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STRENGTH ABILITIES: MODELING OF IMMEDIATE AND DELAYED TRAINING EFFECT OF STRENGTH LOADS IN BOYS AGED 8 YEARS

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Abstract

The purpose of the study was to obtain regression models of immediate and delayed training effect of strength loads in boys aged 8 years, based on a full factorial experiment.

Materials and methods. The study participants were 48 boys aged 8 years. The experiment was performed using a 2² factorial design. The study materials were processed by the IBM SPSS 22 statistical analysis program. The study examined the impact of four variants of strength load on the immediate (ITE) and the delayed (DTE) training effect of orthogonal strength exercises modes and rest intervals in boys aged 8 years.

Results. The study results show that in the proposed matrix of the 2² full factorial design, the chosen step of variation of factors is sufficient to study the influence of different modes of strength exercises on the dynamics of ITE in boys aged 8 years. Based on the data analysis, the study obtained regression models of load for calculating the ITE₁, ITE₂, and DTE. The obtained regression models make it possible to calculate the number of repetitions and rest interval to achieve the most rational load variant.

Conclusions. The analysis of regression equations shows the interrelation between training effects: ITE₁ → ITE₂ → DTE. The value of ITE₁, ITE₂, and DTE at station I (exercises to strengthen arms and shoulders) and station II (exercises to strengthen abdominal muscles) depends on the increase in the number of repetitions in a set and the duration of the rest interval. The value of ITE₁, ITE₂ at station III (exercises to strengthen back muscles) depends on the increase in the number of repetitions in a set and the duration of the rest interval. The value of DTE – on the increase in the number of repetitions in a set and the reduction of the rest interval duration. The value of ITE₁ at station IV (exercises to strengthen leg muscles) depends on the increase in the number of repetitions in a set and the reduction of the rest interval duration. To strengthen the DTE, it is necessary to reduce the number of repetitions in a set and the duration of the rest interval.

Keywords: boys aged 8 years, training effects, strength exercises, combined method of strength development, factorial design.

Introduction

Normalization of physical loads in physical education classes is one of the factors that ensure the effectiveness of schoolchildren's physical education (Ivashchenko, Khudolii, Iermakov, Veremeenko, & Lopatiev, 2018; Veremeenko, Khudolii, & Ivashchenko, 2019; Ivashchenko, 2020). Washabaugh, Augenstein, and Krishnan (2020), Benzing, and Schmidt (2019) emphasize the use of dosed efforts in both physical

education and sports training. Bogdanis, Donti, Papia, Donti, Apostolidis, and Sands (2019), Wertheimer, Antekolovic, and Matkovic (2018) note a positive effect of plyometric loads on the level of motor fitness of both children and adults. The relevance of studying the "dose-effect" (cause-effect) in children's physical activity is indicated by Lovric, Mandic Jelaska, and Bilic (2018), Marttinen, Fredrick III, and Silverman (2018).

Technological approaches to assessing the training effects of strength loads in primary schoolchildren are presented in the studies by Ivashchenko (2020), Ivashchenko, Khudolii, Prusik, and Giovanis (2020), Iermakov, Ivashchenko,

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Khudolii, and Chernenko (2020). One of the technological approaches is the use of pattern recognition methodology in research (Neimark & Teklina, 2007, 2012; Ivashchenko et al., 2018). Ivashchenko, Khudolii, Iermakov, Chernenko, and Honcharenko (2018) indicate the effectiveness of using factorial designs and discriminant analysis in physical education research.

The importance of developing methodological approaches to normalization and management of training loads in physical education classes in order to improve the effectiveness of teaching is pointed out in the studies by Khudolii, Iermakov, and Bartik (2020), Ivashchenko, Berezhna, and Cieślacka (2020), Ivashchenko and Sirichenko (2020).

Thus, the problem of normalization of strength loads in primary schoolchildren's physical education classes is relevant and requires additional research.

The purpose of the study was to obtain regression models of immediate and delayed training effect of strength loads in boys aged 8 years, based on a full factorial experiment.

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, regression analysis.

Table 1. Factorial design in studying the influence of different modes of the combined method of strength development (variant I) in primary schoolchildren (x_1 – number of repetitions in a set; x_2 – 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+

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 (station I), abdominal muscles (station II), back muscles (station III), and leg muscles (station IV). At each station, 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 stations are given in Table 1. The study examined the impact of four variants of strength load on the immediate training effect (ITE₁) after performing exercises at four stations, the immediate training effect (ITE₂) after training, and the delayed training effect (DTE) 24 hours after training.

