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The level of selected coordination abilities in badminton players at various ages and sport skill levels as compared to non-athletes

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abstract

Background The main aim of the study was to determine variation of some coordination motor abilities between badminton players at various ages and with various training experience and their level compared to non-athletes.

Material/Methods The results of the tests of coordination motor abilities were collected from 30 badminton players (younger cadets, cadets and juniors) and 54 peers who were non-athletes. Computer tests were used to evaluate selected coordination motor abilities using a touch screen laptop. Means between age groups of athletes were compared based on one-way analysis of variance or its non-parametric counterpart. The significance of differences between means of the two groups was evaluated using Student's t-test for unrelated samples, the Cochran-Cox test and the Mann-Whitney U test.

Results Comparison of the results of tests of coordination motor abilities between groups of athletes at various chronological ages revealed statistically significant differences in 11 cases. Furthermore, differences in the level of coordination motor abilities between badminton players and non-athlete peers were found at individual training stages (younger cadets, cadets, juniors). These regularities were especially noticeable for times of simple reaction to visual and auditory stimuli.

Conclusions Training experience has a significant effect on the level of the analysed coordination motor abilities of badminton players. This correlation concerns all the analysed coordination abilities. With regard to practical implications of the training process of young badminton players, one should emphasize the development of coordination motor abilities.

Key words racket sports, badminton, coordination motor abilities

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INTRODUCTION

Contrary to what could be expected, badminton is not a new sport. This physical activity dates back as far as three thousands years ago. The historical evidence is provided by drawings and descriptions of religious rituals and playing using an item similar to modern shuttlecock [1]. The sport is especially popular in Asian countries (Malaysia, China, Indonesia, India, Japan, Korea, Vietnam), where it is considered a national sport. Badminton was quickly popularized in other continents, leading to the inclusion of the sport into the Olympic programme during the Olympic Games in Barcelona in 1992 [2]. Formal beginnings of this sport in Poland date back to 1977, when the Polish Badminton Association was founded. However, compared to Asian countries, badminton remains a niche sport in Poland, played mainly in smaller urban areas. Unfortunately, its benefits are not used to promote comprehensive and multifaceted ontogenetic development of children and young people [3] and to improve health status and maintain good mood and fitness in the adult population.

Badminton is one of the fastest racket sports [4], with the temporal structure of a game or a match characterized by short bouts of activity during individual actions and very high intensity [5]. It was found that 60 to 70% of energy during the game is supplied from the aerobic systems whereas other 30% is from anaerobic sources [2]. The duration of a match varies substantially and ranges from 40 minutes to over an hour [5, 6, 7]. An interesting review of the duration of singles Olympic finals (from the Olympic Games in Barcelona 1992 to London 2012) was performed by Laffaye et al. [8]. In general, finals were played for slightly over 40 minutes, with the exception of a three-game match in the Olympic final in London, which took over 78 minutes. However, it should be emphasized that the changes of the rules introduced by the International Badminton Federation have led to the modifications of the temporal structure of the match. The duration of modern matches, individual actions and rests have shortened significantly compared to the previous system, with matches being faster, more intensive and more spectacular for the spectators [7, 9].

Numerous studies have examined correlations between playing effectiveness in badminton and basic somatic characteristics. Obviously, similarities were observed in the body build of badminton players at various stages of training. Analysis of 13 review studies [2] suggests in general that anthropometric characteristics are not leading variables to determine playing effectiveness. For instance, a comparison of mean values of body height and body mass for each continent revealed the highest values for the white population (180 cm, 74 kg), slightly lower for players from Africa (176 cm, 70 kg) and the lowest one for athletes from Asia (167 cm, 60 kg). In general, it can be concluded that for many badminton players, high levels of mesomorphy and ectomorphy should be preferred [2, 10, 11].

