Original Article

Strength abilities: assessment of cumulative training effects of strength loads of a series of classes in 8 years old boys

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Published online: April 30, 2021

(Accepted for publication April 15, 2021)

DOI:10.7752/jpes.2021.s2158

Abstract

The purpose of the study was to determine the impact of orthogonal strength loads on the dynamics of cumulative training effects of a series of classes in 8 years old boys. **Materials and methods.** The study participants were 48 boys 8 years old. The experiment was conducted using a 2² factorial design. The study materials were processed by the IBM SPSS 22 statistical analysis program. Discriminant analysis was performed. The study examined the impact of four variants of strength load on the formation of the cumulative training effect of a series of classes in 8 years old boys. **Results.** The study obtained data on the informativeness of canonical functions in assessing the cumulative training effect of strength loads, and carried out their verification. Structure coefficients and group centroids for the 1st-4th variants of strength load were analyzed. The discriminant analysis made it possible to obtain information about the dynamics of the cumulative training effect of strength exercises with different focuses, taking into account their modes after 3, 6, 9, and 12 classes. **Conclusions.** It is possible to classify the cumulative training effect of a series of classes based on discriminant analysis. The effectiveness of discriminant analysis increases with the use of active 2^k full factorial experiments. The verification of the obtained discriminant functions shows their high discriminative ability and value in interpretation with respect to the general population ($p < 0.05$). The analysis of structure coefficients showed the most significant changes in the CTE after work at places 1-4, the analysis of group centroids – the impact of strength loads on the dynamics of the CTE after 3, 6, 9, and 12 classes. In boys 8 years old, the cumulative training effect of strength exercises after 3, 6, 9, and 12 classes as compared with the initial level differs statistically significantly and has different focuses: variant I – strengthening arms, abdominal muscles, and leg muscles; variant II – strengthening abdominal, back, and leg muscles; variant III – strengthening abdominal muscles; variant IV – strengthening all muscles. The greatest overall positive effect is observed in: variants I and II – after 9 classes; variant III – after 3 classes; variant IV – after 6 classes.

Keywords: 8 years old boys, cumulative training effect, strength loads, discriminant analysis.

Introduction

The assessment and management of training effects are those factors that ensure the effectiveness of physical education and sports training (Veremeenko, Khudolii, & Ivashchenko, 2019; Abaïdia, Delecroix, Leduc, Lamblin, McCall, Baquet, & Dupont, 2017; Alves, Marta, Neiva, Nunes, Izquierdo, & Marques, 2020).

The effective use of loads in schoolchildren's physical education involves both motor skills and motor abilities development (Khudolii, Iermakov, & Bartik, 2020; Petrov, Khudolii, & Cieśllicka, 2020; Nikšić, Beganović, Joksimović, 2020). The importance of studying the influence of physical loads on the functional state of junior schoolchildren is pointed out in the studies by Krivolapchuk and Chernova (2019), Krivolapchuk, Chernova, and Gerasimova (2020), Krivolapchuk, Gerasimova, Myshnikov, and Chicherin (2020). The obtained results show that children aged 5-6 and 6-7 years who performed high-intensity physical exercises have better indicators of physical fitness than children who performed moderate-intensity exercises (Krivolapchuk, Chernova, & Gerasimova, 2020).

Studies on the problems of schoolchildren's physical education focus on the development of strength and coordination abilities (Polevoy, 2020; Tkachenko, 2020; Mohamad, Choo, 2021). It was found that the indicators of junior schoolchildren's speed-strength and coordination abilities significantly improve, if special exercises are used during physical education classes (Polevoy, 2020), the level of schoolchildren's motor fitness depends on coordination and speed-strength training carried out during physical education classes (Tkachenko, 2020).

