ORIGINAL ARTICLE

Strength abilities: pattern recognition method in the management of the cumulative effect of strength loads in 8-year-old boys

Olha Ivashchenko[1ABCDE], Oleg Khudolii[1ABCDE], Wladyslaw Jagiello[2ABCDE]

[1]*H.S. Skovoroda Kharkiv National Pedagogical University, Ukraine*
[2]*Gdansk University of Physical Education and Sport, Poland*

Authors' Contribution: A – Study Design; B – Data Collection; C – Statistical Analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: The purpose of the study was to determine the peculiarities of using pattern recognition method in the management of the cumulative effect of strength loads in 8-year-old boys.

Material and Methods: The study participants were 48 boys aged 8. The experiment was conducted using a 2^2 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 three, six, nine, and twelve classes in 8-year-old boys.

Results: The discriminant analysis provided information about the impact of four orthogonal variants of strength loads on the formation of the cumulative training effect of strength exercises of three, six, nine, and twelve classes in 8-year-old boys. The obtained data make it possible to choose a load mode at each step of the CTE formation and to manage schoolchildren's strength training.

Conclusions: The verification of the obtained discriminant functions shows their high discriminative ability and value in interpretation with respect to the general population ($p < 0.05$). It was found that the formation of the CTE of three classes is most influenced by the third load variant, six classes – by the third load variant, nine classes – the third load variant, twelve classes – the first load variant. The discriminant function structure coefficients made it possible to identify the factor structure of the CTE of 3, 6, 9, 12 classes, to find that the CTE3, CTE6 are associated with the work at the first place "Exercises to strengthen arm muscles", the CTE9, CTE12 – with the work at the third ("Exercises to strengthen back muscles") and the fourth ("Exercises to strengthen leg muscles") places. The CTE of three, six, nine, and twelve classes depends on the modes of strength exercises and has different focuses. The CTE3 – speed and strength focus; CTE6, 9 – comprehensive focus; CTE12 – explosive-strength focus. The obtained values of centroids for the CTE of 3, 6, 9, 12 classes enable the management of schoolchildren's strength training.

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

Introduction

One of the factors that ensure the effectiveness of physical education and sports training is the assessment and management of training effects in the process of teaching and developing motor abilities [1-3].

Motor skills formation [4, 5] and motor abilities development depend on the number of repetitions and rest interval [6-8]. Luz et al. [9], Krivolapchuk et al. [10], Krutsevich et al. [11] point out the importance of studying the impact of physical loads on the functional state of primary schoolchildren. The results obtained show a positive effect of high-intensity exercises on the body of children aged 5-6 and 6-7 years [10].

Polevoy [12], Smits-Engelsman et al. [13], Veremeenko et al. [14] focus on the process of developing strength and coordination abilities in schoolchildren's physical education. It was found that primary schoolchildren's indicators of speed-strength and coordination abilities significantly improve, if special exercises are used during physical education classes [12], the level of schoolchildren's motor fitness depends on their coordination and speed-strength fitness [14].

Pattern recognition methodology is one of the technological approaches to studying the processes, the data of which represent time series at each step of discretization [15, 16]. In research on the effectiveness of strength development, there is a problem of studying single-factor and multi-factor impacts on the formation of the cumulative training effect of a series of classes. An aspect of research is studying the laws of regulating strength exercises which result in the cumulative training effect of a series of classes, and the obtained data represent time series at each step of discretization [7, 17, 18]. It was found that the effectiveness of pattern recognition increases with the use of active 2^k experiments [2, 18]. However, there are few studies aimed at investigating multi-factor impacts on the formation of the cumulative training effect of 3, 6, 9, 12 classes in primary-school-aged children. Most studies consider the impact of 2-, 4-, 6-, 8-, and 16-week training on strength development in young people [19-21].

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.

doi:10.15561/26649837.2021.0407

The purpose of the study was to determine the peculiarities of using pattern recognition method in the management of the cumulative effect of strength loads in 8-year-old boys.

Materials and Methods

Participants

The study participants were boys aged 8 (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. The study protocol was approved by the Ethical Committee of H. S. Skovoroda Kharkiv National Pedagogical University.

Research Design

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, 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 8-year-old boys:

CTE3: I mode → II mode → III mode → IV mode
CTE6: I mode → II mode → III mode → IV mode
CTE9: I mode → II mode → III mode → IV mode
CTE12: I mode → II mode → III mode → IV mode

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.

