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Changes in circumference sizes of bodybuilders using machine and free weight exercises in combination with different load regimes

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Abstract

Purpose. To evaluate the changes in circumference sizes of bodybuilders using machine and free weight exercises in conditions of different load regimes at the stage of specialized basic training.

Methods. 64 bodybuilders aged 20±1.2 years were divided into 4 study groups. The stage of specialized basic training lasted 12 weeks. Group 1 and 2 participants used free weight and machine exercises in conditions of medium-intensity training load (R_a=0.58). Group 3 and 4 athletes performed the same exercises in conditions of high-intensity training load (R_a=0.71). The changes in circumference measurements (shoulder, hip and shin) were recorded every 30 days. Non-parametric methods of mathematical statistics were used in the study.

The results. Using free weight exercises in the regime of high-intensity loads (R_a=0.71) contributed to the greatest increase in the body circumference (by 4.9%) compared to the initial data. The smallest increase in the controlled indicators (by 1.8%) was found in athletes using machine exercises in the regime of medium-intensity loads (R_a=0.58). Performing free weight exercises in different load regimes led to more than double increase in the body circumference measurements. The dependence of the controlled indicators dynamics on the load regimes was observed when using machine exercises. The dynamics of body circumference depends on the features of the training load regimes but not on the type of exercises.

Conclusions. At the stage of specialized basic training in bodybuilding, the use of high-intensity training loads (R_a=0.71) was the main factor that affected the accelerated increase in body circumference of athletes. Combination of machine strength exercises with high-intensity loads allowed achieving the most pronounced adaptive changes.

Keywords: bodybuilding, body circumference, strength exercises, specialized basic training, load regime, intensity

Анотація

Володимир Потоп, Віктор Манолакі, Андрій Чернозуб, Валентин Козін, Едуард Сивохоп, Антоніна Співак, Василь Шароді, Чжао Цзе. Особливості зміни обвідних розмірів тіла бодібілдерів під час використанням вправ на тренажерах та з вільною вагою обтяження в різних режимах навантаження

Мета. Дослідити зміну обвідних розмірів тіла у бодібілдерів на етапі спеціалізовано-базової підготовки в умовах використання комплексів вправ на тренажерах та з вільною вагою обтяження в різних режимах навантаження

Методи. В дослідженнях приймали участь 64 бодібілдери віком 20±1,2 років. Дослідження відбувались на етапі спеціалізованої базової підготовки протягом 12 тижнів. Сформовано 4 дослідні групи по 16 спортсменів в кожній. Учасники 1 та 2 груп в умовах режиму навантажень середньої інтенсивності (R_a=0,58) використовували комплекс вправ с вільною вагою обтяження та на тренажерах. Відповідні комплекси вправ використовували представники 3 та 4 груп, але в умовах режиму навантажень високої інтенсивності (R_a=0,71). Контроль за динамікою обвідних розмірів (плеча, стегна та гомілки) відбувався через кожні 30 діб. В процесі досліджень використовували непараметричні методи математичної статистики.

Результати. Виявлено, використання вправ з вільною вагою обтяження в режимі навантажень високої інтенсивності (R_a=0,71) сприяє найбільшому зростанню обвідних розмірів тіла на 4,9% порівняно з вихідними даними. Найменше зростання контролюючих показників на 1,8% протягом 12 тижнів, виявлено у спортсменів в використання вправ на тренажерах в режимі навантажень середньої інтенсивності (R_a=0,58). Використання вправ з вільною вагою обтяження, але в різних режимах навантажень призводить до різниці більше ніж в 2 рази збільшення обвідних розмірів тіла. Відповідну залежність динаміки досліджуваних показників від особливостей режимів навантаження, спостерігаємо під час використання комплекс вправ на тренажерах. виражене Динаміка обвідних розмірів тіла залежить саме від особливостей використовуваних режимів навантаження, а не від комплексу тренувальних вправ.

