

MOVEMENT COORDINATION: IDENTIFICATION OF DEVELOPMENT PECULIARITIES IN GIRLS AND BOYS AGED 11-13

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Abstract

The study objective is to determine the possibility of identifying the state of coordination abilities development in girls and boys aged 11-13 using the methodology of multidimensional statistics.

Materials and methods. *Study participants.* The study involved girls: 11 (n=20), 12 (n=23), 13 (n=19) years old; boys: 11 (n=21), 12 (n=20), 13 (n=19) years old.

Study organization. The paper used analysis and generalization of scientific literature data, testing, discriminant analysis. *Testing procedure.* The testing program included well-known tests (Liakh, 2000; Serhiienko, 2001; Ivashchenko, 2016).

Study results. The first canonical function explains 65.7% of the results variation, the second one – 25.1%, the third – 4.8%, which indicates their informative value. The coefficients of canonical correlation indicate the prognostic value of these functions. The first canonical discriminant function is most substantially related to the results of tests 4 ($r=0.526$), 14 ($r=0.377$), 2 ($r=-0.306$): therefore, a significant difference between the girls and boys aged 11-13 is observed in the development level of relative and speed strength, movement coordination. The structure coefficients of the second canonical discriminant function indicate that the function is most substantially related to variables 2 ($r=0.502$), 16 ($r=0.434$), 9 ($r=0.379$), 17 ($r=0.357$): so, a significant difference between the girls aged 12-13 and boys aged 11-13 is observed in speed strength, vestibular stability, and anthropometric data.

Conclusions. The discriminant models characterize both age- and gender-related peculiarities of movement coordination development in the girls and boys aged 11-13. The data obtained show significant differences between the groups of girls and boys aged 11-13 both in the structure of coordination abilities development and the level of preparedness, and highlight the need to conduct separate physical education classes for girls and boys. Different programs should be used to develop coordination abilities in boys and girls aged 11-13.

Keywords: discriminant analysis, coordination abilities, comprehensive control, girls, boys

Introduction

One of the key tasks of the modern school is to develop motor function in schoolchildren. Data on age- and gender-related regularities of motor function development provide background for organizing physical education of children and adolescents. Physical activity and its impact on population health is one of the research problems in physical education (Bădicu, & Balint, 2016; Bădicu, 2018). Physical education of schoolchildren aims at developing children's motor

function and includes: optimizing children's physical development (Balsevich, 2000; Ilyin, 2003), improving their motor abilities, promoting and protecting their health (Ivashchenko, 2016; Emeljanovas, Mieziene, & Putriute, 2015), developing motor skills (Han, Fu, Cobby, & Sanders, 2017). Coordination abilities belong to the basic abilities and can be developed in school age (Balsevich, 2000; Liakh, 2000).

Numerous studies have reached conclusions on the following points:

- the effectiveness of comprehensive development of motor abilities in children (Liakh, 2000; Krutsevych, & Bezverkhnia, 2010);

- the influence of movement coordination level on building motor skills in schoolchildren (Khudolii, Ivashchenko, & Chernenko, 2015; Ivashchenko, 2016; Kapkan, 2015);
- the interrelation of anthropometric, motor and cognitive abilities in children (Iadreev, Cherkashin, Vujkov, & Drid, 2015; Novak, Podnar, Emeljanovas, & Marttinen, 2015);
- the relationship between the body mass index, subcutaneous fat and the manifestation of movement coordination in children aged 11-14 (Drid, Vujkov, Jaksic, Trivic, Marinkovic, & Bala, 2013; Han, A., Fu, A., Copley, S., & Sanders R. H., 2017);
- the influence of visual perception on children's movement coordination of different parts of the body (Agricola, Psotta, Abdollahipour, & Nieto, 2015; Palomo-Nieto, Psotta, Agricola, Abdollahipour, & Valtr, 2015);
- the effect of physical activity modes on the plasticity of motor skills in schoolchildren (Hadžić, Bjelica, Vujović, & Popović, 2015; Khudolii, & Ivashchenko, 2014).

When studying the structure of schoolchildren's motor preparedness, it is effective to use multidimensional methods of mathematical statistics, such as factor and discriminant analyses (Ivashchenko, 2016; Lopatiev, Ivashchenko, Khudolii, Pjanylo, Chernenko, & Yermakova, 2017). Discriminant analysis also proved effective for studying the training process of athletes (Doğan, Işık, & Ersöz, 2016; Miarka, Fukuda, Del Vecchio, & Franchini, 2016).

