Original Article

Classification of motor fitness of 7-9 years old boys

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Abstract:

The purpose: determination of classification model of 7-9 years old boys' motor fitness.

The methods of the research: we used the following methods of research: analysis of scientific literature data, pedagogic testing, methods of mathematical statistics. As method of simulation we used discriminant analysis. In our researches 7 boys of 7 yrs. age (n=22), 8 years. age (n=27), 9 yrs. age (n=29) participated.

Results: we the calculated canonic coefficients of discriminant function (not standardized). They play role of multipliers of the set values of variables, which are components of discriminant function. On the base of them it is possible to classify pupils by level of motor fitness according to their age that is of practical importance. Analysis of discriminant functions' structural coefficients permitted to specify indicators, by which it is possible to classify boys of 7, 8 and 9 years old (function 1). Besides it permits to specify indicators, by which we could separate 8 years old boys from 9 years age (function 2). Discriminant analysis permitted to answer the question: how confidently one can divide one class from the other by the set of offered variables; which of these variables influence the most substantially on specifying of forms; to which form the object belongs on the base of discriminant variables.

Conclusions: Statistically confident differences of mean group results of testing were observed in the following tests: walking of segments of hexagon (steps, $p<0.033$); 30 meters' run (s, $p<0.001$); long jump from the spot (cm, $p<0.002$); 300 meters' run (min, $p<0.001$); chin ups on rope in mixed hanging (quantity of times, $p<0.038$); shuttle run 4x9 meters (s, $p<0.001$); rising in sitting position per 1 minute (quantity of times, $p<0.009$); body height (cm, $p<0.001$); distance from acromion to acromion (cm, $p<0.001$); index assessment of mobility in shoulder joints ($p<0.005$); side circles with stick (points, $p<0.009$); frequency of arms' movements (quantity of times, $p<0.048$); walking along straight line after 5 rotations (cm, $p<0.002$); catching of falling stick of Dietrich (cm, $p<0.036$). For finalizing pedagogic control of 7 yrs. age boys' motor fitness first discriminant function can be use, with accent on the most informative variables. If results of 7 yrs. Boys are classified as results similar to 8 yrs. boys it would be possible to speak about effectiveness of physical education. For summarizing pedagogic control of 8 yrs. age boys' physical fitness results of 9 years old boys are benchmarks, providing they are accented on the most informative indicators of discriminant function.

Key words: discriminant function, classification, simulation, motor fitness, boys of 7-9 years old age.

Introduction

One of problems of school physical education is optimizing of children's and adolescents' motor functioning for improvement of their health and workability (Baltsevych V.K., 2000; Krutsevych T.Yu., Bezverkhnya G.V., 2010; Vink K. et al., 2015; Yermakova T.S., 2015). The problem of motor functioning and health strengthening is important both for Ukraine and for European countries (Cieřlicka M., Napierała M., 2009; Iermakov S.S. et al., 2011; Cieslicka Mirosława, Slowinski Mariusz, 2012; Paczuski R., Cieřlicka M., 2013; Coskun Ali, Sahin Gulsah, 2014; Iermakova T.S., 2014; Piccinno Andrea, Colella Dario, 2014; Harris J., 2014).

One of conditions of increase of schoolchildren's motor fitness is organization of pedagogic control both at physical culture lessons (Karpunec T.V., 2001; Lynch T., 2013; Khudolii O.M., Ivashchenko O.V., 2014; Pedersen S., 2014; Ivashchenko O.V. et al., 2015), and in conditions of sport trainings (Dmitruk K. et al., 2008; Iermakov S.S. et al., 2010; Khudolii O.M., Iermakov S.S., 2011; Khudolii O.M., Ivashchenko O.V., 2013; Logan S.W. et al., 2014). Pedagogic control implies classification of current state of motor and functional fitness, which influence on taking decisions in managing of children's and adolescents' physical education.

In recent publications it was noted that simulation is effective method of receiving of new information about possibility to carry out current and finalizing control on the base of testing of children's and adolescents' motor fitness (Ivashchenko O.V., 2001; Sheppard J.M., Young W.B., 2006; Adashevskiy V.M. et al., 2013; Khudolii O.M., Ivashchenko O.V., 2014). Discriminant analysis is one of statistic simulation's methods.

