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Original Article

General and individual factor structure of complex preparation of young tennis players of 10-12 years

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Abstract
The aim of the study: to determine the general and individual factor structure of the preparedness of young tennis players 10-12 years old. **Material and methods**. 24 tennis players aged 10-12 years (boys) participated in the study. All athletes gave their consent to conduct examinations, which are performed in the tennis section of Kharkiv. The level of integral readiness of young tennis players of 10-12 years was determined. 61 indicators were analyzed. Comprehensive testing was conducted in September 2018. The selection of tests was carried out according to the program for children and youth sports schools. To determine the place of technical and tactical preparedness in the general structure of training of young athletes on the basis of complex testing was conducted factor analysis by the method of principal components. **Results.**In the structure of complex training of young athletes were identified 6 main factors: "Special physical and technical-tactical preparedness", "Mobility of the nervous system", "Special endurance", "Short-term memory", "Speed of complex reaction", "Strength nervous system. " The total total variance was 71.3%. The individual factor structure of athletes' readiness was revealed, for which percentages of expression of each factor in each athlete were determined. All athletes have different expressions of different factors, which indicates that there are significant individual differences. This should be reflected in the different features of the game and the need to use individual training programs for young tennis players. **Conclusions**. For all athletes it is necessary to combine the development of technical and tactical preparedness and special physical with the development of cognitive and psychophysiological functions. This requires the selection of special tools that have a complex effect on physical and psychophysiological and cognitive functions. Such means include the use of special simulators of complex influence on the level of readiness of players and means of visualizing technical and tactical actions.
Keywords:tennis, technical and tactical training, factor structure

Introduction

Contemporary tennis involves participation in international competitions in childhood, and therefore requires a high level of technical and tactical and physical fitness of young athletes (Alfonso &Menayo, 2019; Andrade, Casagrande, Bevilacqua, Pereira, Alves, Goya, & Coimbra, 2018; Borisova , 2012; Emshanova, 2013; Ibraimova, 2012). This is especially true for the 10-12 year olds, as this period is transitional in becoming a young tennis player (Krespo, Reid, 2013; Sobko, Koliesov, &Ulaeva, 2019; Tarpishchev, Samoilov, & Guba, 2006). It is from the age of young athletes that 10 years of age start competing separately for boys and girls (Yakubovsky, Ivanova, 2012). In addition, the age of 10-12 years precedes the pubertal period when hormonal changes in the body of the child (Cieślicka, Sobko, Ulaeva, Ishenko, Shepelenko, Tamozhanska, Bugayets, 2019; Kozina, Goloborodko, Boichuk, Sobko, et.al., 2018). That is why at this age the child's body is vulnerable, and when exceeding the optimum values of volume and intensity of loading easily there is fatigue, overtraining and increased traumatism. Thus, a contradiction is created: modern tennis demands from young athletes maximum development and manifestation of all levels of technical, tactical and physical fitness. But the training of tennis players, especially the young ones, requires great care. Therefore, in order to create optimal conditions for the development of young athletes, it is necessary to determine: which aspects of training should be given the most attention; what are the motor abilities, physical qualities, abilities and skills of young tennis players that are interconnected; how to determine the leading qualities of young athletes and the individual characteristics of tennis players for the most correct construction of the training process.

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One of the prerequisites for a qualitative improvement in the training process is the determination of the factor structure of athletes' preparedness (Kozina, Cieslicka, Prusik, Muszkieta, Sobko, Ryepko, et.al., 2017; Kozina, Shepelenko, Osiptsov, Kostiukevych, et.al., 2017) . For this, factor analysis is used (Lisenchuk G., Tyshchenko V., Zhigadlo G., 2019; Lytovchenko, Breus, Kozina, 2018). In sports, factor analysis is recommended to be carried out using the principal component method (Shepelenko, Kozina, Cieślicka, Prusik, 2017; Tyshchenko, Hnatchuk, Pasichnyk, Bubela, Semeryak, 2018). With its help it is possible to combine indicators of complex testing in groups. At the same time, each group includes indicators that are most closely correlated with each other and are determined by some common factor. Therefore, factor analysis allows you to quickly analyze the correlation relationships of a large array of indicators.

