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Original Article

Correlation between load volume and indicators of adaptive body changes in untrained young men participating in fitness

ANDRII CHERNOZUB[1], IVAN HLUKHOV[2], KATERYNA DROBOT[3], ANDRII SYNYTSIA[4], ROMAN RYMYK[5], HALYNA PYATNYCHUK[6], OLEKSANDR LESHCHAK[7], LYUBOMYR MALANYUK[8], VLADIMIR POTOP[9]
[1]Lesya Ukrainka Volyn National University, Lutsk, UKRAINE
[2,3] Kherson State University, Kherson, UKRAINE
[4,5,6,7,8] Vasyl Stefanyk Precarpathian National University, UKRAINE
[9]Department of Physical Education and Sport, National University of Science and Technology Politehnica Bucharest, University Center Pitesti, Pitesti, ROMANIA
[9]State University of Physical Education and Sport, REPUBLIC OF MOLDOVA

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Abstract:
Background: With the increasing popularity of fitness, there is a growing need for novel mechanisms to evaluate the compliance of load parameters with adaptive body reserves. This study aims to evaluate the correlation between load volume and adaptive compensatory body responses among untrained young individuals undergoing various power fitness regimens. *Material and methods:* The study comprised 60 young men, aged 17±0.4 years, with no prior fitness experience. They were divided into two groups and subjected to the most prevalent load modes in power fitness (R_a=0.53 and R_a=0.72) for a duration of 12 weeks. Methods of bioimpedancemetry, anthropometry, testing of maximum strength development (1 PM), and biochemical blood tests (creatinine, cortisol, testosterone) were used to analyze adaptative compensatory reactions to physical stimulus. The correlation between load volume parameters (Wn) and controlled indicators of adaptive body changes was determined using Spearman's rank correlation coefficient. Results: In the study, Wn varied depending on the load mode characteristics. The initial parameters of maximum strength development were almost identical in all study participants. The load volume parameters were 61.9% higher in group 1. During the research, the maximum strength development increased by 20.9% in group 2 representatives. The studied morphometrical indicators expressed the highest adaptative changes in group 2. The biochemical blood markers provided different manifestations of adaptative compensatory reactions of study participants depending on load modes. An increase in the basal creatinine level, indicating muscle mass growth, was found only in young men of group 2. A significant increase in blood cortisol, which demonstrates compensatory reactions, was observed during all stages of the study in participants of group 1. A strong correlation between the load volume and 1 PM, FFM, and BCM indicators was observed in both groups. An inverse moderate to strong correlation between Wn and basal testosterone level was found in both groups during the observation period. The absence of correlation between Wn values, circumferential body measurements, and fat mass in young men of group 1 is justified by the peculiarity of the load mode. Conclusions: Using a low-volume load mode (R_a=0.72) by untrained young men contributed to the most accelerated adaptive body changes during fitness training. The obtained correlation allows for ascertaining a distinct correlation between the external stimulus magnitude and adaptive body change formation. The determination of strong correlations between the studied indicators in different load modes will contribute to the improvement of the training system in fitness.
Keywords: fitness, correlation, adaptive body changes, load regimes, young men.

Introduction

The increasing trend of using various forms of fitness training requires establishing new methods to evaluate the alignment of load parameters with adaptive body reserves. In recent years, considerable attention has been paid to studying how athletes with different levels of training adapt to power loads (Batista et al., 2023; Noteboom et al., 2023). Several researchers (Toledo et al., 2021; Davis et al., 2022) studied in detail the peculiarities of the impact of fitness training on the nature of adaptative compensatory reactions of mature people. Some scholars conducted a comparative analysis of the impact of different volumes and intensity of fitness loads on the processes of adaptation in women and men. Various training session models were developed using variations in load components and individual characteristics of the structure of muscle fibers (Refalo et al., 2023; Silva et al., 2023). The issues of identifying informative biochemical blood markers that demonstrate the manifestation of compensatory reactions to physical stimuli in the context of fitness training were also explored (Chernozub et al., 2023).

