The coordination determinants of technical skills of female tennis players aged 9 and 11

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Received: 01 December 2022; **Accepted:** 16 December 2022; **Published online:** 27 December 2022

AoBID: 16236

Abstract

Background & Study Aim: Observation of recent years of sports competition confirms a definite increase in the demands of fitness preparation of professional tennis players. The reason is the preference for a fast, offensive, and defensive style of play. The aim of this study was knowledge on coordination determinants of technical skills of female tennis players aged 9 and 11.

Material & Methods: The research included girls (n = 96), body height (9 years: 137 ±5.7 cm; 10 years: 143 ±4.3 cm, 11 years: 148 ±5.2 cm), body mass (9 years: 34 ±1.9 kg; 10 years: 38 ±2.1 kg; 11 years: 43 ±2.3 kg). Motor abilities, flexibility and technical skills were evaluated. In order to collect objective data, the research involved tests used both in physical education and in sport that are thoroughly described in the literature and were checked in terms of validity and reliability (it was established that for all the tests, intraclass correlation coefficient ranged from 0.87-0.99, which meant the tests were reliable).

Results: The findings of the research revealed statistically significant correlations of technical skills and performance with motor abilities, whose strength and number changed with age of the examined girls aged 9-11. The effectiveness of performing the test 100 balls depends on different predictors of motor abilities.

Conclusions: The results confirm the predictive value of the tests used, but also the need to include in future studies tools that diagnose other components of a tennis player's motor skills.

Keywords: fitness preparation • motor skills • tennis wall test • training session

Conflict of interest: Authors have declared that no competing interest exists

Ethical approval: The study was approved by the local Ethics Committee

Provenance & peer review: Not commissioned; externally peer reviewed

Source of support: Departmental sources

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Training session – *noun* a period of time during which an athlete trains, either alone, with a trainer or with their team [64].

Forehand – *noun* (*in racket games*) a basic stroke played with the palm of the racket hand facing forwards ■ *adjective*, *adverb* (*in racket games*) played with the palm of the racket hand facing forwards or relating to a stroke played in this way ■ *verb* in racket Games, to hit the ball with a forehand stroke [64].

Backspin – *noun* the movement of a ball that spins backwards as it travels forwards, usually imparted by hitting the lower half of the ball [64].

Motor skills – *plural noun* the ability of a person to make movements to achieve a goal, with stages including processing the information in the brain, transmitting neural signals and coordinating the relevant muscles to achieve the desired effect [64].

INTRODUCTION

Observation of recent years of sports competition confirms a definite increase in the demands of fitness preparation of professional tennis players. The reason is the preference for a fast, offensive, and defensive style of play. The variety and number of technical elements performed during a match with high intensity is very high: ball exchange from deep in the court, return, volley, smash, shortcut cause the necessity of reaching the ball with maximum speed and performing the given action with high accuracy and efficiency in a very short time [1-3]. So, there is no doubt that the fundamental value for a tennis player is fitness preparation. In the research on optimizing the training process, many authors attempt to identify the factors that determine sports performance in tennis, pointing to their diversity. Some of them attribute an important role to such motor skills as speed, agility, muscle strength or motor coordination [4, 2, 5-7]. Fernanndez-Fernandez et al. [8] claim that one of the main problems in training tennis players is teaching the basics of technique. According to the authors, achieving an effective technique that would guarantee, during tournaments, the proper execution of the strokes that make up the fragments of the game and, later, the tactical actions, requires a specific procedure for fitness preparation from an early age.

Tennis is one of the sports characterized by great unpredictability. It relates to the effectiveness of the serve, the time it takes to score a point, the choice of stroke and its strength and direction, the strategy of the game, the duration of the gamete, sets and match, the weather and the opponent all affect complex aspects of the game of tennis. Planning and implementing training in tennis requires an understanding of the many variables (mental, tactical, technical and fitness) critical to building the right player at a given stage of training and their form for the season. During the course of tennis, a player is required to repeatedly obtain maximum available power in the shortest possible time during strokes repeated hundreds of times both during a match and during a training session. This is because during a tennis match, the average length of time required to score a point is much less than 10 seconds, and the rest "between points" is usually 20-25 seconds, depending on sport-specific rules [9]. Although each tennis point is different, tennis players make an average of 4 changes in running direction [9]. Directional changes can range from one to more than 15 in a very long and demanding ball game. As a result, during a match, it is not uncommon for players to make more than 1,000 directional changes [10]. Therefore, tennis is one of the few sports that does not have time limits for matches. Thus, matches can last even more than five hours, and the shortest – not a whole hour.