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”. After performing the exercises at station I – Tests 2, 1; at station II – Test 3; at station III – Test 4; at station IV – Test 5. After training – Tests 2, 1, 3, 4. Twenty-four hours after training – 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. The Yates' algorithm was used to calculate the regression coefficients.

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

Results

Tables 2-7 show the results of the 2^2 full factorial design. The study examined the impact of four variants of strength load on the ITE_1 after performing exercises at four stations, the ITE_2 after training, and the DTE 24 hours after training.

The results of analysis of the immediate training effect (ITE_1) after performing exercises at four stations: station I “Exercises to strengthen arms and shoulders”; station II “Exercises to strengthen abdominal muscles”; station III “Exercises to strengthen back muscles”; station IV “Exercises to strengthen leg muscles” are given below (see Tables 2-3).

The analysis of the regression equations given in Table 2 made it possible to determine the influence of strength loads on the immediate training effect (ITE_1) of different modes of

exercises in boys aged 8 years. After training at stations I-IV, the following data were obtained:

- after training at station I – exercises to strengthen arms and shoulders – the ITE_1 is most influenced by the number of repetitions in a set (x_1) (exercise No. 1) and the rest interval (x_2) (exercise No. 2). To strengthen the ITE_1 , it is necessary to increase the number of repetitions in a set and the duration of the rest interval;
- after training at station II – exercises to strengthen abdominal muscles – the ITE_1 is most influenced by the rest interval (x_2), the number of repetitions in a set (x_1), and the interaction between the number of repetitions in a set and the rest interval (x_1x_2). To strengthen the ITE_1 , it is necessary to increase the number of repetitions in a set and the duration of the rest interval;
- after training at station III – exercises to strengthen back muscles – the ITE_1 is most influenced by the rest interval (x_2), the interaction between the number of repetitions in a set and the rest interval (x_1x_2), and the number of repetitions in a set (x_1). To strengthen the ITE_1 , it is necessary to increase the number of repetitions in a set and the duration of the rest interval;
- after training at station IV – exercises to strengthen leg muscles – the ITE_1 is most influenced by the rest interval (x_2), the interaction between the number of repetitions in a set and the rest interval (x_1x_2), and the number of repetitions in a set (x_1). To strengthen the ITE_1 , it is necessary to increase the number of repetitions in a set and reduce the duration of the rest interval.

The analysis of variance given in Table 3 made it possible to determine the percentage influence of the factors on the immediate training effect (ITE_1) of different modes of exer-

Table 2. Models of influence of different strength training modes on the change in the immediate training effect (ITE_1) in boys aged 8 years ($n = 40$) (x_1 – amount of training, x_2 – rest interval). The first variant of the combined method of strength development.

Place of training	Test	Conditions of recording	Regression equations
Station I	No. 1 “Push-ups”	after performing the exercises	$Y = 90.113 - 2.998x_1 - 1.168x_2 - 0.967x_1x_2$
	No. 2 “Speed push-ups, 3 times”	after performing the exercises	$Y = 104.660 + 2.655x_1 + 3.315x_2 - 1.240x_1x_2$
Station II	No. 3 “Sit-ups in 30 seconds”	after performing the exercises	$Y = 92.753 - 1.553x_1 - 2.708x_2 + 1.138x_1x_2$
Station III	No. 4 “Trunk lift in 10 seconds”	after performing the exercises	$Y = 93.943 - 0.918x_1 - 1.958x_2 + 0.963x_1x_2$
Station IV	No. 5 “Standing long jump”	after performing the exercises	$Y = 98.768 - 0.078x_1 + 1.238x_2 + 0.392x_1x_2$

Table 3. Results of the analysis of variance for the 2^2 FFE in studying the influence of different strength training modes on the change in the immediate training effect (ITE_1) in boys aged 8 years ($n = 40$) (x_1 – amount of training, x_2 – rest interval). The first variant of the combined method of strength development.