Corresponding Author: ANDRII CHERNOZUB, E-mail: chernozub@gmail.com

The search for effective ways to increase the adaptive reserves of the younger generation is one of the main tasks of the modern system of physical education in the world. Their practical implementation depends on the adequacy of physical activity, mainly indicators of volume and intensity, to the functional capabilities of the body of young people (Cavarretta et al., 2022; Castilla-López & Romero-Franco, 2023). The identification of informative markers for assessing the level of body resistance to external stressful physical stimuli is a key factor for improving the physical training system (Nobari et al., 2021; Martin et al., 2023). The issue is especially acute in the context of power fitness training due to the use of different load modes by untrained young people. The problem lies in the peculiarities of the neuromuscular system adaptation to power loads of different volumes and intensities (Schoenfeld et al., 2023; Weakley et al., 2023). It is important to provide an adequate energy supply, especially for young people with no experience of using power loads, to effectively cope with an external stimulus. The solution to these issues requires an in-depth study of the peculiarities of adaptative compensatory body reactions of untrained youth using different volumes of power load.

The vast majority of scientists pay attention to intensity parameters (Vermeire et al., 2021; Weaving et al., 2021) of training load regimes used in fitness. The intensity of power fitness training is regulated by the duration of a set and the rest between sets. The number of repetitions in such sets depends on the parameters of the projectile working mass, which is influenced by the duration of the concentric and eccentric phases of movement (Chernozub et al., 2018). When determining the parameters of these indicators, the physiological features of adaptive changes associated with the growth of maximum strength and muscle mass are taken into account (Matos et al., 2021; Posnakidis et al., 2022). At the same time, the volume of loads as a criterion for assessing an external stimulus in fitness training is practically not taken into account. There is also no data regarding the impact of different volumes of power load modes on the nature of adaptative compensatory reactions of young men with no experience in fitness. There is a lack of data on the correlation between various parameters of load volume and indicators of adaptive changes in the body of untrained young men engaging in fitness.

The aim of the work. To define the correlation between the volume of training load and adaptative compensatory body reactions of untrained young men in different regimes of power fitness.

Material & methods

Participants

60 young men aged 17±0.4 years with no fitness experience participated in the study, which was conducted in fitness centers Relief Gym, Airflex, SkyFit Club, and Body Target (Ukraine) in 2021. The study participants were randomly divided into 2 groups, 30 men in each group. Representatives of each group used the most popular load regimes in power fitness (Chernozub et al., 2018, 2022). During training, young men of group 1 used a high-volume load mode (R_a=0.53), and group 2 representatives – a low-volume load mode (R_a=0.72).

Following the ethical standards of the Declaration of Helsinki, the organization of the series of studies was approved by the Ethical Committee for Biomedical Research of Lesya Ukrainka Volyn National University. The study participants and their parents provided written consent by the recommendations of biomedical research ethics committees (WHO Regional, 2000). The equipment of the university medical and biological laboratory was used to conduct biochemical monitoring of the participants' blood serum and to assess the adaptive body changes.

Measurements

Maximal muscle strength

The main muscle groups' average maximum strength (1 PM) parameters during the performance of basic and isolation exercises were determined. The following muscle groups were involved: pectoralis major, deltoid, triceps brachii and biceps brachii, back and leg muscles. These parameters were controlled at the beginning of the study, after 6 and 12 weeks of using suggested load regimes of power fitness.

Training load parameters

To determine the load coefficient (R_a), which reflects the load regime features, we used the integral method of assessing an external stimulus in power fitness (Chernozub et al., 2018). This method allowed for calculating the average parameters of the projectile working mass (m) and the load volume in a set (Wn).

Circumferential body measurements

Average body circumferences were determined at the beginning and during the next 12 weeks of the study with an interval of 6 weeks. These values were calculated based on the measurement of the circumferential measurements of the chest, shoulder, and hip of the study participants. The measurements were made with a centimeter tape using a generally accepted method.