This variability requires players, early in their training, to have an appropriate level of fitness training, which not all talented tennis players (in a coordination sense) can meet. From the perspective of health concerns, it should be added that obtaining specific potential will allow the player to train safely, participate in competitions, recover both during the match and between matches, and protect against injury [11-13]. Unfortunately, published knowledge of training processes with the use of a player's motor potential is rather limited, and it is difficult to provide specific recommendations for coaches, parents, or tennis associations alike. Understanding the mechanisms of the training process in tennis, especially before and during the player's adolescence, is an absolute necessity in Long-Term Athlete Development [14, 15].

Based on studies [16-18], it has been established that technical skills play a special role in tennis, which are considered crucial for high sports performance. The results of studies on technical skills in tennis show that players at a higher level of sportsmanship outperform players at a lower level in such aspects as ball speed, percentage of errors and accuracy of strokes [19]. Increased ball speed shortens the time in which an opponent can successfully deflect the ball and apply pressure to dominate the opponent [20].

Another important aspect is the scale of errors made, which is important from the perspective of reaching the professional level. Research results have shown that the percentage rate of errors is lower among professional players compared to elite youth players [21]. An indispensable aspect is the ability of self-control during the match. During competition, players should execute their strokes with appropriate accuracy, that is, to a specific spot on the court. The choice of place on the court not only keeps the ball in play but can force the opponent to make a mistake [22]. In addition to the aforementioned aspects, the technique, called in the professional language of tennis: *spin rate*, deserves attention.

This is particularly important because the force of the stroke and the spin given to the ball (including backspin) affect its trajectory. This is useful for executing strokes with a larger curve and closer to the end line, thus increasing the chance of gaining a tactical advantage over the opponent [23].

A number of authors [24-27] studying the influence of conditioning and coordination motor skills on technical skills in the early stages of training point to the possibility of stimulating these phenomena during training. The authors also pointed out the need for a progressive and targeted training model, taking into account the long-range goals of long-term sports training. In studies of tennis players, attention was paid to the importance of conditioning and coordination motor skills in relation to technical skills and their relationship to performance during the game. Some have focused on the influence of conditioning motor skills [28, 27, 29], while others have looked for the effect of coordination motor skills on technical skills [30-32, 7, 19]. There have also been studies on the impact of the determinants of athletic performance in tennis, as well as the agility of the upper and lower body that are the foundation of the motor preparation of tennis players [9].

We see the need for further scientific research including more precise identification of predictors (endogenous variables) of technical skills assessed in both training and competition settings. For example, there is a lack of data in the literature on the correlation of fitness and coordination abilities with technical skills and sports performance at tournaments for girls aged 9-11. Hence, we intentionally consider the following questions to be important: what level of conditioning and coordination abilities should girls have at the all-around training stage? how does the training process affect the dynamics of conditioning and coordination motor abilities? which abilities should be considered leading? and can we identify the conditioning and coordination predictors of technical skills of tennis players at the initial stage of training?

There is also a lack of data on the correlation of fitness and coordination abilities with performance during tournaments. Obtaining information on the conditioning-coordination determinants of the technical skills of young female tennis players is particularly important from a cognitive and application point of view from the earliest stages of sports training. On the one hand, it will increase the chances of discovering sports talent, determining the level and possible changes in motor skills, and on the other hand, it will help identify the conditioning and coordination motor skills that need to be formed both for harmonious development, but also so as not to miss the opportunity to master increasingly difficult technical skills useful in sports competition (which is anyway limited by the prospect of only a few years of an effective career), taking care to prevent injuries.

The aim of this study is knowledge on coordination determinants of technical skills of female tennis players aged 9 and 11.

MATERIAL AND METHODS

Participants

The study included female tennis players (n = 96), body height (9 years: 137 ±5.7 cm; 10 years: 143 ±4.3 cm, 11 years: 148 ± 5.2 cm), body mass (9 years: 34 ±1.9 kg; 10 years: 38 ±2.1 kg; 11 years: 43 ±2.3 kg).

All participants began their training at the age of 6. Prior to the study, they were divided into three age groups of 32 individuals each. They were all at a similar sports level.

Study design

The frequency of training sessions depended on the girls' age. Those aged 9 had three 90-minute training sessions per week, while 10-11-year-olds had four 90-minute sessions per week.

