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Original Article

Formation of doubles and mixed categories in badminton using multivariate analysis methods

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Abstract:
The purpose of the this study work is to experimentally substantiate the use of multivariate analysis methods for creating doubles and mixed categories in badminton by, taking into account the physical, technical, and psychophysiological capabilities of 14–15-year-old badminton players aged 14-15 years. Materials and methods. This e experimentstudy involved 14–15-years-old badminton players from of the WBC sports club (age 14-15): girls (n = 10), boys (n = 10). The experiment study was performed carried out induring the preparatory period in, September 2019. The Testing of athletes were tested in terms of physical readiness (100 meter m run, shuttle run 4 × x9 meterm shuttle run, bending of the arms in a lying position, jumping rope, pulling up on the bar, forward bending of the body from a sitting position, long jump from a place) and, technical readiness (stuffing shuttlecocks by open and the closed side of the racket in 1 minutemin, mistakes when filling shuttlecocks, hitting shuttlecocks from the wall in 1 minutemin, and mistakes when hitting shuttlecocks from the wall). To determine the psychophysiological state of athletes, psychophysiological indexes were experimented withevaluated using the "Psychodiagnostics" computer program, which measured (the speed of a simple and complex reaction in various testing modes). The results of our cluster analysis of testing showed that athletes are were divided into three groups, with similar outcomes for both boys and girls. Clusters were determined according to the degree of "similarity" of athletes in terms of complex testing. Mixed discharges were formed using expert assessment methods. As a result of one-way analysis of variance, a significant difference ($p << 0.05$) between the groups in terms of the level of physical fitness of boys was revealed in terms of the level of physical fitness of boys. In girls, the groups significantly ($p < <0.05$) differed among themselves in terms of physical fitness and psychophysiological capabilities. Our analysis has revealed two ways of forming doubles discharges. The first method, “similarity,” is based on the similarity of athletes in terms of the pace of play and, the level of development of physical and psychological qualities. This method is suitable for the formation of men and women doubles, where the athletes are equal and have the same tasks. The second method, “compensation”, is where a partner with pronounced leading physical qualities will be suitable for a partner who can compensate for his shortcomings. It is recommended to use rational means and methods of physical and technical training of badminton players at the stage of special basic training for the optimal construction of the training process of athletes.
Key words: badminton players, physical training, cluster analysis, methods of expert assessments

Introduction

Modern badminton is a challenging athletic game that requires players to react instantly, move quickly around the court and quickly make decisions. Badminton combines muscular and mental stress, teaches logical thinking and strategizing various combinations in the game (Vial, Croft, Schroeder, Blazevich, & Wilkie, 2020). A badminton player needs to drive an opponent into a dead end, put the opponent in an uncomfortable position and prevent him or her from hitting the shuttlecock and at the same time defend his field and not fall for the opponent's tricks. Therefore, planning, tactics and strategy give a positive result (Luo, Yang, Tan & Ma, 2020). The training process of an athlete in badminton in adolescence is associated with a systematic formation of all functions, which ensure high efficiency (Goh et al., 2013; Doron, Rouault, Jubeau, & Bernier, 2020). In addition, at this stage the problem of choosing a specialization arises including the distribution of athletes into single, double or mixed categories. The effectiveness of the game of doubles and mixed categories depends not only on the individual characteristics of the athlete but also on the compatibility with the partner. Players must be close to each other both physically and psychologically. The advantages of one partner should compensate for the disadvantages of the other. Players must have the same rhythm, pace of the game, find rapport on the court, and contact during the game to make the right strategy as soon as possible (Karatnyk, Hrechaniuk, & Pityn, 2015; De Waegeneer, Constandt, Van der Hoeven, & Willem, 2019). The range of tactical actions in doubles play is determined by technical skill, the ability to move correctly and the physical qualities of the partners. It is necessary to improve the training process in such a way that the practice of using exercises that increase the