Effectiveness of its application in classification of children's and adolescents' functional and motor

fitness is proved in scientific literature (Geoffrey D. Broadhead, Gabie E. Church, 1982; Milić M. et al., 2011; Gert-Jan de Bruijn, Benjamin Gardner, 2011; Dorita du Toit et al., 2011; Gulbin J.P. et al., 2013; Khudolii O.M., Ivashchenko O.V., 2014; Ivashchenko O.V. et al., 2015).

So, classification of motor fitness is practically significant for taking decisions in physical education as well as for working out of effective physical training programs for children and adolescents.

Material and methods

The purpose of the research: determination of classification model of 7-9 years old boys' motor fitness.

The methods of the research: we used the following methods of research: analysis of scientific literature data, pedagogic testing, method of mathematical statistics. As method of simulation we used discriminant analysis.

In planning of the research we used conceptual approaches to working out of scientific research programs in physical education and sports (Ashmarin B.A., 1978; Krutsevych T.Yu., 1985; Filin V.P., Rovnij A.S., 1992; Ruslanov D.V. et al., 2011; Zaytsev V.P. et al., 2011; Khudolii O.M., Ivashchenko O.V., 2014). Testing program included commonly known tests (Liakh V.I., 2000; Sergiienko L.P., 2001; Cale L., Harris J., 2009; Khudolii O.M., Iermakov S.S., 2011; Harris J., Leggett G., 2013; Khudolii O.M., Ivashchenko O.V., 2014).

For assessment of 7-9 yrs. age boys' motor fitness re registered results of the following tests:

- №1 Static posture on one foot (s),
- №2 Walking on segments of hexagon (steps),
- №3 30 meters' run (s),
- №4 Long jump from the spot (cm),
- №5 300 m run (min),
- №6 Chin ups on rope in mixed hanging (times),
- №7 Shuttle run 4x9m (s),
- №8 Rising in sitting position per 1 minute (times),
- №9 Forward torso bending in sitting position (cm),
- №10 Distance between hands and heels (cm) (in bridge),
- №11 Body height (cm),
- №12 Index assessment (in bridge),
- №13 Bridge with straight legs (points), side circles with stick,
- №14 Width of hold (cm),
- №15 Distance from acromion to acromion (cm),
- №16 Index assessment of mobility in shoulders,
- №17 Side circles with stick (points),
- №18 Frequency of arms' movements (times),
- №19 Exercise for combining of arms', torso, legs' movements (points),
- №20 Walking along straight line after 5 rotations (cm),
- №21 Catching of falling stick of Dietrich (cm).

In our researches 7 boys of 7 yrs. age (n=22), 8 years. age (n=27), 9 yrs. age (n=29) participated.

The study protocol was approved by the Ethical Committee of H.S. Skovoroda Kharkiv National Pedagogical University. In addition, 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.

Results of the research

Analysis of testing results is given in table 1. Statistically confident differences between mean group indicators were observed in the following below tests:

- №2 Walking on segments of hexagon (steps), (p<0.033),
- №3 30 m run (s) (p<0.001),
- №4 Long jump from the spot (cm) (p<0.002),
- №5 300 m run (min) (p<0.001),
- №6 Chin ups on rope in mixed hanging (times), (p<0.038),
- №7 Shuttle run 4x9m (s), (p<0.001),
- №8 Rising in sitting position per 1 minute (times), (p<0.009),
- №11 Body height (cm) (p<0.001),
- №15 Distance from acromion to acromion (cm), (p<0.001),
- №16 Index assessment of mobility in shoulders, (p<0.005),
- №17 Side circles with stick (points), (p<0.009),
- №18 Frequency of arms' movements (times), (p<0.048),
- №20 Walking along straight line after 5 rotations (cm), (p<0.002),
- №21 Catching of falling stick of Dietrich (cm), (p<0.036).

Thus, with age there happened some changes of anthropometric indicators (test № 11, 15), in coordination (tests № 7, 2, 20), power fitness, (tests № 4, 6, 8), endurance (test № 5), quickness (tests № 3, 18, 21), flexibility (tests № 16).

Table 1. Results of testing of 7-9 yrs. age boys' motor fitness 1.