Technical skills of the female tennis players were evaluated using the tennis wall test [29]. To check coordination motor abilities, the following tests were applied: some EUROFIT tests (the flamingo test, tapping the discs), the Spalding slalom running test [33], the shuttle run test, the Spider test [34], the jump rope test, jumps in the hexagon, the Starosta test [35], the eye-hand test, the test of simple reaction and the test of complex reaction. The intention was to find out which motor abilities model in the groups under investigation would be the best to anticipate technical skills. The predictors introduced in the analysis were the results of the subsequent motor abilities tests, and the dependent variable was the result of the tennis wall test.

Testing procedures

Each age group was tested separately. The tests lasted for three days. Each day (Friday, Saturday, Sunday), licensed coaches (n = 4) examined 32 individuals. The same coaches evaluated particular abilities as well as technical skills.

On the first day of research, participants representing particular age categories performed nine tests assessing conditioning motor abilities. On the second day, they did eleven tests of coordination motor abilities, while on the third day, tests evaluating technical skills were applied. All the tests were performed at the same time and in the same sports hall with Gerflor TARAFLEX surface, after a 10-minute warm-up.

On the first day, the tests were carried out in the following order: sit-and-reach, standing broad jump, a tennis ball throw (as far as possible), hand grip strength test using a dynamometer, sit-ups, flexed-arm hang test, 20 m run, 50 m run and the Cooper test.

On the second day, the tests were performed as follows: the flamingo test, simple reaction test, complex reaction test, eye-hand test, disc tapping test, Starosta test, jump rope test, hexagon jumps test, Spalding test, Spider test and 5x8.23 m shuttle run [34].

On the third day, the tennis wall test [29] was carried out. The test checks the level of mastering forehand and backhand strokes in terms of the rhythm of technique of these strokes (the ball is hit against the wall after it bounces off the ground). Test description: the player stands behind the control line with a ball in her hand. She begins the test by performing a forehand stroke. When the ball hits the wall, an assistant coach starts a stopwatch, and the coach begins counting the wall hits. The test duration is 2 minutes. If the player crosses the control line marked 6 m away from the wall (before or while hitting the ball) or the ball hits the wall below the net height, the hit is not counted as correct. If the hit is not correct, the player takes another ball and resumes the procedure. The coach should count each correct hit out loud. The test is performed once.

Statistical analysis

Normality of distribution was checked with the Shapiro-Wilk test (StatSoft, Inc. STATISTICA version 13.0). As it was normal, parametric tests were applied. Subsequently, correlation analyses were carried out using multivariate linear regression analyses with the stepwise method of inserting predictors into the model. All the statistical analyses were performed using STATISTICA software (TIBCO Software Inc., 2017, ver. 13, http://statistica.io).

RESULTS

The result of the study (arithmetic means) compiled by ordinal variable from the youngest to the oldest tennis players clearly illustrate the positive effect of training on the development of their motor skills. However, the standard deviations of some indicators show either greater or lesser inter-individual variation despite the passage of the same time and the application of similar stimuli (exercises) of a general and specific nature (Table 1).

Table 1. Mean (M) and standard deviation (SD) of technical, fitness and coordination tests.

Test	Group (years)					
	9		10		11	
	M	SD	M	SD	M	SD
The 100 Ball Skill Test	93.13	19.1	132.97	15.7	162.77	27.69
Wall game test	50.47	5.18	67.03	8.55	78.57	9.91
Sit-and-reach	4.4	3.29	4.23	2.98	3.1	4.21
Standing broad jump	1.3	0.13	1.48	0.16	1.63	0.09
Hand grip strength test	11.33	1.76	12.77	2.27	14.67	2.15

Test	Group (years)					
	9		10		11	
	M	SD	M	SD	M	SD
Sit-ups	16.73	2.94	20.17	4.23	24.33	2.95
Flexed-arm hang test	6.9	8.68	15.64	10.65	20.53	6.37
Cooper test	1452	148.21	1554	136.29	1653.33	112.39
50m run	11.46	0.87	10.88	0.82	10.3	0.53
20m run	4.58	0.34	4.39	0.33	4.33	0.29
Tennis ball throw	7.97	1.68	9.97	2.49	12.4	1.79
Spalding test	11.89	0.83	11.39	0.87	11.11	0.72
Spider test	23.03	0.72	22.06	1.17	21.28	1.15
Disc tapping test	35.07	14.81	49.9	8.28	56.07	10.28
Hexagon jumps test	15.74	1.6	13.98	2.2	13.19	1.11
Shuttle run 5 x 8.23 m	15.55	0.5	14.46	1.02	14.1	0.62
Starosta test	576	51.52	630.33	66.49	672.33	52.55
Eye-hand test	2.4	1.59	6.1	3.89	10.5	2.65
Flamingo test	12.19	14.49	9.89	1.35	8.71	0.78
Disc tapping test	23.06	4.36	20.75	3.66	18.55	1.21
Simple reaction test	48.4	2.53	50.27	1.89	50.83	0.99
Complex reaction test	10.4	4.61	18.33	6.51	26.7	6.43

Table 2. Results of regression analysis in a group of 9-year--old girls.