Place of training	Test	Conditions of recording	Ratio of mean squares		
			x_1	x_2	x_1x_2
Station I	No. 1 “Push-ups”	after performing the exercises	79.6	12.0	8.4
	No. 2 “Speed push-ups, 3 times”	after performing the exercises	36.0	56.1	7.9
Station II	No. 3 “Sit-ups in 30 seconds”	after performing the exercises	21.8	66.4	11.8
Station III	No. 4 “Trunk lift in 10 seconds”	after performing the exercises	15	68.4	16.6
Station IV	No. 5 “Standing long jump”	after performing the exercises	0.35	90.5	9.15

Table 4. Models of influence of different strength training modes on the change in the immediate training effect (ITE₂) in boys aged 8 years (n = 40) (x_1 – amount of training, x_2 – rest interval). The first variant of the combined method of strength development. Comprehensive strength development of arm, abdominal, back, and leg muscles.

Test	Regression equations
No. 1 “Push-ups”	$Y = 87.790 - 0.740x_1 - 0.1x_2 - 2.1x_1x_2$
No. 2 “Speed push-ups, 3 times”	$Y = 106.108 + 0.877x_1 + 1.258x_2 + 0.068x_1x_2$
No. 3 “Sit-ups in 30 seconds”	$Y = 91.698 + 0.968x_1 - 2.258x_2 - 0.627x_1x_2$
No. 4 “Trunk lift in 10 seconds”	$Y = 92.875 - 0.395x_1 - 1.465x_2 + 0.265x_1x_2$
No. 5 “Standing long jump”	$Y = 98.985 + 0.095x_1 - 0.19x_2 + 0.1x_1x_2$

cises in boys aged 8 years. After training at stations I-IV, the following data were obtained:

- after training at station I – exercises to strengthen arms and shoulders – the ITE₁ is most influenced by the number of repetitions in a set (x_1) – 79.6% (exercise No. 1) and the rest interval (x_2) – 56.1%;
- after training at station II – exercises to strengthen abdominal muscles – the ITE is most influenced by the rest interval (x_2) – 66.4%;
- after training at station III – exercises to strengthen back muscles – the ITE is most influenced by the rest interval (x_2) – 68.4%;
- after training at station IV – exercises to strengthen leg muscles – the ITE is most influenced by the rest interval (x_2) – 90.5%.

The data of analysis of the immediate training effect (ITE₂) after training are given in Tables 4-5.

The analysis of the regression equations given in Table 4 made it possible to determine the influence of strength loads on the immediate training effect (ITE₂) of different modes of exercises in boys aged 8 years. After training, the following data were obtained:

- exercises to strengthen arms and shoulders – the ITE₂ is most influenced by the interaction between the number of repetitions in a set and the rest interval (x_1x_2) (exercise No. 1) and the rest interval (x_2) (exercise No. 2). To strengthen the ITE₂, it is necessary to increase the number of repetitions in a set and the duration of the rest interval;
- exercises to strengthen abdominal muscles – the ITE₂ is most influenced by the rest interval (x_2), the number of repetitions in a set (x_1), and the interaction between the number of repetitions in a set and the rest interval (x_1x_2). To strengthen the ITE₂, it is necessary to increase the number of repetitions in a set and the duration of the rest interval;
- exercises to strengthen back muscles – the ITE₂ is most influenced by the rest interval (x_2), the number of repetitions in a set (x_1), and the interaction between the number of repetitions in a set and the rest interval (x_1x_2). To strengthen the ITE, it is necessary to increase the number of repetitions in a set and the duration of the rest interval;
- exercises to strengthen leg muscles – the ITE₂ is most influenced by the rest interval (x_2), the interaction between the number of repetitions in a set and the rest interval (x_1x_2), and the number of repetitions in a set (x_1). To strengthen the ITE, it is necessary to reduce the number of repetitions in a set and the duration of the rest interval.

The analysis of variance given in Table 5 made it possible to determine the percentage influence of the factors on the immediate training effect (ITE₂) of different modes of exercises in boys aged 8 years. After training, the following data were obtained:

- exercises to strengthen arms and shoulders – the ITE₂ is most influenced by the interaction between the number of repetitions in a set and the rest interval (x_1x_2) – 88.8% (exercise No. 1) and the rest interval (x_2) – 67.1%;
- exercises to strengthen abdominal muscles – the ITE is most influenced by the rest interval (x_2) – 79.3%;
- exercises to strengthen back muscles – the ITE is most influenced by the rest interval (x_2) – 90.5%;
- exercises to strengthen leg muscles – the ITE is most influenced by the rest interval (x_2) – 65.5%.