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+

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". Twenty-four 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.

Statistical analysis

The study materials were processed using 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 provided information about the impact of four orthogonal modes of strength exercises on the CTE of three, six, nine, and twelve classes (Table 2).

CTE3: statistically significant changes are observed in the dynamics of the results of Test 2 "Speed push-ups, 3 times", load variant I helps to increase the speed of performing the test task, variants II-IV lead to an increase in the time of performing the exercise ($p = 0.013$).

CTE6: the dynamics of the results of Tests 1-3, 5 statistically significantly depends on the modes of strength exercises.

CTE9: the dynamics of the results of Tests 1-5 statistically significantly depends on the modes of strength exercises.

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

No	Indicators	Variants of performing exercises									
		I		II		III		IV			
		X	s	X	s	X	s	X	s	F	p
		CTE of 3 classes									
1	Push-ups	100.00	5.02	103.62	4.19	106.31	39.71	96.65	9.87	.496	.687
2	Speed push-ups, 3 times	98.60	3.85	101.31	10.20	110.22	10.61	103.11	7.81	4.045	**.013**
3	Sit-ups in 30 seconds	99.30	3.71	100.08	2.46	98.53	9.80	101.67	6.38	.551	.650
4	Trunk lift in 10 seconds	100.11	4.83	100.86	6.35	98.43	9.49	98.66	5.91	.345	.793
5	Standing long jump	99.51	.72	97.92	1.68	99.61	3.01	97.97	5.48	.980	.411
		CTE of 6 classes									
1	Push-ups	109.44	7.89	106.15	6.83	86.23	20.77	105.24	16.35	6.566	.001
2	Speed push-ups, 3 times	90.31	13.20	98.70	6.88	108.16	11.37	97.77	13.52	4.815	.006
3	Sit-ups in 30 seconds	104.10	6.50	101.52	5.94	95.91	6.25	105.09	4.52	5.919	.002
4	Trunk lift in 10 seconds	100.23	5.07	100.23	3.31	102.06	5.85	97.15	4.22	2.245	.096
5	Standing long jump	100.67	2.21	96.87	2.87	99.33	4.06	99.09	2.32	3.399	.026
		CTE of 9 classes									
1	Push-ups	100.44	7.44	105.22	13.22	91.65	13.23	87.07	19.60	4.121	.012
2	Speed push-ups, 3 times	94.14	5.20	100.50	5.54	110.39	14.36	101.95	12.75	5.027	.004
3	Sit-ups in 30 seconds	97.54	5.31	94.90	10.27	102.09	4.26	92.83	9.92	3.059	.038
4	Trunk lift in 10 seconds	100.10	4.83	107.99	12.24	102.59	7.88	89.29	5.95	10.927	.000
5	Standing long jump	103.20	1.99	96.41	4.17	98.16	3.27	93.81	5.03	13.134	.000
		CTE of 12 classes									
1	Push-ups	110.34	3.59	104.42	9.06	102.66	3.12	107.30	18.86	1.180	.328
2	Speed push-ups, 3 times	94.05	11.21	97.73	6.89	102.04	3.69	92.87	11.03	2.659	.060
3	Sit-ups in 30 seconds	101.72	2.55	101.84	3.66	102.12	3.73	99.37	7.10	.920	.439
4	Trunk lift in 10 seconds	101.51	3.53	103.71	6.49	101.51	3.53	97.43	3.78	4.040	.013
5	Standing long jump	101.97	2.52	99.53	2.39	99.28	2.39	98.18	2.01	5.620	.002

Note: *initial level – 100%

CTE12: the dynamics of the results of Tests 2, 4, 5 statistically significantly depends on the modes of strength exercises.

Thus, the formation of the CTE of three, six, nine, and twelve classes depends on the modes of strength exercises and has different focuses. The CTE3 – speed and strength focus; CTE6, 9 – comprehensive focus; CTE12 – explosive-strength focus.

Tables 3-6 show the results of discriminant analysis of a set of data for the CTE of three, six, nine, and twelve classes after four modes of strength exercises.

CTE3: The first canonical function explains 76.2% of the variation of results, the second one – 12.5%, which indicates a high informativeness of the first canonical function ($r_1 = 0.634$) (Table 3, CTE3).

