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Comparative analysis of the effectiveness of different strength training methods for the formation of muscle relief in bodybuilder athletes

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Abstract. The aim of the study was to determine how different options for organising strength loads affect the development of muscle mass, changes in body composition and expressiveness of the relief in bodybuilder athletes. The study was conducted at the Uman National University (Ukraine) from October 20 to December 12, 2025 with the participation of 66 male bodybuilder athletes who performed 8-week programmes of traditional hypertrophic training, drop sets and periodised strength-hypertrophic training, and the effectiveness was assessed using a pedagogical experiment, bioimpedance analysis, anthropometry, single-repetition maximum testing, calculation of the total strength index and statistical analysis. The most significant changes in body composition occurred in the periodised strength-hypertrophic training group: skeletal muscle mass increased by 2.4 kg, lean mass by 2.6 kg, and the proportion of adipose tissue decreased by 2.3%, which is explained by the combination of high mechanical stress in basic exercises with sufficient hypertrophic volume in auxiliary movements. Anthropometric indicators confirmed the improvement of the relief: shoulder girth increased by 1.6 cm, chest by 2.5 cm, hips by 2.3 cm, while the waist decreased by 2.9 cm, which reflects the improvement of body proportions. The total strength index increased by 57.2 kg versus 31.7 kg in the drop-set group and 29.9 kg in the traditional method group, confirming the advantage of periodisation for the development of maximum strength. Correlation analysis showed a relationship between skeletal muscle mass gain and strength index ($r = 0.74$), and waist reduction – with a decrease in adipose tissue ($r = 0.72$), which proves the interdependence of morphological and functional changes. Thus, periodised strength-hypertrophic training most effectively combined muscle mass gain, fat component reduction, improvement of proportions and strength increase in bodybuilders. The results can be used by bodybuilding coaches, physical education and sports specialists and athletes to plan training programmes aimed at the formation of muscle relief and control of body composition

Keywords: body composition; fat-free mass; anthropometric parameters; adaptation; hypertrophy; morphological changes; drop set

Introduction

In bodybuilding, the selection of a strength training technique determines not only the increase in muscle mass, but also the expressiveness of the muscle relief, the proportionality of the physique and the stability of changes in body composition. The effectiveness of training depends on the combination of skeletal muscle hypertrophy, a decrease in the fat component, the optimal volume of the load, the intensity of exercises and full recovery. Different training techniques have different effects on mechanical stress, metabolic stress, local muscle fatigue and the adaptive capabilities of the body, so the effectiveness should be assessed by morphological and strength indicators. Incorrect selection of loads can cause excessive fatigue, trauma, disproportionate development of muscle groups and unstable changes in the ratio of muscle and fat mass, since the body does not have time to fully recover between workouts, and

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individual muscle groups receive either excessive or insufficient stimulus for adaptation. Under such conditions, the quality of the hypertrophic response decreases, body composition control deteriorates, and it becomes more difficult to achieve a pronounced muscle relief.

The training of bodybuilders involves combining the selection of exercises with the planning of a training system in which the volume of the load, intensity, recovery, adaptation control, and targeted morphological changes are functionally interconnected. The problem of scientific support for strength sports was analysed by L. Podrigalo *et al.* (2025), focusing on areas of research related to strength training, functional capabilities of athletes, training effectiveness, and risks of overload. The results demonstrated the need to consider strength training not only as a means of increasing strength, but also as a controlled process of the body's adaptation to repetitive loads. Methodological approaches to the systematic training of bodybuilders were considered by S.I. Karaulova & A.Y. Troian (2024), focusing on planning training stages, selecting exercises, regulating intensity, and taking into account the level of fitness of athletes. Researchers proved that the effectiveness of bodybuilders' training is determined not only by the total amount of work performed, but also by the structure of the training programme, in particular, the sequence of exercises, load distribution, intensity, and compliance of the training effect with the training stage. Optimisation of training loads in novice athletes specialising in bodybuilding was studied by S.I. Karaulova *et al.* (2025). The authors showed that gradual dosing of volume and intensity contributes to the formation of adaptation, while the mismatch of the load to the level of fitness limits the increase in muscle mass and increases the risk of functional exhaustion.