The results of analysis of the delayed training effect (DTE) 24 hours after training are given in Tables 6-7.

Table 5. Results of the analysis of variance for the 2² FFE in studying the influence of different strength training modes on the change in the immediate training effect (ITE₂) in boys aged 8 years (n = 40) (x_1 – amount of training, x_2 – rest interval). The first variant of the combined method of strength development. Comprehensive strength development of arm, abdominal, back, and leg muscles.

Test	Ratio of mean squares		
	x_1	x_2	x_1x_2
No. 1 “Push-ups”	11	0.2	88.8
No. 2 “Speed push-ups, 3 times”	32.7	67.1	0.2
No. 3 “Sit-ups in 30 seconds”	14.6	79.3	6.1
No. 4 “Trunk lift in 10 seconds”	6.6	90.5	2.9
No. 5 “Standing long jump”	16.4	65.5	18.1

The analysis of the regression equations given in Table 6 made it possible to determine the influence of strength loads on the delayed training effect (DTE) of different modes of exercises in boys aged 8 years. 24 hours after training, the following data were obtained:

- exercises to strengthen arms and shoulders – the DTE is most influenced by the number of repetitions in a set (x_1), the rest interval (x_2), the interaction between the number of repetitions in a set and the rest interval (x_1x_2) (exercise No. 1), and the interaction between the number

Table 6. Models of influence of different strength training modes on the change in the delayed training effect (DTE) in boys aged 8 years ($n = 40$) (x_1 – amount of training, x_2 – rest interval). The first variant of the combined method of strength development. Comprehensive strength development of arm, abdominal, back, and leg muscles.

Test	Regression equations
No. 1 “Push-ups”	$Y = 96.785 + 2.195x_1 - 1.315x_2 - 1.095x_1x_2$
No. 2 “Speed push-ups, 3 times”	$Y = 103.99 - 0.59x_1 + 0.475x_2 - 1.275x_1x_2$
No. 3 “Sit-ups in 30 seconds”	$Y = 95.413 + 0.092x_1 + 0.232x_2 - 0.278x_1x_2$
No. 4 “Trunk lift in 10 seconds”	$Y = 96.23 - 0.07x_1 + 1.505x_2 + 0.015x_1x_2$
No. 5 “Standing long jump”	$Y = 99.115 + 1.765x_1 + 0.81x_2 - 1.73x_1x_2$

Table 7. Results of the analysis of variance for the 2^2 FFE in studying the influence of different strength training modes on the change in the delayed training effect (DTE) in boys aged 8 years ($n = 40$) (x_1 – amount of training, x_2 – rest interval). The first variant of the combined method of strength development. Comprehensive strength development of arm, abdominal, back, and leg muscles.

Test	Ratio of mean squares		
	x_1	x_2	x_1x_2
No. 1 “Push-ups”	62.2	22.3	15.5
No. 2 “Speed push-ups, 3 times”	15.8	10.3	73.9
No. 3 “Sit-ups in 30 seconds”	6.1	38.7	55.2
No. 4 “Trunk lift in 10 seconds”	0.2	99.8	0
No. 5 “Standing long jump”	46.1	9.7	44.2

of repetitions in a set and the rest interval (x_1x_2) (exercise No. 2). To strengthen the DTE, it is necessary to increase the number of repetitions in a set and the duration of the rest interval;

- exercises to strengthen abdominal muscles – the DTE is most influenced by the interaction between the number of repetitions in a set and the rest interval (x_1x_2), the rest interval (x_2), the number of repetitions in a set (x_1). To strengthen the DTE, it is necessary to increase the number of repetitions in a set and the duration of the rest interval;
- exercises to strengthen back muscles – the DTE is most influenced by the rest interval (x_2), the interaction between the number of repetitions in a set and the rest interval (x_1x_2), and the number of repetitions in a set (x_1). To strengthen the DTE, it is necessary to increase the number of repetitions in a set and reduce the duration of the rest interval;
- exercises to strengthen leg muscles – the DTE is most influenced by the number of repetitions in a set (x_1), the interaction between the number of repetitions in a set and the rest interval (x_1x_2), and the rest interval (x_2). To strengthen the DTE, it is necessary to reduce the number of repetitions in a set and the duration of the rest interval.