In available literature, however, there are not enough data on comparative analysis of coordination abilities development in girls and boys aged 11-13 years.

Therefore, it is relevant to study the peculiarities of dynamics of coordination abilities development by identifying their state of development in girls and boys aged 11-13.

The study objective is to determine the possibility of identifying the state of coordination abilities development in girls and boys aged 11-13 using the methodology of multidimensional statistics.

Materials and methods

Study participants. The study involved girls: 11 (n=20), 12 (n=23), 13 (n=19) years old; boys: 11 (n=21), 12 (n=20), 13 (n=19) years old.

Study organization. The paper used analysis and generalization of scientific literature data, testing, methods of mathematical statistics.

Testing procedure. The testing program included well-known tests (Liakh, 2000; Serhienko, 2001; Ivashchenko, 2016). To evaluate motor preparedness,

the study recorded the results of motor tests, body height and weight:

- Test 1 "30 m running (s)";
- Test 2 "Standing long jump (cm)";
- Test 3 "Six standing accuracy ball handlings to a partner from a 7 m distance using one of the techniques learned";
- Test 4 "Pull-ups (number of times)";
- Test 5 "Sit-ups in 30 seconds";
- Test 6 "Evaluation of the sense of movement speed in sprinting";
- Test 7 "Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 80% intensity of maximum)";
- Test 8 "Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 90% intensity of maximum)";
- Test 9 "Static equilibrium evaluation by E. Ya. Bondarevsky's method";
- Test 10 "Evaluation of dynamic equilibrium by the BESS method";
- Test 11 "Evaluation of the ability for vestibular (statokinetic) stability. Running with turns";
- Test 12 "Rhythmic hand tapping";
- Test 13 "Rhythmic movements of upper and lower limbs";
- Test 14 "Shuttle run (4×9 m)";
- Test 15 "Tossing a ring over a peg";
- Test 16 "Height (cm)";
- Test 17 "Body weight (kg)".

Statistical analysis. The study materials were processed by the IBM SPSS 20 statistical analysis software. In the process of discriminant analysis, the study created a prognostic model for group membership. This model develops a discriminant function (or, when there are more than two groups — a set of discriminant functions) in the form of a linear combination of predictor variables, ensuring the best division of groups. These functions are developed according to a set of observations, for which their group membership is known. These functions can continue to be used for new observations with known values of predictor variables and unknown group membership.

For every variable, the study calculated the following: mean values, standard deviations, single-factor dispersion analysis (Box's M test, in-group correlation matrix, in-group covariance matrix, covariance matrices for separate groups, general covariance matrix). For every canonical discriminant function, the study calculated: eigenvalue, dispersion percentage, canonical correlation, Wilks' Lambda, Chi-square. For every step, it calculated: prior probabilities, Fisher's function coefficients, unstandardized function coefficients, Wilks' Lambda for every canonical function.

Table 1. Results of Comparative Analysis of Coordination Preparation of Girls and Boys Aged 11-13