Morphological changes in bodybuilding are formed under the influence of the loading mode, the type of exercises and the nature of energy supply, therefore, the assessment of the effectiveness of the training method should cover not only the strength result, but also the dynamics of girths, muscle mass and functional state. Changes in the girth dimensions of the body of bodybuilders under the influence of training exercises, free weight and various loading modes were investigated by V. Potop *et al.* (2023). The results confirmed that girth parameters reflect the local direction of hypertrophic changes and can be used as an applied criterion for assessing muscle relief. The features of the adaptive reactions of bodybuilders were clarified in the work of A. Chernozub *et al.* (2023), which analysed the influence of various energy supply modes, load intensity, training exercises and free weight exercises on the morphofunctional indicators of athletes. The authors found that the combination of exercises in simulators and exercises with free weights forms a different morphofunctional response, which confirms the need to compare training methods by several indicators. Control of the functional state of athletes during physical exertion was considered by Y. Mykhaliuk *et al.* (2025). The results obtained showed that monitoring of functional reactions is necessary to assess load tolerance and prevent the accumulation of fatigue.

The formation of muscle relief in bodybuilding is associated with the simultaneous development of muscle mass, a decrease in the fat component, an increase in local muscle expressiveness and the use of techniques that combine mechanical tension with metabolic stress. The construction of the training process of qualified bodybuilders in the competitive period was studied in the work of O.B. Piven *et al.* (2023), where attention is focused on the relationship between muscle mass development, physique improvement and the selection of training equipment. Researchers established that the effectiveness of training in the competitive period depends on the targeted regulation of the volume and intensity of the load, since it is these parameters that affect the preservation of muscle mass and the improvement of the visual characteristics of the physique. The effect of drop sets on uneven hypertrophy of the quadriceps femoris muscle was studied by D. Varović *et al.* (2021). The authors found that this method can cause local differences in the increase in muscle thickness; for bodybuilding, this means the possibility of targeted influence on individual muscle segments, on which the visual detail of the physique depends. L.K. Sødal *et al.* (2023) summarised the data on the effect of drop sets on skeletal muscle hypertrophy, analysing the results of studies with different strength load protocols. Scientists found that drop sets can provide a hypertrophic stimulus due to a combination of high local fatigue, increased muscle time under load and approaching muscle failure, however, the effectiveness is determined by the total volume of work, intensity, and place of this technique in the training programme.

Previous studies did not sufficiently reveal the comparative effectiveness of different strength training methods in bodybuilders in terms of a set of indicators of muscle relief, body composition, girth parameters and strength fitness. The aim of the study was to establish the effectiveness of different training approaches in ensuring morphological and strength changes associated with improving the physique of bodybuilders. The objectives of the study were: to assess the initial indicators of body composition, girth parameters and strength fitness of bodybuilders; to determine changes in muscle mass, fat component and strength indicators after applying different strength training methods; to compare the effectiveness of the studied methods according to morphological and functional criteria.

Materials and Methods

Design, basis and ethical principles of the study. The study had an empirical comparative design with elements of a pedagogical experiment, as it involved the targeted application of different strength training techniques and the subsequent comparison of the impact on the morphological and strength indicators of bodybuilder athletes. The study was conducted at the Uman National University, Uman, Ukraine. The choice of this research was due to the profile of the university, which trained specialists in speciality 017 Physical Culture and Sports, in particular, in the educational programmes "Physical Culture and Sports" and "Fitness and Recreation"; this base ensured the involvement of some participants with experience in strength training, the organisation of classes in an educational and sports environment and the control of the technique of performing exercises, training load, anthropometric and strength indicators under the same conditions. The experimental phase lasted 8 weeks – from October 20 to December 12, 2025. This period was chosen due to the stability of the training schedule in the first semester, as it did not coincide with holidays, examination sessions and long holiday breaks. The eight-week mesocycle was sufficient to detect initial morphological and strength changes in athletes with experience in strength training, provided the same number of training microcycles for all groups, and did not create an excessive risk of accumulating chronic fatigue.