The analysis of variance given in Table 7 made it possible to determine the percentage influence of the factors on the delayed training effect (DTE) of different modes of exercises in boys aged 8 years. 24 hours after training, the following data were obtained:

- exercises to strengthen arms and shoulders – the DTE is most influenced by the number of repetitions in a set (x_1) – 62.2% (exercise No. 1) and the interaction between the number of repetitions in a set and the rest interval (x_1x_2) – 73.9%;
- exercises to strengthen abdominal muscles – the DTE is most influenced by the interaction between the number of repetitions in a set and the rest interval (x_1x_2) – 55.2%;
- exercises to strengthen back muscles – the DTE is most influenced by the rest interval (x_2) – 99.8%;
- exercises to strengthen leg muscles – the DTE is most influenced by the number of repetitions in a set (x_1) – 46.1% and the interaction between the number of repetitions in a set and the rest interval (x_1x_2) – 44.2%.

Discussion

The study assumed that a full factorial experiment would allow to determine the influence of strength loads on the immediate training effect (ITE) and the delayed training effect (DTE) of different modes of exercises in boys aged 8 years. The study results show that in the proposed matrix of the 2^2 full factorial design, the chosen step of variation of factors is sufficient to study the influence of different modes of strength exercises on the dynamics of ITE in boys aged 8 years (Table 1). Based on the data analysis, the study obtained regression models of load for calculating the ITE₁ (Table 2), ITE₂ (Table 4), and DTE (Table 6).

The studies by Iermakov, Ivashchenko, Khudolii, and Chernenko (2020), Ivashchenko, Khudolii, Prusik, and Giovanis (2020), Ivashchenko, Nosko, and Ferents (2019) substantiated the influence of different load variants on the dynamics of the immediate and delayed training effect on the basis of discriminant analysis. Iermakov, Ivashchenko, Khudolii, and Chernenko (2020) found the interrelation of training effects. The obtained data indicate that each of the variants of strength load can be effectively used depending on the educational tasks of both one and a series of physical education classes, and also show that the ITE and DTE of strength exercises depend on the initial level of fitness and the total amount of strength exercises in a physical education class. Ivashchenko, Khudolii, Prusik, and Giovanis (2020) point out that in the first variant of strength load, the greatest contribution to the dynamics of training effects is made by training at the first station “exercises to strengthen arms and shoulders”; in the second variant, the greatest contribution to the dynamics of training effects is made by training at the third station “exercises to strengthen back muscles”;

in the third variant, the greatest contribution to the dynamics of training effects is made by training at the first station “exercises to strengthen arms and shoulders” and the third station “exercises to strengthen back muscles”; in the fourth variant, the greatest contribution to the dynamics of the ITE is made by training at the first “exercises to strengthen arms and shoulders” and the third “exercises to strengthen back muscles” stations; the most significant changes in the DTE are connected with training at the fourth station “exercises to strengthen leg muscles”.

The obtained regression models make it possible to calculate the number of repetitions and rest interval to achieve the most rational load variant. These data supplement the results presented in the studies by Iermakov, Ivashchenko, Khudolii, and Chernenko (2020), Ivashchenko, Khudolii, Prusik, and Giovanis (2020) and form a methodology for studying training loads, which differs from the methods used in the studies by Arazi et al. (2012), Ratamess et al. (2012), Miranda et al. (2010) in that research is conducted using an active 2^k FFE and materials are processed with the help of regression and discriminant analysis.

The results supplement the information of Ivashchenko and Cieśllicka (2017), Cieśllicka and Ivashchenko (2017) about the effectiveness of using factorial designs in studying training effects of strength loads in children; that of Ivashchenko, Khudolii, Iermakov, Chernenko and Honcharenko (2018), Marchenko and Kovalenko (2020) about the reliability of obtained regression equations for modeling the process of motor skills and motor abilities development in schoolchildren.

The effectiveness of using a 2^k full factorial experiment is confirmed by data of Correa, Grima, and Tort-Martorell (2009, 2012), Ivashchenko, Nosko, and Ferents (2019). The main purpose of designs is to neutralize the influence of unknown factors, the authors recommend using designs with three and four factors. The results of presented research (Tables 2-7) show the effectiveness of using a 2² FFE in studying the ITE of strength loads in boys aged 8 years.

The obtained results specify the conceptual approaches to experiment planning in studying the effectiveness of children's physical education, factorial designs are an objective tool for obtaining data to calculate regression models of training effects in children (Khudolii, Ivashchenko, Iermakov, Nosko, & Marchenko, 2019; Khudolii, 2019; Ivashchenko, 2020).