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performance indicators of badminton players' activity in the game is of particular importance. The training process must provide the badminton player with a high potential for playing activity. The indicators of the effectiveness of the activity of badminton players in the game are: a high level of technical skill; the ability to perform complex techniques at high speed and with high accuracy; a high level of development of skills and abilities to conduct various game combinations; the ability to choose the optimal methods of tactical influence on the opponent during the game, the feeling of a shuttlecock. Also important is the ability to: quickly make the only correct decisions during the game and clearly implement them; foresee the opponent's actions during the game and take timely measures to neutralize them; choose the right game plan based on the capabilities and skill of the opponent. Therefore, at each stage of growing up, the coach must pay special attention to the development of each physical quality. At the same time, the development and improvement of physical qualities occurs simultaneously with the mastery and improvement of technology (Ortega-Toro, Blanca-Torres, Gimenez-Egido, 2020). Modern coaches are constantly looking for new ways related to the training of young athletes. In the course of the educational and training process, the role of the coach is the correct selection and use of all means and methods of developing the physical qualities of an athlete in accordance with their age and individual physical characteristics (Sobko, et. al., 2020). Investigating the individual abilities of badminton allows you to select the players who are best suited to each other for working in doubles and mixed discharges (Chino, Inoue, Iizuka, Masuda, & Park, 2019). Currently, there is a large number of studies that consider the structure and content of the competitive activity of badminton players of different qualifications (Dai, 2019; Gomez et. al., 2019; Shevchenko, Merzlikin, & Chucha, 2020). Rojas-Valverde et. al. (2020) analyzed the activity of badminton players (men and women) under 18 during international tournaments. The results of this study were used to develop tactical strategies and effective means of recovery for athletes during tournaments.

Specialists pay big attention to the physical fitness of badminton players (Preeti, Kalra, Yadav, & Pawaria, 2019). Speed, coordination, flexibility and special endurance in modern badminton are among the main physical qualities. The maximum speed of badminton players depends on muscle strength, aerobic endurance, joint mobility and the ability of the muscles to quickly relax after exertion. The speed abilities of a badminton player are determined by the latent time of the motor reaction, the speed of a single movement, and the frequency of movements. Playing actions of badminton players at high speeds require high precision and speed of response. Therefore, speed is the main factor limiting the effectiveness of badminton players and largely depends on the magnitude of specific types of simple and complex sensorimotor reactions. There are several types of studies of specific types of sensorimotor reactions of badminton players, which include tests to determine a simple sensorimotor reaction to a light stimulus, a choice reaction time and a reaction time to a moving object. In studies devoted to the training of an athlete in badminton, the problem of the development of coordination abilities is widely considered. Of particular importance for a badminton player is the ability to differentiate movement parameters, the ability to maintain posture stability and the comprehensive ability to coordinate movements (Lyuwei, Karatnyk, Pityn, 2019; Shogo, Nagano & Ichikawa, 2020).

In modern scientific research, not enough attention is paid to the problem of selecting the most suitable badminton players for doubles and mixed categories. In practice, the coaching staff select athletes based on their own experience and the available reserve to form doubles and mixed doubles, putting them in competitions and changing them in response to negative outcomes. In case of non-viable substitutions, athletes are forced to play in the set doubles while paying more attention to adjusting their game to their partner's play, which reduces team effectiveness. Given this situation, we consider it expedient to use objective, mathematical methods to determine the most optimal combinations of badminton players in doubles and mixed categories. For these purposes our assertion is to use multivariate analysis, in particular cluster, factor and variance analysis. The algorithm of application relevant team sports games is described in the works of Kozina, Zh. L. et. al. (2017).

Based on the above, the purpose of our research is to experimentally substantiate the use of multivariate analysis methods for completing doubles and mixed categories in badminton, taking into acnumber of times the physical, technical and psychophysiological capabilities of badminton players 14-15 years old.

Material & methods

Participants: The research participants are 10 boys and 10 girls aged 14-15 years. They each have five years of experience in badminton and are part of the group of the WBC badminton sports club (Elena Prus is the head coach). The studies were carried out in the preparatory period during September 2019. To determine the level of development of physical readiness of athletes, the following tests and attributes were used:

- Sit-ups (number of times).
- Jumps with skipping-rope (number of times).
- Double jumps (with two turns of the hands) on a skipping rope in 30 s, (number of times).
- Jumps with pulling the knees to the chest (number of times).
- Push-ups 30 s (number of times).
- Standing long jump (cm).
- Shuttle run 4x9 meter was performed with a stop and touching the line. The execution time was fixed (s).
- 100 meter run (s).
- Pulling up on the bar (number of times).