№	Description of test	7 yrs. age boys		8 yrs. age boys (n=27)		9 yrs. age boys (n=29)		Criteria of equality of mean group values 7		
		X	s	X	s	X	s	λ	F	p
1	Static posture on one foot (s).	5.0	3.36	5.65	4.04	7.53	6.76	.955	1.760	.179
2	Walking on segments of hexagon (steps),	1.27	1.07	2.55	1.98	2.68	2.52	.913	3.579	.033
3	30 m run (s)	6.71	.45	6.23	.32	6.10	.59	.772	11.06	.000
4	Long jump from the spot (cm)	122.5	18.33	140.11	19.86	139.89	17.50	.843	7.004	.002
5	300 m run (min)	1.61	.33	1.32	.25	1.27	.24	.781	10.50	.000
6	Chin ups on rope in mixed hanging (times),	10.27	3.78	15.22	7.32	13.17	7.47	.916	3.421	.038
7	Shuttle run 4x9 m (s)	13.24	.89	12.28	.66	12.20	1.11	.799	9.446	.000
8	Rising in sitting position per 1 minute (times),	24.09	9.91	33.14	10.31	31.51	11.00	.882	5.029	.009
9	Forward torso bending in sitting position (cm),	3.36	4.94	4.11	4.32	4.93	5.54	.984	.627	.537
10	Distance between hands and heels (cm)	59.23	8.85	60.85	14.56	61.93	15.46	.993	.248	.781
11	Body height (cm)	139.95	5.97	150.40	9.06	155.79	6.61	.564	28.97	.000
12	Index assessment (bridge)	42.27	5.93	40.48	9.57	39.96	10.14	.988	.441	.645
13	Bridge with straight legs (points)	5.88	.96	6.19	1.60	6.16	1.32	.990	.378	.687
14	Width of hold (cm)	62.90	8.18	64.92	10.39	61.24	8.73	.971	1.122	.331
15	Distance from acromion to acromion (cm),	26.11	1.42	27.66	1.77	29.33	1.39	.577	27.5	.000
16	Index assessment of mobility in shoulders,	2.40	.35	2.35	.43	2.08	.30	.867	5.747	.005
17	Side circles with stick (points),	.78	.79	1.00	1.21	1.68	1.13	.883	4.978	.009
18	Frequency of arms' movements (times)	25.27	6.25	26.51	12.17	32.55	13.26	.922	3.168	.048
19	Exercise for combining of arms', torso, legs'	2.45	2.89	1.20	2.52	1.27	2.49	.957	1.694	.191
20	Walking along straight line after 5 rotations	132.95	76.68	77.44	76.80	61.50	55.06	.842	7.026	.002
21	Catching of falling stick of Dietrich (cm),	35.13	7.76	31.48	8.00	29.27	7.85	.915	3.474	.036

Results of discriminant analysis are presented in tables 2 - 7.

First canonic function explains variation of results by 88.2 %, second – by 11.8 % that witness about their high informative character (see table 2). Correlation coefficient between calculated values of discriminant

function and indicators of belonging to group equal to $r=0,815$ and witnesses about high prognostication potential of first canonic function. The first canonic function's own value witnesses about successfully selected coefficients in it.

Table 2. Canonic discriminant function. Own values.

Function	Own values	% of explained dispersion	Cumulative %	Canonic correlation
1	1,982	88,2	88,2	,815
2	,265	11,8	100,0	,458

In table 3 there is material of canonic functions' analysis. The first line contains value $\lambda=0,265$ and statistic significance $p=0.001$ for all set of canonic functions, the second line contains data after exclusion of the first function. The first and the second functions have high discriminant ability and values in interpretation concerning general set.