Висновки. На етапі спеціалізовано-базової підготовки в бодібілдингу використання під час тренувань режиму навантажень високої інтенсивності (R_a=0,71) є основним фактором, який впливає на прискорене збільшення обвідних розмірів тіла спортсменів. Використання в процесі тренувальних занять варіантів поєднання комплексу силових вправ на тренажерах з навантаженнями високої інтенсивності дозволяє досягти найбільш виражених адаптаційних змін.

Ключові слова: бодібілдинг, обвідні розміри тіла, комплекси силових вправ, спеціалізована базова підготовка режим навантаження, інтенсивність

Аннотация

Владимир Потоп, Виктор Манолаки, Андрей Чернозуб, Валентин Козин, Эдуард Сивохоп, Антонина Спивак, Василий Шароди, Чжао Цзе. Особенности изменения охватных размеров тела бодибилдеров при использовании упражнений на тренажерах и со свободным весом отягощения в различных режимах нагрузки

Цель. Исследовать изменение охватных размеров тела у бодибилдеров на этапе специализированно-базовой подготовки в условиях использования комплексов упражнений на тренажерах и со свободным весом отягощения в различных режимах нагрузки

Методы. В исследованиях принимали участие 64 бодибилдера в возрасте 20±1,2 лет. Исследования проводились на этапе специализированной базовой подготовки в течение 12 недель. Сформированы 4 опытные группы по 16 спортсменов в каждой. Участники 1 и 2 групп в условиях режима нагрузок средней интенсивности (R_a=0,58) использовали комплекс упражнений со свободным весом отягощения и на тренажерах. Подходящие комплексы упражнений использовали представители 3 и 4 групп, но в условиях режима нагрузок высокой интенсивности (R_a=0,71). Контроль за динамикой охватных размеров (плеча, бедра и голени) проходил через каждые 30 суток. В процессе исследований использовали непараметрические методы математической статистики.

Результаты. Выявлено, что использование упражнений со свободным весом отягощения в режиме нагрузок высокой интенсивности (R_a=0,71) способствует наибольшему росту охватных размеров тела на 4,9% по сравнению с исходными данными. Наименьший рост контролирующих показателей на 1,8% в течение 12 недель обнаружен у спортсменов в использовании упражнений на тренажерах в режиме нагрузок средней интенсивности (R_a=0,58). Использование упражнений со свободным весом отягощения, но в разных режимах нагрузок приводит к разнице более чем в 2 раза увеличения охватных размеров тела. Соответствующую зависимость динамики изучаемых характеристик от особенностей режимов перегрузки, наблюдаем при использовании комплекс упражнений на тренажерах. Выраженная динамика охватных размеров тела зависит именно от особенностей используемых режимов нагрузки, а не от комплекса тренировочных упражнений.

Выводы. На этапе специализированно-базовой подготовки в бодибилдинге использование во время тренировок режима нагрузок высокой интенсивности (R_a=0,71) является основным фактором, влияющим на ускоренное увеличение охватных размеров тела спортсменов. Использование в процессе тренировочных занятий вариантов сочетания комплекса силовых упражнений на тренажерах с нагрузками высокой интенсивности позволяет добиться наиболее выраженных адаптационных изменений.

Ключевые слова: бодибилдинг, охватные размеры тела, комплексы силовых упражнений, специализированная базовая подготовка, режим нагрузки, интенсивность

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Introduction

The development of integral models for improving the training process in bodybuilding at the stage of specialized basic training has been of great interest for the past 20-30 years. Not only leading coaches and professional athletes, but also scientists pay great attention to this issue. There is a number of scientific researches related to studying body adaptative mechanisms to strength training loads (Cintineo et al., 2018; Benavente et al., 2021; Sun & Wang, 2022). Scientists in the field of physical education and sports physiology have actively studied the issue of developing effective mechanisms for training load optimization, quantitative criteria for their assessment and control of adaptive and compensatory reactions in power sports (Chernozub et al., 2018; Johnen & Schott, 2018; Zhao & Oleshko, 2022).

