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The Association Between Morphology, Speed, Power and Agility in Young Tennis Players

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A B S T R A C T

The aim of this study was to investigate the correlation of anthropometric variables and motor abilities in change of direction speed and reactive agility performance in young tennis players. 50 tennis players (age 12.3 ± 1.2 years, height 156.7 ± 12.8 cm, body mass 45.9 ± 8.9 kg), who were ranked within the top 50 ranking places of the National Tennis Association, as well as within the top 300 on the international "Tennis Europe" rankings, participated in the study. The sample of anthropometric variables in this study comprised the measurement of participant height, body mass, body mass index and percentage of body fat. Also, participants performed tests assessing speed (5, 10, and 20 m sprints), agility (20 yards, 4x10 yards, T–test, TENCODS, and TENRAG), and explosive power (countermovement jump, single-leg countermovement jump, squat jump, standing long jump and single-leg triple jump). The results showed that there is a statistically significant correlation of agility with anthropometric characteristics, running speed tests and horizontal explosive power variables, whereas there was no significant correlation with vertical explosive power variables. In conclusion, the results of this research confirmed the hypothesis that there is a significant correlation in almost all anthropometric variables and motor abilities in change of direction speed and reactive agility performance in young tennis players. Thus, our findings provide useful information for coaches to create a wide range of tennis-specific exercises to develop performance, especially in a players neuromuscular fitness.

Key words: *specific agility, neuromuscular fitness, physiological load, specific endurance, conditioning performance*

Introduction

Explosive speed has many properties, some of these being general speed, change of direction speed (CODS), and explosive power. These three aspects represent a key set of motor abilities that are proven to be very important for success in tennis. These abilities can be considered to be very similar, due to several common characteristics: they use the same energy resources, they stimulate the nervous system, and they meet the same prerequisites for intensive training of a particular motor ability[1]. In addition, it is considered that athletes with more pronounced explosive speed properties find it easier to control their body in urgent training and competition situations, subsequently contributing to not only their game, but also to the prevention of injuries[2].

A review of the literature shows that there are several studies that observe the correlations and effects of explosive speed properties in change of direction and reactive agility in soccer and futsal players.[3–5]. In these studies, a significant correlation between the effects of motor abilities on agility was determined. A greater impact was found in change of direction speed than reactive agility. It is obvious that reactive agility is affected not only by motor abilities, but also by many other cognitive factors such as observation, perception, anticipation, or speed of decision-making. Such results were also confirmed in previous research that indicated a significant connection between speed, explosiveness and certain morphological characteristics in agility performance in ball sports[6,7]. In tennis, players change their direction of movement very regularly, so change of direction speed and reactive agility are considered very important motor dimensions[8,9]. Regardless of the importance of agility in tennis, there is very little scientific research that has dealt with this motor dimension, especially in specific conditions. The basic problem for the lack of such research is related to the lack of adequate tests, and the trend of constructing and val-

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idating new one is becoming increasingly pronounced. Until now, agility in tennis has mostly been measured with standardized basic tests, however in this research, agility was measured with a newly constructed test that shows extremely good metric characteristics and gives valid and reliable results[10]. This is therefore one of the first studies that aims to investigate the correlations between anthropometric characteristics, speed, and explosive power variables in change of direction speed and reactive agility in tennis. Moreover, this research will answer whether the results achieved in basic motor tests affect the result in change of direction speed and reactive agility, with this being one of the most important abilities in tennis. With such knowledge, it is possible to predict the possible improvement of the tennis player's agility more reliably in regards to the improvement of other characteristics.

Considering these results and the previous lack of research in this area in relation to tennis, the aim of this paper is to investigate the correlation of anthropometric variables and motor abilities in change of direction speed and reactive agility performance in young tennis players. It is expected that there is a significant correlation of explosive speed properties in change of direction speed and reactive agility performance in young tennis players in the phase of pre-puberty and early puberty.