Technological approaches to assessing the training effects of strength loads in primary schoolchildren were examined in a number of studies (Ivashchenko, Khudolii, Prusik, & Giovanis, 2020; Iermakov, Ivashchenko, Khudolii, & Chernenko, 2020; Khudolii, Iermakov, Ivashchenko, & Nosko, 2020). One of the technological approaches is the use of pattern recognition methodology in research (Neimark & Teklina, 2007, 2012; Ivashchenko, Khudolii, Prusik, & Giovanis, 2020). In studying the effectiveness of strength development, there is a problem of single-factor and multi-factor influences on the formation of the cumulative training effect of a series of classes. The aspect of research is the study of the patterns of regulating strength exercises, the result of which is the cumulative training effect of a series of classes, and the obtained data represent time series at each step of discretization. The effectiveness of pattern recognition increases with the use of active 2^k experiments (Ivashchenko, 2020; Ivashchenko, Khudolii, Iermakov, Chernenko, & Honcharenko, 2018). However, there are few studies aimed at examining multi-factor influences on the formation of the cumulative training effect of a series of exercises. Most studies consider the impact of 2-, 4-, 6-, 8-, and 16-week training on strength development in young people (Glass, Ahmad, & Gabler, 2020; Bendikova, Marko, Rozim, & Martinsky, 2019; Hagstrom, Shorter, & Marshall, 2019).

Thus, the problem of assessing the cumulative training effects of a series of classes and managing strength training of primary schoolchildren is relevant and requires further research.

The purpose of the study was to determine the impact of orthogonal strength loads on the dynamics of cumulative training effects of a series of classes in boys aged 8 years.

Materials and methods

Study participants

The study participants were boys aged 8 years (n = 48). The children and their parents were fully informed about all the features of the study and gave their consent to participate in the experiment.

Study organization

To solve the tasks set, theoretical and empirical methods were used: analysis and generalization of scientific and methodological literature; modeling, pedagogical observation and experiment, discriminant analysis.

To determine the dynamics of strength training effects in boys aged 8 years, the study carried out an experiment according to the plan given in Table 1. Variant I of the combined method was used to strengthen arm and shoulder muscles (place I), abdominal muscles (place II), back muscles (place III), and leg muscles (place IV). At each place, the following methods were used: dynamic effort method, maximal effort method, isometric effort method, repeated effort method. The modes of performance for each group, for the indicated places are given in Table 1.

The study examined the impact of four variants of strength load on the cumulative training effect (CTE) of 3, 6, 9, and 12 classes in boys aged 8 years:

Mode I CTE₃ → CTE₆ → CTE₉ → CTE₁₂;
 Mode II CTE₃ → CTE₆ → CTE₉ → CTE₁₂;
 Mode III CTE₃ → CTE₆ → CTE₉ → CTE₁₂;
 Mode IV CTE₃ → CTE₆ → CTE₉ → CTE₁₂.

Table 1. Factorial design in studying the influence of different modes of the combined method of strength development (variant I) in primary schoolchildren (X₁ — number of repetitions in a set; X₂ — rest interval, s)

No. of strength load variant	Method	X ₁	X ₂
I	Dynamic effort method	3-	30-
	Maximal effort method	1-	30-
	Isometric effort method	3-	30-
	Repeated effort method	6-	30-
II	Dynamic effort method	5+	30-
	Maximal effort method	3+	30-
	Isometric effort method	5+	30-
	Repeated effort method	12+	30-
III	Dynamic effort method	3-	60+
	Maximal effort method	1-	60+
	Isometric effort method	3-	60+
	Repeated effort method	6-	60+
IV	Dynamic effort method	5+	60+
	Maximal effort method	3+	60+
	Isometric effort method	5+	60+
	Repeated effort method	12+	60+

At each station, the following exercises were performed:

Station I. Exercises for arm and shoulder muscles.

1. Dynamic effort method. Knee push-ups. The exercise is performed as quickly as possible.
2. Maximal effort method. Weighted push-ups (stuffed ball).
3. Isometric effort method. Knee push-ups. The exercise is performed with two stops and fixation of joint angles (5 s).
4. Repeated effort method. Knee push-ups.