The verification of the first function shows its high discriminative ability and value in interpretation with respect to the general population ($\lambda_1 = 0.490$; $p_1 = 0.011$; Table 4, CTE3). The first function characterizes the impact of strength load variants I-IV on the CTE3.

Structure coefficients indicate that the most significant changes in the CTE3 are associated with the work at the first place "Exercises to strengthen arm muscles", Test 2 "Speed push-ups, 3 times", (r = 0.583; Table 5, CTE3).

Table 3. Eigenvalues. Boys aged 8

CTE	Function	Eigenvalue	% of Variance	Cumulative %	Canonical correlation
	1	.672[a]	76.2	76.2	.634
CTE3	2	.110[a]	12.5	88.8	.315
	3	.099[a]	11.2	100.0	.300
	1	.845[a]	62.2	62.2	.677
CTE6	2	.383[a]	28.2	90.3	.526
	3	.132[a]	9.7	100.0	.341
	1	1.405[a]	49.9	49.9	.764
CTE9	2	.936[a]	33.2	83.2	.695
	3	.474[a]	16.8	100.0	.567
	1	.900[a]	55.0	55.0	.688
CTE12	2	.676[a]	41.3	96.3	.635
	3	.061[a]	3.7	100.0	.240

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

CTE	Test of function(s)	Wilks' Lambda	Chi-square	df	Sig.
	1 through 3	.490	30.300	15	.011
CTE3	2 through 3	.819	8.465	8	.389
	3	.910	4.011	3	.260
	1 through 3	.346	45.054	15	.000
CTE6	2 through 3	.639	19.030	8	.015
	3	.884	5.259	3	.154
	1 through 3	.146	81.857	15	.000
CTE9	2 through 3	.351	44.555	8	.000
	3	.678	16.485	3	.001
	1 through 3	.296	51.776	15	.000
CTE12	2 through 3	.562	24.487	8	.002
	3	.942	2.528	3	.470

Table 5. Structure matrix. Boys aged 8

No	Indicators	CTE3 Function			CTE6 Function			CTE9 Function			CTE12 Function		
		1	2	3	1	2	3	1	2	3	1	2	3
1	Push-ups	.195	-.151	-.240	-.683	.090	.620	.221	.053	.666	.023	.334	-.270
2	Speed push-ups, 3 times	.583*	.449	.504	.548	.263	-.607	.075	.388	-.640	.176	-.423	.727
3	Sit-ups in 30 seconds	-.146	-.081	.477	-.690	-.016	-.081	.331	.003	-.340	.241	-.123	.055
4	Trunk lift in 10 seconds	-.076	-.353	-.243	.349	-.143	.569	.565	.393	.567	.438	-.309	-.787
5	Standing long jump	.114	.490	-.564	-.063	-.761	-.229	.574	-.651	.270	.556	.385	-.282

Table 6. Functions at group centroids. Boys aged 8

Terms of recording	CTE3	CTE6	CTE9	CTE12
I mode	-0.748	-.622	.651	.964
II mode	0.039	-.027	.124	.204
III mode	1.263	1.442	1.098	.324
IV mode	-0.554	-.793	-1.873	-1.492

CTE3 – 54.2%; CTE6 – 68.8%; CTE9 – 83.3%; CTE12 – 66.7%.

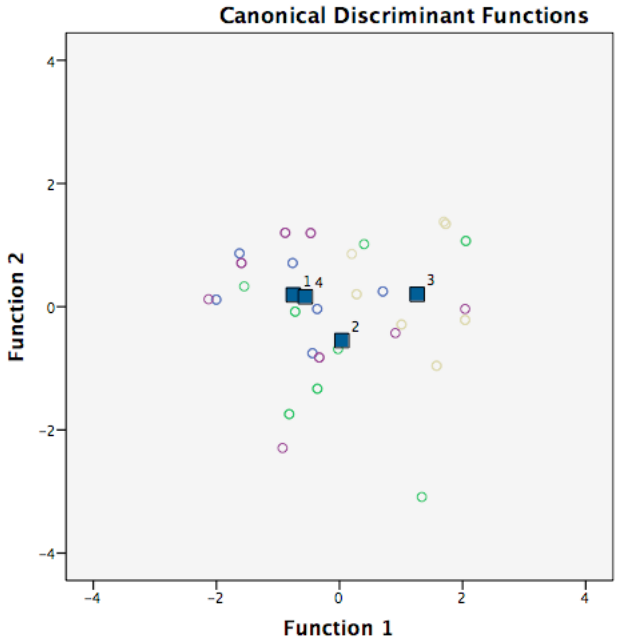

Fig. 1. Dynamics of test results in boys aged 8. CTE3: 1 – load variant I, 2 – load variant II, 3 – load variant III, 4 – load variant IV

