

Coordinating abilities: recognition of a state of development of 11-13 years old boys

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Abstract

Purpose: To determine the possibility of recognizing the state of development of coordination abilities in boys 11-13 years old based on the methodology of multidimensional statistics.

Material: The study involved boys: 11 (n = 21), 12 (n = 20), 13 (n = 19) years. It was used 14 tests.

Results: In the recognition of the state of development of coordination abilities in boys of 11-13 years old, the most important are the results in the tests: №2 "Standing long jump (cm)" (0.633); №12 "Rhythmic hand tapping" (-0.493); №15 "Tossing a ring over a peg" (-0.347). The enumerated tests characterize speed-power abilities, coordination of movements by hands and spatial precision of throws. In recognition of the state of development of coordination abilities in boys of 12-13 years old, the most important are the results in the tests: №12 "Rhythmic hand tapping" (0.691); №2 "Standing long jump (cm)" (0,387); №1 "30 m running (s)" (-0,356). The enumerated tests characterize the coordination of movements by the hands, speed-strength abilities and speed.

Conclusions: Discriminant analysis allowed to determine: informative indicators for the walkthrough of the development of coordination abilities in boys of 11-13 years old; to answer such question as how significantly distinguished the state of development of coordination abilities in boys of 11-13 years old; which motor tests most significantly affect the differentiation of classes; to which class the object belongs to based on the values of discriminant variables.

Keywords: discriminant analysis, walkthrough, motor tests, boys.

Introduction

In the process of physical education of schoolchildren the tasks of optimizing the physical development of the child are solved [1, 2], improvement of motor abilities, strengthening and health protection [3, 4].

Based on numerous studies, conclusions are drawn:

- the need for a comprehensive development of strength, coordination, endurance and flexibility in children [5, 6];

- the importance of developing coordination of movements in the process of physical education of schoolchildren [3, 7];

- on the relationship of anthropometric, motor and cognitive abilities in children [8, 9];

- the association of the body mass index and subcutaneous adipose tissue with the manifestation of coordination of movements in children 11-14 years [10];

- on the influence of visual perception on the coordination of movements of various parts of the body of children [11, 12];

- on the effect of loads on the plasticity of motor skills in schoolchildren [13, 14].

In other works, attention was focused on clarification of the concept of coordination abilities [2, 5], as well as on the definition of their structure [15, 16].

It is established that in the motor readiness of children and adolescents, coordination abilities occupy a leading

place [17, 18]. Multidimensional methods of mathematical statistics are used to study the structure of motor readiness of schoolchildren: factor and discriminant analysis [3, 19]. The use of factor analysis allowed to establish the structure of development of coordination abilities in 11-13 years old boys and girls [20, 21]. However, in available literature there is not enough data on the peculiarities of the dynamics of development of coordination abilities in high school students.

Thus, the study of the peculiarities of the dynamics of development of coordination abilities on the basis of recognition of their state of development in middle school boys is relevant.

The purpose of the study is to determine the possibility of recognizing the state of development of coordination abilities in 11-13 years old boys based on the methodology of multidimensional statistics.

Materials and methods

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

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 organization. The study used the following methods: analysis and collation of scientific and

methodological literature, general scientific methods of theoretical level, such as analogy, analysis, synthesis, abstraction, induction, as well as general scientific methods of empirical level: observation, testing, experiment.

Testing procedure. The testing program included well-known tests [3, 5, 22]. To evaluate motor preparedness, the study recorded the results of motor tests, body height and weight [21]:

- 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”.

Pedagogical testing was conducted to determine the possibility of recognizing the state of development of coordination abilities in boys aged 11-13 years based on the methodology of multidimensional statistics.

Statistical analysis.

In discriminant analysis we formed prognostic model of belonging to group. This model builds discriminant function (or if the quantity of groups is more than two – a set of discriminant functions) in the form of linear combination of variables-predictors that ensures the

best groups’ division. These functions are built by a set of observations, for which their belonging to groups is known. Further, these functions can be used for new observations with known values of variables- predictors and unknown belonging to group.

For every variable we calculated the following: mean values, standard deviations, single - factorial dispersion analysis for every variable (Box’s M test, in-group correlation matrix, in-group covariance matrix, covariance matrixes for separate groups, general covariance matrix). For every canonic discriminant function we calculated: eigenvalue, dispersion percentage, canonic correlation, Wilks’ Lambda, Chi-square. For every step we calculated: priory probabilities, Fisher function’s coefficients, non-standardized coefficients of function, Wilks’ Lambda for every canonic function.

Results

The tables show the results of discriminant analysis, which allows to recognize the state of development of coordination of movements in boys of 11-13 years.

The first canonical function explains the variation of the results by 77.2%, the second - by 22.8%. This indicates their informativity (Table 1). The coefficients of canonical correlation indicate the prognosticity of the first and second functions.

Table 2 shows the analysis of canonical functions. The first line contains the value $\lambda = 0.099$ ($p = 0.001$) for the entire set of canonical functions. The second line contains data after the exclusion of the first function ($\lambda = 0,472$; $p = 0,002$). The first and second functions have a high discriminative ability and meaning in the interpretation of the general population.