In addition, strength training of schoolchildren is considered as a necessary condition of the educational process (Kapkan, Khudolii, & Bartik, 2019a,b). Based on the analysis of regression equations, it is possible to choose a load by focus, based on discriminant analysis – to choose a total load.

Conclusions

The study results show that in the proposed matrix of the 22 full factorial design, the chosen step of variation of factors is sufficient to study the influence of different modes of strength exercises on the dynamics of ITE in boys aged 8 years. Based on the data analysis, the study obtained regression models of load for calculating the ITE₁, ITE₂, and DTE. The obtained regression models make it possible to calculate the number of repetitions and rest interval to achieve the most rational load variant.

The analysis of regression equations shows the interrelation between training effects: ITE₁ → ITE₂ → DTE. The value of ITE₁, ITE₂, and DTE at station I (exercises to strengthen arms and shoulders) and station II (exercises to strengthen abdominal muscles) depends on the increase in the number of repetitions in a set and the duration of the rest interval. The value of ITE₁, ITE₂ at station III (exercises to strengthen back muscles) depends on the increase in the number of repetitions in a set and the duration of the rest interval. The value of DTE – on the increase in the number of repetitions in a set and the reduction of the rest interval duration. The value of ITE₁ at station IV (exercises to strengthen leg muscles) depends on the increase in the number of repetitions in a set and the reduction of the rest interval duration. To strengthen the DTE, it is necessary to reduce the number of repetitions in a set and the duration of the rest interval.

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Conflict of interest

The authors declare no conflict of interest.

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СИЛОВІ ЗДІБНОСТІ: МОДЕЛЮВАННЯ ТЕРМІНОВОГО І ВІДСТАВЛЕНОГО ТРЕНУВАЛЬНОГО ЕФЕКТУ СИЛОВИХ НАВАНТАЖЕНЬ У ХЛОПЦІВ 8 РОКІВ

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 6 табл., 30 джерел

Мета дослідження – на основі повного факторного експерименту отримати регресійні моделі термінового і відставленого тренувального ефекту силових навантажень у хлопців 8 років.

Матеріали і методи. У дослідженні прийняли участь 48 хлопців 8 років. Експеримент був проведений за планом факторного експерименту 2². Матеріали дослідження опрацьовані в програмі статистичного аналізу IBM SPSS 22. Вивчався вплив чотирьох варіантів силового навантаження на терміновий (ТТЕ) і відставлений (ВТЕ) тренувальний ефект ортогональних режимів виконання силових вправ та інтервалів відпочинку у хлопчиків 8 років.

Результати. Результати дослідження свідчать, що у запропонованій матриці плану повного факторного експерименту типу 2² вибраний крок варіювання факторів є достатнім для вивчення впливу різних режимів виконання силових вправ на динаміку ТТЕ у хлопчиків 8 років. На основі аналізу даних отримані регресійні моделі навантаження для розрахунку ТТЕ₁, ТТЕ₂ та ВТЕ. Отримані регресійні моделі дають змогу розрахувати кількість повторень та інтервал відпочинку

для досягнення найбільш раціонального варіанта навантаження.

Висновки. Аналіз рівнянь регресії вказує на взаємозв'язок тренувальних ефектів: ТТЕ₁ → ТТЕ₂ → ВТЕ. Величина ТТЕ₁, ТТЕ₂, ВТЕ на I станції (вправи для розвитку сили рук і плечового поясу) та II станції (вправи для розвитку сили м'язів черевного пресу) залежить від збільшення кількості повторень у підході й тривалості інтервалу відпочинку. Величина ТТЕ₁, ТТЕ₂ на III станції (вправи для розвитку сили м'язів спини) – від збільшення кількості повторень у підході й тривалості інтервалу відпочинку. Величина ВТЕ – від збільшення кількості повторень у підході й зменшення тривалості інтервалу відпочинку. Величина ТТЕ₁ на IV станції (вправи для розвитку сили м'язів ніг) залежить від збільшення кількості повторень у підході й зменшення тривалості інтервалу відпочинку. Для підсилення ВТЕ необхідно зменшити кількість повторень у підході й зменшити тривалість інтервалу відпочинку.

Ключові слова: хлопців 8 років, тренувальні ефекти, силові вправи, комбінований метод розвитку сили, план факторного експерименту.

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