Station II. Exercises to strengthen abdominal muscles.

1. Dynamic effort method. Sit-ups. The exercise is performed as quickly as possible.
2. Maximal effort method. *Hanging 90-degree leg raises on wall bars.*
3. Isometric effort method. *Decline bench 90-degree leg raises.* The exercise is performed with two stops and fixation of joint angles (5 s).
4. Repeated effort method. *Decline bench leg raises to plow.*

Station III. Exercises to strengthen back muscles.

1. Dynamic effort method. Trunk lift. The exercise is performed as quickly as possible.
2. Maximal effort method. Trunk lift on a pommel horse with feet supported under wall bars.
3. Isometric effort method. Trunk lift with two stops and holding each static position for 5 s. The exercise is performed with two stops and fixation of joint angles (5 s) (hold positions in the upper point and horizontally).
4. Repeated effort method. The same starting position. Trunk lift.

Station IV. Exercises to strengthen leg muscles.

1. Dynamic effort method. Squats. The exercise is performed as quickly as possible.
2. Maximal effort method. Weighted squats (stuffed ball, dumbbells).
3. Isometric effort method. Weighted squats with stops. The exercise is performed with two stops and fixation of joint angles (5 s) (90°, 135°).
4. Repeated effort method. Squats.

During the experiment, the study recorded the results of the following tests: 1. Push-ups. 2. Speed push-ups, 3 times. 3. Sit-ups in 30 seconds. 4. Trunk lift in 10 seconds. 5. Standing long jump.

On the first day before the experiment, the study recorded the results of test 2 “Speed push-ups, 3 times”, test 1 “Push-ups”, test 3 “Sit-ups in 30 seconds”, test 4 “Trunk lift in 10 seconds”, test 5 “Standing long jump”. 24 hours after 3, 6, 9, and 12 classes— tests 2, 1, 3, 4, 5. The dynamics of test results was determined as a percentage relative to the initial level.

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

Statistical analysis

The study materials were processed by the IBM SPSS 22 statistical analysis program. In the process of discriminant analysis, a prognostic model for group membership was created. This model builds 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, which ensures the best division of groups. These functions are built 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 each canonical discriminant function, the study calculated: eigenvalue, dispersion percentage, canonical correlation, Wilks’ lambda, Chi-square.

Results

The discriminant analysis made it possible to obtain information about the dynamics of the cumulative training effect (CTE) of strength exercises with different focuses, taking into account their modes after 3, 6, 9, and 12 classes.

After the first mode of strength exercises, the results of tests 1, 3, 5 differ statistically significantly ($p = 0.001$; $p = 0.009$). The dynamics of the results of tests 2 and 4 is not statistically significant ($p = 0.06$).

After the second mode of strength exercises, the results of tests 3, 4, 5 differ statistically significantly ($p = 0.036$; $p = 0.075$; $p = 0.058$, respectively). The dynamics of the results of tests 1, 2 is not statistically significant ($p > 0.1$).

After the third mode of strength exercises, the results of test 3 differ statistically significantly ($p = 0.063$). The dynamics of the results of tests 1, 2, 4, and 5 is not statistically significant ($p > 0.1$).

After the fourth mode of strength exercises, the results of tests 1, 3, 4, and 5 differ statistically significantly ($p = 0.018$; $p = 0.001$; $p = 0.001$; $p = 0.012$, respectively). The dynamics of the result of test 2 is not statistically significant ($p = 0.134$) (see Table 2).

Thus, the CTE_{3, 6, 9, 12} of strength exercises in boys aged 8 years as compared with the initial level differs statistically significantly and has different focuses.