• Stretch of the upper-body forward from a sitting position, (cm). The test was carried out while sitting on the floor and the result of the test was the mark on the perpendicular markings in cm, in which the athletes reached with their fingertips using the best of three attempts.

To determine the level of technical development of athletes, the following tests were used:

• Stuffing of shuttlecocks with the open side of the racket in one minute (number of times).
• Errors when stuffing the shuttlecocks with the open side of the racket (number of times).
• Stuffing of shuttlecocks with the closed side of a racket for one minute (number of times).
• Errors when stuffing the shuttlecocks with the closed side of the racket (number of times).
• Stuffing of shuttlecocks with open and closed side of the racket in one minute (number of times).
• Errors when stuffing the shuttlecocks with the open and closed sides of the racket (number of times).
• Reflection of shuttlecocks from the wall in one minute (number of times)
• Errors when reflecting the shuttlecocks from the wall (number of times).
• Test №1. A 10x10 cm box is installed in the rear corridor of the court. It is necessary to make a high feed and hit the box (touching the steering wheel of the box is taken into acnumber of times for a successful attempt). The number of hits is number of timesed from 10 times (number of times).
• Test №2. It is necessary to make a short feed through the grid and hit the feed line. The number of hits is number of timesed from 10 times (number of times).

To determine the psycho-physiological state of athletes, psycho-physiological indexes were recorded using the computer program "Psychodiagnostics" (Kozina, Iermakov, Bartík, Yermakova, Michal, 2018). The following parameters were fixed:

• a set of indexes for the rate of a simple visual-motor reaction; duration of exposure (signal) - 900 ms;
• complex indexes of a complex visual-motor reaction of selecting two of the three elements; duration of exposure (signal) - 900 ms; s

The digital material was processed and analyzed using traditional methods of mathematical statistics with Microsoft Excel and IBM SPSS Statistics. The method of expert assessments, one-factor analysis of variance and hierarchical cluster analysis of indexes of psychophysiological, physical and technical testing were applied (in total, 22 index factors were selected). In hierarchical cluster analysis, each particular case first forms its own separate cluster. At each stage, two separate clusters that are closest to each other in their structure are combined into one cluster. To determine what number of clusters is optimal, our approach subtracted the increment number from the number of analyzed athletes at which the cluster coefficients begin to increase nonlinearly.

Results

In this study, to determine doubles, a hierarchical cluster analysis of indexes of psychophysiological, physical and technical testing was carried out to determine the groups within which badminton players are most similar to each other in psychophysiological and pedagogical indexes. The cluster analysis of testing was carried out separately for boys and girls. In hierarchical cluster analysis, each particular case first forms its own separate cluster. At each stage, two separate clusters that are closest to each other in their structure are combined into one cluster. The stages of clustering are shown in Fig. 1.1 and 1.2. The cluster analysis of the indexes of testing boys badminton athletes showed that athletes are divided into 3 groups. In addition, there are athletes in the sample who can be distinguished separately, since they are the last to join the clusters (Fig. 1.1). Clusters were determined according to the degree of "similarity" of athletes in terms of complex testing. From the dendrogram it can be seen that at the first stage athletes 5 and 10 were united into one cluster, and at the next stage athlete 4 and then athlete 8 is added to the group. In this group, two subgroups can be formed. If we consider the results of one-factor analysis of variance (Table 1), it can be noted that athletes in this group have low indexes of coordination abilities and technical readiness. Conditional scale of differences between athletes when they are combined into clusters by indexes of complex testing (boys)