Despite the rapid development of bodybuilding in the world, the question of finding the newest effective but safe ways to optimize the training process is one of the priority problems. It can be solved by in-depth research of load correction mechanisms and the correspondence of their parameters to the adaptation reserves of the body. The solution of this problem also requires the unification of the efforts of scientists of various direction (Aerenhouts & D'Hondt, 2020; Alves et al., 2020).

During the last decades, specialists in bodybuilding have been debating the question of the effectiveness of using free weight and machine exercises at various stages of training (Miller et al., 2020; Coratella et al., 2022). The analysis of available scientific literature shows the contradictory results of research on this issue. This concerns the influence of these exercises in combination with different load regimes on the nature of adaptive changes in bodybuilders at various stages of long-term training (Shibata et al., 2021; Chernozub et al., 2023). In turn, there have been no studies of the impact of various combinations of free weight and machine exercises on the morphometric indicators changes at the stage of specialized basic training in bodybuilding.

The purpose of the study. To evaluate the changes in circumference sizes of bodybuilders using machine and free weight exercises in conditions of different load regimes at the stage of specialized basic training.

Materials and methods

Participants

64 bodybuilders aged 20±1.2 years were examined during the research and divided into 4 study groups, 16 athletes in each group. Their experience in bodybuilding was 5±0.8 years. The study lasted 12 weeks at the stage of specialized basic training in Gold Gym, Septem Fitness, Gym Style fitness centers. The participants of groups 1 and 2 used free weight and machine exercises in conditions of medium-intensity loads (R_a=0.58). The same exercises were used by groups 3 and 4 representatives but in conditions of high-intensity loads (R_a=0.71).

In accordance with the Helsinki Declaration ethical standards, the research was approved by the ethics committee of Lesya Ukrainka Volyn National University. According to recommendations of the Biomedical Research Ethics Committee (WHO Regional, 2000), a written consent was given by all study participants.

Measurements

The method of quantitative assessment of the power load regime. Using this method (Chernozub et al., 2018) allowed developing training load regimes with high (R_a=0.71) and medium (R_a=0.58) intensity at the beginning of the study. To implement this method, the repetition maximum weight (1 RM), which a person can use when performing a physical exercise, was determined taking into account the generally accepted technique.

The load factor (R_a), which reflects the features of the load regime in power fitness, was determined by the formula:

$R_a = R_{max} - (n \cdot Q \cdot t \cdot f_o)$, where

R_{max} is the maximum load factor, its value is R_{max}=1;

n is the specified number of repetitions in a set;

Q is the conditional amplitude coefficient. Strength exercises are performed with full or partial amplitude. Quantitative values of this indicator are within $0.8<Q<1$;

t is the duration of one repetition during a physical exercise (s). This indicator is within $3<t<9$;

f_o is an empirical coefficient obtained by using multiple regression analysis; when the values

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of independent variables (n, t, Q, m) are found experimentally, the value of f_o = 0.0098 1/s.

Method of anthropometry (circumferential body measurements)

The body circumference measurements (shoulder, hip and shin) were conducted at the beginning of the study and each month during the 12 weeks of the research. In accordance with methodology (Norton, K., & Eston R., 2018), bodybuilders' circumference measurements were made with a centimeter tape.

When measuring the thigh circumference, the tape was placed on the thigh under the buttock fold. Circumferential size of the shin was measured at the place of greatest development of the calf muscle. The sizes of the right and left shins were added and divided by two. The shoulder circumferential measurements under tension were made at the place of greatest muscle development. The results of the right and left limbs were added and divided by two. All measurements were performed at the same time before the start of the training session according to the generally accepted methodology. The obtained results were recorded in the research protocols.