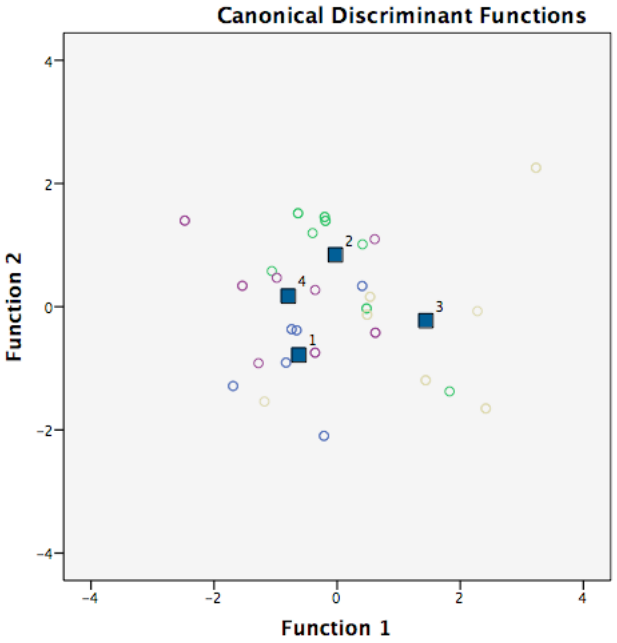

Fig. 2. Dynamics of test results in boys aged 8. CTE6: 1 – load variant I, 2 – load variant II, 3 – load variant III, 4 – load variant IV

During a discriminant analysis, it was found that 54.2% of cases were classified correctly. The analysis of group centroids for the CTE3 shows that at the positive pole of the first function, there are the centroids of state after load variant III, at the negative pole – the centroids of state after load variants I and IV. Thus, the third variant of strength load has the greatest overall impact on the CTE after 3 classes (Table 6, Fig. 1). Strength load variant I can be recommended for developing speed strength.

CTE6: The first canonical function explains 62.2 % of the variation of results, the second one – 28.2%, which indicates the informativeness of the first and second canonical functions ($r_1 = 0.677$; $r_2 = 0.526$; Table 3, CTE6).

The verification of the functions shows their high discriminative ability ($\lambda_1 = 0.346$; $p_1 = 0.000$; $\lambda_1 = 0.639$; $p_1 = 0.015$; Table 4, CTE6).

Structure coefficients indicate that the most significant changes in the CTE are associated with the work at the first place "Exercises to strengthen arm muscles" and the second one "Exercises to strengthen abdominal muscles" (r_1 = -0.683, r_2 = 0.548, r_3 = -0.690; Table 5, CTE6). During a discriminant analysis, it was found that 68.8% of cases were classified correctly. The analysis of group centroids for the CTE6 shows that at the positive pole of the first function, there are the centroids of state after load variant III, at the negative pole – the centroids of state after load variants I, II and IV. Thus, the third variant of strength load has the greatest overall impact on the CTE after 6 classes (Table 6, Fig. 2).

CTE9: The first canonical function explains 49.9% of the variation of results, the second one – 33.2%, the third – 16.8%, which indicates the informativeness of the canonical functions ($r_1 = 0.764$; $r_2 = 0.695$; $r_3 = 0.567$; Table 3, CTE9).

The verification of the functions shows their high discriminative ability and value in interpretation with respect to the general population ($\lambda_1 = 0.146$; $p_1 = 0.000$; $\lambda_2 = 0.351$; $p_2 = 0.000$; $\lambda_3 = 0.678$; $p_3 = 0.001$; Table 4, CTE9). The first function characterizes the impact of strength load on the dynamics of test results after 9 classes.

