MOTOR ABILITIES: IDENTIFICATION OF DEVELOPMENT LEVEL IN BOYS AGED 12-14

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Abstract

The study objective is to determine the possibility of identifying the state of strength abilities development in boys aged 12-14, using the methodology of multidimensional statistics.

Materials and methods. The study involved boys: 12 (n =35), 13 (n = 36), 14 (n = 36) years old. 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. The testing program included well-known tests.

Results. In identifying the state of motor abilities development in boys aged 12-14, the most important results were obtained in tests: 10 "Squats Test (two legs), quantity of times" (0.519), 9 "Trunk Lift Test, quantity of times" (0.497), 21 "Flamingo Balance Test - single leg balance test" (-0.496), 1 "Pull-Up / Chin Up Test (low crossbar), quantity of times" (0.428), 19 "Hand Tapping Test, sec." (-0.427), 20 "Seated Forward Bend, cm" (-0.412), 5 "The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds" (0.408). These tests characterize the comprehensive development of motor abilities in boys aged 12-14.

In identifying the state of motor abilities development in boys aged 13-14, the most important results were obtained in tests: 8 "Decline Reverse Crunch on Bench, quantity of times" (-0.989), 11 "Single Leg Squat (SLS) Test - right leg, quantity of times" (0.965), 1 "Pull-Up / Chin Up Test (low crossbar), quantity of times" (0.676), №13 "Single Leg Squat (Pistol) - right leg" (0.682), 17 "Eurofit Sit Up Test (for 30 sec.), quantity of times" (0.454). These tests characterize the development level of relative and static leg strength, strength endurance of abdominal muscles, and dynamic strength of shoulder muscles.

Conclusions. A discriminant analysis made it possible to determine informative indicators for comprehensive control of motor abilities development in boys aged 12-14; to answer the question as to how significantly the states of motor abilities development in boys aged 12, 13 and 14 differ; what motor tests most substantially influence the differentiation of classes; what class the object belongs to based on the values of discriminant variables.

To identify the level of motor abilities development in boys aged 12-14 years, it is necessary to focus on the indicators of relative strength and strength endurance; in boys aged 13 and 14 years – on the indicators of strength endurance of abdominal muscles and endurance of leg muscles.

Keywords: motor abilities, discriminant analysis, pattern recognition, boys aged 12-14.

Introduction

Physical activity and its impact on population health is one of the problems actively studied in the field of physical education. Studies of the level of physical activity and its impact on the quality of life of adult population showed that the highest levels of physical activity positively affect the quality of life (Bădicu, & Balint, 2016; Bădicu, 2018). Physical education of schoolchildren aims at optimizing the child's physical development (Balsevich, 2000; Novak, Podnar, Emeljanovas, Marttinen, 2015), improving the process of motor skills development and teaching physical ex-

ercises (Ivashchenko, 2016; Emeljanovas, Mieziene, & Putriute, 2015), health promotion and protection (Krutsevych, & Bezverkhnia, 2010). Strength abilities are part of the basic ones, their level of development influences the effectiveness of teaching physical exercises and motor preparedness of schoolchildren (Ilyin, 2003; Ivashchenko, 2016).

Numerous studies reached the following conclusions:

- on the regularities of development of strength, speed, coordination, endurance, and flexibility in children (Liakh, 2000; Khudolii, 2008; Serhiienko, Chekmarova, & Khadzhynov, 2012);
- on the influence of the level of motor abilities development on building motor skills in schoolchildren (Ivashchenko, 2016; Ivashchenko, Prykhodko, & Cieslicka, 2018);
- on the effectiveness of using tools and methods of training in motor abilities development (Liu, Chen, Ho, Fule, Chung, Shiang, 2013; Khudolii, Iermakov, & Prusik, 2015; Cieślicka, Ivashchenko, 2016).