Study organization

At the first stage of study, taking into account the results of research by modern scientists in bodybuilding and fitness (Weakley et al., 2017; Coratella et al., 2021; Mitsuya et al., 2023), 2 complexes of machine and free weight exercises were developed (Table 1). Using the method of quantitative assessment of training load, two different intensity load regimes (A and B) were built up (Table 2).

Table 1

Complexes of training exercises used by the athletes of the examined groups during the research

Muscle groups	A complex of strength free weight exercises	A complex of machine exercises
Chest muscles	Basic: barbell chest press lying on a horizontal bench Isolated: 30-degree incline dumbbells press	Basic: Smith machine bench press Isolated: crossovers on the block; butterfly chest exercise
Deltoid muscles	Basic: seated bench press (dumbbells) Isolated: seated dumbbells curls; seated dumbbell lateral raise	Basic: overhead press Isolated: seated block pull; dumbbell lateral raise
Back muscles	Basic: barbell row or deadlift Isolated: incline bench pulls; dumbbells hyperextension, pull-ups on the crossbar	Basic: behind the head upper block pulling Isolated: seated lower block pull; standing pullover with a rope
Triceps brachii muscle	Basic: French press Isolated: close grip bench press; single-arm dumbbell overhead extension	Basic: machine French press or the upper arm stretching on the block standing Isolated: reverse grip single-arm triceps extension; single-arm extension from the upper block
Biceps brachii muscle	Basic: standing hammer curl Isolated: seated arm extension with support, 30-degree incline barbell press	Basic: bending arms on the Scott bench Isolated: incline push-ups on the block; single-arm bending with support on the block
Lower limbs muscles	Basic: squats with a barbell Isolated: lunges with dumbbells; deadlift (on straight legs) with dumbbells	Basic: leg press in the block Isolated: seated leg extension; bending legs in the simulator lying

Notes: 4 models of training sessions were created:
1) performing free weight exercises in conditions of medium-intensity training loads (R_a=0.58);
2) performing machine exercises in conditions of medium-intensity training loads (R_a=0.58);
3) performing free weight exercises in conditions of high-intensity training loads (R_a=0.71);
4) performing machine exercises in conditions of high-intensity training loads (R_a=0.71)

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Table 2

Strength training load regimes used by the study participants during the research

Indicators of training load	Load regimes	
	Regime A	Regime B
The amplitude of performing the exercise, %:	Full (100%) amplitude without fixing the projectile at the peak point	Partial amplitude (90% of maximum)
Conditional coefficient of motion amplitude (Q)	0.9	0.8
Duration of movement phases	Concentric phase – 2 s; Eccentric phase – 4 s.	Concentric phase – 3 s; Eccentric phase – 6 s.
Duration of performing one repetition (t, s)	6	9
Duration of rest between sets, s	60	45
The number of repetitions in a set	8-9	4-5
The number of sets in one exercise	4	4
Maximum duration of work in a set (Tmax, s)	48-54	36-45
Projectile working mass (m), % of the maximum (1 RM)	63-64	73-74
Load factor (R_a)	0.58	0.71
Level of training load intensity and volume	medium-intensity	high-intensity
Energy supply of muscle activity	Anaerobic-lactate	Anaerobic-alactate
Duration of the training session, min	40-43	30-35

At the second stage, the peculiarities of changes in body circumference sizes were investigated in athletes of all 4 groups. Trainings were held 4 days a week. The results of the studied morphometric body indicators were compared during the research in order to determine the most effective training model for the specialized basic stage of training in bodybuilding.

Statistical analysis

Statistical analysis of the research results was performed using the IBM *SPSS*Statistics 26 program package (StatSoftInc., USA). The median, interquartile range (IQR) was determined. The G-Power 3.1.96 program was used to calculate the statistical power (determining the smallest sample size for the study). The non-parametric H-Kruskal-Wallis test, Friedman’s two-factor rank variance analysis, W-Kendall (Kendall’s concordance coefficient) were used.

Results

The nature of changes in the studied indicators (circumference sizes of the chest, shoulder, thigh, and shin) in conditions of using a combination of exercises with load regimes are presented in Tables 3-5.