Body composition

Using the bioelectrical impedance (BIA) method with detailed computer data processing, the parameters of each participant's body composition were determined. The following parameters were determined during the control: fat-free mass (FFM, kg), body fat mass (BFM, %), and active cellular body mass (BCM, kg). The diagnostic computerized hardware and software complex KM-AR-01 "Diamond-AST" (VUSK. 941118.001 RE) was used to measure the body composition.

Biochemical parameters

The creatinine concentration in the blood serum of the young men was determined by the kinetic method using the equipment of High Technology Inc (USA) with a set of reagents PRESTIGE 24i LQ LDH (Poland). The concentration of testosterone and cortisol in the blood serum was determined by enzyme-linked immunosorbent assay using a reagent kit SteroidIFA-testosterone on the equipment of Alkor Bio. A medical professional took blood at the beginning and after 12 weeks of training following international requirements for biomedical research (Tietz, Finley & Pruden, 1995). Control of the studied blood biochemical parameters was carried out before and after exercise.

Experimental design

In the first stage, the baseline level of 1 PM was determined for participants in each group. Using the integral method of external stimulus evaluation, the initial indicators of the projectile working mass (m) and the load volume (Wn) were determined for each group. Representatives of both groups were offered an identical complex of strength exercises on simulators. During the study period, 36 training sessions were conducted. The duration of a training session was 29-30 minutes.

In the second stage, we studied the dynamics of morphometric body parameters, and indicators of 1 PM, m, and Wn during all stages of control. Changes in the concentration of creatinine, cortisol, and testosterone in the participants' blood serum in response to a stressful physical stimulus were also studied. The analysis of the dynamics of morphofunctional parameters and biochemical blood tests allows for determining the nature of adaptative compensatory reactions of study participants in the suggested load modes. It also helps to define the effectiveness of using suggested load modes by untrained young people.

In the third stage, the correlation between the volume of workload (Wn), morphofunctional parameters, and biochemical blood markers was performed. The correlation between the controlled parameters was performed at the beginning and end of the study. The obtained results allowed for determining the level of correlations between the magnitude of the external stimulus and markers of adaptive body changes in different load modes.

Statistical analysis

Statistical processing of the study results was performed using the IBM *SPSS*Statistics 26 software package (StatSoftInc., USA). Methods of descriptive statistics were used to calculate the mean and error of the mean. The G-Power 3.1.96 program was used to determine the smallest sample size for the study. The sample size was assessed using statistical tests: Wilcoxon rank sum test (one sample case); and ANOVA: repeated measures, between factors. The relationship between certain variables and individual-typological characteristics of the subjects was established using Spearman's rank correlation coefficients.

Results

Table 1 presents the indicators of power load that participants of both groups used during 12 weeks of research.

The analysis of the research results showed that the initial indicators of the projectile working mass were 18.5% ($p<0.05$) higher in group 2 participants. The load volume indicator in group 2 was 61.9% ($p<0.05$) smaller. At the same time, the initial research indicators of the maximum strength development (tab. 2) practically did not differ in both groups. This fact testifies to the peculiarities of the load modes' impact on the parameters of projectile working mass and load volume. The difference between the value of the controlled indicators of power load (Wn and m) in the examined groups is observed during the whole period of the research. The dynamics of changes in power load indicators depend on features of the maximum strength (1 PM) development in both groups during the research.

Table 1

Indicators of power load used by study participants during 12 weeks of fitness training, n=50

Power load indicator	group	Time of observation, weeks			χ^2 df=2
		initial data	6	12	
Projectile working mass (m), kg	1	15.52±0.73	17.62±0.78 13.5%^{1*}	20.16±0.79 14.4%^{1}; 29.9%^{2*}	χ^2=46.5***
	2	18.40±0.71	22.28±0.83 21.1%^{1*}	27.72±0.76 24.4%^{1*}; 50.6%^{2*}	χ^2=49.6***
Load volume in a set (Wn), кг	1	134.75±5.05	155.28±6.66 15.2%^{1*}	181.24±7.75 16.7%^{1*}; 34.5%^{2*}	χ^2=46.5***
	2	83.20±4.69	101.20±5.59 21.6%^{1*}	125.37±5.73 24.1%^{1*}; 50.7%^{2*}	χ^2=49.6***

Notes: ^{1} – difference (%) compared to the previous results; ^{2} – difference (%) compared to the initial values; df – number of degrees of freedom; χ2 – Friedman's test. *– p< .05; ***– p< .001

Changes in the maximum strength parameters and morphometrical indicators of the body composition of study group participants during the research are presented in Table 2.