Structure coefficients indicate that the most significant changes in the CTE are associated with the work at the third and fourth places (Table 5, CTE9). During a discriminant analysis, it was found that 83.3% of cases were classified correctly. The analysis of group centroids for the CTE9 shows that at the positive pole of the first function, there are the centroids of state after load variant III, at the negative pole – the centroids of state after load

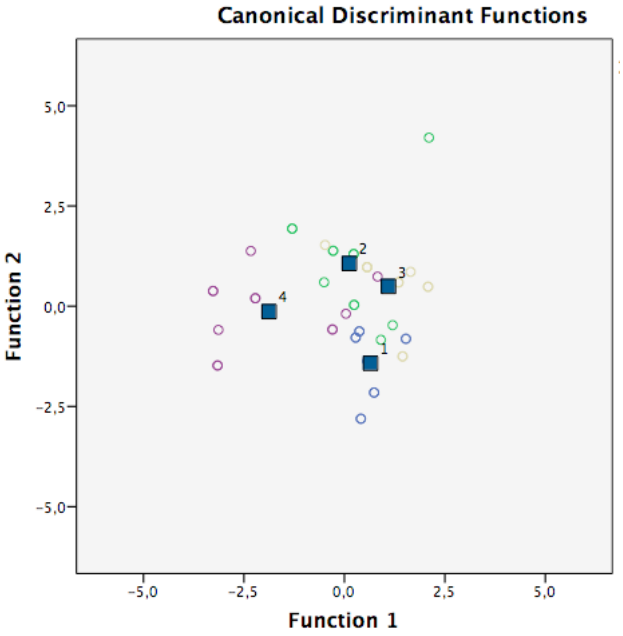

Fig. 3. Dynamics of test results in boys aged 8. CTE9: 1 – load variant I, 2 – load variant II, 3 – load variant III, 4 – load variant IV

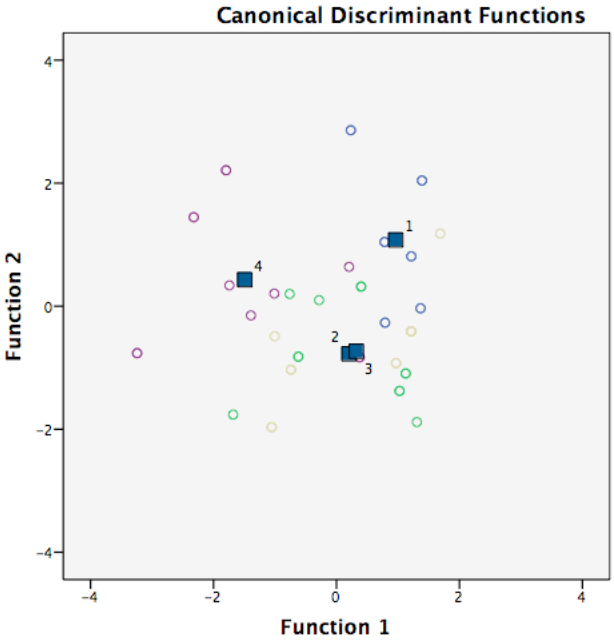

Fig. 4. Dynamics of test results in boys aged 8. CTE12: 1 – load variant I, 2 – load variant II, 3 – load variant III, 4 – load variant IV

variant IV. Thus, the third variant of strength load has the greatest overall positive impact, and the fourth variant has the greatest negative impact on the CTE after 9 classes (Table 6, Fig. 3).

CTE12: The first canonical function explains 55.7% of the variation of results, the second one – 41.3%, which indicates the informativeness of the first and second canonical functions (r_1 = 0.688; r_2 = 0.635; Table 3, CTE12).

The verification of the first and second functions shows their high discriminative ability and value in interpretation with respect to the general population (λ_1 = 0.296; p_1 = 0.000; λ_2 = 0.562; p_2 = 0.002; Table 4, CTE12). The first function characterizes the impact of strength load on the dynamics of test results after 12 classes.

Structure coefficients indicate that the most significant changes in the CTE12 are associated with the work at the third and fourth places (Table 5, CTE12). During a discriminant analysis, it was found that 66.7% of cases were classified correctly. The analysis of group centroids for the CTE12 shows that at the positive pole of the first function, there are the centroids of state after load variants I-III, at the negative pole – the centroids of state after load variant IV. Thus, the first variant of strength load has the greatest overall positive impact on the CTE12, negative impact – the fourth variant of strength load (Table 6, Fig. 4).

Discussion

The study assumed that the formation of the CTE of three, six, nine, and twelve classes has its peculiarities depending on the mode of strength exercises. It was found that the formation of the CTE of three classes is most influenced by the third load variant, six classes – by the third load variant, nine classes – the third load variant, twelve classes – the first load variant.