Materials and Methods

Participants

The sample included 50 young male tennis players (12.3 ± 1.2 years, height 156.7 ± 12.8 cm and weight 45.9 ± 8.9 kg), who were ranked within the top 50 of the National Tennis Association ranking, as well as in the top 300 on the international "Tennis Europe" rankings. The G-Power program (version 3.1.9.2; Heinrich Heine University, Dusseldorf, Germany) was used to estimate the appropriate number of participants. The inclusion criteria consisted of being in good health, and physically active players who train at least three times per week and compete in regional, national, or international tournaments. The exclusion criteria consisted of participants with any injury that influences their ability to play tennis as well as their physical performance. The research was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb (protocol number 34; approval date December 13, 2021). All participants were familiar with the protocol and aim of the research prior to the study commencing, and both the participants and their parents gave prior written consent to participate. The complete testing protocol was explained to them in detail, with special emphasis on the fact that research requires a certain additional effort and presents a possible risk of injury, similar to any usual training session or competition.

Measurements

The sample of anthropometric variables in this study comprised of the measurement of participant height, body mass, body mass index (BMI) and percentage of body fat (%). Height (cm) and mass (kg) were assessed with a Seca stadiometer and a scale (Seca Instruments Ltd., Hamburg, Germany) using standard procedures, while body fat percentage (%) was measured using the MALTRON BF 900 analyser (Maltron International Ltd, Rayleigh, UK)[11]. Further, participants performed tests assessing speed (5, 10, and 20 m sprints), agility (20 yards, 4x10 yards, T–test, TENCODS, and TENRAG), and explosive power (countermovement jump (CMJ), single-leg countermovement jump (CMJ L,R), squat jump (SJ), standing long jump (L_JUMP) and single-leg triple jump (SLTJ_L,R). Speed was measured with Powertimer system photocells (Newtest Oy, Oulu, Finland), agility was measured with the SportReact system (SportReact, Zagreb, Croatia) and explosive power during jumps were measured with the Optojump system (Microgate, Bolzano, Italy). Each test was performed three times, and the mean value of three trials was taken for further processing.

Experimental protocol

The sport-specific change of direction speed (TENCODS) and reactive agility (TENRAG) variables were measured on clay tennis surface using tests that exhibit valid and reliable metric results[12]. The tests was conducted using the SportReact system (SportReact, Zagreb, Croatia) made up of laser tape sensors and LED screens with differing signs and colours[12]. The pre-planned ability to change direction (TENCODS) and reactive agility (TENRAG) tests were constructed in such a way that the participants imitate specific movements in tennis (Figure 1). In both tests, participants start from a predetermined starting line. When the infrared signal (IR1) located next to the starting line is interrupted by the "split step" the

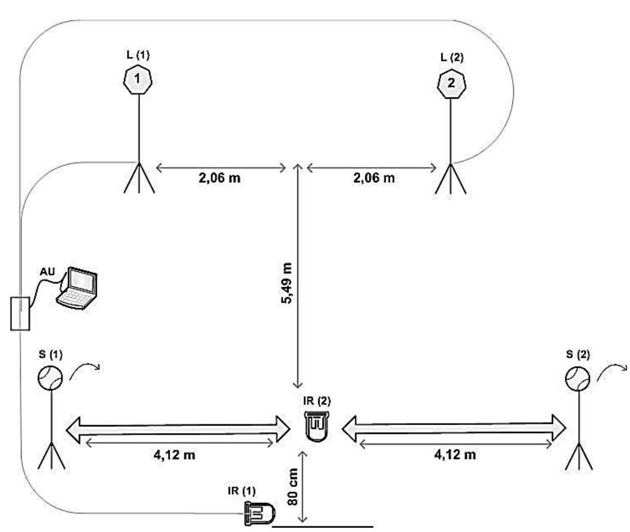

Fig. 1. TENCODS and TENRAG test.