The results of control over adaptative body changes in untrained young men of both groups testify to various dynamics of the studied indicators during 12 weeks of training. The 1 PM indicator development in young men of the 2nd group exceeded the results of the 1st group by 20.9% ($p<0.05$). The circumferential body measurements in young men of group 2 were 3.2 times higher than in group 1. The dynamics of fat-free mass in group 2 representatives was 2.3 times higher compared to the results of group 1. The body fat mass indicators showed the same tendency to decrease regardless of the peculiarities of the used load modes.

Table 2

Morphofunctional indicators of the study participants during 12 weeks of fitness training, n=50

Indicators	group	Term of observation, weeks			χ^2, p df=2
		initial data	6	12	
Maximum strength (1 PM), kg	1	29.30±0.89	33.25±1.05 13.5%^{1*}	38.05±1.18 14.0%^{1*}; 29.8%^{2*}	χ^2=46.5***
	2	25.55±0.93	30.94±1.04 21.1%^{1*}	38.50±1.02 22.9%^{1*}; 50.7%^{2*}	χ^2=49.6***
Circumferential body measurements, cm	1	59.95±0.93	60.99±0.72 1.7%^{1*}	61.24±0.85 0.4%^{1}; 2.1%^{2*}	χ^2=46.5***
	2	57.12±0.68	59.39±0.76 3.9%^{1*}	60.98±0.75 2.6%^{1*}; 6.7%^{2*}	χ^2=49.6***
Body fat mass (BFM), %	1	19.26±0.80	18.06±0.84 1.2%^{1}	16.99±0.69 1.0%^{1}; -2.2%^{2*}	χ^2=29.8*
	2	15.89±0.99	14.59±0.87 1.3%^{1*}	14.14±0.95 -0.4%^{1} ; -1.7%^{2*}	χ^2=13.1*
Fat free mass (FFM), kg	1	55.78±1.22	55.92±1.20 0.2%^{1}	56.89±0.98 1.7%^{1}; 1.9%^{2}	χ^2=2.1
	2	55.56±0.81	56.60±0.73 1.8%^{1}	58.00±0.65 2.5%^{1*}; 4.4%^{2*}	χ^2=43.7***
Active cellular body mass (BCM), kg	1	36.50±0.87	36.05±0.84 -1.2%^{1}	37.42±0.61 3.8%^{1*}; 2.5%^{2*}	χ^2=26.1*
	2	37.04±0.45	37.05±0.46 0.0%^{1}	37.58±0.47 1.4%^{1*}; 1.4%^{2*}	χ^2=31.2*

Notes: ^{1} – difference (%) compared to the previous results; ^{2} – difference (%) compared to the initial values; df – number of degrees of freedom; $\chi 2$ – Friedman's test. *– p< .05; ***– p< .001

The changes in biochemical blood parameters in study participants in response to power loads during the study are presented in Table 3.

Table 3

Changes in biochemical blood markers of study participants in response to training loads during the research, n=50