Test number

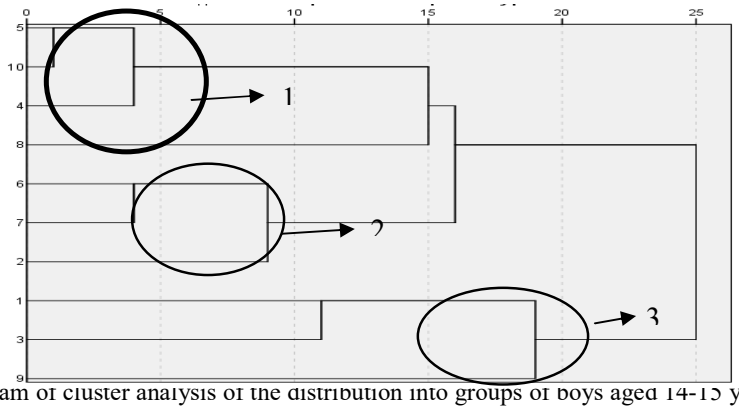

Fig. 1.1. Dendrogram of cluster analysis of the distribution into groups of boys aged 14-15 years according to the indexes of complex testing:

1 - the first cluster;
2 – the second cluster;
3 – the third cluster.

In the second cluster, athletes 6 and 7 stood out in a pair, and in the next step athlete 2 joined the group. These athletes are similar in their structure of preparedness, so the coach can try different options for forming a double. Table 1 shows that athletes in this group have low power and speed-power qualities.

In the last cluster united athletes 1, 3, 9, according to the results of one-factor analysis of variance (Table 1), we can say that the athletes of this group have the highest indices in almost all indexes of complex testing. Cluster analysis of 22 indexes of psychophysiological testing, physical and technical readiness showed the presence of 3 groups of badminton players. In Fig. 1.2. the membership of each girls-badminton player to a certain cluster is visible. Conditional scale of differences between athletes when they are combined into clusters by indexes of complex testing (girls)

Test number:

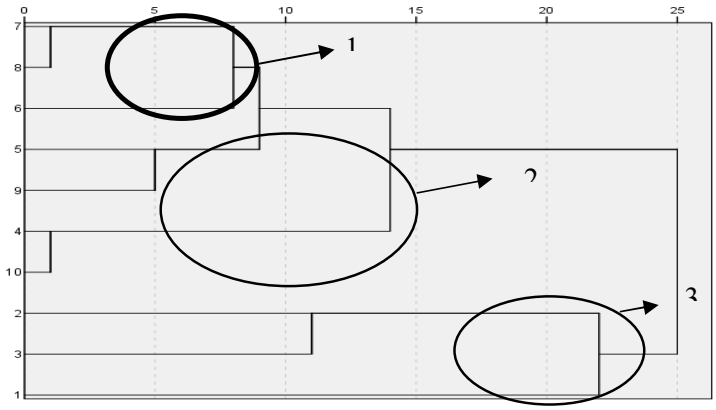

Fig. 1.2. Dendrogram of cluster analysis of the distribution into groups of girls aged 14-15 years according to the indexes of complex testing:
1 - the first cluster;
2 – the second cluster;
3 – the third cluster.

At the first stage, athletes 7 and 8 joined a double, and then athlete. 6 was added to the group - this is the first cluster. Table 1 shows that the athletes of this group have low indicators of flexibility, speed and speed-power qualities. In the second cluster, the athletes united in two doubles: athletes 5 and 9, and athletes 4 and 10. Athletes in this group are distinguished by low rates of simple and complex reactions.

Athletes 2, 3 and 1 unite in the third cluster, with the athletes of this group having high rates of reaction speed and running speed, which presupposes an impetuous style of play requiring a quick response to a changing situation with quick decision-making. If we analyze the average indexes of complex testing for each group of boys (Table 1), we can conclude that the highest test results are in group 3, average results in group 2 and low results in group 1. Analysis of the average indexes of complex testing for each group of girls (Table 1) showed that the highest test results were in group 3, average results in group 2 and low results in group 1.

Table 1 Results of univariate analysis of variance by indexes of complex testing of young badminton players aged 14-15 years