Table 3 shows the normalized coefficients of the canonical discriminant function, which allow us to determine the ratio of the contribution of variables to the result of a function. The greatest contribution to the first canonical function is the variables number 2, 16, 12, 15: the larger the values of these variables, the greater the value of the function. With the greatest contribution to the second canonical function, the variables are number 12, 2, 1: the larger the values of these variables, the greater the value of the function.

In identifying the state of development of coordination

Table 1. Summary of Canonical Discriminant Functions. Eigenvalues. Boys of 11-13 years

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	3,789 ^a	77,2	77,2	,889
2	1,120 ^a	22,8	100,0	,727

Table 2. Canonical discriminatory functions. Wilks’ Lambda. Boys of 11-13 years

Test of Function(s)	Wilks’ Lambda	Chi-square	df	Sig.
1 through 2	,099	113,563	34	,000
2	,472	36,817	16	,002

abilities in boys of 11-13 years old, the most important are the results in tests: №2 “Standing long jump (cm)” (0.633), №12 “Rhythmic hand tapping” (-0.493), №15 “Tossing a ring over a peg” (-0.347). The named tests characterize speed-power abilities, coordination of movements by hands and spatial precision of throws.

In the recognition of the state of development of coordination abilities in boys of 12-13 years old the most important are the results in tests: №12 “Rhythmic hand tapping” (0.691), №2 “Standing long jump (cm)” (0.377), test №1 “30 m running (s)” (-0.356). The enumerated tests characterize the coordination of movements by the hands, speed-strength abilities and speed.

Table 4 shows the structural coefficients of the first and second canonical discriminant functions, which are coefficients of the correlation of variables with a function. Thus, the first canonical discriminant function is most closely connected with the results of tests №2, 17, 16, 9, 14: hence, the significant difference between boys 11, 12 and 13 years is observed in the level of development of high-speed force, coordination of movements and anthropometric data. The structural coefficients of the second canonical discriminant function indicate that the function is most closely related to the variables №12, 13, 15, 3: hence, the significant difference between the boys of 12 and 13 years is observed in coordinating the movements of the hands and the accuracy of the throws.

Table 5 shows the results of classification of groups, 93.3% of the output grouped observations are categorized correctly. Thus, a canonical discriminatory function can be used to recognize the state of coordination of movements in boys aged 11-13 years.

Discussion

The presented results indicate that discriminant analysis allows to recognize the state of development of coordination abilities in boys aged 11-13 years on the results of testing. Our research complements data on the use of discriminant function in the classification of students by motor activity [23, 24]. According to our results, there is a high discriminant and prognostic ability of the received functions in assessing the motor readiness of children and adolescents. Similar results were obtained in Geoffrey D.B. et al [25], Ivashchenko et al. [26].

For the practical application of the results of discriminant analysis, the coefficients of the canonical discriminant function are used (Table 6). The probability of belonging to a certain case to the predicted group is calculated based on the substitution of the discriminant function of the values of the set of variables. These variables correspond to this case. Comparison of the obtained results with the size of centroids makes it possible to determine the group to which the result belongs (Table 7).

Previously, it was found that in the structure of coordination abilities of boys aged 11-13 years the most informative is vestibular stability. For pedagogical control of motor readiness of boys aged 11-13 years can be recommended: test №2 “Standing long jump (cm)”; test №9 “Static equilibrium evaluation by E. Ya. Bondarevsky’s method”; test №10 “Evaluation of dynamic equilibrium by the BESS method” [27].

The results of the discriminant function allowed to determine that for recognizing the level of development of coordination abilities in boys aged 11, 12 and 13 years

Table 3. Standardized Canonical Discriminant Function Coefficients. Boys aged 11-13 years old

№	Test	Function	
		1	2
1	30 m running (s)	,001	-,356
2	Standing long jump (cm)	,633	,387
3	Six standing accuracy ball handlings to a partner from a 7 m distance using one of the techniques learned	-,370	-,349
4	Pull-ups (number of times)	,240	-,064
5	Sit-ups in 30 seconds	,287	-,090
6	Evaluation of the sense of movement speed in sprinting	,162	,303
7	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 80% intensity of maximum)	-,074	-,307
8	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 90% intensity of maximum)	,211	-,001
9	Static equilibrium evaluation by E. Ya. Bondarevsky’s method	,113	-,314
10	Evaluation of dynamic equilibrium by the BESS method	-,290	-,165
11	Evaluation of the ability for vestibular (statokinetic) stability. Running with turns	,148	,132
12	Rhythmic hand tapping	-,493	,691
13	Rhythmic movements of upper and lower limbs	,024	,330
14	Shuttle run (4x9 m)	-,301	,312
15	Tossing a ring over a peg	-,347	-,269
16	Height (cm)	,547	,210
17	Body weight (kg)	,226	,348