Marker	group	at the beginning of the research		after 12 weeks of training	
		before exercise	after exercise	before exercise	after exercise
Cortisol, nmol/L	1	318.25±14.08	459.96±25.35 44.5%^{3*}	411.07±26.23 29.1%^{4*}	568.46±38.88 38.1%^{3*}
	2	330.71±11.64	517.29±34.76 56.4%^{3*}	504.23±26.28 52.4%^{4*}	509.92±28.95 1.1%^{3}
Testosterone, nmol/L	1	19.88±1.43	21.04±1.92 5.8%^{3*}	25.66±2.32 29.1%^{4*}	27.74±2.06 8.1%^{3*}
	2	29.09±1.40	29.39±1.46 1.0%^{3}	34.82±0.60 19.7%^{4*}	35.93±0.70 3.1%^{3*}
Creatinine, µmol/L	1	85.24±0.85	83.88±0.95 -1.6%^{3}	85.84±1.18 0.7%^{4}	94.52±1.14 10.1%^{3*}
	2	84.08±2.49	81.68±3.03 -2.8%^{3}	98.84±1.50 17.5%^{4*}	99.60±1.24 0.7%^{3}

Notes: ^{3} – difference (%) compared to results before exercise; ^{4} – difference (%) between basal parameters (before exercise) in comparison with the previous results (at rest) *– p< .05

At the beginning of the study representatives of both groups had a low level of body resistance to power loads, due to the lack of experience in fitness. However, the level of cortisol and testosterone concentration in the blood of young men of both groups varied during the study depending on the power load modes and the Wn index. After 3 months of training, the cortisol concentration in the blood of young men of group 1 increased by 38.1% ($p<0.05$) in response to the load. These changes indicate that the load volume parameters for participants of group 1 continued to be a powerful stressful stimulus and activated compensatory body mechanisms. This fact is confirmed by an increase in basal testosterone levels by 29.1% ($p<0.05$) and no changes in basal creatinine levels in the blood of young men of group 1. In young men of group 2, there was a manifestation of long-term body adaptation to the low-volume load mode (R_a=0.72). The cortisol concentration in the blood serum of group 2 participants did not increase in response to power loads and the basal level of creatinine increased by 17.5% ($p<0.05$).

The monitoring of changes in the studied indicators after 12 weeks of using training regimes helped to obtain the following correlations. The Spearman's rank correlation coefficient was used to determine the correlation. The number of strong correlations between the load volume and indicators of adaptive body changes indicated the effectiveness of the used training regime in fitness (Fig. 1-2).

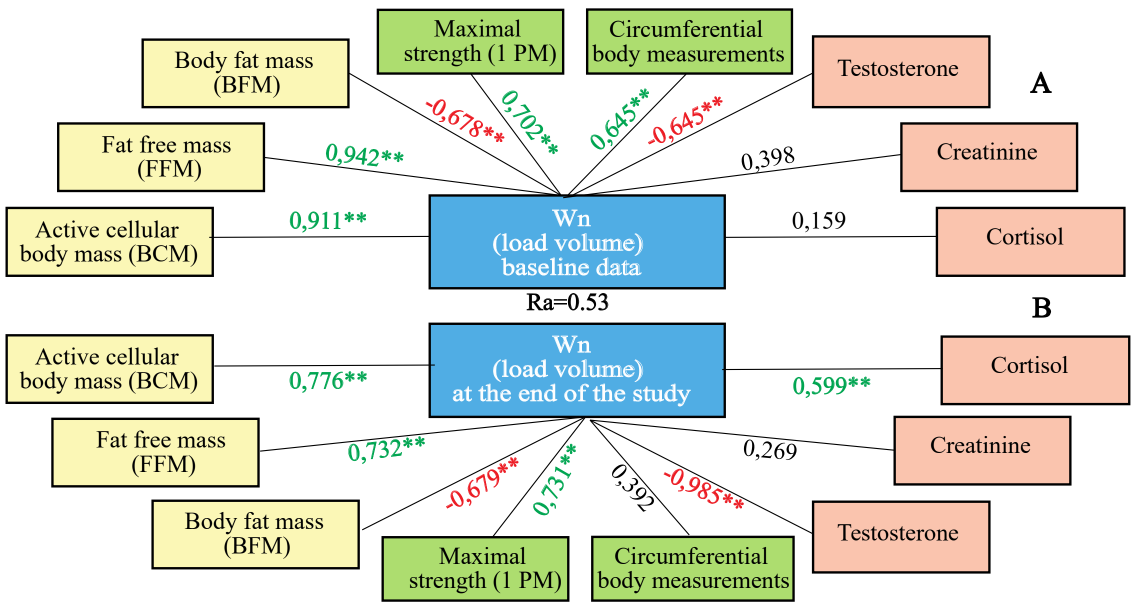

Fig. 1. Features of the correlation between load volume parameters (Wn), morphofunctional indicators, and biochemical blood markers of group 1 participants at the beginning (A) and at the end (B) of the study