From the standpoint of energy systems, badminton is one of the most demanding racket sports. Players have to perform very fast movements, with frequent directional changes that result from the character of the actions. Furthermore, with a relatively long duration of a match, athletes also have to show good physical capacity. Therefore, it can be adopted that badminton requires movements with very high intensity (based on the anaerobic system) combined with movements with moderate intensity (based on the aerobic system, resulting from the duration of the game). Consequently, badminton players have to demonstrate high aerobic and anaerobic capacity. This is why the related literature has dealt with various aspects with the emphasis on physiological determinants of the sport. Studies have analysed maximal and mean heart rates over the match [5, 12]. Mean values of HRmax during a match was 191.0 bpm in male players and 197.6 bpm in female players. Differences were also found due to the sports skill level, with the lowest values found in players with high skill levels [2]. There have also been many studies that examined maximal oxygen uptake (VO_{2max}) and metabolic thresholds (e.g. [12, 13, 14, 15]). The overview of the studies reveals that mean VO_{2max} of all the studies was 56.1 ml/kg/min for men and 47.2 ml/kg/min for women [2]. Blood lactic acid (LA) levels were also analysed. As results from the review of 28 studies, the mean post-exercise LA level was 7.0 mmol/L for men and 7.1 mmol/L for women [2].

Several studies have documented significant correlations with playing effectiveness for: locomotor speed, agility, flexibility, upper limb strength and explosive strength (a review of the problem is contained in [2]).

A literature review shows that, from the standpoint of training and becoming a sport champion, it is essential to examine the problems of the level and development of motor abilities [11, 16, 17, 18, 19, 20]. Unfortunately, most studies in this field have focused only on reaction times.

The present study is concerned with this area of research and its principal aim is to provide the answer to the following research questions:

Are there differences in the level of certain coordination motor abilities between players at different ages and with different training experience?

Are there differences in the level of coordination abilities between badminton players and their non-athlete peers at individual stages of training (younger cadets, cadets, juniors)?

MATERIAL AND METHODS

The study was based on the results collected from 30 badminton players and 54 peers who were non-athletes. The group of younger cadets was composed of 10 boys aged 11–13 years; the group of cadets was 10 boys aged from 14 to 16 years, and the group of juniors was formed by 10 players aged 17 to 19 years. The examinations concerned the athletes from the following sports clubs: MKS "Spartakus" (Niepołomice, Poland), UKS "Orbitek" (Straszęcin), LKS "Technik" (Głubczyce), UKS "Sokół" (Ropczyce), UKS "Trójka" (Tarnobrzeg), UKS "Badmin" (Gorlice), UKS "Hubal" (Białystok) and MKS "Orlicz" (Suchedniów). The sports skills level was evaluated indirectly, using the ranking lists prepared by the Polish Badminton Association. It is remarkable that the study group was composed of players who were regularly qualified for the national team, including Polish champions, vice-champions and athletes who regularly participated in international tournaments (first twenty players from the ranking).

Table 1 presents the characteristics of chronological age, experience and basic parameters of the somatic body build of study participants. As expected, training experience increased with the age category. On average, training experience was 2.5 years in younger cadets, 5 years in cadets and 8 years in juniors. The control group was non-athletes (boys) living in rural areas near Krakow, Poland (up to 25 km from the city).

Table 1. Training experience and basic somatic characteristics of badminton players and non-athletes

	N	x̄	X_{min}	X_{max}	SD	N	x̄	X_{min}	X_{max}	SD
	Younger cadets					Non-athletes				
Chronological age (years)	10	12.5	12	13	0.5	18	12	12	12	0
Body height (cm)	10	153.0	139.8	161.1	8.1	18	154.0	145.3	165.4	6.0
Body mass (kg)	10	42.8	32.2	70.9	11.4	18	50.2	35.2	71.5	10.2
Training experience (years)	10	2.5	2.0	5	1.0					
	Cadets					Non-athletes				
Chronological age (years)	10	14.6	14	16	0.8	18	15.5	15	16	0.5
Body height (cm)	10	173.3	164.3	181.4	5.9	18	174.9	165.2	183.9	6.0
Body mass (kg)	10	68.8	51.3	81	10.0	18	66.7	49.1	85.9	11.4
Training experience (years)	10	5.0	4	6	0.9					
	Juniors					Non-athletes				
Chronological age (years)	10	17.4	17	18	0.5	18	17.5	17	18	0.5
Body height (cm)	10	180.1	172.3	190.2	4.8	18	180.6	169.5	190.1	6.2
Body mass (kg)	10	74.2	67.7	88.1	5.8	18	75.0	50.5	117.8	15.1
Training experience (years)	10	8.0	7	10	1.2					

Computer tests were used to evaluate the levels of selected coordination motor abilities using a touch screen laptop. Other examined characteristics were: kinaesthetic differentiation of temporal parameters of movements, the frequency of movements of upper limbs, times of reaction to an auditory stimulus (minimal, mean, maximal), times of reaction to a visual stimulus (minimal, mean, maximal), times of selective reaction to visual and auditory stimuli (minimal, mean, maximal), movement rhythmization, movement integration and spatial orientation (free mode). A detailed description of the equipment and the method to perform the tests was presented in a publication by Sterkowicz and Jaworski [21]. Each study participant was examined for ca. 15 minutes.