Table 2. The results of the impact of strength exercises modes on test results of boys aged 8 years (%)

Place	N	Indicators	Terms of recording	Variant I (n = 12)		Variant II (n = 12)		Variant III (n = 12)		Variant IV (n = 12)	
				X	s	X	s	X	s	X	s
Place I “Exercises for arm and shoulder muscles”	1. Push-ups	IL* after 3 classes after 6 classes after 9 classes after 12 classes F; p	IL	100.00							
				100.00	5.02	103.62	4.19	106.30	39.72	96.65	9.87
				109.44	7.89	106.15	6.83	86.23	20.77	105.25	16.35
				100.44	7.44	105.22	13.22	91.65	13.23	87.07	19.60
				110.34	3.59	104.42	9.06	102.66	3.12	107.31	18.86
				9.644; 0.001		0.175; 0.913		1.917; 0.141		3.700; 0.018	
	2. Speed push-ups, 3 times	IL after 3 classes after 6 classes after 9 classes after 12 classes F; p	IL	100.00							
				98.60	3.85	101.31	10.21	110.22	10.61	103.11	7.82
				90.31	13.20	98.70	6.88	108.16	11.37	97.77	13.52
				94.14	5.20	100.50	5.54	110.39	14.36	101.95	12.75
				94.05	11.21	97.73	6.89	102.04	3.69	92.87	11.03
				1.612; 0.200		0.559; 0.645		1.588; 0.206		1.959; 0.134	
Place II “Exercises to strengthen abdominal muscles”	3. Sit-ups in 30 seconds	IL after 3 classes after 6 classes after 9 classes after 12 classes F; p	IL	100.00							
				99.30	3.70	100.08	2.46	98.53	9.81	101.67	6.38
				104.10	6.50	101.52	5.94	95.91	6.25	105.09	4.52
				97.54	5.31	94.90	10.27	102.09	4.26	92.83	9.92
				101.72	2.55	101.84	3.66	102.12	3.73	99.37	7.10
				4.331; 0.009		3.096; 0.036		2.609; .063		6.106; 0.001	
Place III “Exercises to strengthen back muscles”	4. Trunk lift in 10 seconds	IL after 3 classes after 6 classes after 9 classes after 12 classes F; p	IL	100.00							
				100.10	4.83	100.86	6.35	98.43	9.49	98.66	5.92
				100.23	5.07	100.23	3.31	102.06	5.85	97.15	4.22
				100.10	4.83	107.99	12.24	102.59	7.88	89.29	5.95
				101.51	3.53	103.71	6.49	101.51	3.53	97.43	3.78
				.266; .850		2.463; 0.075		0.841; 0.479		8.548; 0.000	
Place IV “Exercises to strengthen leg muscles”	5. Standing long jump	IL after 3 classes after 6 classes after 9 classes after 12 classes F; p	IL	100.00							
				99.51	.72	97.92	1.68	99.61	3.01	97.97	5.48
				100.67	2.21	96.87	2.87	99.33	4.06	99.09	2.32
				103.20	1.99	96.41	4.17	98.16	3.27	93.81	5.03
				101.97	2.52	99.53	2.39	99.28	2.39	98.18	2.01
				7.779; 0.001		2.690; 0.058		0.465; 0.708		4.100; 0.012	

*IL – initial level

Tables 3-6 show the results of discriminant analysis for a set of data for four modes of strength exercises.

The following data were obtained for the first variant of strength exercises.

The first canonical function explains 49.1% of the variation of results, the second one—46.4%, which indicates a high informativeness of the first and second canonical functions ($r_1 = 0.653$; $r_2 = 0.643$); (see Table 3, variant I).

The verification of the first and second functions shows their high discriminative ability and value in interpretation with respect to the general population ($\lambda_1 = 0.315$; $p_1 = 0.001$; $\lambda_2 = 0.550$; $p_2 = 0.001$; Table 4, variant I). The first function characterizes the impact of strength load on the dynamics of test results after 3, 6, 9, and 12 classes.