participant performed, the clock began counting and one of the two lights (L1 or L2) lit up. The participants would recognize which light has turned on, run with overstepping and lateral technique to the side to the stand with a ball placed on it (S1 or S2) and hit the ball in a forehand or backhand motion with enough force for the ball to hit the ground. After playing the shot the player would return as quickly as possible to the device in front of the starting line and interrupt the infrared signal (IR2) again, which ended the timer. In the pre-planned change of direction speed test (TENCODS), the subjects would know in advance which light will turn on, meaning they can pre plan which direction to run in. Each test was performed nine times with a 60-second intermission between each measurement, and the mean measured value for both tests was taken for further processing[12].

Statistical Analysis

The obtained data was then processed in the program Statistica 14.0.1.25 (TIBCO software, Inc.) on the Windows operating system and in Microsoft Excel 2016 (Palo Alto, CA, USA). Basic descriptive parameters (mean—$\bar{x}$; standard deviation—SD) were used to describe each variable. The normality of the distribution was tested with the Shapiro-Wilk W test. Correlation statistical analysis was used to investigate the correlation of anthropometric variables and motor abilities with change of direction speed and reactive agility performance. The level of statistical significance was set at $p < 0.05$.

Results

Table 1 shows the basic descriptive statistical parameters of anthropometric and motor ability variables. Arithmetic mean ($\bar{x}$) and standard deviation (SD) were calculated for each variable mentioned. The Shapiro-Wilk W test showed a normal distribution, which enabled further statistical analysis. The agility tests showed that young tennis players achieve better results in preplanned motions of changing direction (3.20 ± 0.16 seconds) compared to reactive agility (3.36 ± 0.16 seconds).

Tables 2 and 3 show the results of a correlation analysis that established the correlation between anthropometric characteristics, running speed and explosive power with sport-specific pre-planned and reactive agility. Correlations between anthropometric and explosive speed variables with measures of preplanned and reactive agil-

TABLE 1

BASIC DESCRIPTIVE PARAMETERS ($\bar{x}$ and SD)

Variables	$\bar{x}$	SD
Body height (cm)	156.70	12.85
Body mass (kg)	45.87	8.87
Body mass index (BMI)	18.22	1.87
Body fat (%)	15.62	5.05
Sprint 5m (s)	1.26	0.06
Sprint 10m (s)	2.12	0.09
Sprint 20m (s)	3.74	0.18
CODS 4x10 yards (s)	10.55	0.56
CODS 20 yards (s)	5.60	0.30
CODS T-test (s)	12.14	0.67
Standing long jump (cm)	160.01	16.70
Triple jump_L (cm)	449.96	60.35
Triple jump_R (cm)	449.34	55.79
CMJ (cm)	22.58	3.29
SJ (cm)	22.20	3.66
CMJ_L (cm)	11.19	1.41
CMJ_R (cm)	11.31	1.31
TENCODS (s)	3.20	0.16
TENRAG (s)	3.36	0.16

CMJ (cm) – countermovement jump with arms set on hips; SJ (cm) – squat jump; CMJ_L (cm) – single leg (left) countermovement jump with arms set on hips; CMJ_R (cm) – single leg (right) countermovement jump with arms set on hips; TENCODS (s) – change of direction speed test; TENRAG (s) – reactive agility test; $\bar{x}$ – mean; SD – standard deviation

TABLE 2

CORRELATIONS BETWEEN AGILITY AND MORPHOLOGY

Variables	TENCODS (s)	TENRAG (s)
Body height (cm)	–0.30*	–0.40*
Body mass (kg)	–0.30*	–0.41*
Body mass index (BMI)	–0.22	–0.30*
Body fat (%)	–0.08	–0.18