In studying the impact of the mode of strength exercises on the CTE using the scheme:

I variant: CTE3 → CTE6 → CTE9 → CTE12;
II variant: CTE 3 → CTE6 → CTE9 → CTE12;
III variant: CTE3 → CTE6 → CTE9 → CTE12;
IV variant: CTE3 → CTE6 → CTE9 → CTE12,

it was found that after the first variant of strength exercises the greatest overall training effect is observed after nine classes, the second variant – after nine classes, the third variant – after three classes, the fourth variant – after six classes [7]. The data obtained using the scheme:

CTE3: I variant → II variant → III variant → IV variant
CTE6: I variant → II variant → III variant → IV variant
CTE9: I variant → II variant → III variant → IV variant
CTE12: I variant → II variant → III variant → IV variant

provided an opportunity to assess the total impact of each variant of strength exercises on the dynamics of the CTE of 3, 6, 9, 12 classes and to clarify their peculiarities.

If the analysis of data using the first scheme revealed how each of the load variants affects the CTE, then the analysis of data using the second scheme answered the question as to which load variant is the best for developing a separate CTE of 3, 6, 9, 12 classes and what its focus is.

The obtained data make it possible to choose a load mode at each step of the CTE formation and supplement the information about the results of analysis of the impact of strength loads: on the dynamics of the immediate and delayed training effect [3, 17, 22]; on strength development in a two-week training cycle [19, 23]; on strength development in a four-week training cycle [14,

20, 24]; on strength development in a six-week training cycle [25, 26]; on strength development in an eight-week training cycle [27].

The discriminant function structure coefficients made it possible to identify the factor structure of the CTE of 3, 6, 9, 12 classes, to find that the CTE3, CTE6 are associated with the work at the first place "Exercises to strengthen arm muscles", the CTE9, CTE12 – with the work at the third and fourth places. The CTE of three, six, nine, and twelve classes depends on the modes of strength exercises and has different focuses. The CTE3 – speed and strength focus; CTE6, 9 – comprehensive focus; CTE12 – explosive-strength focus. The obtained data supplement the information on the formation of training effects of strength loads in primary schoolchildren [2, 3, 22].

The results of the study can be used to plan and control strength training in physical education classes in junior school. For planning, the data given in Table 1 are recommended, taking into account the values of group centroids (Table 6, Fig. 1-4). The main method of strength development is the combined method according to 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. The development of strength is seen as a condition for successful formation of motor skills. The results given in Table 1 can be used as guidelines for monitoring the formation of the CTE.

Conclusion

The verification of the obtained discriminant functions shows their high discriminative ability and value in interpretation with respect to the general population ($p < 0.05$).

It was found that the formation of the CTE of three classes is most influenced by the third load variant, six classes – by the third load variant, nine classes – the third load variant, twelve classes – the first load variant.

The discriminant function structure coefficients made it possible to identify the factor structure of the CTE of 3, 6, 9, 12 classes, to find that the CTE3, CTE6 are associated with the work at the first place "Exercises to strengthen arm muscles", the CTE9, CTE12 – with the work at the third ("Exercises to strengthen back muscles") and the fourth ("Exercises to strengthen leg muscles") places. The CTE of three, six, nine, and twelve classes depends on the modes of strength exercises and has different focuses. The CTE3 – speed and strength focus; CTE6, 9 – comprehensive focus; CTE12 – explosive-strength focus. The obtained values of centroids for the CTE of 3, 6, 9, 12 classes enable the management of schoolchildren's strength training.

Conflict of interest

The authors state no conflict of interest.