In previously published papers, it was found that the system of schoolchildren's physical education has a hierarchical structure where the development of motor abilities is subordinated to the process of building motor skills: strength development — development of movement coordination, speed, endurance, and flexibility — building motor skills (Khudolii, Ivashchenko, 2014; Ivashchenko, 2017; Ivashchenko, Khudolii, Iermakov, Lochbaum, Cieslicka, Zukow, Nosko, & Yermakova, 2016; Khudolii, Iermakov, & Prusik, 2015).

Multidimensional methods of mathematical statistics such as factor and discriminant analyses are effective for studying the structure of schoolchildren's motor preparedness (Ivashchenko, 2016; Lopatiev, Ivashchenko, Khudolii, Pjanylo, Chernenko, & Yermakova, 2017; Vlasov, Demichkovskij, Ivashchenko, Lopatiev, Pitin, Pjanylo, & Khudolii, 2016). There are two vectors in the methodological approach to the use of multidimensional methods of mathematical statistics. The first vector is an assessment of the current state, the second is an assessment of the state dynamics. Factor analysis, which determines informative indicators, is used to evaluate the current state. To evaluate the state dynamics in the series of lessons and in an age range, discriminant analysis is used, it allows to determine informative indicators for comprehensive control and to determine what class of preparedness the pupil belongs to based on discriminant functions (Ivashchenko, 2017; Ivashchenko, Kapkan, Khudolii, Yermakova, 2017). In available literature, however, there are not enough data on the peculiarities of evaluating motor abilities development in middle school students.

Thus, it is relevant to study the peculiarities of motor abilities development based on identification of their state of development in middle school boys.

The study objective is to determine the possibility of identifying the state of motor abilities development in boys aged 12-14, using the methodology of multidimensional statistics.

Materials and methods

Study participants

The study involved boys: 12 (n = 35), 13 (n = 36), 14 (n = 36) 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 (Liakh, 2000; Serhiienko, 2001; Ivashchenko, 2016). To evaluate motor preparedness, the study recorded the results of motor tests:

- Test 1. Pull-Up / Chin Up Test (low crossbar), quantity of times;
- Test 2. Bent Arm Hang Test (two hands), sec.;
- Test 3. Pull-Up / Chin Up Test (Rope Climbing), quantity of times;
- Test 4. Cadence Push-Up Test, quantity of times;
- Test 5. The subject lies in prone position, arms bent at the elbow 90 degrees — hold position in seconds;
- Test 6. Pull Up Bar — Straight Leg Hanging Leg Raises, quantity of times;
- Test 7. Hanging Leg Raises, sec.;
- Test 8. Decline Reverse Crunch on Bench, quantity of times;
- Test 9. Trunk Lift Test, quantity of times;
- Test 10. Squats Test (two legs), quantity of times;
- Test 11. Single Leg Squat (SLS) Test — right leg, quantity of times;
- Test 12. Single Leg Squat (SLS) Test — left leg, quantity of times;

- Test 13. Single Leg Squat (Pistol) — right leg;
- Test 14. Single Leg Squat (Pistol) — left leg;
- Test 15. Handgrip Strength Test, kg;
- Test 16. Standing Long Jump Test (Broad Jump), cm;
- Test 17. Eurofit Sit Up Test (for 30 sec.), quantity of times;
- Test 18. 4×9 m Shuttle Run Test, sec.;
- Test 19. Hand Tapping Test, sec.;
- Test 20. Seated Forward Bend, cm;
- Test 21. Flamingo Balance Test — single leg balance test.

Statistical analysis

In discriminant analysis, the study formed a prognostic model for group membership. This model builds a discriminant function (or if the quantity of groups is more than two – a set of discriminant functions) in the form of a linear combination of predictor variables, ensuring the best division of groups. These functions are built according to a set of observations, for which their group membership is known. Further, these functions can 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, we calculated: prior probabilities, Fisher function coefficients, unstandardized function coefficients, Wilks' Lambda for every canonical function.

Results

The tables show the results of discriminant analysis, which allow to identify the state of strength abilities development in boys aged 12-14.