Depending on which indicators are included in each group, i.e. made up individual factors, gives a characteristic or a short, capacious name for each factor. The identification and characterization of the main factors determining the phenomenon under study (in our case, the state of athletes) will be called the structure of this phenomenon (in our case, the structure of athletes' preparedness).

Researchers who have applied factor analysis in sports, as a rule, stop at the stage of determining the structure of a team's preparedness, and, based on an analysis of the main factors, give practical recommendations. However, factor analysis by the method of principal components also involves the determination of factor values for each case, i.e. for each player (Kozina, Cieslicka, Prusik, Muszkieta, Sobko, Ryepko, et.al., 2017; Kozina, Shepelenko, Osiptsov, Kostiukevych, et.al., 2017).

After that, the individual factor structure of each athlete's preparedness is determined, where not individual indicators are shown as characteristics, but absolute or percentage values of each factor, and thus the player is characterized from the point of view of the interaction of various systems. Individual recommendations are given on the basis of which factors of each player prevail and which are underdeveloped.

In tennis, there are currently no clear recommendations on which aspects of preparedness to emphasize in training young athletes. Some authors (Alfonso &Menayo, 2019; Andrade, Casagrande, Bevilacqua, Pereira, Alves, Goya, & Coimbra, 2018) point out the need for the main emphasis on the physical preparation of athletes, in a number of works (Krespo, Reid, 2013; Sobko, Koliesov, Ulaeva, 2019; Tarpishchev, Samoilov, Guba, 2006) obtained results indicating the need to focus on the technical training of young tennis players. However, there is practically no mention of the tactical training of young athletes. It is traditionally believed that tactical training is a priority for adult athletes, in childhood only the foundations of future tactical thinking are laid (Araújo, ND, & Greco, PJ (2018; Baiget, Iglesias, Fuentes, & Rodriguez, 2019; Bankosz, &Winiarski, 2018). However, there is evidence showing a close relationship between tactical training and the success of young athletes and its impact on future ratings during the growing up of young tennis players (Emshanova, 2013). In tennis, tactical training is a whole with technical training, it is called technical and tactical training. It is known that in adult athletes, technical and tactical preparedness is closely interconnected with other types of preparedness (physical, psychological and others) (Korobeynikov, Potop, Ion, Korobeynikova, Borisova, et.al., 2019; Kozina, Iermakov, Bartík, Yermakova , Michal, 2018.) However, the question of what place in the overall structure of the training of young tennis players takes tactical training, how much the technical and tactical training of young tennis players is related to other types of training remains open.

Therefore, the hypothesis was put forward in this study: the technical and tactical training of young tennis players aged 10-12 occupies an important place in the overall structure of the preparedness of young athletes; the relationship of technical and tactical preparedness with other types of preparedness of young tennis players of 10-12 years old has different individual expressiveness.

Purpose of work: to determine the general and individual factor structure of the preparedness of young tennis players 10-12 years old.

Material and methods

Participants

24 tennis players aged 10-12 years (boys) participated in the study. All athletes gave their consent to conduct examinations, which are performed in the tennis section of Kharkiv.

Procedure

The level of integral readiness of young tennis players of 10-12 years was determined. 61 indicators were analyzed. Comprehensive testing was conducted in September 2018.

Methods of pedagogical testing

Methods of pedagogical testing were used to determine the level of fitness of tennis players 10-12 years. The selection of tests was carried out according to the program for children and youth sports schools. Testing was performed before and after the ascertainment and forming experiment.