No	Test	Aged	Girls		Boys		t	P
			X	s	X	s		
1	30 m running (s)	11	7,06	,45	6,45	,38	4,740	<0,001
		12	6,86	,39	6,28	,35	5,078	<0,001
		13	6,65	,43	6,29	,37	2,704	<0,010
2	Standing long jump (cm)	11	124,75	9,09	138,90	11,94	-4,253	<0,001
		12	128,48	10,99	150,50	10,69	-6,633	<0,001
		13	141,42	8,13	160,89	10,71	-6,315	<0,001
3	Six standing accuracy ball handlings to a partner from a 7 m distance using one of the techniques learned	11	2,30	1,08	4,14	1,35	-4,805	<0,001
		12	2,26	,96	3,40	,94	-3,910	<0,001
		13	2,16	1,01	3,68	,95	-4,796	<0,001
4	Pull-ups (number of times)	11	5,25	1,74	2,71	,85	5,972	<0,001
		12	8,00	2,29	3,20	1,19	8,401	<0,001
		13	10,32	2,60	4,00	1,33	9,409	<0,001
5	Sit-ups in 30 seconds	11	14,00	3,04	19,67	5,05	-4,322	<0,001
		12	17,30	4,17	18,25	5,57	-,635	>0,529
		13	17,32	4,84	21,84	4,47	-2,992	<0,005
6	Evaluation of the sense of movement speed in sprinting	11	,50	,18	,36	,14	2,745	<0,009
		12	,38	,08	,37	,11	,211	>0,834
		13	,31	,086	,33	,13	-,777	>0,442
7	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 80% intensity of maximum)	11	,33	,12	,32	,12	,379	>0,706
		12	,30	,11	,29	,14	,251	>0,803
		13	,37	,09	,35	,09	,469	>0,642
8	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 90% intensity of maximum)	11	,27	,07	,25	,09	,674	>0,504
		12	,31	,09	,27	,08	1,457	>0,153
		13	,32	,07	,32	,09	0	
9	Static equilibrium evaluation by E. Ya. Bondarevsky's method	11	34,80	11,27	28,64	11,25	1,753	>0,087
		12	38,59	8,88	31,54	10,08	2,437	<0,019
		13	49,12	7,68	45,31	9,41	1,369	>0,179
10	Evaluation of dynamic equilibrium by the BESS method	11	42,65	8,58	40,05	5,67	1,150	>0,257
		12	36,30	8,06	39,70	6,12	-1,537	>0,132
		13	36,05	8,76	34,79	7,43	,479	>0,635
11	Evaluation of the ability for vestibular (statokinetic) stability. Running with turns	11	4,75	1,13	4,24	1,12	1,443	>0,157
		12	4,80	,99	4,48	,98	1,067	>0,292
		13	5,42	1,17	4,52	,97	2,585	<0,014
12	Rhythmic hand tapping	11	5,65	1,72	5,38	1,39	,550	>0,585
		12	5,78	1,54	6,40	1,73	-1,240	>0,222
		13	4,00	1,15	3,84	,95	,459	>0,649
13	Rhythmic movements of upper and lower limbs	11	4,25	,96	4,00	1,00	,813	>0,421
		12	4,48	1,12	4,70	1,13	-,644	>0,523
		13	3,63	1,12	3,89	1,10	-,732	>0,469
14	Shuttle run (4x9 m)	11	13,75	,97	12,48	,90	4,310	<0,001
		12	14,22	1,06	12,45	,95	5,727	<0,001
		13	14,16	1,18	11,35	,85	8,408	<0,001
15	Tossing a ring over a peg	11	9,05	2,94	11,05	2,39	-2,387	<0,022
		12	10,17	2,37	9,70	2,62	,619	>0,540
		13	10,58	2,43	11,42	2,48	-1,057	>0,298
16	Height (cm)	11	143,00	6,49	142,67	5,73	,174	>0,862
		12	148,96	7,18	151,40	6,56	-1,158	>0,253
		13	157,11	8,55	156,63	10,44	,153	>0,879
17	Body weight (kg)	11	35,80	7,76	34,62	6,48	,530	>0,599
		12	39,37	10,45	44,10	7,88	-1,654	>0,106
		13	46,21	8,93	50,89	11,26	-1,420	>0,164

The study protocol was approved by the Ethical Committee of H. S. Skovoroda Kharkiv National Pedagogical University. In addition, the children and their parents or legal guardians were fully informed about all the features of the study, and a signed informed-consent document was obtained from all the parents.

Study results

Table 1 shows the results of comparison between the coordination preparedness of the girls and boys aged 11-13. According to the anthropometric indices, the difference between the girls and boys is statistically insignificant ($p > 0.05$).

The girls show statistically significantly better results in test 9 “Static equilibrium evaluation by E. Ya. Bondarevsky’s method” (12 years old). There is a statistically insignificant ($p > 0.05$) difference in the results of the tests evaluating running speed: test 6 “Evaluation of the sense of movement speed in sprinting”, test 7 “Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 80% intensity of maximum)”, test 8 “Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 90% intensity of maximum)”. In tests 12, 13 evaluating movement coordination of different parts of the body and in test 15 evaluating spatial accuracy of movements, the difference in the results of the girls and boys aged 11-13 is statistically insignificant ($p > 0.05$).

In tests 1, 2, 3, 4, 5, 14, the girls show statistically significantly worse results than the boys.

To clarify the peculiarities of coordination abilities development in the girls and boys aged 11-13, the study conducted a discriminant analysis. The results obtained during the discriminant analysis allow to identify the state of movement coordination development in the girls and boys (see Table 2-7).

The first canonical function explains 65.7% of the results variation, the second one — 25.1%, the third — 4.8%, which indicates their informative value (see Table 2). The coefficients of canonical correlation indicate the prognostic value of these functions.