The first canonical function explains 78.9% of the results variation, the second — 21.1%, which indicates their informative value (see Table 1). The coefficients of canonical correlation ($r = 0.884$; $r = 0.699$) indicate the prognostic value of the first and second functions.

Table 2 shows the analysis of canonical functions. The first line contains the value $\lambda_1 = 0.112$ ($p_1 = 0.001$)

Table 1. Summary of Canonical Discriminant Functions. Eigenvalues. Boys Aged 12-14

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	3.585a	78.9	78.9	.884
2	.956a	21.1	100.0	.699

Table 2. Canonical Discriminant Functions. Wilks' Lambda. Boys Aged 12-14

Test of Function(s)	Wilks' Lambda	Chi-Square	df	Sig.
1 through 2	.112	206.209	42	.000
2	.511	63.074	20	.000

Table 3. Standardized Canonical Discriminant Function Coefficients. Boys Aged 12-14

No	Test	Function 1	Function 2
1.	Pull-Up / Chin Up Test (low crossbar), quantity of times	.428	.676
2.	Bent Arm Hang Test (two hands), sec.	-.198	.104
3.	Pull-Up / Chin Up Test (Rope Climbing), quantity of times	-.174	-.474
4.	Cadence Push-Up Test, quantity of times	-.244	.174
5.	The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds	.408	-.171
6.	Pull Up Bar - Straight Leg Hanging Leg Raises, quantity of times	.304	.246
7.	Hanging Leg Raises, sec.	.195	.317
8.	Decline Reverse Crunch on Bench, quantity of times	-.134	-.989
9.	Trunk Lift Test, quantity of times	.497	.180
10.	Squats Test (two legs), quantity of times	.519	-.141
11.	Single Leg Squat (SLS) Test - right leg, quantity of times	-.088	.965
12.	Single Leg Squat (SLS) Test - left leg, quantity of times	.344	.115
13.	Single Leg Squat (Pistol) - right leg	-.169	-.670
14.	Single Leg Squat (Pistol) - left leg	-.257	-.289
15.	Handgrip Strength Test, kg	-.168	.230
16.	Standing Long Jump Test (Broad Jump), cm	.227	-.234
17.	Eurofit Sit Up Test (for 30 sec.), quantity of times	.265	.454
18.	4×9 m Shuttle Run Test, sec.	-.193	.045
19.	Hand Tapping Test, sec.	-.427	.188
20.	Seated Forward Bend, cm	-.412	.064
21	Flamingo Balance Test - single leg balance test	-.496	-.164

for the entire set of canonical functions, the second line contains the data after the exclusion of the first function ($\lambda_2 = 0.511$; $p_2 = 0.001$). The first and second functions have a high discriminative ability and meaning in the interpretation with regard to the general totality.

Table 3 shows the standardized canonical discriminant function coefficients, which allow to determine the ratio of the contribution of variables to the result of the function. Variables 10, 9, 21, 1, 19, 20, 5 make the greatest contribution to the first canonical function: the larger the values of these variables, the greater the value of the function. Variables 8, 11, 1, 13, 17 contribute most

Table 4. Structure Matrix. Boys Aged 12-14

No	Test	Function	
		1	2
2	Bent Arm Hang Test (two hands), sec.	.530*	.025
6	Pull Up Bar- Straight Leg Hanging Leg Raises, quantity of times	.466*	.093
19	Hand Tapping Test, sec.	-.362*	.221
9	Trunk Lift Test, quantity of times	.345*	-.191
5	The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds	.325*	-.138
10	Squats Test (two legs), quantity of times	.325*	-.224
3	Pull-Up / Chin Up Test (Rope Climbing), quantity of times	.266*	-.222
1	Pull-Up / Chin Up Test (low crossbar), quantity of times	.266*	.054
5	The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds	.264*	.061
18	4×9 m Shuttle Run Test, sec.	-.212*	.015
12	Single Leg Squat (SLS) Test - left leg, quantity of times	.198*	-.014
16	Standing Long Jump Test (Broad Jump), cm	.191*	-.072
20	Seated Forward Bend, cm	-.184*	.026
4	Cadence Push-Up Test, quantity of times	.183*	-.142
11	Single Leg Squat (SLS) Test - right leg, quantity of times	.182*	.094
15	Handgrip Strength Test, kg	.157*	-.017
13	Single Leg Squat (Pistol) - right leg	.149*	-.125
8	Decline Reverse Crunch on Bench, quantity of times	.364	-.412*
14	Single Leg Squat (Pistol) - left leg	.201	-.220*
17	Eurofit Sit Up Test (for 30 sec.), quantity of times	.081	.203*
21	Flamingo Balance Test - single leg balance test	-.153	-.196*