The following tests were used to control the general physical fitness of tennis players of 10-12 years: level of development of speed abilities - running of 30 m (s); level of development of speed and power abilities - jump up (cm), long jump from place (cm); throwing a stuffed ball 1 kg (m); the level of development of stubbornness - exercise "shuttle running 6x8" (c); exercise "fan" (c); jumping rope in 1 minute. (time); the level of development of the reaction rate - catching a stick (cm); level of development of force - flexion and extension

of the arms in the rest lying 30 s (once); lifting into the saddle 1 min (time); level of technical and tactical preparedness (according to the method of International tennis number) - depth of blows from the bounce of the open and closed plane of the racket; the depth of impact of the open and closed plane of the rocket; the accuracy of hitting the open and closed plane of the racket; innings. The study also included the assessment of technical and tactical skills including a test of physical fitness according to the method of the International tennis number - "Mobility of movements of a tennis player" (Fig. 1). Immediately after each exercise, the heart rate (beats · min^{-1}) was measured.

Fig. 1. The system of evaluation of bounces on the bouncing ball by testsITF (International Tennis Number — Testing Procedure. International Tennis Federation, 2004. http://www.tennisplayandstay.com/media/131803/131803.pdf)

Methods of psychophysiological testing

The following tests were applied (Kozina, Goloborodko, Boichuk, Sobko, et.al., 2018):

1. Determination of the speed of simple reaction to the light stimulus. In the process of testing, colored spots on a black background appear on the computer screen, where the subjects must respond by pressing the space bar (before the end of the test). The average response time of 25 trials, the mean square deviation and the coefficient of variation for each subject are recorded.

2. Determination of the rate of complex reaction in different modes of testing. The tests were conducted under the program “Psychodiagnostics” (Kozina, Goloborodko, Boichuk, Sobko, et.al., 2018). The rate of complex reaction of choosing one element from two (ms) was determined; one element out of three response rate, one out of three response rate selected in feedback mode (ms). From the psychophysiological methods of the study also used to determine the complex response to light stimuli in different modes of testing.

The latent time of the complex visual-motor reaction in the feedback mode was also determined. In this mode, the next signal appears the faster the respondent responds to the previous signal. The latent response time in the feedback mode (ms), the standard deviation (ms), the number of errors in the test in the feedback mode, the time of the minimum signal exposure (ms), and the time of the exit to the minimum signal exposure (s) were determined.). In determining the strength and mobility of the nervous system, the following provisions were observed: the smaller the number of errors in the sub-modes of complex visual-motor reaction with so-called, feedback, the higher the strength of the nervous system; the less time in the sub-modes of complex visual-motor reaction with feedback, the higher the mobility of the nervous system.

Perceptual memory metrics for the Perception-1 program were also determined. Testing was performed as follows. The letters (6 pieces) appear in one line on the computer screen. Image lasts 200ms. Then a window will appear in which you want to play the letters memorized by the test subject. The number of correctly reproduced letters is recorded. In another embodiment ("Perception-2") the letters (9 pieces) are arranged not in one line but in three. Image lasts 200ms. Then a window will appear in which you want to play the letters memorized by the test subject. The number of correctly reproduced letters is recorded.

Statistical analysis

To determine the place of technical and tactical preparedness in the general structure of training of young athletes on the basis of complex testing was conducted factor analysis by the method of principal components. According to the classical factor analysis procedure, the principal components method is most justified to identify the most significant factors and, consequently, the factor structure. The essence of this method is to replace the correlated components with uncorrelated factors. Another important characteristic of the method is the ability to limit itself to the most informative principal components and exclude others from the analysis, which simplifies the interpretation of the results. The general and individual factor structure of the training of young tennis players was determined, as well as the optimal options for combining athletes into training groups by cluster analysis. For this purpose, indicators of complex testing of athletes were analyzed, which included data on functional fitness, psychophysiological capabilities, physical development, technical and tactical and special physical fitness.