The study used basic descriptive statistics: arithmetic means and standard deviation. The analysis of variance was based on the F test or Kruskal-Wallis H test, depending on the distribution and homogeneity of variance. Differences between means from individual groups were evaluated by means of the Mann-Whitney U test with the Bonferroni correction, which consisted in dividing the level of significance $p = 0.05$ by the number of comparisons [22]. The Shapiro-Wilk W test was used to examine the normality of distributions. Homogeneity of variance was verified by means of Levene's test [23]. Depending on the distribution and homogeneity of variance, pairs of means were compared using Student's t-test for unrelated samples, the Cochran-Cox test and the Mann-Whitney U test. Calculations were made using Statistica 12.0 PL for Windows statistical software package. The significance level was set at $p < 0.05$.

RESULTS

Comparison of the results of the tests that evaluated coordination motor abilities between groups of athletes at various chronological ages revealed statistically significant differences in 11 cases (see Table 2).

Table 2. Mean values of the results of the tests of coordination motor abilities in thestudied groups of athletes

No.	Variable	Unit	Younger cadets (N = 10)	Cadets (N = 10)	Juniors (N = 10)
			x̄ ±SD (1)	x̄ ±SD (2)	x̄ ±SD (3)
1	Kinaesthetic differentiation, temporal parameters	pixel	29.0 ±12.3	28.6 ±11.0	29.0 ±15.6
2	**Frequency of movements**	**n – number**	**40.1 ±6.28**	**44.1 ±6.0**	**44.8 ±9.91**
3	Minimal visual reaction time(*)	ms	228 ±20.44 (3#)	224.0 ±12.7 (3#)	206.0 ±14.3
4	Mean visual reaction time(**)	ms	249.5 ±18.0 (3##)	238.9 ±16.0 (3#)	220.6 ±13.7
5	Maximal visual reaction time (**)	ms	281.0 ±42.8 (3##)	261.0 ±33.2	237.0 ±14.9
6	Minimal auditory reaction time (*)	ms	194.0 ±12.6 (3#)	192.0 ±18.1	177.0 ±13.4
7	Mean auditory reaction time (**)	ms	210.5 ±15.0 (3##)	208.2 ±15.05 (3##)	185.4 ±11.6
8	Maximal auditory reaction time (**)	ms	232.0 ±20.4 (3##)	233.0 ±20.0 (3##)	197.0 ±15.7
9	Minimal selective reaction time (*)	ms	383.0 ±67.7 (3#)	337.0 ±47.9	312.0 ±27.4
10	Mean selective reaction time (*)	ms	461.7 ±93.2	419.9 ±70.5	380.1 ±40.2
11	Maximal selective reaction time	ms	563.0 ±126.8	550.0 ±125.0	466.0 ±76.3
12	Rhythmization	ms	191.6 ±96.8	130.8 ±66.2	115.0 ±82.1
13	Movement integration, labyrinth to the left (**)	s	55.2 ±4.8 (3##)	53.1 ±8.1 (3#)	44.1 ±6.0
14	Movement integration, labyrinth to the left (*)	n – mistakes	20.1 ±6.1 (2##, 3#)	12.0 ±4.9	11.4 ±7.3
15	Spatial orientation, free mode (*)	s	68.5 ±10.4 (3##)	59.4 ±12.4	54.9 ±7.8

The stimulants were written in bold (higher values correspond to better results)
*: $p < 0.05$; **: $p < 0.01$, for multiple comparisons using the U test:#: $p < 0.016$; ## $p < 0.01$

The lowest mean results for minimal visual reaction time, the mean visual reaction time, the mean auditory reaction time and the maximal auditory reaction time were found for the group of juniors, significantly different from the mean results in the group of cadets and younger cadets, who formed a uniform group.