Table 3. Canonic discriminant function. Wilky's lambda

Checking of functions	Wilky's lambda	χ -square	Degrees of freedom	p
from 1 to 2	,265	89,634	32	,000
2	,790	15,892	15	,389

We received standardized coefficients of canonic discriminant function, which permit to determine correlation of variables' contribution in results of functions. Indicators, characterizing mobility in shoulders make the highest contribution: [test № 14 Width of hold (cm, -2,185), tests № 15 Distance from acromion to acromion (cm, 1,31), test № 16 Index assessment of mobility in shoulders (2,443)]. Then group of indicators, which characterize coordination of 7-9 years old boys: [test № 19 Exercises for combining of arms', torso, legs' movements (points, -0,470), test № 1 Static position on one foot (s, 0,318), test № 7 Shuttle run 4x9 m (s, -0,282)]. So, the above mentioned indicators permit to separate 7 years old boys from boys of 8 and 9 yrs. age. Variables, characterizing mobility in shoulders, make the highest contribution in second canonic function [test № 14 Width of hold (cm) (-4,39); test № 15 Distance from acromion to acromion (cm) (1,949); test № 16 Index assessment of mobility in shoulders (3,324)]. Next go indicators, characterizing level of strength [test № 6 Chin ups on rope in mixed hanging (times) (-0,499); test № 4 Long jump from the spot cm (-0,259)]. The second function permits to separate 8 yrs. age boys from 9 years old boys.

The above noted witness that in classification of 7-9 years old boys' motor fitness leading role is played by flexibility, coordination and strength.

We received structural coefficients of canonic discriminant function, which are coefficients of variables' correlation with function. The given coefficients (like in factorial analysis) permit to interpret canonic function; to find out influence of independent variables on dependent – in our case on level of 7-9 years old boys motor fitness. For each function coefficients with highest correlation with it are noted.

The first canonic function has the highest correlation: with anthropometric indicators [test № 11 Body height, cm (0,624); test № 15 Distance from acromion to acromion (cm) (0,596)]; with indicators of quickness, endurance and coordination [test № 3 30 m run, s (-0,382), test № 5 300 m run, min (0,366), test № 7 Shuttle run 4x9 m, s (-0,341), test № 20 Walking along straight line after 5 rotations, cm (-0,304)].

The second canonic function has the highest correlation with the following: with power indicators [test № 6 Chin ups on rope in mixed hangings, times (-,433); test № 8 Rising in sitting position per 1 minute, times 375); test № 4 Long jump from the spot, cm (-,314)]; indicators of flexibility [test № 16 Index assessment of mobility in shoulders (-,388); test № 14 Width of hold, cm (-,316); test № 17 Side circles with stick, points (,316)]; with indicators of quickness [test № 18 Frequency of arms' movements, times (,292)] and coordination i [test № 1 Static position on one foot, s (,186)].

Thus, structural coefficients of discriminant functions specify indicators, by which classification of 7, 8 and 9 years old boys can be realized (function 1). Also, it specifies indicators, which permit to separate 8 years old boys from 9 years old boys (function 2).

In table 4 we present canonic coefficients of discriminate function (not standardized). They play role of multipliers of the set variables, which are components of discriminant functions. In table 5 we give example of classification.

Table 4. Coefficients of canonic discriminate function

№	Description of test	Function	
		1	2
1	Static position on one foot (s)	,062	,050
3	30 m run (s)	-,294	,340
4	Long jump from the spot (cm)	,011	-,014
5	300 m run (min)	-,988	,828
6	Chin ups on rope in mixed hanging (times)	,005	-,076
7	Shuttle run 4x9 m (s)	-,307	-,088
8	Rising in sitting position per 1 minute (times)	-,016	-,004
11	Body height (cm)	,041	-,014
14	Width of hold (cm)	-,237	-,477
15	Distance from acromion to acromion (cm)	,847	1,261
16	Index assessment of mobility in shoulders	6,653	9,052
17	Side circles with stick (points)	,179	-,796
18	Frequency of arms' movements (times)	-,004	,023
19	Exercise for combining of arms', torso, legs' movements (points)	-,179	-,005
20	Walking along straight line after 5 rotations (cm),	-,004	,003
21	Catching of falling stick of Dietrich (cm)	-,009	,014
	(Constant value)	-23,430	-23,432

Table 5. Statistic for separate cases

Number of observation	Actual group	The most probable group				Discriminant points	
		Prognosticate d belonging to group	P(D>d G=g) df	P(G=g D=d)	Mahalonobis's square of distance to center	Function 1	Function 2
1	7	7	,528 2	,696	1,277	-1,067	,846
2	7	7	,498 2	,977	1,394	-2,057	1,473
4	7	7	,390 2	,995	1,883	-3,368	-,096
5	7	7	,111 2	,996	4,388	-2,530	2,332
6	7	7	,750 2	,916	,576	-2,204	-,451

Placing of separate cases' data in equations, given in table 4, we obtain value of function. On the base of comparing of the obtained data with centroids of functions (see table 6) we classify every certain case.