The study was conducted in accordance with the ethical principles of The Declaration of Helsinki (2024) for research involving human subjects, which provided for voluntary participation, obtaining informed consent, prior assessment of potential risks, confidentiality of personal data and the right of participants to discontinue participation at any stage without negative consequences. The experiment was approved by the Ethics Committee of the Uman National University, protocol No. 4 dated October 1, 2025.

Sample formation and characteristics of study participants. The study included 66 male bodybuilders aged 19 to 32 years, who systematically engaged in strength training and had experience in bodybuilding training from 2 to 6 years. The average age of the participants was 24.8 ± 3.1 years, the average training experience was 4.2 ± 1.1 years. Only men were included in the sample, since the study was aimed at comparing training methods, and not at analysing gender differences. The homogeneity of the sample by gender made it possible to reduce the influence of biological factors on the assessment of changes in muscle mass, body composition and strength indicators.

The sample was formed purposefully; the selection of participants was carried out in two stages. At the first stage, information about the study was disseminated at the university through an information announcement at the department, messages in the faculty's educational and sports groups, verbal information to students during classes in sports and practical disciplines, and appeals to teachers and coaches who worked with students who systematically engaged in strength sports. Additionally, the recruitment message was transmitted through coaches of Uman sports clubs and placed in gyms where amateur bodybuilders trained. Of the 66 participants, 30 were students of the Uman National University in the 2nd-4th year of the bachelor's degree and the 1st year of the master's degree, and 36 were athletes who trained in Uman sports clubs and underwent testing and training intervention at the faculty. This method of forming the sample made it possible to attract athletes with sufficient experience in strength training and ensure that measurements were carried out under the same conditions. At the second stage, those wishing to participate in the study filled out a primary selection questionnaire (Table 1).

Table 1. Questionnaire for selecting bodybuilder athletes to participate in the study

Questionnaire block	Question / indicator	Answer option or method of fixation
General information	Last name, first name or individual participant code	Researcher's note
	Age	Full years
	Sex	Male
	Participant status	Student of Uman National University / athlete of the Uman sports club
	For students: course of study	2nd / 3rd / 4th year of undergraduate studies / 1st year of graduate studies
Training experience	Total strength training experience	Number of years
	Bodybuilding experience	Number of years
	Average training frequency per week	3 / 4 / 5 / 6 or more times
	Duration of one workout	Up to 60 min / 60-90 min / over 90 min
	Experience in bodybuilding competitions	Yes / no
	The main type of preliminary training program	Split programme / full body / strength programme / mixed program
	Were drop sets used before?	Yes / no / occasionally
	Was load periodisation used before?	Yes / no / partially
Health status	Presence of acute musculoskeletal injuries in the last 3 months	Yes / no
	Presence of chronic diseases in the acute stage	Yes / no
	The presence of medical contraindications to strength training	Yes / no
	A break in training of more than 2 weeks in the last 3 months	Yes / no
Mode and recovery	Average sleep duration	Less than 6 hours / 6-7 hours / 7-8 hours / more than 8 hours
	The presence of additional intense physical activity outside of bodybuilding	Yes / no
Food	Is changing diet for 8 weeks planned?	Yes / no
	Does the participant maintain a stable protein diet?	Yes / no / partially
Control of experimental conditions	Willingness to train according to a specific program	Yes / no
	Willingness not to change the number of sets, repetitions, and exercises	Yes / no
	Willingness to undergo initial and repeated testing	Yes / no
Ethical consent	Confirmation of voluntary participation	Yes / no
	Confirmation of familiarisation with possible loading risks	Yes / no
	Consent to the processing of anonymised research results	Yes / no