* Largest absolute correlation between each variable and any discriminant function.

to the second canonical function: the larger the values of these variables, the larger the value of the function.

In identifying the state of motor abilities development in boys aged 12-14, the most important results were obtained in tests: 10 "Squats Test (two legs), quantity of times" (0.519), 9 "Trunk Lift Test, quantity of times" (0.497), 21 "Flamingo Balance Test - single leg balance test" (-0.496), 1 "Pull-Up / Chin Up Test (low crossbar), quantity of times" (0.428), 19 "Hand Tapping Test, sec." (-0.427), 20 "Seated Forward Bend, cm" (-0.412), 5 "The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds" (0.408). These tests characterize the comprehensive development of motor abilities in boys aged 12-14.

In identifying the state of motor abilities development in boys aged 13-14, the most important results were obtained in tests: 8 "Decline Reverse Crunch on Bench, quantity of times" (-0.989), 11 "Single Leg Squat (SLS) Test - right leg, quantity of times" (0.965), 1 "Pull-Up / Chin Up Test (low crossbar), quantity of times" (0.676), 13 "Single Leg Squat (Pistol) - right leg" (0.682), 17 "Eurofit Sit Up Test (for 30 sec.), quantity of times" (0.454). These tests characterize the development level of relative and static leg strength, strength endurance of abdominal muscles, and dynamic strength of shoulder muscles.

Table 4 shows the structure coefficients of the first and second canonical discriminant function, which are the coefficients of correlation between the variables and the function. Thus, the first canonical discriminant function is most closely connected with the results of tests 2, 6, 19, 9, 5, 10: hence, a significant difference between the boys aged 12, 13, 14 is observed in the development level of relative strength and strength endurance.

The structure coefficients of the second canonical discriminant function indicate that the function is most closely connected with variables 8, 14: hence, a significant difference between the boys aged 13 and 14 is observed in the development level of strength endurance of abdominal muscles and endurance of leg muscles.

Table 5 shows the results of classification of groups, 88.8% of the original grouped observations were classified correctly. Therefore, a canonical discriminant function can be used to identify the state of strength abilities development in boys aged 12-14.

Table 5. Classification Resultsa. Boys Aged 12-14

Scale		Age (years)	Predicted Group Membership			Total
			12	13	14	
Original	Count	12	33	2	0	35
		13	4	30	2	36
		14	0	4	32	36
	%	12	94.3	5.7	.0	100.0
		13	11.1	83.3	5.6	100.0
		14	.0	11.1	88.9	100.0

a. 88.8% of original grouped cases correctly classified.

Discussion

The above-mentioned results show that discriminant analysis allows to identify the state of motor abilities development in boys aged 12-14 by the results of testing and supplement data on the use of discriminant function in classifying schoolchildren by motor activity (Gert-Jan de Bruijn, & Benjamin Gardner, 2011; Lulzim, 2013). As in the papers by Broadhead and Church (1982), Ivashchenko, Kapkan, Khudolii, and Yermakova (2017), Ivashchenko, Khudolii, Iermakov, Veremeenko, and Lopatiev (2018), we observed a high discriminative and predictive ability of these functions in evaluating motor preparedness of boys aged 12-14.

