majority of strokes and take-off and direction change are made up of these contractions.

Proper flexibility ensures the anatomic range of motion at the joint, the optimal length of the muscles at rest, optimizes the flexibility of the muscles, improves movement coordination, and increases the effectiveness of force exertion (Eliott, 2003; Roetert & Ellenbecker, 2007). Thus, the speed of serve and flexibility of the shoulder are not surprising.

The data showed that the flexibility of the lower limb correlated negatively with the flexibility of the shoulder joint. The result confirms the results of Anloague et al., (2012), who carried out research on college baseball players, finding the flexibility of the lower limb can provide useful information in judging the dysfunction of the shoulder joint.

The explosive strength endurance of the upper limb showed a positive correlation with the speed of serve. In tennis the explosive strength of the upper limb is as important as that of the lower one. In the speeding up phases of the technical elements (forehand and backhand groundstrokes and serve) it is the pectoralis major muscles, the muscles in the shoulder girdle and those of the stroking arm which show great activity (Reid, Chow & Crespo, 2003). Furthermore, stemming from the nature of the sport, a huge repeated and unbalanced load has an effect on the upper body (trunk) in the junior age category players, also. Matches can last for hours, during which the players can execute even several hundred strokes; this is why, if they want to maintain the level of their hitting quality and do not want to get injured, the endurance of the explosive strength in the upper body and the half-symmetric strengthening of the dominant and non-dominant part of the body has to play an important role in the preparation of junior tennis players.

Conclusions

A differentiation in the conditioning training of elite junior boy tennis players is recommended based on their age, from the age of 11, together with the joint developmental trainings of explosive strength and flexibility, agility and explosive strength of the leg, the improving of explosive strength in the lower and upper limbs, and the use of 5 meter linear run and the athletic throws as a means of training.

REFERENCES

Anloague, P., Spees, V., Smith, J., Herbenick, M., & Rubino, L. (2012). Glenohumeral range of motion and lower extremity flexibility in collegiate-level baseball players. *Sports Health*, *4*, 25-30. doi: 10.1177/1941738111422336

Asadi, A. (2012). Effects of six weeks depth jump and countermovement jump training on agility performance. *Sport Science, 5*, 67-70.

Baiget, E., Fernández-Fernández, J., Iglesias, X., Vallejo, L., Rodríguez, F.A. (2013). On-court endurance and performance testing in competitive male tennis players. *Journal of Strength & Conditioning Research*, 28, 256-264. doi:10.1519/JSC.0b013e3182955dad

Baker, D., & Nance, S. (1999). The relation between running speed and measures of strength and power in professional rugby league players. *Journal of Strength & Conditioning Research*, 13, 230-235.

Cronin, J.B., & Hansen, K.T. (2005). Strength and Power Predictors of Sports Speed. *Journal of Strength and Conditioning Research*, 19, 349-357. doi: 10.1519/14323.1

Dobos, K. (2011). Analysis of the speed of the serve of certified tennis players between the age of 12 and 14. *Kalokagathia,* 49, 79-87.

Elliott, B. (2003). The development of racquet speed. In B. Elliott, M. Reid, & M. Crespo, (Ed.). *Biomechanics of Advanced Tennis* (pp. 33-70). London: International Tennis Federation.

Eurofit (1993). *Eurofit Tests of Physical Fitness.*2nd edition. Strasbourg: Council of Europe, Strasbourg.

Fernández-Fernández, J., Ulbricht, A., & Ferrauti, A. (2014). Fitness testing of tennis players: How valuable is it? *British Journal of Sports Medicine,* 48, 22-31. doi:10.1136/bjsports-2013-093152

Filipčič, A., & Filipčič, T. (2005a). The relationship of tennis-specific motor abilities and the competition efficiency of young female tennis players. *Kinesiology*, 37, 164-170.

Filipčič, A., & Filipčič, T. (2005b). The influence of tennis motor abilities and anthropometric measures on the competition successfulness of 11 and 12 year-old female tennis players. *Acta Universitatis Palackianae Olomucensis Gymnica*, 35, 35-41.

Filipčič, A., Pisk, L., & Filipčič, T. (2010). Relationship between the result of selected motor tests and competitive successfulness in tennis for different age categories. *Kinesiology*, 42, 175-183.

Girard, O., & Millet, G.P. (2009). Physical determinants of tennis performance in competitive teenage players. *Journal of Strength and Conditioning Research*, 23, 1867-1872. doi:10.1519/JSC.0b013e3181b3df89

Harriss, D.J., & Atkinson, G. (2011). Ethical Standard in Sport and Exercise Science Research. *International Journal of Sports Medicine*, 32, 819-821. doi:10.1055/s-0033-1358756

Kibler, W.B., Chandler, T.J., Livingston, B.P., & Roetert, E.P. (1996). Shoulder range of motion in elite tennis players. Effect of age and years of tournament play. *American Journal of Sport Medicine*, 24, 279-285. doi: 10.1177/036354659602400306

Klika, B. (2010). Speed, agility and quickness training for performance enhancement. In M.A. Clark, & S.C. Lucett (Ed.). *NASM's Essential of Sport Performance Training* (pp. 227-257). Baltimore: Lippincott Williams & Williams.