Source: developed by the authors

After the questionnaire, a short interview was conducted and, if available, a review of the athlete's training diary or self-report data. Additionally, during the familiarisation training, the technique of performing basic strength exercises was assessed to confirm the participants' ability to safely perform bench presses, squats, pulling movements and auxiliary exercises according to the experimental programme, with such assessment being used as a criterion for admission to participation and safety control, and not as a separate outcome indicator of the study. Final inclusion in the sample was carried out after confirmation of compliance with the criteria: male gender; age 19-32 years; experience of systematic strength training from 2 to 6 years; regular bodybuilding classes at least 4 times a week; absence of acute injuries of the musculoskeletal system; absence of medical contraindications to strength loads; willingness to adhere to a specific training programme for 8 weeks; consent to undergo anthropometric, compositional and strength testing. Exclusion criteria were: the presence of acute or chronic diseases in the acute stage; injuries to muscles, ligaments, or joints that limited the performance of strength exercises; a break in training for more than 2 weeks during the last 3 months; irregular attendance at classes during the experiment; independent change of the training program; abrupt change in diet; use of pharmacological agents that could affect muscle mass, water balance or recovery; refusal to participate at any stage of the study.

Participants were divided into three experimental groups of 22 participants. The distribution was carried out taking into account age, training experience, body weight, percentage of adipose tissue and the initial level of strength training, so that the groups were comparable in terms of basic morphological and functional characteristics and to minimise the impact of initial differences on the interpretation of the results. The first group included athletes who trained using the traditional hypertrophic method; the second – athletes who performed training using drop sets; the third – athletes who trained using the periodised strength-hypertrophic method. Initially, 72 bodybuilder athletes were included in the experiment, who were divided into three groups of 24 people. During the study, 4 participants dropped out: in the first group – 2 participants due to irregular attendance at classes, in the second group – 1 participant due to a change in diet, in the third group – 1 participant due to a domestic injury not related to the implementation of the training programme. To maintain the same number of groups and the correctness of the statistical comparison, before the final analysis, data from 2 more participants were randomly removed from the groups in which more athletes remained after the end of the experiment. The final analysis included the results of 66 bodybuilders.

Organisation and methods of training of the experimental groups. After the initial testing, the participants performed training programmes for 8 weeks according to the group distribution. In all groups, classes were held 4 times a week (Monday, Wednesday, Friday, Saturday) according to the same split microcycle structure. The first class was aimed at working out the pectoral muscles and triceps, the second – the back and biceps muscles, the third – the lower limb muscles, the fourth – the deltoid muscles, core muscles and additional work on muscle groups that needed correction. This structure made it possible to ensure recovery between repeated loads on the same muscle groups and to standardise the frequency of training exposure in all experimental groups. The duration of one session was 70-90 minutes. Each training session had the same structure: the preparatory part lasted 10-12 minutes, the main part – 50-65 minutes, the final – 5-8 minutes. In the preparatory part, light cardio warm-up, joint mobilisation and 1-2 approaches to the first basic exercise were used. The main part contained strength exercises according to the methodology of a specific group. In the final part, respiratory recovery, relaxation exercises and short stretching of the muscle groups that received the main load were used.

To reduce the impact of differences in the total training volume, the number of training days, the structure of the microcycle, the duration of classes and the number of basic exercises were standardised for all groups. The total training volume was controlled by the number of working sets and repetitions within each training day; the differences between the groups were primarily in the way the intensity was organised, the use of drop sets or wave-like progression, and not in changing the frequency of training or the overall structure of the programme.

The working weight for each participant was determined individually based on the results of the initial testing of the one-repetition maximum (1RM, kg) in basic exercises; in these movements, the intensity was set as a percentage of the 1RM. In auxiliary and isolated exercises, the load was selected based on the target repetition range, technically correct amplitude of movement, and the absence of premature violation of technique. If the participant performed the upper limit of repetitions in all approaches without technical errors, the working weight in the next session was increased by 2.5-5.0%. The dynamics of strength training were analysed only by the results of basic exercises and the total strength index, while auxiliary exercises were used to standardise the training effect, maintain the overall hypertrophic volume and local work on muscle groups, and not as a separate performance criterion.