Table 2. Summary of Canonical Discriminant Functions. Eigenvalues. Girls and boys aged 11-13

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	7.459a	65.7	65.7	.939
2	2.851a	25.1	90.8	.860
3	.542a	4.8	95.6	.593
4	.372a	3.3	98.9	.521
5	.127a	1.1	100.0	.336

Table 3. Canonical discriminant functions. Wilks’ Lambda. Girls and boys aged 11-13

Test of Function(s)	Wilks’ Lambda	Chi-square	df	Sig.
1 through 5	.013	476.662	85	.000
2 through 5	.109	242.854	64	.000
3 through 5	.419	95.201	45	.000
4 through 5	.646	47.787	28	.011
5	.887	13.139	13	.437

Table 3 shows the analysis of the canonical functions. The first line contains the value $\lambda=0.013$ ($p=0.001$) for the entire set of canonical functions, the second line contains the data after the exclusion of the first function ($\lambda=0.109$; $p=0.001$), the third line — the data after the exclusion of the first and second functions ($\lambda=0.419$; $p=0.001$). The first, second, and third functions have a high discriminative ability and value of interpretation with regard to the general totality.

Table 4 shows the standardized canonical discriminant function coefficients, which allow to determine the contribution ratio of the variables to the function result.

- function 1: variables 4 (0.837), 14 (0.526), 2 (-0.488) make the largest contribution to the canonical function;
- function 2: variables 2 (0.518), 16 (0.483), 12 (-0.415), 9 (0.370) make the largest contribution to the canonical function;
- function 3: variables 6 (0.696), 1 (0.432), 12 (-0.390), 9 (0.365) make the largest contribution to the canonical function;
- function 4: variables 12 (0.395), 3 (-0.389), 2 (0.363) make the largest contribution to the canonical function;
- function 5: variables 10 (0.543), 5 (-0.414), 1 (-0.377), 11 (0.360) make the largest contribution to the canonical function.

In identifying the state of coordination abilities development in the girls and boys aged 11-13, the first canonical discriminant function is the most important one. By these variables characterizing the level of relative and speed strength development and the level of movement coordination development, it is possible to classify the girls and boys into groups.

Table 5 shows the structure coefficients of the canonical discriminant functions, which are the coefficients of correlation between the variables and the function. The first canonical discriminant function is most substantially related to the results of tests 4 ($r=0.526$), 14 ($r=0.377$), 2 ($r=-0.306$): thus, a significant difference between the girls and boys aged 11-13 is observed in the level of development of relative and speed strength and movement coordination. The structure coefficients of the second canonical discriminant function show that

Table 4. Standardized Canonical Discriminant Function Coefficients. Girls and boys aged 11-13

No	Test	Function				
		1	2	3	4	5
1.	30 m running (s)	.423	-.099	.432	-.101	-.377
2.	Standing long jump (cm)	-.488	.518	.200	.363	.239
3.	Six standing accuracy ball handlings to a partner from a 7 m distance using one of the techniques learned	-.284	-.078	-.252	-.389	.206
4.	Pull-ups (number of times)	.837	.214	-.235	-.026	.070
5.	Sit-ups in 30 seconds	-.043	.182	-.382	-.201	-.414
6.	Evaluation of the sense of movement speed in sprinting	-.174	-.093	.696	.327	.045
7.	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 80% intensity of maximum)	-.039	.087	.358	-.253	.144
8.	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 90% intensity of maximum)	.059	.171	-.121	.067	-.352
9.	Static equilibrium evaluation by E. Ya. Bondarevsky's method	.095	.370	.365	-.167	-.016
10.	Evaluation of dynamic equilibrium by the BESS method	-.079	-.156	.106	-.044	.543
11.	Evaluation of the ability for vestibular (statokinetic) stability. Running with turns	.173	.133	.089	.167	.360
12.	Rhythmic hand tapping	.020	-.415	-.390	.395	-.042
13.	Rhythmic movements of upper and lower limbs	-.121	-.167	-.215	.338	-.332
14.	Shuttle run (4x9 m)	.526	-.043	-.244	.045	.205
15.	Tossing a ring over a peg	-.068	.055	-.237	-.331	-.097
16.	Height (cm)	.141	.483	-.295	.263	.180
17.	Body weight (kg)	-.111	.001	.319	.179	-.313

the function is most substantially related to variables 2 ($r=0.502$), 16 ($r=0.434$), 9 ($r=0.379$), 17 ($r=0.357$): thus, a significant difference between the girls aged 12-13 and boys aged 11-13 is observed in speed strength, vestibular stability, and anthropometric data.