With regard to the maximal visual reaction time, the minimal auditory reaction time, the minimal selective reaction time, the time of performing the labyrinth to the left and spatial orientation tests, the following homogeneous groups were obtained based on the multiple comparisons:

- younger cadets and cadets
- cadets and juniors.

Arithmetic means in the groups show that the lowest (the best) values were documented in the group of juniors. They were statistically significantly different compared to the group of younger cadets, who obtained the highest (the worst) results.

The highest mean (the worst results) for the number of mistakes in the test of labyrinth to the left was found in the group of younger cadets and was statistically significantly different fromthe means recorded for cadets and juniors, who formed a homogeneous group. No statistically significant differences were observed for kinaesthetic differentiation, the frequency of movements, the maximal selective reaction time and rhythmization.

Table 3. Mean values of the results of the tests that evaluated coordination motor abilities in the group of younger cadets and their non-athlete peers

No.	Variable	Unit	Younger cadets (N = 10) x̄ ±SD	Control group (N = 18) x̄ ±SD	Test value	p
1	Kinaesthetic differentiation, temporal parameters	pixel	29.0 ±12.3	38.8 ±15.7	t = -1.7	0.1026
2	Frequency of movements	n – number	40.1 ±6.28	37.3 ±5.2	t = 1.3	0.2102
3	Minimal visual reaction time	ms	228 ±20.44	263.9 ±21.7	U = 17.5	0.0005
4	Mean visual reaction time	ms	249.5 ±18.0	290.8 ±29.5	t = 4.0	0.0004
5	Maximal visual reaction time	ms	281.0 ±42.8	330.5 ±51.9	U = 37.0	0.0111
6	Minimal auditory reaction time	ms	194.0 ±12.6	218.8 ±17.2	U = 20.5	0.0009
7	Mean auditory reaction time	ms	210.5 ±15.0	239.1 ±17.9	t = -4.3	0.0002
8	Maximal auditory reaction time	ms	232.0 ±20.4	268.9 ±29.9	U = 23.5	0.0014
9	Minimal selective reaction time	ms	383.0 ±67.7	297.7 ±50.6	t = 3.8	0.0008
10	Mean selective reaction time	ms	461.7 ±93.2	447.3 ±69.7	t = 0.5	0.6458
11	Maximal selective reaction time	ms	563.0 ±126.8	632.7 ±139.1	t = -1.3	0.2021
12	Rhythmization	ms	191.6 ±96.8	112.4 ±54.3	C-C = 2.4	0.0339
13	Movement integration, labyrinth to the left	s	55.2 ±4.8	61.7 ±12.9	C-C = -1.9	0.0666
14	Movement integration, labyrinth to the left	n- mistakes	20.1 ±6.1	18.2 ±8.0	t = 0.7	0.5120
15	Spatial orientation, free mode	s	68.5 ±10.4	72.2 ±9.7	t = -0.9	0.3568

U – value of the Mann-Whitney test, t – value of Student’s test, C-C – value of the Cochran-Cox test

A comparison of mean values of indices between the group of younger cadets and their non-athlete peers (Table 3) revealed statistically significant differences in 8 cases. With regard to the minimal visual reaction time, the mean visual reaction time, the maximal visual reaction time, the minimal auditory reaction time, the mean auditory reaction time, the maximal auditory reaction time and the minimal selective reaction time, lower means (better results) were documented for the badminton players. In the rhythmization test, a lower mean (better result) was found for the control group.

Table 4. Mean values of the results of the tests that evaluated coordination motor abilities in the group of cadets and their non-athlete peers