Name of metrics	Boys				Girls			
	cluster1	cluster2	cluster3	p	cluster1	cluster2	cluster3	p
	$\overline{x}$ (n=4)	$\overline{x}$ (n=3)	$\overline{x}$ (n=3)		$\overline{x}$ (n=3)	$\overline{x}$ (n=4)	$\overline{x}$ (n=3)	
Sit-ups, number of times	51,0	45,33	54,66	0,05	50,5	51,66	52,66	0,82
Jumps with skipping-rope, number of times	177,7	181,0	212,33	0,24	187,5	185	189	0,68
Double jumps (with two turns of the hands) on a skipping rope in 30 s, number of times	36,75	50,33	59,0	0,02	50,66	49,33	54,0	0,51
Jumps with pulling the knees to the chest, number of times	51	46,75	56	0,03	43,0	50,33	60,33	0,05
Push-ups 30 s, number of times	29,0	25,33	38,66	0,05	25,75	30,75	32,0	0,33
Standing long jump, cm.	200,25	205,66	197,0	0,22	192,0	199,25	200,0	0,04
Shuttle run 4 x 9 m, s.	9,17	9,26	9,33	0,91	10,13	9,07	9,93	0,01
Running 100 m, s	11,8	11,1	11,1	0,05	13,26	12,3	11,6	0,05
Pulling up on the bar, number of times	9,5	11,6	9,3	0,02	3,2	8,6	4,66	0,01
Stretch of the upper-body forward from a sitting position, sm	9,5	14,66	16,33	0,15	14,25	16,66	19,33	0,05

Stuffing of shuttlecocks with the open side of the racket in 1 minute, number of times	86,0	92,33	77,33	0,14	79	84,75	72,33	0,48
Errors when stuffing the shuttlecocks with the open side of the racket, number of times	1,25	0,66	0	0,24	0,3	0,75	0,3	0,22
Stuffing of shuttlecocks with the closed side of a racket for 1 min, number of times	75,75	80,66	82,33	0,30	81,66	76,25	79	0,58
Errors when stuffing the shuttlecocks with the closed side of the racket, number of times	1,5	0	1	0,21	0	1,5	1,66	0,53
Stuffing of shuttlecocks with open and closed side of the racket in 1 minute, number of times	69,5	70	82,66	0,18	80,33	82	74	0,01
Errors when stuffing the shuttlecocks with the open and closed sides of the racket, number of times	1	1,33	0,66	0,66	0,66	0,25	0,66	0,70
Reflection of shuttlecocks from the wall in 1 minute, number of times	80,25	84,33	80,66	0,93	100	80,75	100,66	0,68
Errors when reflecting the shuttlecocks from the wall, number of times	1,75	1	2,33	0,78	1	1,25	0,66	0,38
Test 1, number of times	2	2,3	4,3	0,04	4	2,75	4	0,49
Test 2, number of times	6,	5,0	7,0	0,14	6	5,5	6,33	0,87
"Simple visual-motor reaction" is the time of the latent period., ms	285,74	276,63	282,98	0,70	276,03	289,94	267,85	0,01
"Reaction of choice 2-3" time of latent period, ms	508,89	493,54	487,51	0,27	488,74	503,16	477,61	0,04

As a result of univariate analysis of variance, a significant difference ($p < 0.05$) was revealed between the groups in terms of physical fitness in boys. In girls, the groups significantly ($p < 0.05$) differ among themselves in terms of physical fitness and psychophysiological capabilities. In the mixed category, coordination and mutual understanding of partners is very important. The main goal of the boys is to protect the field, with an attack and hammering the shuttlecock, at the same time the girls insures the net, intercepts the shuttlecock if possible to speed up the pace of the game and, of course, finishes the shuttlecock on the net. During the competitive process, there are many situations that cannot be foreseen and trained, therefore, this is where the connection between partners is important: defense of the girls, timely interception, moving the game to your own pace, attack of the boys all this and much more are components of an ideal double. In this regard, the directions of physical and technical training are slightly different from other categories. For the formation of mixed categories, the method of expert assessments was used. The expert commission consisted of three people: a head coach, an assistant coach and a physical training coach. For comparison, the main parameters for the formation of a mixed double were selected: coordination capabilities, speed capabilities, speed-strength capabilities, technical capabilities and psychophysiological capabilities. Further, the coefficient of importance of each parameter "weight" was determined based on the total amount of 1. The highest priority was given a higher value. At the next stage, the expert commission evaluates the athletes for each parameter on a 10-point scale, where 10 is the maximum score. Further, the scores were multiplied by the weight of this parameter. In the "Sum" line, the sum of the "weights" of the parameters for each athlete was added and the strongest and weakest athlete in each group was determined. Then they connected a strong boys and a strong girls, etc. Also, in table 2, the maximum values for boys and girls are highlighted for each parameters, the coach can pair athletes according to high indicators of a particular type of fitness.