The results of changes in the shoulder parameters of the bodybuilders participating in the 12-week study and using the proposed models of exercises and training load regimes are demonstrated in Table 3.

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Table 3

Changes in the shoulder circumferential measurements in bodybuilders of the examined groups during the study (median, interquartile range (IQR), n=64

Groups	Term of observation, months				χ^2, p df=3
	Initial data	1	2	3	
1	38.75 (1.10) H=2.83 p=0.41	38.60 (1.22) -0.4%[1]	39.35 (0.87) 1.9%[1*]	39.90 (0.68) 1.4%[1*] 2.9%[2***]	χ^2=39.88*** W=0.83***
3	38.60 (1.08) H=2.83 p=0.41	39.30 (1.03) 1.8%[1*]	40.10 (0.67) 2.0%[1*]	40.60 (0.82) 1.2%[1*] 5.2%[2***]	χ^2=48.00*** W=1.00***
2	38.30 (1.27) H=2.83 p=0.41	38.05 (1.35) -0.6%[1]	38.85 (1.50) 2.1%[1*]	39.85 (0.97) 2.5%[1*] 4.0%[2***]	χ^2=45.00*** W=0.93***
4	38.95 (1.45) H=2.83 p=0.41	39.95 (1.18) 2.5%[1*]	40.80 (1.23) 2.1%[1*]	41.60 (1.15) 1.9%[1*] 6.8%[2***]	χ^2=48.00*** W=1.00***

Notes: 1 – difference (%) compared to previous results; 2 – difference (%) in comparison with the initial values; df is the number of degrees of freedom; H – Kruskal-Wallis criterion; χ2 – Friedman's test; W is the Kendall's concordance coefficient; *– p<0.05; *** – p<0.001

The shoulder circumference sizes in the 3rd group athletes almost twice exceeded the results of the 1st group participants during 12 weeks of the study. These changes indicate the advantage of using high-intensity loads in combination with free weight exercises. The change of the controlled parameters was by 2.8% (p<0.05) higher in the 4th group representatives compared to the results of the 2nd group athletes. The obtained results indicated the effectiveness of the high-intensity load regime (R_a=0.71) application, regardless of types of exercises used during the study.

Table 4 presents the results of thigh circumference measurements in the bodybuilders participating in 12-week research and using the proposed combinations of load regimes and complexes of machine and free weight exercises.

Table 4

Changes in the thigh circumferential measurements in bodybuilders of the examined groups during the study (median, interquartile range (IQR), n=64

Groups	Term of observation, months				χ^2, p df=3
	Initial data	1	2	3	
1	57.00 (1.68) H=19.99* p=0.03	56.10 (1.27) -1.6%[1*]	57.20 (1.50) 1.9%[1*]	58.00 (1.28) 1.4%[1*] 1.7%[2***]	χ^2=41.28*** W=0.86***
3	56.20 (2.18) H=19.99* p=0.03	57.25 (1.68) 1.8%[1*]	58.00 (1.75) 1.3%[1*]	58.20 (1.28) 1.0%[1] 3.5%[2***]	χ^2=45.90*** W=0.95***
2	56.45 (2.73) H=19.99* p=0.03	56.15 (2.70) -0.5%[1]	57.40 (2.62) 2.2%[1*]	58.00 (1.87) 1.0%[1] 2.7%[2***]	χ^2=46.21*** W=0.96***
4	58.50 (1.45) H=19.99* p=0.03	59.90 (1.47) 2.4%[1*]	60.75 (1.18) 1.4%[1*]	61.25 (0.87) 0.8%[1] 4.7%[2***]	χ^2=47.71*** W=0.99***

Notes: 1 – difference (%) compared to previous results; 2 – difference (%) in comparison with the initial values; df is the number of degrees of freedom; H – Kruskal-Wallis criterion; χ2 – Friedman's test; W is the Kendall's concordance coefficient; *– p<0.05; *** – p<0.001