Structure coefficients indicate that the most significant changes in the CTE are associated with the work at the fourth place “Exercises to strengthen leg muscles” ($r = 0.822$, see Table 5, variant I). During a discriminant analysis, it was found that 58.3% of cases were classified correctly. The analysis of group centroids for the first load variant shows that at the positive pole of the first function, there are the centroids of state after 9 classes, at the negative pole — the centroids of training effects of strength loads after 3 classes. Thus, the first variant of strength load has the greatest overall impact on the CTE after 9 classes (see Table 6. Fig. 1).

The following data were obtained for the second variant of strength exercises.

The first canonical function explains 57.3 % of the variation of results, the second one—37.4%, which indicates the informativeness of the first and second canonical functions ($r_1 = 0.5$; $r_2 = 0.422$) (see Table 3, variant II).

The verification of the functions shows their low discriminative ability.

Structure coefficients indicate that the most significant changes in the CTE are associated with the work at the second place “Exercises to strengthen abdominal muscles” ($r = -0.788$, see Table 5, variant II). During a discriminant analysis, it was found that 56.2% of cases were classified correctly. The analysis of group centroids for the second load variant shows that at the positive pole of the first function, there are the centroids of state after 9 classes, at the negative pole — the centroids of training effects of strength loads after 12 classes. Thus, the second variant of strength load has the greatest overall impact on the CTE after 9 classes (see Table 6. Fig. 2).

The following data were obtained for the third variant of strength exercises.

The first canonical function explains 75.8 % of the variation of results, the second one–16.1%, which indicates the informativeness of the first and second canonical functions ($r_1 = 0.768$; $r_2 = 0.485$) (see Table 3, variant III).

The verification of the first and second functions shows their high discriminative ability and value in interpretation with respect to the general population ($\lambda_1 = 0.272$; $p_1 = 0.001$; $\lambda_2 = 0.663$; $p_2 = 0.026$; Table 4, variant III). The first function characterizes the impact of strength load on the dynamics of test results after 3, 6, 9, and 12 classes.

Structure coefficients show that the most significant changes in the CTE are associated with the work at the first and second places (see Table 5, variant III). During a discriminant analysis, it was found that 62.5% of cases were classified correctly. The analysis of group centroids for the third load variant shows that at the positive pole of the first function, there are the centroids of state after 3 classes, at the negative pole – the centroids of training effects of strength loads after 9 classes. Thus, the third variant of strength load has the greatest overall impact on the CTE after 3 classes (see Table 6. Fig. 3).

The following data were obtained for the fourth variant of strength exercises.

The first canonical function explains 69.7 % of the variation of results, the second one– 21.7%, which indicates the informativeness of the first and second canonical functions ($r_1 = 0.692$; $r_2 = 0.471$) (see Table 3, variant IV).

The verification of the first and second functions shows their high discriminative ability and value in interpretation with respect to the general population ($\lambda_1 = 0.365$; $p_1 = 0.001$; $\lambda_2 = 0.699$; $p_2 = 0.055$; Table 4, variant IV). The first function characterizes the impact of strength load on the dynamics of test results after 3, 6, 9, and 12 classes.

Structure coefficients show that the most significant changes in the CTE are associated with the work at the second and third places (see Table 5, variant IV). During a discriminant analysis, it was found that 56.2% of cases were classified correctly. The analysis of group centroids for the fourth load variant shows that at the positive pole of the first function, there are the centroids of state after 6 classes, at the negative pole – the centroids of training effects of strength loads after 9 classes. Thus, the fourth variant of strength load has the greatest overall positive impact on the CTE after 6 classes, and the negative one – after 9 classes (see Table 6. Fig. 4).