Results

In the structure of complex training of young athletes it was determined that the number of factors with an eigenvalue of more than 1 is 14. Using the method of "rocky scree" Kettel the number of factors was reduced and 6 main factors were isolated, since after the sixth factor the change of eigenvalues of factors becomes much

smaller, creates a so-called "plateau". The total total variance was 71.3% (Table 1). The characteristics that went into it were analyzed to characterize each factor.

The first factor (35.5% of the total total variance) included indicators of technical and tactical preparedness and special physical fitness (r = 0.93-0.50).

Based on the above, the first factor was named "Special physical and technical-tactical preparedness" (Table 1).

Table 1

The matrix of components of testing indicators of young tennis players is returned (n=24)

Testing indicators	Factor number					
	1	2	3	4	5	6
Two-to-one test (number of hits)	0,926					
Eight test (number of hits)	0,915					
Two to two test (number of hits)	0,914					
Blow Complex test (number of hits)	0,908					
Three-on-one test (number of hits)	0,884					
Triangle test (number of hits)	0,836					
Cooper test (m)	0,835					
Right Shot (Quantity)	0,801					
Strike right (number)	0,787					
Catching a stick (cm)	-0,784					
Jumping rope in 1 minute (number)	0,784					
Take off left (quantity)	0,768					
Long Jump (cm)	0,767					
Body lift in the saddle in 1 minute (quantity)	0,76					
Blow cut to the left (number)	0,746					
Shuttle Run (c)	-0,735					
Body length (cm)	0,688					
Blow to the left (number)	0,679					
Jump up (cm)	0,675	0,519				
Running 30m (s)	-0,66					
"Fan" (c)	-0,652					
Feed (number of strokes)	0,639					
Takeoff Strike Right (Number of Strikes)	0,629					
Mix (number of strokes)	0,521					
Playing against the wall	0,501					
Latency period of simple visual motor communication response (ms)		-0,902				
Feedback Minimum Exposure Time (ms)		-0,874				
Total feedback test time (s)		-0,743				
Minimum Exposure Feedback Time (s)	-0,592	-0,651				
Heart rate after test 4 (beats·min^{-1})			-0,971			
Heart rate after test 1 (beats·min^{-1})			-0,939			
Heart rate after test 3 (beats·min^{-1})			-0,925			
Heart rate after test 2 (beats·min^{-1})			-0,898			
HR after performing the Harvard step test (beats·min^{-1})			0,666			
Short Term Memory Test 1 (number of letters)				0,82		
Short Term Memory Test 1 (number of letters)				0,633		
The latency period of the reaction of selecting one element from two (ms)					-0,837	
The latency period of the response of the choice of one element of three (ms)					-0,811	
Feedback mode latency (ms)					-0,787	
Test Feedback Latency Test Errors (Quantity)						-0,91
Errors in the test for determining the latent time of simple visual-motor reaction (number)						-0,827
Mean square deviation of the individual latency response times of the feedback response (ms)						-0,767
The contribution of the factor to the total total variance	35,48%	10,145%	8,988%	6,729%	5,621%	4,369%
Total variance	71,332%					

* Note: the rotation of the matrix was performed by the Varimax method; the correlation coefficients of factors with factors greater than 0.5 are presented

The second factor (10.1% of the total total variance) included such indicators as the time of simple visual-motor reaction (r = -0,90), the time of complex reaction in the test under the program "Psychodiagnostics" for the mobility of the nervous system (r = -0.87), minimum signal exposure time (r = -0.74), minimum signal exposure time (r = -0.65) (Table 1). The indicators included in the second factor mainly reflect the level of mobility of the nervous system. Based on the data obtained, the second factor was called "Nervous system mobility".

The third factor (9.0% of total cumulative variance) included heart rate after performing standard exercise training and the Harvard Step Test (r = -0.97-0.66) (Table 1). Thus, the third factor included indicators that characterize the change in heart rate in response to load. The indicators included in the third factor have a negative relationship with it, the exception is the index of the Harvard steppe test, the correlation coefficient of which is positive. Because the lower the heart rate in response to the standard load, the higher the endurance level; the higher the Harvard steppe test index, the greater the endurance level. Thus, the third factor was called "Special Endurance" (Table 1).