After determining individual workloads, participants performed programmes according to group distribution. The first group used a traditional hypertrophic technique, in which the main training stimulus was created through moderately high intensity, stable workload and a range of 8-12 repetitions. The load progression was carried out after the athlete technically correctly performed the upper limit of repetitions in all planned approaches. This mode was used as a basic model of strength training against which other techniques were compared (Table 2).

Table 2. Structure of the training programme of the first experimental group

Training day	Exercise	Sets × repetitions	Intensity	Rest
Day 1	Bench press	4 × 8-10	75-80% 1RM	90 s
	Incline dumbbell press	3 × 10-12	70-75% 1RM	75 s
	Lying dumbbell flyes	3 × 12	65-70% 1RM	60 s

Table 2, Continued

Training day	Exercise	Sets × repetitions	Intensity	Rest
Day 1	Push-ups on the parallel bars	3 × 8-12	body weight / additional weight	75 s
	Arm extension on the block	3 × 10-12	70% 1RM	60 s
Day 2	Incline barbell pull	4 × 8-10	75-80% 1RM	90 s
	Pull-ups / upper block pull	3 × 8-12	70-75% 1RM	75 s
	Horizontal cable row	3 × 10-12	70% 1RM	75 s
	One-arm dumbbell row	3 × 10	70-75% 1RM	75 s
	Arm curls with a barbell	3 × 10-12	70% 1RM	60 s
Day 3	Squats with a barbell	4 × 8-10	75-80% 1RM	90 s
	Leg press	3 × 10-12	70-75% 1RM	90 s
	Romanian deadlift	3 × 10	70-75% 1RM	90 s
	Leg curls in the simulator	3 × 12	65-70% 1RM	60 s
	Standing calf raises	4 × 12-15	65-70% 1RM	60 s
Day 4	Barbell/Dumbbell Overhead Press	4 × 8-10	75-80% 1RM	90 s
	Dumbbell side raises	3 × 12	65-70% 1RM	60 s
	Barbell upright row	3 × 10	70% 1RM	75 s
	Reverse dumbbell raises	3 × 12	65-70% 1RM	60 s
	Plank/Hanging Leg Raises	3 × 10-15	own body weight	60 s

Source: developed by the authors

In the second group, the main difference was the use of drop sets in the last working approach. After performing the main part of the approach, the working weight was reduced by 20-30% without a long pause, after which the athlete continued the exercise until pronounced local fatigue. In large muscle groups, one drop set was used per exercise, and in small muscle groups, no more than one drop set per training block (Table 3). This method of organising the load was aimed at increasing the time the muscles were under load, increasing metabolic stress and enhancing the local hypertrophic stimulus. The third group used a periodised strength-hypertrophic technique that combined higher-intensity work in basic exercises and a hypertrophic regime in auxiliary exercises. Basic exercises were performed at the beginning of the session, when the level of fatigue was lower and athletes could work with a higher relative weight. Auxiliary exercises were used after the strength block to increase the training volume and local work of muscle groups. The load progression was carried out in a wave-like manner: during the first three weeks, the volume and working weight gradually increased, in the fourth week the load was reduced by 15-20% for partial recovery, after which the cycle was repeated with updated working weights (Table 4).