Kramer, T., Huijgen, B., Elferink-Gemser, M.T., Visscher, C. (2017). Prediction of tennis performance in junior elite tennis players. *Journal of Sports Science and Medicine, 16,14-21.*

Meckel, Y., Hophy, A., Dunsky, A., & Eliakim, A. (2015). Relationships between physical characteristics and ranking of young tennis players in Central Europe. *Central European Journal of Sport Science and Medicine,* 10, 5-12.

Mészáros, J. (1990). A szervrendszerek szerkezetének és működésének fejlődési jellegzetességei. In J. Mészáros. (Ed.). *A gyermeksport biológiai alapjai* (pp. 121-164). Budapest: Testnevelési Egyetem.

Miller, M.G. Herniman, J.J., Ricard, M.D., Cheatham, C.C., & Michael, T.J. (2006): The effects of a 6-week plyometric training program on agility. *Journal of Sport Science and Medicine,* 5:3. 459-465.

Nádori, L., Derzsy, B., Fábián, Gy., Ozsváth, K., Rigler, E., & Zsidegh, M. (2005). *Sportképességek mérése*. 3nd edition. Budapest: Semmelweis Egyetem Testneveléstudományi Kar.

Ochi, S., & Campbell, M.J. (2009). The progressive physical development of a high-performance tennis player. *Strength and Conditioning Journal,* 31, 59-67. doi:10.1519/SSC.0b013e3181af8053

Quinn, A., & Reid, M. (2003). Screenin and Testing. In M. Reid, A. Quinn, & M. Crespo (Ed.). *Strength and Conditioning for Tennis* (pp. 17-47). London: International Tennis Federation.

Reid, M., Chow, J. W. & Crespo, M. (2003). Muscle activity an indicator for training. In B. Elliot, M. Reid, & M. Crespo (Ed.). *Biomechanics of advanced Tennis* (pp. 111-136). London: International Tennis Federation.

Roetert, E.P., Brown, S.W., Piorkowski, P.A., & Woods, R.B. (1996). Fitness comparisons among three different levels of elite tennis players. *Journal of Strength and Conditioning Research*, 10, 139-143.

Roetert, E.P., Garrett, G.E., Brown, S.W., & Camaione, D.N. (1992). Performance profiles of nationally ranked junior tennis players. *Journal of Applied Sport Science Research*, 6, 225-231.

Roetert, E.P., Ellenbecker, T.S., & Brown, S.W. (2000). Shoulder internal and external rotation range of motion in nationally ranked junior tennis players. *Journal of Orthopaedic and Sports Physical Therapy*, 24, 336-341.

Roetert, E.P., & Ellenbecker, T. (2007). *Complete Conditioning for Tennis*. 2nd edition. Champaign: IL: Human Kinetics..

Thomas, K., French, D., & Hayes, P.R. (2009). The effect of two plyometric training techniques on muscular power and agility in youth soccer players. *Journal of Strength and Conditioning Research,* 23, 332-335. doi:10.1519/JSC.0b013e318183a01a

Ulbricht, A., Fernandez-Fernandez, J., & Ferrauti, A. (2013). Conception for Fitness Testing and individualized training programs in the German Tennis Federation. *Sports Orthopaedics and Traumatology,* 29, 180-192.doi: 10.1016/j.orthtr.2013.07.005

Unierzyski, P. (1994). *Motor abilities and performance level among young tennis players*. Poznan: Academy of Physical Education.

Weber, K., Pieper, S., & Exler, T. (2007). Characteristics and Significance of Running Speed at the Australian Open 2006 for Training and Injury Prevention. *Medicine and Science in Tennis,* 12, 14-17.

Wilson, G.J., Murphy, A.J., & Pryor, J.F. (1994). Musculotendinous stiffness: its relationship to eccentric, isometric and concentric performance. *Journal of Applied Physiology*, 76, 2714-2719. doi:10.1152/jappl.1994.76.6.2714

Wisloff, U., Castagna, C., Helgerud, J., Jones, R., & Hoff, J. (2004). Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *British Journal of Sports Medicine*, 38, 285-288. doi:10.1136/bjsm.2002.002071

Young, W.B., James, R., & Montgomery, J.I. (2002). Is muscle power related to running speed with changes of direction? *Journal of Sport Medicine and Physical Fitness*, 42 (3), 282-8.