No.	Variable	Unit	Cadets (N=10)	Control group (N=18)	Test value	p
			x̄ ±SD	x̄ ±SD		
1	Kinaesthetic differentiation, temporal parameters	pixel	28.6 ±11.0	43.2 ±20.2	U = 50.5	0.0583
2	Frequency of movements	n – number	44.1 ±6.0	47.9 ±5.9	t = -1.6	0.1178
3	Minimal visual reaction time	ms	224.0 ±12.7	234.4 ±17.2	t = -1.7	0.1056
4	Mean visual reaction time	ms	238.9 ±16.0	258.3 ±27.2	t = -2.1	0.0504
5	Maximal visual reaction time	ms	261.0 ±33.2	292.1 ±50.3	U= 51	0.0615
6	Minimal auditory reaction time	ms	192.0 ±18.1	222.2 ±46.3	U = 31.5	0.0050
7	Mean auditory reaction time	ms	208.2 ±15.05	237.8 ±27.7	U = 24.5	0.0017
8	Maximal auditory reaction time	ms	233.0 ±20.0	280.0 ±48.5	U = 21.5	0.0010
9	Minimal selective reaction time	ms	337.0 ±47.9	271.1 ±22.7	t = 5.0	0.0000
10	Mean selective reaction time	ms	419.9 ±70.5	430.4 ±92.1	U = 87	0.8856
11	Maximal selective reaction time	ms	550.0 ±125.0	724.4 ±259.9	U = 39.5	0.0155
12	Rhythmization	ms	130.8 ±66.2	131.9 ±67.9	U = 87.5	0.9046
13	Movement integration, labyrinth to the left	s	53.1 ±8.1	50.9 ±12.1	U = 59	0.1372
14	Movement integration, labyrinth to the left	n – mistakes	12.0 ±4.9	15.2 ±10.3	U = 77.5	0.5490
15	Spatial orientation, free mode	s	59.4 ±12.4	58.1 ±5.3	U = 78	0.5651

* as in Table 3.

Compared to the control group, cadets obtained better results for the minimal auditory reaction time, the mean auditory reaction time and the maximal selective reaction time (statistically significant differences). Worse results were found for the minimal selective reaction time (see Table 4).

Table 5. Mean values of the results of the tests that evaluated coordination motor abilities in the group of juniors and their non-athlete peers

No.	Variable	Unit	Juniors (N = 10)	Control group (N = 18)	Test value	p
			x̄ ±SD	x̄ ±SD		
1	Kinaesthetic differentiation, temporal parameters	pixel	29.0 ±15.6	45.1 ±25.5	U=53	0.0761
2	Frequency of movements	n – number	44.8 ±9.91	45.2 ±7.5	t = -0.1	0.9126
3	Minimal visual reaction time	ms	206.0 ±14.3	237.8 ±15.9	t = -5.2	0.0000
4	Mean visual reaction time	ms	220.6 ±13.7	252.7 ±13.2	t = -6.1	0.0000
5	Maximal visual reaction time	ms	237.0 ±14.9	269.4 ±17.0	U = 10.5	0.0001
6	Minimal auditory reaction time	ms	177.0 ±13.4	208.9 ±20.0	t = -4.5	0.0001
7	Mean auditory reaction time	ms	185.4 ±11.6	227.8 ±18.6	C-C= -7.4	0.0000
8	Maximal auditory reaction time	ms	197.0 ±15.7	252.8 ±23.2	t = -6.8	0.0000
9	Minimal selective reaction time	ms	312.0 ±27.4	274.4 ±39.0	U = 33.5	0.0068
10	Mean selective reaction time	ms	380.1 ±40.2	417.6 ±70.5	U = 72.5	0.4014
11	Maximal selective reaction time	ms	466.0 ±76.3	637.8 ±130.3	U = 15.5	0.0004
12	Rhythmization	ms	115.0 ±82.1	148.5 ±74.5	U = 55.5	0.0981
13	Movement integration, labyrinth to the left	s	44.1 ±6.0	50.1 ±9.4	t = -1.8	0.0799
14	Movement integration, labyrinth to the left	n – mistakes	11.4 ±7.3	16.1 ±7.4	t = -1.6	0.1227
15	Spatial orientation, free mode	s	54.9 ±7.8	60.6 ±9.5	U = 50.5	0.0582

* as in Table 3.

Significantly lower means (better results) in juniors compared to non-athlete peers were observed for the minimal visual reaction time, the mean visual reaction time, the maximal visual reaction time, the minimal auditory reaction time, the mean auditory reaction time, the maximal auditory reaction time and the maximal selective reaction time. A statistically higher mean (a worse result) was found for the minimal selective reaction time (see Table 5).

DISCUSSION

In the present study, coordination motor abilities were evaluated based on computer tests which are included in one of the laboratory measurement methodologies. Testing validity and reliability was verified in a previous pilot study [24]. The ICC values obtained for the analysed computer tests ranged from 0.79 to 0.53 and were similar to the results obtained for the Vienna Test Battery [25]. However, interpretation of the results should take into consideration that coordination tests concerned mainly fine motor skills and were performed under non-specific conditions for badminton players. Nevertheless, the literature concerning the determinants of sports performance uses a similar methodological approach.