Table 6 shows the classification results of the groups, 93.4% of the original grouped observations were classified correctly. Therefore, the canonical discriminant function can be used to identify the state of movement coordination development in the girls and boys aged 11-13.

Discussion

The above-mentioned results give evidence of a statistically significant difference in the strength preparedness of the girls and boys aged 11-13, as well as in the results of movement coordination tasks that require speed and strength preparedness ($p<0.001$): the boys show better results. The girls have better results in vestibular stability than the boys. The girls' and boys' results of the tests evaluating temporal characteristics of movement, spatial accuracy, and movement

coordination of different parts of the body do not statistically significantly differ ($p>0.05$).

As a result of the discriminant function analysis, the study determined that to identify the level of coordination abilities development in boys aged 11, 12 and 13, the following tests can be used: test 9 "Static equilibrium evaluation by E. Ya. Bondarevsky's method" and test 14 "Shuttle run (4x9 m)", which characterize vestibular stability and general movement coordination (Ivashchenko, Khudolii, Iermakov, & Prykhodko, 2018). Unlike boys, to identify the level of coordination abilities development in girls aged 11, 12 and 13, it is advisable to use the tests that characterize relative and speed strength, the sense of running speed and vestibular stability (Ivashchenko, Khudolii, Iermakov, Prykhodko, & Cieslicka, 2018).

The discriminant analysis of the girls' and boys' data allowed to obtain models that characterize both age- and gender-related peculiarities of movement coordination development. The study determined statistically significant differences between multidimensional mean values (centroids) in each group ($p<0.001$) (see Table 7).

Table 5. Structure Matrix. Girls and boys aged 11-13

No	Test	Function				
		1	2	3	4	5
4.	Pull-ups (number of times)	.526*	.350	-.164	.028	.081
14.	Shuttle run (4x9 m)	.377*	-.165	-.156	.092	.260
2.	Standing long jump (cm)	-.306	.502*	-.100	.283	.194
16.	Height (cm)	.018	.434*	-.067	.370	.002
9.	Static equilibrium evaluation by E. Ya. Bondarevsky's method	.123	.379*	.228	-.020	-.191
17.	Body weight (kg)	-.041	.357*	.071	.356	-.137
6.	Evaluation of the sense of movement speed in sprinting	.020	-.223	.398*	.133	-.127
1.	30 m running (s)	.215	-.207	.371*	-.085	-.336
12.	Rhythmic hand tapping	-.016	-.318	-.267	.505*	-.052
13.	Rhythmic movements of upper and lower limbs	-.017	-.117	-.116	.390*	-.283
3.	Six standing accuracy ball handlings to a partner from a 7 m distance using one of the techniques learned	-.259	-.004	-.212	-.368*	.100
15.	Tossing a ring over a peg	-.043	.117	-.130	-.312*	-.154
10.	Evaluation of dynamic equilibrium by the BESS method	-.017	-.186	.154	.042	.426*
5.	Sit-ups in 30 seconds	-.130	.176	-.236	-.229	-.340*
8.	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 90% intensity of maximum)	.051	.154	.044	.009	-.316*
11.	Evaluation of the ability for vestibular (statokinetic) stability. Running with turns	.108	.094	.049	.069	.242*
7.	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 80% intensity of maximum)	.019	.101	.173	-.175	.178*

Table 6. Classification Resultsa. Girls and boys aged 11-13

Scale	Group	Predicted Group Membership						Total	
		Girls			Boys				
		1.00	2.00	3.00	5.00	6.00	7.00		
Original	Count	1.00	21	0	0	0	0	0	21
		2.00	1	19	0	0	0	0	20
		3.00	0	1	18	0	0	0	19
		5.00	0	0	0	19	1	0	20
		6.00	0	0	0	1	20	2	23
		7.00	0	0	0	1	1	17	19
	%		1.00	100.0	.0	.0	.0	.0	.0
		2.00	5.0	95.0	.0	.0	.0	.0	100.0
		3.00	.0	5.3	94.7	.0	.0	.0	100.0
		5.00	.0	.0	.0	95.0	5.0	.0	100.0
		6.00	.0	.0	.0	4.3	87.0	8.7	100.0
		7.00	.0	.0	.0	5.3	5.3	89.5	100.0