Table 3. Eigenvalues. Boys aged 8 years

Variant	Function	Eigenvalue	% of Variation	Cumulative %	Canonical Correlation
I	1	.744	49.1	49.1	.653
	2	.703	46.4	95.5	.643
	3	.068	4.5	100.0	.252
II	1	.333	57.3	57.3	.500
	2	.217	37.4	94.7	.422
	3	.031	5.3	100.0	.173
III	1	1.442	75.8	75.8	.768
	2	.307	16.1	91.9	.485
	3	.154	8.1	100.0	.365
IV	1	.917	69.7	69.7	.692
	2	.285	21.7	91.4	.471
	3	.113	8.6	100.0	.318

Table 4. Test of function(s). Boys aged 8 years

Variant	Test of function(s)	Wilks' lambda	Chi-square	df	Sig.
I	1 through 3	.315	49.058	15	.000
	2 through 3	.550	25.419	8	.001
	3	.937	2.782	3	.427
II	1 through 3	.598	21.848	15	.112
	2 through 3	.797	9.648	8	.291
	3	.970	1.298	3	.730
III	1 through 3	.272	55.402	15	.000
	2 through 3	.663	17.458	8	.026
	3	.867	6.080	3	.108
IV	1 through 3	.365	42.860	15	.000
	2 through 3	.699	15.205	8	.055
	3	.899	4.543	3	.208

Table 5. Structure matrix. Boys aged 8 years

Indicators	Variant I Function			Variant II Function			Variant III Function			Variant IV Function		
	1	2	3	1	2	3	1	2	3	1	2	3
1 Push-ups	-.127	.956	.201	.028	-.106	.546	.125	.085	-.830	.399	.536	-.466
2 Speed push-ups, 3 times	-.048	-.303	.804	.217	-.120	-.788	.101	.441	.470	-.088	-.547	.602
3 Sit-ups in 30 seconds	-.345	.531	-.349	-.788	-.148	.000	-.232	.280	-.704	.646	.209	.438
4 Trunk lift in 10 seconds	.035	.110	.358	.527	.546	.594	-.177	-.073	.264	.771	-.073	-.570
5 Standing long jump	.822	.158	-.385	-.558	.573	-.523	.114	-.188	-.111	.534	.241	-.126

Table 6. Functions at group centroids. Boys aged 8 years

Terms of recording	Load variants			
	I	II	III	IV
after 3 classes	-0.856	-0.065	1.753	.684
after 6 classes	-0.690	-0.274	.270	.720
after 9 classes	1.175	.905	-1.228	-1.535
after 12 classes	.371	-0.566	-0.795	.131

Thus, the CTE_{3, 6, 9, 12} of strength exercises in boys aged 8 years as compared with the initial level differs statistically significantly and has different focuses: variant I – strengthening arms, abdominal muscles, and leg muscles; variant II – strengthening abdominal, back, and leg muscles; variant III – strengthening abdominal muscles; variant IV – strengthening all muscles. The greatest overall positive CTE is observed in: variants I and II – after 9 classes; variant III – after 3 classes; variant IV – after 6 classes.

Fig. 1. Dynamics of test results in boys aged 8 years. Load variant I: 1 – after 3 classes, 2 – after 6 classes, 3 – after 9 classes, 4 – after 12 classes

Fig. 2. Dynamics of test results in boys aged 8 years. Load variant II: 1 – after 3 classes, 2 – after 6 classes, 3 – after 9 classes, 4 – after 12 classes

Fig. 3. Dynamics of test results in boys aged 8 years. Load variant III: 1 – after 3 classes, 2 – after 6 classes, 3 – after 9 classes, 4 – after 12 classes

Fig. 4. Dynamics of test results in boys aged 8 years. Load variant IV: 1 – after 3 classes, 2 – after 6 classes, 3 – after 9 classes, 4 – after 12 classes

Discussion

The study assumed that the conditions of performing strength exercises during physical education classes influence the dynamics of the CTE in boys aged 8 years. It was found that each of the four orthogonal load variants has its peculiarities of influence on the formation of the CTE of strength exercises.