*significant correlation

TABLE 3

CORRELATIONS BETWEEN AGILITY, CODS AND EXPLOSIVE SPEED PROPERTIES

Variables	TENCODS (s)	TENRAG (s)
Sprint 5m (s)	0.45*	0.51*
Sprint 10m (s)	0.40*	0.33*
Sprint 20m (s)	0.51*	0.39*
CODS 4x10 yards (s)	0.47*	0.54*
CODS 20 yards (s)	0.47*	0.47*
CODS T-test (s)	0.56*	0.61*
Standing long jump (cm)	–0.39*	–0.21
Triple jump_L (cm)	–0.49*	–0.48*
Triple jump_R (cm)	–0.37*	–0.40*
CMJ (cm)	–0.27	–0.14
SJ (cm)	–0.25	–0.10
CMJ_L (cm)	–0.14	–-0.03
CMJ_R (cm)	–0.19	–0.09

CMJ (cm) - countermovement jump with arms set on hips; SJ (cm) - squat jump; CMJ_L (cm) - single leg (left) countermovement jump with arms set on hips; CMJ_R (cm) - single leg (right) countermovement jump with arms set on hips; TENCODS (s) – change of direction speed test; TENRAG (s) – reactive agility test; *—significant correlation ity were significant in almost all cases. The correlation is set in such a way that Pearson's correlation coefficient (r) of 0 – 0.29 represents a low correlation, from 0.30 – 0.63 a medium correlation, while 0.64 – 1 represents a high correlation. A significant correlation with pre-planned agility is noticeable in almost all measured variables, and we can conclude that the correlation is more significant on pre-planned agility than on reactive agility.

Discussion

The analysis of the results indicate two very important findings. Firstly, young tennis players achieve better results in pre-planned agility (3.20 ± 0.16 seconds) compared to reactive agility (3.36 ± 0.16 seconds). Secondly, there is a statistically significant correlation of agility with anthropometric characteristics, running speed tests and horizontal explosive power variables, while there is no statistically significant correlation with vertical explosive power variables. The reasons for better results in the pre-planned agility tests comes down to the simple fact that in such tests there are no decision-making factors and the movement structure is known in advance, therefore the participants are less susceptible to the influence of errors during execution. On the other hand, the reactive agility test is considered more complex and difficult to perform due to the greater demand on reaction speed, and therefore it is logical that the result is likely to be worse. This unusual phenomenon has been reported in previous literature in relation to other sports, such as the weaker results in specific tests on reactive agility found in young soccer players[13]. Previous research has also shown the difference between pre-planned and reactive agility in professional basketball players in all playing positions[14]. In a sample of male and female handball players, it was determined that in both sexes, weaker results were recorded in the reactive agility test than in the preplanned agility tests[15].

The results of the correlation analysis show that the correlation of the analyzed anthropometric and explosive speed variables with measures of pre-planned and reactive agility is significant in almost all measured variables. It can therefore be said that there is an effect of some anthropometric characteristics and motor abilities on agility in general, with the fact that the effect is more significance on pre-planned agility. According to the results, it is obvious that reactive agility depends on a number of other factors. This is also indicated by previous research in which it is evident that the overall performance of reactive agility is more effected by cognitive factors, such as perception and decision-making as opposed to motor components[16–18]. In conclusion, the assumption was confirmed that young tennis players who achieve higher results in some anthropometric characteristics and motor ability tests are highly likely to achieve better results in the newly constructed tests of specific agility, especially CODS tests. Therefore, for future research it could be beneficial to determine the level of cognitive factors, perception, and decision-making in order to more precisely explain the effect and association between morphology, speed and power with reactive agility (RAG) in young tennis players.