Table 2 presents the results of the peer review of boys and girls who were included in cluster 3.

Table 2 The results of expert evaluation of the group's badminton players 3

№	Parameter	Weigh	boys			girls		
			№1	№3	№9	№2	№3	№1
1	Coordination capabilities	0,2	**10*0,2=2**	8*0,2=1,6	9*0,2=1,8	8*0,2=1,6	9*0,2=1,8	**10*0,2=2**
2	Speed capabilities	0,25	9*0,25=2,2	**10*0,25=2,5**	8*0,25=2	**10*0,25=2,5**	8*0,25=2	9*0,25=2,2
3	Speed-strength capabilities	0,15	8*0,15=1,2	9*0,15=1,3	**10*0,15=1,5**	**10*0,15=1,5**	9*0,15=1,3	8*0,15=1,2
4	Technical capabilities	0,2	9*0,2=1,8	8*0,2=1,6	**10*0,2=2**	9*0,2=1,8	**10*0,2=2**	8*0,2=1,6
5	Psychophysiological possibilities	0,2	9*0,2=1,8	8*0,2=1,6	**10*0,2=2**	8*0,2=1,6	**10*0,2=2**	9*0,2=1,8
Sum		1	9,05	8,65	9,3	9,05	9,15	8,85

As a result of this method, mixed doubles were compiled: 1 pair - boys athelete 9 with girls athletes 3 and 2 pair - boys athlete 1 with girls athletes 2 and 3 pair - boys athlete 3 with girls No 1. The method of expert assessments was carried out in the same way in groups 2 and 1.

With the help of this method, athletes with a similar level of preparedness were combined into mixed doubles. The age period of 14-15 years in girls and boys is characterized by a pronounced uneven increase in physical fitness indexes. Also at this stage, athletes master complex technical elements and master various tactical combinations. Therefore, at this stage of preparation, there is a difficulty in uniting boys and girls. The mixed category differs from others in that it is technically easier to play with two, but tactically it is more difficult. Correct placement and coordinated combination - game-play an important role.

Discussion

In both doubles and mixed categories, the coach needs to determine the most rational ways of tactical interactions between players and determine the role of each player. In this regard, the optimal choice of a partner for a doubles and mixed doubles allows you to correctly build a badminton players training system. The formation and stability of a double affects its performance. As noted by the majority of authors, the effectiveness of the training process (the technicality of performing hits, their effectiveness, etc.) directly depends on the individual approach using those complexes of exercises that are adapted specifically for young badminton players in accordance with their level of fitness.

The data of the authors (Sobko, Ulaeva, Yakovenko & 2016; Kozina et al . 2017; Tsapko, 2018; Sybil et al, 2018) show that the use of multivariate analysis methods allows us to determine the general and individual structure of athletes' fitness. The distribution of athletes into groups using cluster analysis makes it possible to develop special complexes of exercises with integral impact on all types of training of athletes.

As a result of the research, two methods were proposed for the formation of athletes in doubles and mixed doubles. The first method - similarity, is based on the similarity of athletes in terms of the pace of play, the level of development of physical and psychological qualities. This method is more suitable for deciding boys and girls doubles, where athletes are equal and have the same tasks (each player attacks and defends depending on the course of the game). And the second method of compensation is based on the fact that a partner with pronounced guided physical qualities will be suitable for a partner who can compensate for his shortcomings. This method applies more to mixed doubles, when a fast and strong-attacking boys is ideally suited for a highly coordinated girls, thanks to the defense on the net of which the number of time attack of opponents will be covered.

Also, strengths and weaknesses of athletes in each group were identified and training programs were developed for athletes with various features of the structure of complex readiness.

Our observations and data from other researchers (Cabello & Gonzalez-Badillo, 2003; King, Towler, Dillon & McErlain-Naylor, 2020; Jaworski, Lech, Ambrozy, & Zak; Hermilasari, 2020) show that the main physical qualities of a badminton player: coordination ability, differentiation of muscle efforts, operational thinking, speed in all its manifestations, flexibility, speed, strength, special endurance.