Table 6. Canonical Discriminant Function Coefficients (Unstandardized Coefficients). Boys Aged 12-14

No	Test	Function 1	Function 2
1.	Pull-Up / Chin Up Test (low crossbar), quantity of times	.206	.325
2.	Bent Arm Hang Test (two hands), sec.	-.115	.061
3.	Pull-Up / Chin Up Test (Rope Climbing), quantity of times	-.061	-.165
4.	Cadence Push-Up Test, quantity of times	-.064	.046
5.	The subject lies in prone position, arms bent at the elbow 90 degrees - hold position in seconds	.165	-.069
6.	Pull Up Bar - Straight Leg Hanging Leg Raises, quantity of times	.271	.219
7.	Hanging Leg Raises, sec.	.218	.355
8.	Decline Reverse Crunch on Bench, quantity of times	-.058	-.426
9.	Trunk Lift Test, quantity of times	.168	.061
10.	Squats Test (two legs), quantity of times	.145	-.039
11.	Single Leg Squat (SLS) Test - right leg, quantity of times	-.087	.951
12.	Single Leg Squat (SLS) Test - left leg, quantity of times	.383	.128
13.	Single Leg Squat (Pistol) - right leg	-.147	-.582
14.	Single Leg Squat (Pistol) - left leg	-.246	-.276
15.	Handgrip Strength Test, kg	-.100	.137
16.	Standing Long Jump Test (Broad Jump), cm	1.338	-1.380
17.	Eurofit Sit Up Test (for 30 sec.), quantity of times	.069	.118
18.	4×9 m Shuttle Run Test, sec.	-.334	.077
19.	Hand Tapping Test, sec.	-.449	.198
20.	Seated Forward Bend, cm	-.305	.047
21	Flamingo Balance Test - single leg balance test	-.301	-.100
	(Constant)	1.283	-3.616

Table 7. Functions at Group Centroids. Boys Aged 12-14

Group	Function 1	Function 2
12	-2.233	-.763
13	-.170	1.351
14	2.341	-.609

The study confirmed that multidimensional methods of mathematical statistics such as factor and discriminant analyses (Ivashchenko, 2014; Lopatiev, Ivashchenko, Khudolii, Pjanylo, Chernenko, & Yermakova, 2017; Ivashchenko, Khudolii, Iermakov, Chernenko, & Honcharenko, 2018) are effective for studying the structure of motor preparedness of boys aged 12-14. The study added that he use of discriminant function in the analysis of standardized and structure coefficients allows to determine the structure of strength abilities
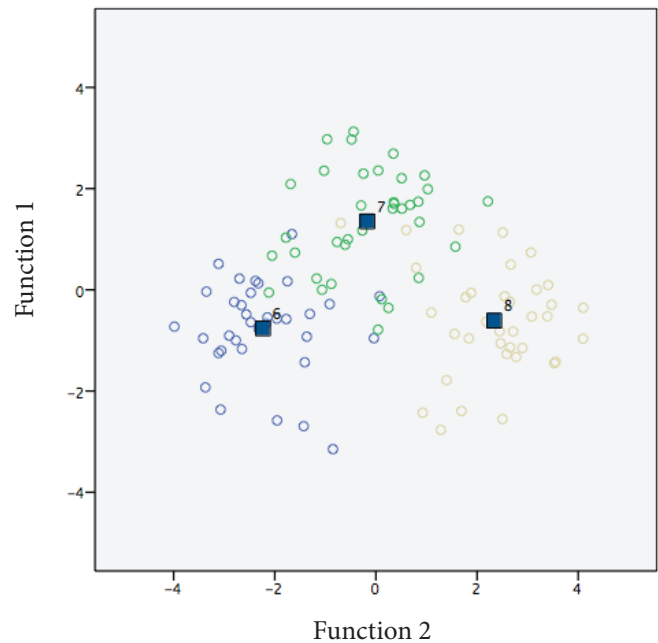

Fig. 1. Canonical discriminant functions. Graphic representation of classification results in boys aged 12-14: ▪ — centroids for data groups 6(12), 7(13), 8(14).

development and their interrelation with endurance in boys aged 12-14 (Ivashchenko, 2017; Ivashchenko, Kapkan, Khudolii, Yermakova, 2017; Ivashchenko, Khudolii, Iermakov, & Harkusha, 2017).