The fourth factor (6.7% of the total cumulative variance) included the following indicators of short-term memory according to the tests “Perception-1” and “Perception-2” (r = 0.82-0.63) (Table 1). In this regard, the fourth factor was called "Short-term memory".

The fifth factor (5.6% of the total cumulative variance) came from the response time of the choice (Table 1). That is why the fifth factor was called "Speed of complex reaction".

The sixth factor came from the number of errors in Psychodiagnostic feedback tests and the standard deviation of simple visual motor response time. These indicators reflect the strength of the nervous system, that is, the fewer errors made by the tested in these tests and the smaller the value of the standard deviation in the indicators of visual-motor reaction time, the stronger his nervous system. Since the correlation coefficients of these indicators with the factor are negative, it can be said that the greater the manifestation of this factor in the athlete, the greater his strength of the nervous system. The factor was named "Strength of the nervous system".

As can be seen from Table 1, the largest contribution to the total variance is made by the first factor, which makes it logical to conclude that the most important in the structure of training of young tennis players is the level of technical, tactical and special physical fitness. Less significant, though important enough, are indicators of nervous system mobility and endurance.

Next, the individual factor structure of athletes' preparedness was revealed, for which percentages of expression of each factor in each athlete were determined. All athletes have different expressions of different factors, which indicates that there are significant individual differences. This should be reflected in the different features of the game and the need to use individual training programs for young tennis players.

For a deeper analysis of the interrelation of various factors in the structure of training of young athletes, a visual analysis of the interrelation of individual expression of factors was conducted (Figs. 2, 3). Figure 2 shows that the low and average expression of the factor "Special physical and technical and tactical preparedness" corresponds to a different degree of expression of the factors "Mobility of the nervous system" and "Special endurance".

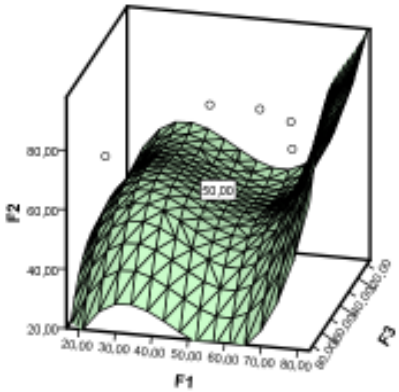

Fig. 2. The relationship of individual expression of factors №№ 1, 2, 3:
F1 - Factor 1 - "Special Physical and Technological Tactical Preparedness";
F2 - Factor 2 - "Mobility of the nervous system";
F3 - Factor 3 - Special Endurance

But the level of manifestation of the factor "Special physical and technical and tactical preparedness" of more than 70 percent also requires the manifestation of the factor "Mobility of the nervous system" above 70%. The Special Endurance factor can be different at this level. From this we can conclude that at this stage in young athletes mobility of the nervous system is of great importance for the development of technical and tactical preparedness. That is why the development of technical and tactical and special physical fitness is needed in

combination with the development of psychophysiological capabilities, which requires the development of special means.

Figure 3 shows that the relationship between the individual manifestation of the factor "Special physical and technical and tactical preparedness" with the factors "Short-term memory" and "Strength of the nervous system" has a parabolic dependence, ie one value of the factor corresponds to both low and high the manifestation of two other factors.

This is due to the fact that at this stage young players have not yet formed a structure of training, characterized by the presence of a high correlation of technical and tactical fitness with psychophysiological indicators. This may also be due to the fact that athletes are characterized by the individual expression of different psychophysiological properties, which provides a basis for the formation of individual style of play. It also confirms the conclusion that the development of technical and tactical and special physical fitness in combination with the individual development of psycho-physiological capabilities is required, which requires the development of special means.