The obtained results of the research determine the main directions of technical and physical training of badminton players of 14-15 years old, specializing in doubles. To optimize the educational and training process of athletes of this age category, the optimal means and methods of training athletes were selected. All exercises were performed by the players in the recommended doubles. To develop coordination abilities, these exercises were used: juggling with shuttlecocks (two, three, four shuttlecocks), juggling with two hands with two rackets; juggling with different sides of the racket; from different positions (back, between the legs, etc.); juggling with closed eyes; juggling in motion; playing in doubles with two, three shuttlecocks; shuttlecock hits into points, into boxes, into banks; playing with closed eyes; paired "feints" (imitation of finishing / repelling a player on the first line with a passing blow and hammering the same shuttlecock by the second player); processing of deceptive shuttlecocks and turnover from a modified trajectory (processing of lucky shuttlecock, edge strikes and trompe l'oeil).

With the development of speed, exercises were used that combine a quick take-off with subsequent jumps in different directions, sharp jerks from a place and quick stops. Acceleration from different starting positions (up to 50 meters), high-speed jumps in place and in motion, all types of movements with the addition of imitation of blows, practicing blows on the court. Jumps to the frequency of leg work in place, followed by acceleration on a signal, playing with two shuttlecocks. throwing a tennis ball in pairs, increasing the power of the throw and closing the distance. The athletes performed imitation exercises with accentuated fast execution of a particular movement.

For general special training, various methods are used, continuous and integral, as well as control or competitive. Exercises: long-distance running, running with juggling shuttlecock, running over barriers, imitation of various strokes in motion - triangles, diagonals, moving along points, in a straight line, upward, practicing hits, jumping lunges with a hit.

Exercises for the development of flexibility all types of lunges, torso turns, circles, turns, eights performed in the shoulder, elbow and wrist joints, arm and leg swings, splits, bridges, overcoming the site in 2-3

steps with a given hit, playing on the spot one leg stays on the floor. Special exercises include: practicing hits with movement and a deep arch in the back or a deep lunge.

The exercises for the development of joint tactical thinking and the speed of decision-making with subsequent movements were the reproduction of characteristic combinations of doubles-opponents on the court, the creation of our own situations, the creation and improvement of working combinations (those that in 85% of cases lead to an earned point).

To develop the psychophysiological capabilities of a badminton player, methods were used to develop the speed of a simple and complex reaction, methods of responding to visual and auditory signals.

The peculiarity of strength training is that exercises with small and medium weight are used, performed with high speed and amplitude. Exercises for the development of speed-strength abilities in badminton: fast running downhill (up to 15°), jumping on the right and left legs with forward and backward movement back forward, running jumps with reaching a high hanging object (suspended shuttlecock), jumping with dumbbells holding a ball.

Thus, using cluster analysis, one-factor analysis of variance and the method of expert estimates, coaches can select the optimal players for doubles and mixed categories in badminton. Correct selection of means and methods of sports training for athletes specializing in doubles will optimize the training process at different stages of long-term training and correct it when changing any training conditions.

Conclusions

It is shown that the use of multivariate analysis methods is effectively suitable for completing both doubles and mixed doubles categories in badminton. of our cluster analysis of testing showed that athletes are were divided into three groups, with similar outcomes for both boys and girls. Clusters were determined according to the degree of "similarity" of athletes in terms of complex testing. Mixed discharges were formed using expert assessment methods. As a result of univariate analysis of variance, a significant difference ($p < 0.05$) was revealed between the groups in terms of physical fitness in boys. In girls, the groups significantly ($p < 0.05$) differ among themselves in terms of physical fitness and psychophysiological capabilities. Our approach shows two ways of forming paired discharges. The first method - similarity, is based on the similarity of athletes in terms of the pace of play, the level of development of physical and psychological qualities. This method is suitable for the formation of men and women doubles, where the athletes are equal and have the same tasks. And the second method of compensation, where a partner with pronounced guided physical qualities will be suitable for a partner who can compensate for his or her shortcomings. It is recommended to use rational means and methods of physical and technical training of badminton players at the stage of special basic training for optimal construction of the training process of athletes.

Conflicts of interest. The authors have no conflicts of interest.

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