Studies on strength fitness outline the results characterizing the influence of:

- strength loads on the dynamics of the immediate and delayed training effect (Ivashchenko, Khudolii, Prusik, & Giovanis, 2020; Iermakov, Ivashchenko, Khudolii, & Chernenko, 2020; Khudolii, Iermakov, Ivashchenko, & Nosko, 2020);
- 2-week training on strength development (Glass, Ahmad, & Gabler, 2020; Floreani, Rejc, Taboga, Ganzini, Pišot, Šimunič, Biolo, Reggiani, Passaro, Narici, Rittweger, Di Prampero, & Lazzer, 2018);
- 4-week training on strength development (Bendikova, Marko, Rozim, & Martinsky, 2019; Chaouachi, Ben Othman, Makhlof, Young, Granacher, & Behm, 2019; Veremeenko, Khudolii, & Ivashchenko, 2019);
- 6-week training on strength development (Cavar, Marsic, Corluka, Culjak, Cerkez Zovko, Müller, Tschakert, & Hofmann, 2019; Lockie, 2018);
- 8-week training on strength development (Hale, Kollock, Pace, & Sanders, 2019);
- 16-week training on strength development (Hagstrom, Shorter, & Marshall, 2019);
- 24-week training on strength development (Cesanelli, Vici, Camilletti, Ceci, Belli, & Polzonetti, 2019; Pirauá, Cavalcante, de Oliveira, Beltrão, de Amorim Batista, Pitangui, Behm, & de Araújo, 2019);
- 10-month training on strength development (Larsen, Nielsen, Helge, Madsen, Manniche, Hansen, Hansen, Bangsbo, & Krstrup, 2018).

The studies also analyzed the impact of different methods on the dynamics of strength fitness of children and adolescents (Cadore, González-Izal, Grazioli, Setuain, Pinto, & Izquierdo, 2019; Michailidis, Tabouris, & Metaxas, 2019).

In contrast to the above, this study obtained data on the impact of orthogonal variants of alternation of strength exercises and rest intervals on the cumulative training effect of strength loads after 3, 6, 9, and 12 classes. The study confirmed the information that the effectiveness of discriminant analysis increases with the use of active 2^k full factorial experiments (Ivashchenko, Khudolii, Iermakov, Chernenko, & Honcharenko, 2018; Khudolii, 2019; Ivashchenko, 2020).

The data obtained supplement the information on the development of training effects of strength loads in primary school children (Ivashchenko et al., 2020; Iermakov et al., 2020; Khudolii et al., 2020).

The results of the study can be used to plan strength training during physical education classes in junior school. For planning, the data given in Table 1 are recommended, taking into account the values of structure coefficients and group centroids (Tables 5, 6, Fig. 1-4). The main method of strength development is the combined method of the first variant. Exercises at one place are performed in the following order: dynamic effort method, maximal effort method, isometric effort method, repeated effort method. Strength development is viewed as a condition for successful motor skills formation.

Conclusion

It is possible to classify the cumulative training effect of a series of classes based on discriminant analysis. The effectiveness of discriminant analysis increases with the use of active 2^k full factorial experiments.

The verification of the obtained discriminant functions shows their high discriminative ability and value in interpretation with respect to the general population ($p < 0.05$). The analysis of structure coefficients showed the most significant changes in the CTE after work at places 1-4, the analysis of group centroids – the impact of strength load on the dynamics of the CTE after 3, 6, 9, and 12 classes.

The analysis of the study results shows that the CTE_{3, 6, 9, 12} of strength exercises in boys aged 8 years as compared with the initial level differs statistically significantly and has different focuses: variant I – strengthening arms, abdominal muscles, and leg muscles; variant II – strengthening abdominal, back, and leg muscles; variant III – strengthening abdominal muscles; variant IV – strengthening all muscles. The greatest overall positive CTE is observed in: variants I and II – after 9 classes; variant III – after 3 classes; variant IV – after 6 classes.

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