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The results analysis indicated that the 1st group athletes had the smallest increase in the thigh circumference sizes by 1.7% ($p<0.05$) compared to the initial data. Thus, using the medium-intensity loads ($R_a=0.58$) regime in combination with free weight exercises brought to minimal changes in thigh morphometric parameters of bodybuilders. However, the dynamics of the studied indicator increased by 3.5% ($p<0.05$) in the 3rd group athletes using a similar set of exercises in conditions high-intensity loads ($R_a=0.71$). The same difference in the dynamics of bodybuilders' thigh circumference sizes was recorded in athletes using machine exercises depending on the peculiarities of the training load regime.

The results reflecting changes in the shin circumference sizes in all groups of bodybuilders participating in 12-week research and using the proposed training activities are shown in Table 5.

Table 5

Changes in the shin circumferential measurements in bodybuilders of the examined groups during the study (median, interquartile range (IQR), n=64

Groups	Term of observation, months				χ^2, p df=3
	Initial data	1	2	3	
1	38.60 (1.08) H=6.53 p=0.08	38.10 (1.05) -1.1%[1]	39.00 (0.95) 2.3%[1*]	39.05 (0.85) 0.1%[1] 1.2%[2*]	$\chi^2=41.26^{***}$ $W=0.86^{***}$
3	38.50 (0.85) H=6.53 p=0.08	39.05 (1.02) 1.4%[1]	39.45 (0.92) 1.0%[1*]	39.50 (0.82) 0.1%[1] 2.6%[2***]	$\chi^2=45.19^{***}$ $W=0.94^{***}$
2	38.70 (1.15) H=6.53 p=0.08	38.55 (1.18) 0.4%[1]	39.40 (1.15) 1.0%[1*]	39.40 (0.95) 0.0%[1] 1.8%[2*]	$\chi^2=37.54^{***}$ $W=0.78^{***}$
4	39.00 (0.80) H=6.53 p=0.08	40.00 (0.45) 2.5%[1*]	40.45 (0.77) 1.1%[1*]	40.30 (0.78) -0.4%[1] 3.3%[2***]	$\chi^2=42.22^{***}$ $W=0.88^{***}$

Notes: 1 – difference (%) compared to previous results; 2 – difference (%) in comparison with the initial values; df is the number of degrees of freedom; H – Kruskal-Wallis criterion; χ2 – Friedman's test; W is the Kendall's concordance coefficient; *– p<0.05; *** – p<0.001

The shin circumference measurements of the 3rd group athletes twice exceeded the results recorded in the 1st group participants during the study period. The 1st group representatives used a similar set of training exercises, but in conditions of medium-intensity ($R_a=0.58$) load regime. Different dynamics were also revealed in groups 2 and 4 athletes who performed similar machine exercises but with the load regimes of different intensity. Thus, the growth of the studied indicator was by 1.5% ($p<0.05$) in group 4 bodybuilders compared to the results of group 2 athletes for the same period of time.

Discussion

The search for effective ways to solve the problem of improving training activities in bodybuilding at the specialized basic stage is an urgent problem today. The process of optimizing training loads requires to use an integrated approach with a combination of a wide range of factors that influence the improvement of bodybuilders' performance. Currently, there are no clear scientific justifications for determining the effectiveness of using machine or free weight exercises (Johnen & Schott, 2018; Zhao & Oleshko, 2022; Coratella et al., 2023). There are no data proving the advantages of using a particular set of training exercises based on the control of adaptive body changes in athletes. It is possible that the problem is not in the effectiveness of using different exercises, but in the conditions of load regime in which these exercises are performed.