In table 6 we give coordinates of centroids for three groups. They permit to interpret canonic functions in respect to their role indistinguishing of classes by level of 7-9 years old boys; motor fitness. On negative pole of the first function there are centroids for 7 years old boys, on positive – for 8 and 9 years old boys. On positive pole of second functions there are centroids of 7 and 9 years old boys and on negative – for 8 years old boys. Graphic material (see fig. 1) witnesses about density of objects inside every class and about distinct border between classes. It permits to affirm that classification of 7-9 years old boys is possible with the help of given above set of tests.

Table 6. Functions in groups' centroids

Age of boys	Function	
	1	2
7 years	-2,052	,293
8 years	,193	-,691
9 years	1,377	,421

In table 7 we give results of groups' classification. 75.9 % of output group observations were classified correctly. Thus, canonic discriminant function can be used for classification of age characteristics of 7-9 years old boys' motor fitness.

Table 7. Results of groups' classification

Indicator	Age of boys	Prognosticated belonging to group			Total
		7 years	8 years	9 years	
Frequency	7 years	18	4	0	22
	8 years	3	20	5	28
	9 years	1	6	22	29
%	7 years	81,8	18,2	,0	100,0
	8 years	10,7	71,4	17,9	100,0
	9 years	3,4	20,7	75,9	100,0

Fig. 1. Canonic discriminant functions. Graphic picture of results of 7-9 years old boys' classification by level of motor fitness

Discussion

The received results supplement the data about usage of discriminant function in classification of pupils by motor fitness (Milić M. et al., 2011; Gert-Jan de Bruijn, Benjamin Gardner, 2011; De Groot S. et al., 2012; Lulzim I., 2012; Dorita DU TOIT et al., 2011; Zaporozhanov V.A., 2013; Logan S.W. et al., 2014). Besides, like in works by Geoffrey D. Broadhead & Gabie E. Church (1982), Titarenko A.A. (2010) we observed high discriminant and prognostic ability of the received functions.

In the process of analysis we calculated canonic coefficients of discriminant function (non standardized). They play role of multipliers of the set variables, which are components of discriminant functions.

On this base it is possible to classify pupils by level of motor fitness according to their age and it is of practical significance.

Analysis of structural coefficients of discriminant functions permitted to specify indicators, by which it is possible to classify boys of 7, 8 and 9 years old age (function 1) and specify indicators by which it is possible to separate 8 years old boys from 9 years old boys (function 2).

So, discriminant analysis permitted to answer the question: how confidently it is possible to separate one class from the other by set of the offered variables; which of these variables influence the most substantially on differentiation of classes; to which class object belongs on the base of discriminant variables.

Conclusions

1. Statistically confident differences between mean group results of testing were observed in the following tests: №2 Walking of hexagon's segments (steps) $p<0,033$; №3 30 m run (s) $p<0,001$; №4 Long jump from the spot (cm) $p<0,002$; №5 300 m run (min) $p<0,001$; №6 Chin ups on rope in different hangings (times) $p<0,038$; №7 Shuttle run 4x9m (s) $p<0,001$; №8 Rising in sitting position per 1 minute (times) $p<0,009$; №11 Body height (cm) $p<0,001$; №15 Distance from acromion to acromion (cm) $p<0,001$; №16 Index assessment of mobility in shoulders, $p<0,005$; №17 Side circles with stick (points) $p<0,009$; №18 Frequency of arms' movements (times) $p<0,048$; №20 Walking along straight line after 5 rotations (cm) $p<0,002$; №21 Catching of falling stick of Dietrich (cm) $p<0,036$.

2. For summarizing pedagogic control of 7 years boys' motor fitness first discriminant function, accented on the most informative variables, can be used. If results of 7 years boys are classified as similar to results of 8 years old boys we can say that physical education is effective. For finalizing pedagogic control of 8 years old boys results of 9 years old boys can serve as bench marks, providing they are accented on most informative variables of discriminant function.

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