With consideration for the information presented in the introduction section, badminton should be included in the third (the most difficult) sport category [26]. They are characterized by the highest level of variability of movement structures due to the dominance of external stimuli. It depends on the level of motor abilities, psychological variables (personality and motivation), sociological characteristics and, finally, morphological and structural aptitudes [27]. It is obvious that an important role in the group of motor abilities (due to the character of the game) is played by coordination motor abilities. Unfortunately, few studies have examined these abilities, with most of them concerning only reaction times. This disproportion in the number of the studies is not surprising since badminton is numbered among the fastest racket sports [4]. Therefore, reaction time is among leading abilities with neurofunctional nature that affects playing effectiveness. A comparison of the results of reaction times [18] of non-athlete peers with the results obtained by badminton players revealed a higher level of this variable in non-athletes. The authors emphasized that the results can be attributable to badminton training. This thesis is consistent with the results of our study. A comparison of the arithmetic means of the times of a simple reaction to a visual stimulus, a simple reaction to an auditory stimulus and a complex reaction between badminton players and non-athlete peers revealed statistically significant differences in most cases. Badminton players had better results in all age groups (younger cadets, cadets, juniors). These findings are significant from the standpoint of optimization of sports training [28]. It is generally known that a «champion model» can be found for each sport, with a set of leading variables which are also determined genetically [29]. In conclusion, anticipation of modifications of these variables requires not only solid knowledge of problems connected with human ontogeny but also the awareness of individual differences in an individual speed of development of children and young people. This approach implies the necessity of using only the variables which can be realistically predicted over the training process.

In the case of other tested coordination abilities, such as kinaesthetic differentiation of temporal parameters of movements, the frequency of movements of upper limbs, rhythmization, movement integration and spatial orientation, no significant differences were found between badminton players and untrained peers. These correlations were observed for all age groups. The results are somewhat surprising, especially with respect to spatial orientation and differentiation of movements (coordination abilities with a higher level of movement organization). As demonstrated by Jaworski and Żak [20], the complex of variables that determine physical abilities has a dominant effect on playing quality in all age groups of badminton players. Nevertheless, spatial orientation (free mode, R^2pop. = 18%) has a significant effect on the model that determines sports performance, especially in the group of cadets. Abilities that allow the player to assess the trajectory of the fast-moving shuttlecock and observation of current situation on the court are very important in badminton. Furthermore, the entire complex of the coordination abilities included in the model explains 36% of the playing effectiveness. It should be emphasized that the developed morphofunctional models [11] point to the importance of spatial orientation at each stage of badminton training. This variable was included in the model of younger cadets, cadets and juniors. With the advances of sport, the role of neurofunctional variables is becoming less pronounced. This is likely to be caused by lower variation of the results of coordination abilities in the oldest age group.

The focus of this study was on the evaluation of differentiation of the level of coordination abilities between individuals at various stages of badminton training. The majority of comparative studies concern reaction time (simple or complex reaction). The level of results obtained for this ability depends on numerous factors, e.g. age, the type of stimulus (visual, auditory, complex), training experience and the stage of training [18, 30, 31, 32, 33]. This study found that the results of young badminton players are improving for consecutive training categories, which is caused by developmental processes and sport-specific training. A characteristic distribution of means depending on the stimulus as described in the literature was also observed. The studies cited above found the fastest reaction to an auditory stimulus, followed by slightly worse reaction to a visual stimulus and the worst results for selective reaction. The results of the present study are consistent with these findings. In most cases, the differences between extreme groups were also significant in light of the statistics. No statistically significant differences between badminton players from different age groups were observed for other coordination abilities, such as kinaesthetic differentiation of temporal parameters of movement, the frequency of movements of the upper limbs and mistakes during a movement integration test. However, a characteristic arrangement of means is noticeable, with the best results obtained by athletes from the oldest age groups.

CONCLUSIONS

The following conclusions can be drawn based on the results:

- Chronological age and training experience have an effect on the level of analysed coordination motor abilities of badminton players.
- Differences in the level of coordination motor abilities between badminton players and non-athlete peers are observed in individual age groups

(younger cadets, cadets, juniors). They are especially pronounced for times of simple reaction to visual and auditory stimuli.

- A higher level of coordination motor abilities of badminton players compared to the control group suggests their significant importance to this sport.

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