The limitations of this study are discussed below. Firstly, the subjects involved in this study were young tennis players in a very sensitive and crucial phase of their developmental. Secondly, the study did not evaluate the biological age of the participants, which is known to have an influence on neuromuscular performance. Future research should be directed towards implementing tests with a larger number of participants in competitive conditions in order to obtain more data, and thus to enable explanations on the correlations of explosive speed properties in change of direction speed and reactive agility in younger tennis players during competitive performance. Also, another limitation to this research is that the motor tests were conducted with a convenient sample of subjects under controlled conditions, the results of which may have been different if the tests had been conducted on a different tennis surface. Therefore, although some causality can be intuitively identified (i.e., anthropometrics are predictors of change of direction speed), the true cause effect between conditioning abilities (i.e., sprinting speed and jumping capacities) should be more precisely studied through longitudinal investigations.

A more detailed analysis of the training volume (i.e., strength, endurance, and/or other qualities) would also help to clarify whether performance differences are also mediated by training. Another limitation was the lack of strength/power related measurements, of which would definitely help to determine whether the differences found herein are mediated by differences in the strength levels or in the ability to change direction rapidly. However, we believe that the present design may offer a starting point to suggest practical applications to tennis professionals. The gained insights from this research in practice could be for both tennis and fitness coaches to understand changes in the tested parameters during training processes. This can be used in planning and programming training loads in order to improve the aforementioned parameters.

Conclusion

The results of this research confirmed the hypothesis and showed that there is a significant correlation of anthropometric variables and motor abilities in change of direction speed and reactive agility performance in young tennis players. Thus, our findings provide useful information for coaches to create a wide range of tennis-specific situations to develop beneficial performance, especially for the player's neuromuscular fitness. A suggested aim for future research could be to conduct tests with subjects of differing genders and differing competition categories in order to obtain the best and most precise data that would enable an even greater practical and scientific understanding and application. Furthermore, a recommendation for additional research could be to determine the best training approaches and content (specific to each maturity stage) to meaningfully improve neuromuscular performance in young tennis players in the phase of both pre-puberty and early puberty.

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POVEZANOST MORFOLOGIJE, BRZINE, SNAGE I AGILNOSTI KOD MLADIH TENISAČA

SAŽETAK

Cilj ovog istraživanja bio je istražiti povezanost antropometrijskih varijabli i motoričkih sposobnosti kod brzine s promjenom smjera kretanja i reaktivne agilnosti kod mladih tenisača. U istraživanju je sudjelovalo 50 tenisača (prosječne dobi 12,3 ± 1,2 godina, visine 156,7 ± 12,8 cm i tjelesne mase 45,9 ± 8,9 kg) koji su rangirani do 50. mjesta na ljestvici nacionalnog teniskog saveza, te do 300. mjesta na međunarodnoj „Tennis Europe“ ljestvici. Uzorak antropometrijskih varijabli u ovom istraživanju sastojao se od mjerenja tjelesne visine, tjelesna mase, indeksa tjelesne mase i postotka potkožnog masnog tkiva ispitanika. Također, sudionici su izvodili testove za procjenu brzine (sprint na 5, 10 i 20 metara), agilnosti (20 jardi, 4x10 jardi, T–test, TENCODS i TENRAG) i eksplozivne snage (skok u vis iz mjesta, jednonožni skok u vis iz mjesta, skok iz čučnja, skok u dalj s mjesta i jednonožni troskok s mjesta). Rezultati su pokazali da postoji statistički značajna povezanost između agilnosti i antropometrijskih karakteristika, te testovima brzine trčanja i varijablama horizontalne eksplozivne snage, dok nije utvrđena značajna povezanost s varijablama vertikalne eksplozivne snage. Zaključno, rezultati ovog istraživanja potvrdili su hipotezu da postoji značajna povezanost kod gotovo svih antropometrijskih varijabli i motoričkih sposobnosti s rezultatima brzine s promjenom smjera kretanja i reaktivne agilnosti kod mladih tenisača. Stoga, navedene spoznaje predstavljaju korisne informacije za trenere kod pripreme širokog raspona vježbi specifičnih za tenis s ciljem poboljšanja izvedbe, posebno za neuromuskularne sposobnosti igrača.