93.4% of the original grouped cases correctly classified

Table 7. Functions at Group Centroids*. Girls and boys aged 11-13

Group	Function				
	1	2	3	4	5
Girls aged 11	-2.327	-1.331	-.547	-.954	.171
Girls aged 12	-2.535	-.385	-.479	1.066	.243
Girls aged 13	-3.049	2.429	.634	-.141	-.365
Boys aged 11	1.350	-1.983	1.309	.090	.072
Boys aged 12	2.808	-.557	-.654	.117	-.517
Boys aged 13	3.468	2.209	-.112	-.163	.470

*Unstandardized canonical discriminant functions evaluated at group means

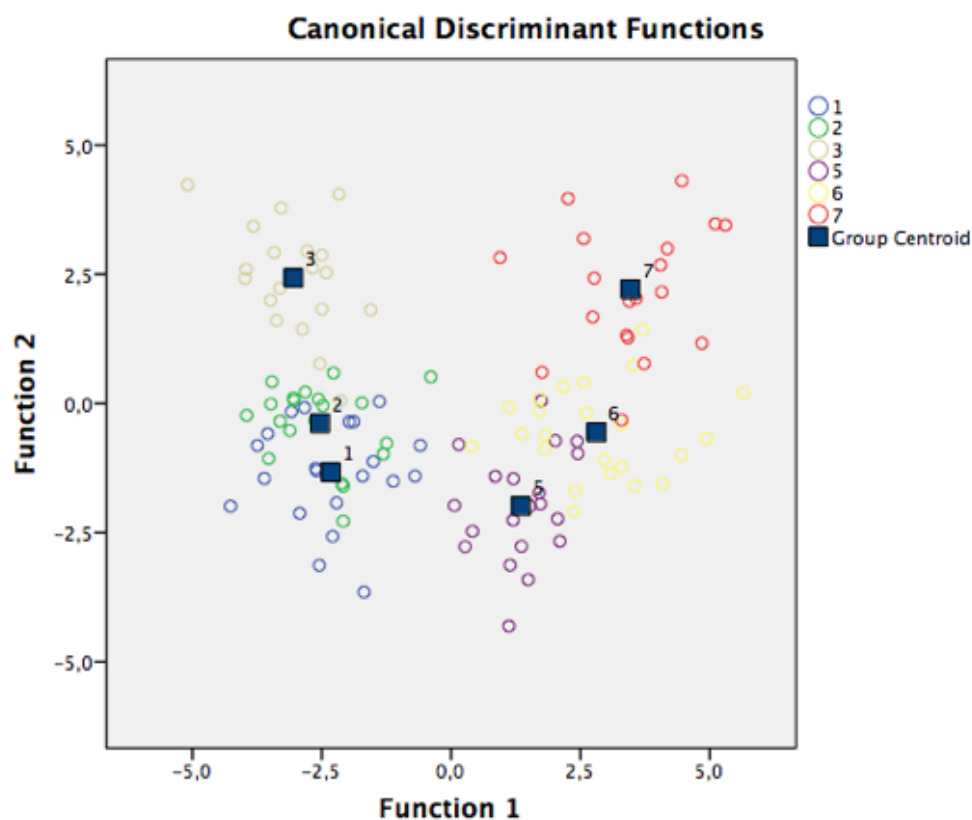


Figure 1. Graphical representation of the classification results (girls: 1 — aged 11, 2 — aged 12, 3 — aged 13; boys: 5 — aged 11, 6 — aged 12, 7 — aged 13)

The graphical material shown in Figure 1 indicates the density of objects in each group and a distinct boundary between them. This makes it possible to argue that the girls and boys aged 11-13 can be classified based on the results of testing using the battery of tests provided.

All the above speak to the existence of substantial differences between the groups of girls and boys aged 11-13 both in the structure of coordination abilities development and the level of preparedness, and highlight the need to conduct separate physical education classes for girls and boys. Different programs should be used for developing coordination abilities in boys and girls aged 11-13.

The above-mentioned results show that discriminant analysis allows to identify the state of coordination abilities development in the girls and boys aged 11-13 by the results of testing, and supplement the data on the use of discriminant function in classifying schoolchildren by motor activity (Gert-Jan de Bruijn, & Benjamin Gardner, 2011; Lulzim, 2013). As well as in the works by Geoffrey, and Gabie (1982), Ivashchenko, Iermakov, and Khudolii (2017), the study observed a high discriminative and predictive ability of these functions in evaluating age- and gender-related peculiarities of coordination abilities development in the girls and boys aged 11-13.