The obtained data made it possible to reveal the peculiarities of motor abilities development in boys aged 12-14. While to identify the state of motor abilities development in girls aged 12-14 years, the most important results are obtained in tests characterizing the development level of strength of shoulder and leg muscles; in girls aged 13-14 – the results of tests characterizing the development level of relative and static leg strength (Ivashchenko, Khudolii, Iermakov, Veremeenko, & Lopatiev, 2018), to identify the state of motor abilities development in boys aged 12-14, the most important results are those obtained in tests that characterize the comprehensive development of motor abilities; in boys aged 13-14 – the results of tests that characterize the development level of relative and static leg strength, strength endurance of abdominal muscles, and dynamic strength of shoulder muscles.

For practical application of the results of discriminant analysis, canonical discriminant function coefficients are used (see Table 6). 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, Figure 1).

The above data supplement the results of study of the peculiarities of schoolchildren's motor prepared-

ness (Ivashchenko, Khudolii, Iermakov, Lochbaum, Cieślicka, Zukow, Nosko, & Yermakova, 2017; Ivashchenko, Shepelenko, 2014; Peric, 2016).

Conclusions

A discriminant analysis made it possible to determine informative indicators for comprehensive control of motor abilities development in boys aged 12-14; to answer the question as to how significantly the states of motor abilities development in boys aged 12, 13 and 14 differ; what motor tests most substantially influence the differentiation of classes; what class the object belongs to based on the values of discriminant variables.

To identify the level of motor abilities development in boys aged 12-14, it is necessary to focus on the indicators of relative strength and strength endurance; in boys aged 13 and 14 – on the indicators of strength endurance of abdominal muscles and endurance of leg muscles.

Acknowledgment

Conflict of Interest

The authors state that there is no conflict of interest.

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РУХОВІ ЗДІБНОСТІ: РОЗПІЗНАННЯ РІВНЯ РОЗВИТКУ У ХЛОПЦІВ 12-14 РОКІВ

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Мета дослідження — визначити можливість розпізнання стану розвитку рухових здібностей у хлопців 12-14 років на основі методології багатовимірних статистик.

Матеріали і методи. У дослідженні брали участь хлопці: 12 (n = 35), 13 (n = 36), 14 (n = 36) років. У дослідженні використовувались такі методи: аналіз науково-методичної літератури, загальнонаукові методи теоретичного рівня, такі як аналогія, аналіз, синтез, абстракція, індукція, а також загальнонаукові методи емпіричного рівня: спостереження, тестування, експеримент. Програма тестування включала відомі тести.

Результати. У розпізнанні стану розвитку рухових здібностей у хлопців 12-14 років найбільший вклад мають результати в тестах: № 10 «Присідання на двох ногах, раз» (0,519), № 9 «Піднімання тулуба із положення лежачи на череві, раз» (0,497), № 21 «Тест на рівновагу «фламінго», кількість спроб» (-0,496), №1 «Згинання і розгинання рук у висі на низькій перекладині, рази» (0,428), № 19 «Тест на частоту рухів руки, с» (-0,427), № 20 «Із положення сидячи нахил тулуба вперед, см» (-0,412), № 5 «Утримання в упорі лежачи на зігнутих руках, с» (0,408). Названі тести характеризують комплексний розвиток рухових здібностей у хлопців 12-14 років.

У розпізнанні стану розвитку рухових здібностей у хлопців 13-14 років найбільший вклад мають результати в тестах: №8 «Піднімання ніг на лаві

під кутом, раз» (-0,989), №11 «Присідання на правій нозі, раз» (0,965), №1 «Згинання і розгинання рук у висі на низькій перекладині, рази» (0,676), №13 «Утримання пози «пістолет» на правій нозі, с» (0,682), №17 «Підйом тулуба із положення лежачи за 30 с, раз» (0,454). Названі тести характеризують рівень розвитку відносної і статичної сили ніг, силової витривалості м'язів черева та динамічної сили м'язів плечового поясу.