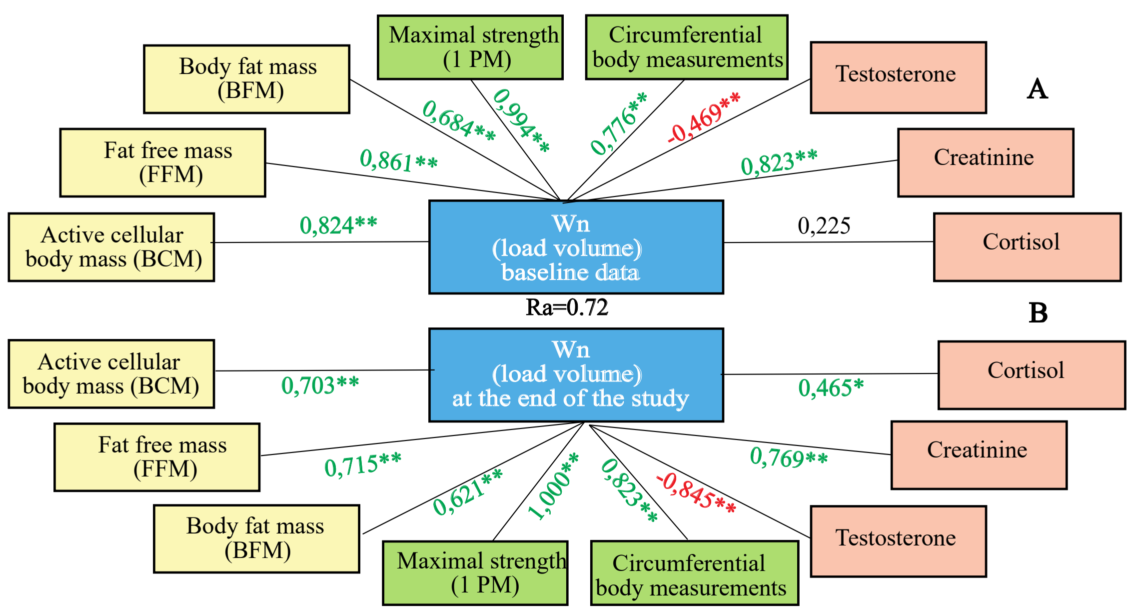

Fig. 2. Features of the correlation between load volume parameters (Wn), morphofunctional indicators, and biochemical blood markers of group 2 participants at the beginning (A) and at the end (B) of the study

At the beginning of the study, both groups showed a strong correlation between the load volume and indicators of 1 PM, FFM, and BCM. In young men of group 2, a strong correlation was observed between Wn parameters, circumferential body measurements, and basal blood creatinine levels. A moderate negative correlation was recorded in group 1 representatives between load volume and body fat mass. The correlation between the load volume and basal testosterone level was also moderately negative in both groups.

The results revealed at the end of the study indicate that the number of strong correlations in both groups has not changed. The negative correlation between the load volume and basal blood testosterone level in both groups became stronger.

Thus, the largest number of strong correlations between Wn and the studied indicators was found in the conditions of using a low-volume load mode (Ra=0.72). The high correlation between the load volume and circumferential body measurements, 1 PM, and creatinine in this training regime indicates the processes of long-term adaptation. Informative markers of positive adaptive body changes in young men performing strength exercises are also indicators of FFM and BCM.