Table 8. Canonical Discriminant Function Coefficients (Unstandardized coefficients).

No	Test	Function				
		1	2	3	4	5
1.	30 m running (s)	1.066	-.249	1.090	-.253	-.951
2.	Standing long jump (cm)	-.047	.050	.019	.035	.023
3.	Six standing accuracy ball handlings to a partner from a 7 m distance using one of the techniques learned	-.268	-.074	-.238	-.367	.194
4.	Pull-ups (number of times)	.469	.120	-.132	-.015	.039
5.	Sit-ups in 30 seconds	-.009	.040	-.083	-.044	-.090
6.	Evaluation of the sense of movement speed in sprinting	-1.371	-.732	5.471	2.575	.357
7.	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 80% intensity of maximum)	-.340	.761	3.154	-2.222	1.265
8.	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 90% intensity of maximum)	.674	1.941	-1.380	.761	-3.995
9.	Static equilibrium evaluation by E. Ya. Bondarevsky's method	.010	.038	.037	-.017	-.002
10.	Evaluation of dynamic equilibrium by the BESS method	-.011	-.021	.014	-.006	.072
11.	Evaluation of the ability for vestibular (statokinetic) stability. Running with turns	.162	.125	.084	.156	.338
12.	Rhythmic hand tapping	.014	-.286	-.269	.272	-.029
13.	Rhythmic movements of upper and lower limbs	-.113	-.155	-.200	.314	-.309
14.	Shuttle run (4x9 m)	.529	-.043	-.246	.045	.206
15.	Tossing a ring over a peg	-.027	.022	-.093	-.130	-.038
16.	Height (cm)	.019	.064	-.039	.035	.024
17.	Body weight (kg)	-.012	.000	.036	.020	-.035
	(Constant)	-10.933	-15.306	-1.236	-9.599	-2.765

To practically apply the results of discriminant analysis, the canonical discriminant function coefficients are used (see Table 8). The probability of a case belonging to the predicted group is calculated by substituting the values of variables that correspond to the case into the discriminant function. By comparing the obtained results with the value of centroids, it is possible to determine the group the result belongs to (Table 7). To classify the preparedness state of the girls and boys aged 11-13, the first and second functions are used.

The above-mentioned data supplement the results:

- Agricola et al. (2015), Palomo-Nieto et al. (2015) on the importance of movement coordination of different parts of the body in evaluating children's and adolescents' coordination abilities;
- Volkov, and Nagovitsyn (2018) about the influence of motor activity and purposeful usage of physical education means on a positive dynamics of movement coordination development in children and adolescents;
- Meadmore, Exell, Burridge, Hughes, Freeman, and Benson (2018) on the gender differences in

children related to the body composition and movement coordination.

During the analysis, the study confirmed Ivashchenko's (2016) conclusions as to the usage of factor analysis for the evaluation of the current state of motor preparedness, and the usage of discriminant analysis for the evaluation of the state dynamics in the age range, which makes it possible to determine informative indicators for a comprehensive control of motor preparedness.

Conclusions

The discriminant analysis made it possible to determine informative indicators for a comprehensive control of coordination abilities development in the girls and boys aged 11-13; to answer the question of whether the difference between the states of coordination abilities development of the girls and boys aged 11-13 is significant; what motor tests most substantially influence the differentiation of classes; what class the object belongs to based on the values of discriminant variables.

The discriminant models characterize both age- and gender-related peculiarities of movement coordination

development in the girls and boys aged 11-13. The data obtained show significant differences between the groups of girls and boys aged 11-13 both in the structure of coordination abilities development and the level of preparedness, and highlight the need to conduct separate physical education classes for girls and boys. Different programs should be used for developing coordination abilities in boys and girls aged 11-13.

The prospect for further exploration is to study methodological approaches to programming the coordination abilities development in schoolchildren of middle school age.

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Conflict of interest

The authors declare no conflict of interest.

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КООРДИНАЦІЯ РУХІВ: РОЗПІЗНАННЯ ОСОБЛИВОСТЕЙ РОЗВИТКУ У ДІВЧАТ І ХЛОПЦІВ 11–13 РОКІВ

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Мета дослідження – визначити можливість розпізнання стану розвитку координаційних здібностей у дівчат і хлопців 11-13 років на основі методології багатовимірних статистик.