For all athletes it is necessary to combine the development of technical and tactical preparedness and special physical with the development of cognitive and psychophysiological functions. This requires the selection of special tools that have a complex effect on physical and psychophysiological and cognitive functions. Such means include the use of special simulators of complex influence on the level of readiness of players and means of visualizing technical and tactical actions.

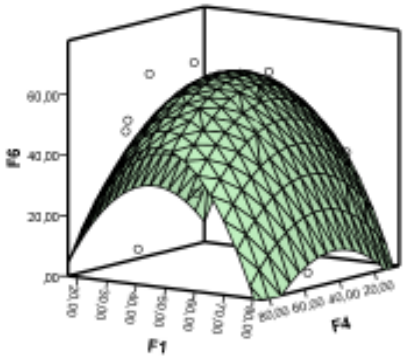

Fig. 3. The relationship of individual expression of factors №№ 1, 2, 3:
F1 - Factor 1 - "Special Physical and Technological Tactical Preparedness";
F4 - Factor 4 - Short-term memory;
F6 - Factor 6 - "Nervous system strength"

Discussion

Our work uses the methodology presented in the works of Kozina et.al. (2017, 2018); Cieślicka, et.al. (2019) on innovative technologies in the training process of athletes [185; 186; 187]. From this point of view of improving the technical and tactical training of tennis players of 10-12 years with the use of interactive tasks and control system of special physical and psychophysiological training, is an extension and complement of knowledge presented in the works of Kozina et.al. (2017, 2018); Cieślicka, et.al. (2019). Our work presents the planning of the training process, taking into account the technical and tactical preparedness of athletes, their psychophysiological and functional features. It should be noted that some authors attempt to provide an integrated assessment of technical and tactical training, taking into account a wide range of indicators. These indicators include the physical features of athletes in combination with the psychophysiological properties of the body, separate technical and tactical training with all their components. However, in this case, the characteristics of the preparation are provided for each group of indicators separately, without their mutual integration. In this regard, we propose the construction of a technical and tactical part of the training process from a comprehensive point of view, which allows to evaluate the indicators both in individual parts and holistically, combining all the measured indicators into a single system of training tennis players of categories 10-12 years. Thus, our results are an extension of the data presented in the works of Kozina et.al. (2017, 2018); Cieślicka, et.al. (2019). In the work of new knowledge is to determine the general and individual factor structure of young tennis players 10-12 years of age on the basis of extended testing. It has been determined that technical and tactical preparedness is a leading factor in the overall preparedness of young tennis players.

Conclusions

In the structure of complex training of young athletes were identified 6 main factors: "Special physical and technical-tactical preparedness", "Mobility of the nervous system", "Special endurance", "Short-term memory", "Speed of complex reaction", "Strength nervous system. " The total total variance was 71.3%.

The individual factor structure of athletes' readiness was revealed, for which percentages of expression of each factor in each athlete were determined. All athletes have different expressions of different factors, which indicates that there are significant individual differences. This should be reflected in the different features of the game and the need to use individual training programs for young tennis players.

The level of manifestation of the factor "Special physical and technical and tactical preparedness" of more than 70 percent also requires the manifestation of the factor "Mobility of the nervous system" above 70%. The Special Endurance factor can be different at this level. The relationship between the individual manifestation of the factor "Special physical and technical and tactical preparedness" with the factors "Short-term memory" and "Strength of the nervous system" has a parabolic dependence, that is, one value of the factor corresponds to both low and high manifestation of the other two factors.

For all athletes it is necessary to combine the development of technical and tactical preparedness and special physical with the development of cognitive and psychophysiological functions. This requires the selection of special tools that have a complex effect on physical and psychophysiological and cognitive functions. Such means include the use of special simulators of complex influence on the level of readiness of players and means of visualizing technical and tactical actions.

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Conflict of interest

Authors state that there is no conflict of interest.

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