Висновки. Дискримінантний аналіз дозволив визначити інформативні показники для наскрізного контролю розвитку рухових здібностей у хлопців 12-14 років; дати відповідь на питання наскільки достовірно різниться стан розвитку рухових здібностей у хлопців 12, 13 і 14 років; які рухові тести найбільш суттєво впливають на розрізнення класів; до якого класу належить об'єкт на основі значень дискримінантних змінних.

Для розпізнання рівня розвитку рухових здібностей у хлопців 12-14 років необхідно орієнтуватися на показниках відносної сили та силової витривалості; у хлопців 13 і 14 років - силової витривалості м'язів брюшного преса та витривалості м'язів ніг.

Ключові слова: дискримінантний аналіз, розпізнання образів, хлопці 12-14 років.

ДВИГАТЕЛЬНЫЕ СПОСОБНОСТИ: РАСПОЗНАВАНИЕ УРОВНЯ РАЗВИТИЯ У РЕБЯТ 12–14 ЛЕТ

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Цель исследования — определить возможность распознавания состояния развития двигательных способностей у ребят 12–14 лет на основе методологии многомерных статистик.

Материалы и методы. В исследовании принимали участие ребята: 12 (n = 35), 13 (n = 36), 14 (n = 36) лет. В исследовании использовались следующие методы: анализ научно-методической литературы, общенаучные методы теоретического уровня, такие как аналогия, анализ, синтез, абстракция, индукция, а также общенаучные методы эмпирического уровня: наблюдение, тестирование, эксперимент. Программа тестирования включала известные тесты.

Результаты. В распознании состояния развития двигательных способностей у ребят 12–14 лет наибольший вклад имеют результаты в тестах: № 10 «Приседания на двух ногах, раз» (0,519), № 9 «Подъем туловища из положения лежа на животе, раз» (0,497), № 21 «Тест на равновесие «фламинго», количество попыток» (-0,496), №1 «Сгибание и разгибание рук в висе на низкой перекладине, раз» (0,428), № 19 «Тест на частоту движений руки, с» (- 0,427), № 20 «С положения сидя наклон туловища вперед, см» (-0,412), № 5 «Удержание в упоре лежа на согнутых руках, с» (0,408). Названные тесты характеризуют комплексное развитие двигательных способностей у ребят 12–14 лет.

В распознании состояния развития двигательных способностей у ребят 13–14 лет наибольший вклад имеют результаты в тестах: №8 «Подъем ног на скамье под углом, раз» (-0,989), №11 «Приседания на правой ноге, раз» (0,965), №1 «Сгибание и разгибание рук в висе на низкой перекладине, раз» (0,676), №13 «Удержание позы «пистолет» на правой ноге, с» (0,682), №17 «Подъем туловища из положения лежа за 30 с, раз» (0,454). Названные тесты характеризуют уровень развития относительной и статической силы ног, силовой выносливости мышц живота и динамической силы мышц плечевого пояса.

Выводы. Дискриминантный анализ позволил определить информативные показатели для сквозного контроля развития двигательных способностей у ребят 12–14 лет, дать ответ на вопрос насколько достоверно отличается состояние развития двигательных способностей у ребят 12, 13 и 14 лет, какие двигательные тесты наиболее существенно влияют на различия классов, к какому классу принадлежит объект на основе значений дискриминантных переменных.

Для распознавания уровня развития двигательных способностей у ребят 12–14 лет необходимо ориентироваться на показателях относительной силы и силовой выносливости; у ребят 13 и 14 лет — силовой выносливости мышц брюшного пресса и выносливости мышц ног.

Ключевые слова: дискриминантный анализ, распознавание образов, ребята 12–14 лет.

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