Table 4. Structure Matrix. Boys aged 11-13 years old

No	Test	Function	
		1	2
2	Standing long jump (cm)	,419*	,127
17	Body weight (kg)	,395*	,167
16	Height (cm)	,378*	,196
9	Static equilibrium evaluation by E. Ya. Bondarevsky's method	,358*	-,156
14	Shuttle run (4x9 m)	-,282*	,200
4	Pull-ups (number of times)	,245*	-,004
10	Evaluation of dynamic equilibrium by the BESS method	-,184*	,119
8	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 90% intensity of maximum)	,164*	-,071
12	Rhythmic hand tapping	-,266	,523*
13	Rhythmic movements of upper and lower limbs	-,039	,313*
15	Tossing a ring over a peg	,047	-,271*
3	Six standing accuracy ball handlings to a partner from a 7 m distance using one of the techniques learned	-,077	-,233*
5	Sit-ups in 30 seconds	,104	-,203*
7	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 80% intensity of maximum)	,077	-,158*
1	30 m running (s)	-,083	-,129*
6	Evaluation of the sense of movement speed in sprinting	-,047	,067*
11	Evaluation of the ability for vestibular (statokinetic) stability. Running with turns	,055	,059*

Table 5. Classification Results^a. Boys aged 11-13 years old

Scale	Age (years)	Group	Predicted Group Membership			Total
			1,00	2,00	3,00	
Original	Count	5,00	21	0	0	21
		6,00	2	17	1	20
		7,00	0	1	18	19
	%	5,00	100,0	,0	,0	100,0
		6,00	10,0	85,0	5,0	100,0
		7,00	,0	5,3	94,7	100,0

93,3% of original grouped cases correctly classified.

Table 6. Canonical Discriminant Function Coefficients. Boys aged 11-13 years old

No	Test	Function	
		1	2
1	30 m running (s)	,002	-,976
2	Standing long jump (cm)	,057	,035
3	Six standing accuracy ball handlings to a partner from a 7 m distance using one of the techniques learned	-,335	-,317
4	Pull-ups (number of times)	,211	-,056
5	Sit-ups in 30 seconds	,057	-,018
6	Evaluation of the sense of movement speed in sprinting	1,237	2,316
7	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 80% intensity of maximum)	-,619	-2,555
8	Evaluation of the ability to differentiate movement speed (reproduction accuracy of running speed at 90% intensity of maximum)	2,290	-,006
9	Static equilibrium evaluation by E. Ya. Bondarevsky's method	,011	-,030
10	Evaluation of dynamic equilibrium by the BESS method	-,045	-,026
11	Evaluation of the ability for vestibular (statokinetic) stability. Running with turns	,143	,128
12	Rhythmic hand tapping	-,351	,493
13	Rhythmic movements of upper and lower limbs	,023	,307
14	Shuttle run (4x9 m)	-,333	,346
15	Tossing a ring over a peg	-,139	-,108
16	Height (cm)	,070	,027
17	Body weight (kg)	,026	,040
	(Constant)	-13,658	-8,482

Table 7. Functions at Group Centroids. Boys aged 11-13 years old

Group	Function	
	1	2
5	-2,061	-,848
6	-,274	1,451
7	2,567	-,590

can be used: test №9 “Static equilibrium evaluation by E. Ya. Bondarevsky’s method”; test № 14 “Shuttle run (4x9 m)”. These tests characterize vestibular stability and overall coordination of movements. For recognition of the state of development of coordination abilities in boys 12 and 13 years can be used tests: № 12 “Rhythmic hand tapping”; №13 “Rhythmic movements of the upper and lower limbs”; №15 “Tossing a ring over a peg”. These tests characterize the coordination of movements of different parts of the body and the accuracy of throws. These data supplement the results of Agricola et al. [11] and Palomo-Nieto et al. [12] on the importance of coordinating movements of various parts of the body in assessing the coordination abilities of children and adolescents. The given data confirm conclusions of Ivashchenko O. [3]: for the estimation of the current state of motor readiness, a factor analysis is used; to assess the dynamics of the state in the age range, a discriminant analysis is used, which makes it possible to determine informative indices for the cross-sectional control of motor readiness.

The above data supplements the results of the study of the peculiarities of motor readiness of middle school students [15, 28].

Conclusions

Discriminant analysis allowed to determine: informative indicators for the end control of the development of coordination abilities in boys aged 11-13 years; to answer the question as to how significantly the state of development of coordination abilities in

boys of 11, 12 and 13 years old; which motor tests most significantly affect the differentiation of classes; to which class the object belongs to based on the values of discriminant variables.

For the recognition of the level of development of coordination abilities in boys 11, 12 and 13 years can be used: test №9 “Static equilibrium evaluation by E. Ya. Bondarevsky’s method”; test № 14 “Shuttle run (4x9 m)”. These tests characterize vestibular stability and overall coordination of movements.

For recognition of the state of development of coordination abilities in boys of 12 and 13 years old can be used tests: № 12 “Rhythmic hand tapping”; №13 “Rhythmic movements of the upper and lower limbs”; №15 “Tossing a ring over a peg”. These tests characterize the coordination of movements of different parts of the body and the accuracy of throws.

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

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Conflict of Interest

The authors state that there is no conflict of interest.

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