References

1. Jagiello W. Perkal's method of natural indicators in the assessment of internal proportions of body composition in persons practising combat sports - a review. *Archives of Budo,* 2019;15:187–93.
2. Ivashchenko O. Research Program: Modeling of Motor Abilities Development and Teaching of Schoolchildren. *Teorìâ ta Metodika Fìzičnogo Vihovannâ*, 2020; 20(1): 32–41. https://doi.org/10.17309/tmfv.2020.1.05
3. Khudolii O, Iermakov S, Ivashchenko O, Nosko M. Strength Abilities: Modeling of Immediate and Delayed Training Effect of Strength Loads in Boys Aged 8 Years. *Teorìâ ta Metodika Fìzičnogo Vihovannâ*, 2020; 20(4): 248–255. https://doi.org/10.17309/tmfv.2020.4.08
4. Iermakov S, Khudolii O, Chupikhin D. Discriminant Analysis: Impact of the Number of Repetitions on the Effectiveness of Teaching Boys Aged 7 Throwing a Small Ball. *Journal of Learning Theory and Methodology,* 2021; 2(2): 75–81. https://doi.org/10.17309/jltm.2021.2.04
5. Khudolii O, Iermakov S, Bartik P. Didactics: Methodological Basis of Motor Learning in Children and Adolescents. *Journal of Learning Theory and Methodology*, 2020;1(1): 5–13. https://doi.org/10.17309/jltm.2020.1.01
6. Nikšić E, Beganović E, Joksimović M. The impact of the program of basketball, volleyball and handball on the situation-motorized capability of the first classes of the elementary school. *Pedagogy of Physical Culture and Sports,* 2020;24:85–92. https://doi.org/10.15561/26649837.2020.0206
7. Iermakov S, Ivashchenko O, Khudolii O. Strength abilities: Assessment of cumulative training effects of strength loads of a series of classes in 8 years old boys. *Journal of Physical Education and Sport*, 2021; 21(s2): 1242–1250. https://doi.org/10.7752/jpes.2021.s2158
8. Ivashchenko O, Khudolii O, Yermakova T, Veremeenko V. Power abilities: the structure of development in girls of 12-14 years old. *Pedagogics, Psychology, Medical-Biological Problems of Physical Training and Sports*, 2018;22(4):195–02. https://doi.org/10.15561/18189172.2018.0405
9. Luz C, Rodrigues LP, de Meester A, Cordovil R. The relationship between motor competence and health-related fitness in children and adolescents. *Plos One*, 2017;12(6). https://doi.org/10.1371/journal.pone.0179993
10. Krivolapchuk IA, Chernova MB, Gerasimova AA. Effect of regular physical activity of various intensity on the functional status of 5-6 and 6-7-year-old children. *Human Sport Medicine*, 2020;20(2): 71–79. https://doi.org/10.14529/HSM200209
11. Krutsevich T, Pangelova N, Trachuk S, Diedukh M. Features of the Reaction of the Cardiorespiratory System of Schoolchildren with Physical Loads on the Tradmile. *International Journal of Applied Exercise Physiology*, 2020;9(1):113-121.
12. Polevoy G. Development of coordination and speed-power abilities in children 8-9 years with the help of exercise Classics. *Physical Activity Review*, 2020; 8(1): 46–50. https://doi.org/10.16926/par.2020.08.06
13. Smits-Engelsman BCM, Jelsma LD, Ferguson GD. The effect of exergames on functional strength, anaerobic fitness, balance and agility in children with and without motor coordination difficulties living in low-income communities. *Human Movement Science,* 2017;55:327–337. https://doi.org/10.1016/j.humov.2016.07.006
14. Veremeenko V, Khudolii O, Ivashchenko O. Motor abilities: methods of strength and strength endurance development in middle-school-aged boys in a 4-week physical training cycle.