Матеріали і методи. У дослідженні прийняли участь дівчата: 11 (n=20), 12 (n=23), 13 (n=19) років; хлопці: 11 (n=21), 12 (n=20), 13 (n=19) років.

У роботі використані аналіз й узагальнення даних наукової літератури, тестування, дискримінантний аналіз.

Результати дослідження. Перша канонічна функція пояснює варіацію результатів на 65,7%, друга – на 25,1%, третя – на 4,8%, що свідчить про їх інформативність. Коефіцієнти канонічної кореляції вказують на прогностичність вказаних функцій. Перша канонічна дискримінантна функція най-

більш суттєво зв'язана з результатами тестів № 4 (r=0,526), 14 (r=0,377), 2 (r=-0,306): отже суттєва різниця між дівчатами і хлопцями 11-13 років спостерігається у рівні розвитку відносної і швидкісної сили, координації рухів. Структурні коефіцієнти другої канонічної дискримінантної функції вказують, що функція найбільш суттєво зв'язана зі змінними № 2 (r=0,502), 16 (r=0,434), 9 (r=0,379), 17 (r=0,357): отже суттєва різниця між дівчатами 12-13 років і хлопцями 11-13 років спостерігається в швидкісній силі, вестибулярній стійкості і антропометричних даних.

Висновки. Дискримінантні моделі характеризують як вікові, так і гендерні особливості розвитку координації рухів у дівчат і хлопців 11-13 років. Отримані дані свідчать про суттєві розбіжності

між групами дівчат і хлопців 11-13 років як у структурі розвитку координаційних здібностей, так і в рівні підготовленості, та вказують на необхідність проведення уроків фізичної культури окремо для дівчат і хлопців. Розвиток координаційних здібнос-

тей у дівчат і хлопців 11-13 років повинен здійснюватися за різними програмами.

Ключові слова: дискримінантний аналіз, координаційні здібності, наскрізний контроль, дівчата, хлопці.

КООРДИНАЦІЯ ДВИЖЕНЬ: РАСПОЗНАВАННЯ ОСОБЕННОСТЕЙ РАЗВИТИЯ У ДЕВОЧЕК И МАЛЬЧИКОВ 11-13 ЛЕТ

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Цель исследования – определить возможность распознавания состояния развития координационных способностей у девочек и мальчиков 11-13 лет на основе методологии многомерных статистик.

Материалы и методы. В исследовании приняли участие девочки: 11 (n = 20), 12 (n = 23), 13 (n = 19) лет; мальчики: 11 (n = 21), 12 (n = 20), 13 (n = 19) лет.

В работе использованы анализ и обобщение данных научной литературы, тестирование, дискриминантный анализ.

Результаты исследования. Первая каноническая функция объясняет вариацию результатов на 65,7%, вторая – на 25,1%, третья – на 4,8%, что свидетельствует об их информативности. Коэффициенты канонической корреляции указывают на прогностичность указанных функций. Первая каноническая дискриминантная функция наиболее существенно связана с результатами тестов № 4 ($r = 0,526$), 14 ($r = 0,377$), 2 ($r = -0,306$): значит существенная разница между девочками и мальчиками 11-13 лет наблюдается в уровне развития относительной и скоростной силы, координации движений. Структурные коэффициенты второй канонической

дискриминантной функции указывают, что функция наиболее существенно связана с переменными № 2 ($r = 0,502$), 16 ($r = 0,434$), 9 ($r = 0,379$), 17 ($r = 0,357$): значит существенная разница между девочками 12-13 лет и мальчиками 11-13 лет наблюдается в скоростной силе, вестибулярной устойчивости и антропометрических данных.

Выводы. Дискриминантные модели характеризуют как возрастные, так и гендерные особенности развития координации движений у девочек и мальчиков 11-13 лет. Полученные данные свидетельствуют о существенных различиях между группами девочек и мальчиков 11-13 лет как в структуре развития координационных способностей, так и в уровне подготовленности, и указывают на необходимость проведения уроков физической культуры отдельно для девочек и мальчиков. Развитие координационных способностей у девочек и мальчиков 11-13 лет должно осуществляться по различным программам.

Ключевые слова: дискриминантный анализ, координационные способности, сквозной контроль, девочки, мальчики.

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