Test	B	SE	β	R^2
(constant)	12.13	32.48		0.13
standing broad jump	75.45	25.16	**0.37****	

**p<0.01

Table 3. Results of regression analysis in a group of 10-year--old girls.

Test	B	SE	β	R^2
(constant)	−36.34	66.38		0.14
standing broad jump	113.98	41.82	**0.34****	

**p<0.01

In the group of girls aged 9, the results of the standing broad jump were the predictors of results in the 100 Ball Skill Test (Table 2). The model with the lowest R^2 was developed in this group (R^2 = 0.13).

Also, in the group of 10-year-old girls, the results of the 100-ball skill test were influenced by standing broad jump (Table 3). This group obtained a model with a slightly higher R^2 (0.14).

In the last group (11-year-old girls), the predictors of results in the 100-ball skill test were the results of the following tests: tennis ball throw, 50m run test and 20m run test (Table 4). The coefficient of determination was R^2 = 0.19. For 11-year-old girls, the tennis ball throw score was a stronger predictor of the 100 ball skill test scores (β = 0.34, p<0.01).

Table 4. Results of regression analysis in a group of 11-year-old girls.

Test	B	SE	β	R^2
(constant)	321.98	92.86		0.19
tennis ball throw	8.26	2.87	0.34**	
50m run	−15.38	6.68	−0.27*	
20m run	−23.07	10.84	−0.25*	

*p<0.05, **p<0.01

DISCUSSION

Competition in tennis is a multifaceted combination of variables that determine sports performance at different stages of training. Some authors lean toward mental preparation, while others lean toward tactical and technical preparation [36, 16] and there are proponents who see sporting success in the player's fitness preparation [11, 22, 15]. Another group of authors leans toward the specificity of fitness variables, which should be characterized from the very beginning by such threads that will be necessary at subsequent stages of training [37, 1].

The implication is that the game of tennis requires a combination of a number of key variables, which include conditioning ability, motor coordination and technical skills; however, the specifics of these variables have yet to be adequately defined. It has been suggested that general fitness training should include specific training that takes into account the peculiarities of the sport, but specific guidelines are still lacking to identify players predisposed to high athletic performance.

Finding ways to achieve high sports performance is one of the important challenges of sports training. Meeting this challenge forces researchers and coaches to constantly seek and deepen their knowledge of the phenomena surrounding the optimization of the training process in sports [24-26, 38]. Many specialists believe that in the long-term training process of a young athlete, in addition to teaching and learning technique and tactics, it is important to develop fundamental and motor skills-including the fundamentals of technique, which is useful in the subsequent stages of training and makes it possible to achieve a higher level of sports mastery [39, 27, 40, 19].

Analysing the results of the 100-ball test, it was found that in the group of nine – and ten-year-old girls, among the fitness motor skills, the predictor explaining the largest percentage of variance (13% and 11%, respectively) was the long jump from a place. On the other hand, in the group of eleven-year-old girls, the model included the tennis ball distance throw and the 50-meter and 20-meter run (43% of the variance of the 100-ball test score). The tennis ball distance throw score is the strongest predictor, while the other two are weaker and similarly strongly related to the explanatory variable.

Similar results were obtained by Kramer et al. [26]. The authors found that in a group of girls, lower body strength was a significant predictor of technical skills. The importance of the lower limbs in tennis was also pointed out by other researchers [41, 42]. They claim that lower limb power and speed of movement form an important link in virtually every kinetic chain applicable to virtually all aspects of tennis. Other authors [9, 40] point out that one of the essential factors determining athletic level in tennis is the value of muscle power manifested during dynamic movements. They emphasize the significant relationship between the obtained values of dynamic muscle strength and sports performance in tennis. Regarding speed as a conditioning motor ability that characterizes the best tennis players.

Fernandez et al. [43] and other authors [44-46] agree that in order to be competitive and successful in this sport a high level of speed, agility and power combined with high aerobic or anaerobic capacity is required of the athlete [47, 48, 27]. Only through proper footwork it will be possible to surprise the opponent in the choice of direction, strength and how to give rotation to the ball. In view of the fact that the game itself is characterized by the execution of many accelerations over short distances, stops and changes of direction, and the combination of arm, trunk, leg and foot work with regard to technical-tactical actions, the above abilities seem to be essential [43, 44, 49, 50, 27, 51-53]. The results of the study indicate the need to create training programs that are built using the concept of "training specificity". Especially with regard to the desired motor preparation goals for a given sport, primarily dedicated to the group of girls training tennis at the stage of comprehensive training.