Pedagogics, Psychology, Medical-Biological Problems of Physical Training and Sports, 2019; 23(2): 102–111. https://doi.org/10.15561/18189172.2019.0208
15. Nejmark IuI, Teklina LG. Planning an experiment in the study of specific dynamical systems using pattern recognition methods. *Matematicheskie metody raspoznavaniia obrazov,* 2007; 13(1): 194–196. (In Russian).
16. Nejmark IuI, Teklina LG. On possibilities of using pattern recognition methods to study mathematical models. *Pattern Recognition and Image Analysis,* 2012; 22(1): 144–149. https://doi.org/10.1134/S1054661812010282
17. Ivashchenko O, Khudolii O, Prusik K, Giovanis V. Strength Abilities: Immediate and Delayed Training Effects of Orthogonal Modes of Strength Training in Boys Aged 8 Years. *Teorìâ ta Metodika Fìzičnogo Vihovannâ*,2020;20(2):109–116. https://doi.org/10.17309/tmfv.2020.2.07
18. Ivashchenko O, Khudolii O, Iermakov S, Chernenko S, Honcharenko O. Full factorial experiment and discriminant analysis in determining peculiarities of motor skills development in boys aged 9. *Journal of Physical Education and Sport*, 2018; 18(4s): 1958–1965. https://doi.org/10.7752/jpes.2018.s4289
19. Glass SC, Ahmad S, Gabler T. Effectiveness of a 2-Week Strength Training Learning Intervention on Self-selected Weight-Training Intensity. *Journal of Strength and Conditioning Research*, 2020; 34(9): 2443–2448. https://doi.org/10.1519/JSC.0000000000003729
20. Bendikova E, Marko M, Rozim R, Martinsky L. Effect of 4-week physical program on musculoskeletal system changes in adolescent sport class students with focus on ice hockey. *Physical Activity Review*, 2019; 7: 63–70. https://doi.org/10.16926/par.2019.07.08
21. Hagstrom AD, Shorter KA, Marshall PWM. Changes in Unilateral Upper Limb Muscular Strength and Electromyographic Activity after a 16-Week Strength Training Intervention in Survivors of Breast Cancer. *Journal of Strength and Conditioning Research*,. 2019; 33(1): 225–233. https://doi.org/10.1519/JSC.000000000000189
22. Iermakov S, Ivashchenko O, Khudolii O, Chernenko S. Strength Abilities: Assessment of Training Effects of Strength Loads in Boys Aged 8 Years. *Teorìâ ta Metodika Fìzičnogo Vihovannâ*, 2020; 20(3):174–181. https://doi.org/10.17309/tmfv.2020.3.07
23. Floreani M, Rejc E, Taboga P, Ganzini A, Pišot R, Šimunič B, Biolo G, Reggiani C, Passaro A, Narici M, Rittweger J, Di Prampero PE, Lazzer S. Effects of 14 days of bed rest and following physical training on metabolic cost, mechanical work, and efficiency during walking in older and young healthy males. *PLoS ONE*, 2018; 13(3). https://doi.org/10.1371/journal.pone.0194291
24. Chaouachi A, Ben Othman A, Makhlouf I, Young JD, Granacher U, Behm DG. Global Training Effects of Trained and Untrained Muscles With Youth Can be Maintained During 4 Weeks of Detraining. *Journal of Strength and Conditioning Research*, 2019; 33(10): 2788–2800. https://doi.org/10.1519/JSC.0000000000002606
25. Cavar M, Marsic T, Corluka M, Culjak Z, Cerkez Zovko I, Müller A, Tschakert G, Hofmann P. Effects of 6 Weeks of Different High-Intensity Interval and Moderate Continuous Training on Aerobic and Anaerobic Performance. *Journal of Strength and Conditioning Research*, 2019; 33(1): 44–56. https://doi.org/10.1519/JSC.0000000000002798
26. Lockie RG. A 6-Week Base Strength Training Program for Sprint Acceleration Development and Foundation for Future Progression in Amateur Athletes. *Strength and Conditioning Journal*, 2018; 40(1): 2–12. https://doi.org/10.1519/SSC.0000000000000341
27. Hale D, Kollock R, Pace J, Sanders G. Vertical jump and agility performance improve after an 8-week conditioning program in youth female volleyball athletes. *Journal of Physical Education and Sport*, 2019; 19(1): 765–771. https://doi.org/10.7752/jpes.2019.01109

Information about the authors:

Olha Ivashchenko; (Corresponding Author); https://orcid.org/0000-0002-2708-5636; ivashchenko@hnpu.edu.ua; Department of Theory and Methodology of Physical Education, H.S. Skovoroda Kharkiv National Pedagogical University; Kharkiv, Ukraine.

Oleg Khudolii; https://orcid.org/0000-0002-5605-9939; khudolii@hnpu.edu.ua; Department of Theory and Methodology of Physical Education, H. S. Skovoroda Kharkiv National Pedagogical University; Kharkiv, Ukraine.

Wladyslaw Jagiello; https://orcid.org/0000-0001-7417-4749; wjagiello1@wp.pl; Gdansk University of Physical Education and Sport, Gdansk, Poland.

Cite this article as:
Ivashchenko O, Khudolii O, Jagiello W. Strength abilities: pattern recognition method in the management of the cumulative effect of strength loads in 8-year-old boys. *Pedagogy of Physical Culture and Sports,* 2021;25(4):253-260. https://doi.org/10.15561/26649837.2021.0407

Received: 15.07.2021
Accepted: 20.08.2021; Published: 30.08.2021