Discussion

This paper describes the peculiarities of the influence of various parameters of load volume on the adaptative compensatory body reactions of untrained young people participating in power fitness. The study showed that using a low-volume load mode (R_a=0.72) contributed to the most pronounced long-term adaptation processes. The number and level of correlations between the load volume, morphofunctional indicators, and biochemical blood markers were studied. The obtained results indicated a strong correlation between the load volume and indicators of long-term adaptation in fitness. First of all, these are indicators of maximum strength, fat-free mass and active cellular body mass, circumferential body measurements, and basal creatinine levels. Determination of strong correlations between the load volume and adaptative compensatory body reactions in different load modes will allow for the development of a correction mechanism for the training system in fitness.

The lack of a clear understanding of the correlation between the magnitude of an external physical stimulus and the nature of adaptive body changes in untrained people is one of the problems of fitness. The study of the influence of the power load regime on the indicators of volume and intensity is one of the current areas of scientific research in fitness (Dobson, 2022; Rakpongsiri & Rakpongsiri, 2023). Determining the optimal ratio of the main load components and combining them with the most common training methods in fitness is particularly acute (Vermeire et al., 2022; Zuo et al., 2022). The problem of developing effective and at the same time safe models of fitness continues to be one of the most relevant among scientists in various fields of study. Therefore, in-depth research on the body's adaptative compensatory reactions to a stressful stimulus in different training regimes attracts the scientific interest of many scholars (Chernozub et al., 2023; Michalik et al., 2023; Schoenfeld et al., 2023). However, the peculiarities of the different load volume training impact of training on the adaptation processes of young people with no experience in fitness have not been thoroughly examined.

The use of a low-volume load regime by untrained young men contributed to the two-fold maximum strength development compared to the baseline data. The dynamics of the circumferential body measurements of the study participants who used this training regime was 3 times higher than the muscle mass growth in group 1. The indicator of low-volume load in power fitness is compensated by a high level of load intensity and vice versa (Chernozub et al., 2018). Accelerated development of 1 PM in conditions of low-volume loads is associated with an increase in the number of active motor units of the main muscle groups due to the high intensity of loads (Weakley et al., 2023). Fast muscle mass growth in this training regime is associated with the processes of long-term hypertrophy of fast-twitch muscle fibers (Schoenfeld et al., 2023). The activity of fast contractile muscle fibers increases when using a projectile working mass (m) in the range of 75-80% of 1 PM (Silva et al., 2022). It is such a mode of power load (R_a=0.72) that was used by group 2 participants during the research. At the same time, an increase in the basal creatinine level in the blood serum during strength training occurs only due to accelerated muscle mass growth (Chernozub et al., 2020).

The maximum number of high correlations between the load volume parameters and other studied indicators was observed in young men using the low-volume regime. The highest correlations (0.769-1.000) were noticed between the load volume and maximum strength indicators, circumferential body measurements, and basal blood creatinine level. The progressive negative correlation between the load volume and basal blood testosterone levels in the study participants, regardless of the training regime, demonstrates a certain pattern. In power fitness, a high correlation is observed between exercise intensity and basal testosterone levels only in trained athletes (Toledo et al., 2021; Chernozub et al., 2023). The level of correlations between an external stressful stimulus (Wn) and increasing adaptive body reserve indicators demonstrates the effectiveness of the training regime in fitness.

Conclusions

A comparative analysis of the effectiveness of the influence of different load volume modes on adaptive body changes in untrained young people allows for determining their priority. Depending on the peculiarities of the variability of the training regime components, the load volume parameters (Wn) can differ by more than 1.6 times. Using a low-volume mode of power loads (R_a=0.72) promotes the most accelerated adaptative body changes in untrained young men. The maximum strength development increased by 20.9% compared with the results of the other group. The dynamics of the circumferential body measurements of young men 3.2 times exceeded the results obtained by the study participants using a high-volume load mode (R_a=0.53).

The obtained correlation allows for defining a distinct correlation between the external stimulus magnitude and adaptive body change formation. The determination of strong correlations between the studied indicators in different load modes will contribute to the improvement of the training system in fitness.

Conflicts of interest - There is no conflict of interest.

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