Observation of recent years of sports competition confirms a definite increase in the requirements of fitness preparation of professional tennis players. The variety and number of technical elements performed during a match with high intensity – which we emphasize again – is very high: the exchange of balls from deep in the court, return, volley, bow, shortcut cause the need to run to the ball with maximum speed and perform the given action with high accuracy and efficiency in a very short time [1-3].

The results of our study are in line with those of Reid et al. [54], who found that athletes better reproduce the rhythm of movements and generate more forceful strokes from the forehand, with the involvement of the lower limbs. Analysing coordinative motor skills as predictors of technical skills assessed (100-ball test score), it was found that in a group of nine-year-old girls, straight reaction time and hexagonal jumping had the highest predictive value (19% and 24%, respectively). In the group of ten-year-old girls, the predictors were the results of the skipping jump test, the Starosta's test, the flamingo's test, tapping the puck, the 5 x 8.23-meter shuttle run and the eye-hand test, which explained a total of 56% of the variance. In the group of 11-year-old girls, it was the result of the 5 x 8.23 m shuttle run, the Spalding's slalom run, and tapping the pulleys that explained 47% of the variance in the dependent variable.

Analysing the results of the study in the different groups of girls and considering different models, it can be seen that among all the coordination predictors involved in explaining the dependent variables in the 100-ball test, a set of predictors becomes apparent, of which dynamic balance does not play a special role. This fact may come as a surprise, especially since researchers as well as coaches believe that in tennis it is body balance that is of fundamental importance when learning and improving technical skills, as well as mastering basic technical-tactical actions.

The results of the study of the ability to rhythmic movements and reaction time lead to a different interpretation. It turned out that both our results and those of other authors confirm that these empirical variables determine the technical skills of tennis players (see Elliott et al. [42]). The authors draw attention to the proper rhythm of the legs, which initiates all movements in tennis. According to their opinion, it is through the proper work initiated by the feet pushing against the ground that it will be possible to transfer force and momentum through the segments of the kinetic chain of the lower limbs to the torso and ultimately to the racket. Therefore, a high level of rhythmic movement and reaction time significantly determines the technical skills of tennis players – it is the basis for the efficiency of almost every aspect of the game of tennis (from generating force when serving or forehand, to moving around the court in such a way as to take the optimal position for a stroke). A high level of reaction time, on the other hand, allows the player to react appropriately and makes it possible to choose the right strategy of technical-tactical moves that give an advantage (forcing the opponent to make a mistake and lose a point).

Notwithstanding the criticism of our own research results interpreted in terms of the importance of body balance during tennis, we emphasize the importance of a high level of the body balance disturbation tolerance skills (we did not study this phenomenon during our experiment, but the results of other studies are convincing enough [55-58]) and rhythmization of movements. Both of these phenomena, in our opinion, are important factors in preventing injuries and improving the efficiency and effectiveness of the game at each stage of training. This way of reasoning (concern for health first and foremost, but without losing sight of starting efficiency, which is the heart of the sport) is confirmed, among other things, by the recommendations of researchers involved in incorporating exercises belonging to the health systems of traditional Chinese medicine into training [59-62]. Knowledge of the long-term assessment of the progress of technical skills, having a direct relationship to the specifics of the sport, but combined with concern for the health of the athlete, can be particularly useful for coaches able to identify athletic talent, and build programs of long-term training also for those for whom tennis (or any other sport) will become an important "sport of life" [63], an activity that strengthens health.

CONCLUSIONS

The results of our experiment, in our opinion, have important implications for tennis training practice, but also can inspire future research. The performance of the 100-ball test depends on various predictors of motor abilities. The results of this study suggest the need to incorporate training strategies to improve specific motor abilities at different stages of tennis specialization. In particular, personal trainers should incorporate exercises that will help tennis students (professional and as a possible lifelong physical activity) to focus their attention on specific movement technique for improving tennis stroke efficiency. The results confirm the predictive value of the tests used, but also the need to include in future studies tools that diagnose other components of a tennis player's motor skills.

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Cite this article as: Waldziński T, Niźnikowski T, Mastalerz A et al. The coordination determinants of technical skills of female tennis players aged 9 and 11. Arch Budo Sci Martial Art Extreme Sport 2022; 18: 185-193