This study presents the results of changes in body circumference measurements of bodybuilders using machine and free weight exercises. It also contains a thorough study of adaptive body changes on the background of the muscle mass growth in different intensity training regimes. This study complements scientific works (Aerenhouts & D'Hondt, 2020; Benavente et al., 2021) devoted to the problems of improving the training system in bodybuilding. The obtained results expand the views of scientists regarding the search for new mechanisms for optimizing power load regimes in this kind of sport (Alves et al., 2020; Sun & Wang, 2022). This especially applies to the problem of researching the effectiveness of correlation between the amount of load indicators and the energy supply systems of muscle activity. Thus, the data we obtained coincide with the research results of some scientists (Coratella et al., 2021; Mitsuya et al., 2023), which prove that the accelerated muscle mass growth in bodybuilders occurs only in conditions of anaerobic loads. However, the mentioned studies did not specify the variability of using exercises different in biomechanics and complexity of training tools. In most cases, the comparative analysis of the effectiveness of certain sets of machine and free weight exercises was carried out using identical loads (Weakley et al., 2017; Shibata et al., 2021). A number of researchers (Miller et al., 2020; Trindade al., 2022;) studied the body circumference dynamics depending on the combination of exercises with training principles in conditions of 80-85% of 1 RM loads. However, their results are significantly different from the data obtained in this study. It is possible that the difference is related to various resistance levels of the study participants to the proposed stressful stimuli. One of the justified reasons for the difference between the results found in these studies is the use of excessive training loads before the start of the specialized basic training stage (Martorelli et al., 2021; Sun & Wang, 2022).

The study results showed that using high-intensity training loads (R_a=0.71) at the stage of the specialized basic training in bodybuilding contributed to the most pronounced adaptive body changes. Identified differences between the growth of body circumference measurements of athletes depend primarily on the features of the load regime. Using various machine and free weight exercises is only an additional factor affecting the performance of athletes (Barnes et al., 2019; Becker et al., 2021; Martorelli et al., 2021). The variability of combining certain load regimes with machine and free weight exercises in order to achieve the maximum adaptation effect is of secondary importance. Accelerated increase in body circumference sizes in conditions of high-intensity loads and, accordingly, the muscle mass growth occurs due to hypertrophy of mainly fast-twitch muscle fibers (Gala et al., 2020; Ramos-Campo et al., 2021; Jurasz et al., 2022). It can be assumed that training loads of high intensity (R_a=0.71) in terms of energy are mainly provided by the creatine phosphokinase mechanism of ATP resynthesis. It is possible that using a high-intensity load regime will allow to increase the creatine phosphate reserves in muscles and thus the effectiveness of the long-term adaptation process. However, even using high-intensity loads in combination with free weight exercises does not cause such changes in body circumference measurements as performing machine exercises. Perhaps this happens due to the significant energy expenditure on stabilizer muscles, the activation of which is extremely important for performing free weight exercises. Such energy expenditure leads to premature body exhaustion and the development of fatigue in bodybuilders (Mihăiță et al., 2022; Trindade al., 2022; Bauer al., 2023).

Conclusion

1. The use of machine exercises in conditions of a high-intensity load regime (R_a=0.71) contributed to the greatest increase in the parameters of body circumference sizes in bodybuilders. Expressed dynamics of body circumference measurements occurs due to the accelerated growth of muscle mass in athletes. It is possible that this combination of exercises with a training load regime allows to reduce energy consumption because there is no need to activate a significant number of stabilizer muscles. The obtained results indicated pronounced long-term adaptation processes precisely in the conditions of using the high-intensity load regime.

2. The implementation of research results in training activities will allow to find effective ways of optimizing loads taking into account the

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adaptation potential of the body. The development of experimental mechanisms for improving the training process at the stage of specialized basic training in bodybuilding will contribute to the accelerated growth of performance in the shortest possible time.

Prospects for further research. In the future, it is planned to carry out research using a complex of physiological and biochemical methods of body systems diagnosis. This research will be aimed at determining the peculiarities of adaptation processes in bodybuilders using free weight and machine exercises in combination with different load regimes.

Conflict of Interest

The authors hereby declare that they don't have any financial and personal conflict of interest.

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