Table 3. Structure of the training programme of the second experimental group

Training day	Exercise	Basic approaches	Drop set	Rest
Day 1	Bench press	3 × 8-10 at 75-80% 1RM	last set: -25% weight, 6-8 repetions	90 s
	Incline dumbbell press	3 × 10	last set: -20% weight, 6-8 repetions	75 s
	Lying dumbbell flyes	2 × 12	last set: -20% weight to local fatigue	60 s
	Arm extension on the block	3 × 10-12	last set: -25% weight, 6-10 repetions	60 s
Day 2	Incline barbell pull	3 × 8-10 at 75-80% 1RM	last set: -20% weight, 6-8 repetions	90 s
	Upper-block pulldown	3 × 10-12	last set: -25% weight, 6-10 repetions	75 s
	Horizontal cable row	3 × 10	last set: -20% weight, 6-8 repetions	75 s
	Arm curls with a barbell	3 × 10-12	last set: -20% weight, 6-10 repetions	60 s
Day 3	Squats with a barbell	3 × 8-10 at 75-80% 1RM	last set: -20% weight, 6-8 repetions	90 s
	Leg press	3 × 10-12	last set: -25% weight, 8-10 repetions	90 s
	Romanian deadlift	3 × 10	last set: -20% weight, 6-8 repetions	90 s
	Leg curls in the simulator	3 × 12	last set: -25% weight to local fatigue	60 s
	Standing calf raises	3 × 12-15	last set: -25% weight, 8-12 repetions	60 s
Day 4	Dumbbell Overhead Press	3 × 8-10	last set: -20% weight, 6-8 repetions	90 s
	Dumbbell side raises	3 × 12	last set: -25% weight to local fatigue	60 s
	Barbell upright row	3 × 10	last set: -20% weight, 6-8 repetions	75 s
	Reverse dumbbell raises	3 × 12	last set: -20% weight to local fatigue	60 s
	Hanging leg raises/twists	3 × 12-20	without drop set	60 s

Source: developed by the authors

Table 4. Structure of the training programme of the third experimental group

Training day	Exercise	Strength block	Hypertrophic block	Rest
Day 1	Bench press	4 × 4-6 at 80-88% 1RM	-	120 s
	Incline dumbbell press	-	3 × 8-12 at 70-75% 1RM	75-90 s
	Lying dumbbell flyes	-	3 × 10-12 at 65-70% 1RM	60 s
	Push-ups on the parallel bars	-	3 × 8-10	75 s
	Arm extension on the block	-	3 × 10-12	60 s
Day 2	Incline barbell pull	4 × 4-6 at 80-88% 1RM	-	120 s
	Pull-ups / upper block pull	-	3 × 8-12 at 70-75% 1RM	75-90 s
	Horizontal cable row	-	3 × 10-12 at 70% 1RM	75 s
	One-arm dumbbell row	-	3 × 10	75 s
	Arm curls with a barbell	-	3 × 10-12	60 s
Day 3	Squats with a barbell	4 × 4-6 at 80-88% 1RM	-	120 s
	Leg press	-	3 × 8-12 at 70-75% 1RM	90 s
	Romanian deadlift	-	3 × 8-10 at 70-75% 1RM	90 s
	Leg curls in the simulator	-	3 × 10-12	60 s
	Standing calf raises	-	4 × 12-15	60 s
Day 4	Barbell/Dumbbell Overhead Press	4 × 4-6 at 80-85% 1RM	-	120 s
	Dumbbell side raises	-	3 × 10-12	60 s
	Barbell upright row	-	3 × 8-10	75 s
	Reverse dumbbell raises	-	3 × 10-12	60 s
	Plank/Hanging Leg Raises	-	3 sets	60 s

Source: developed by the authors

Individual correction of the programmes concerned only the working weight, the rate of progression and the technical safety of the exercises; the list of basic exercises remained the same within each group. If discomfort appeared, the amplitude or variant of the exercise was adjusted without changing its muscular focus. Individual dietary programmes were not prescribed: participants were recommended to maintain the usual diet and drinking regimen, not to drastically change calorie content, protein intake and fluid volume, especially 24 hours before measuring body composition.

Methods of evaluating research indicators. The assessment was carried out twice: 2-3 days before the start of the experiment and 48-72 hours after the last training session. This interval was used to reduce the influence of acute post-training fatigue, local muscle swelling and short-term fluctuations in body weight on the measurement results. All measurements were performed in the morning, before training, in approximately the same hydration conditions and after refraining from intensive loads the day before. Body composition was assessed by body weight, percentage of adipose tissue, lean mass and skeletal muscle mass. For this purpose, the method of bioelectrical impedance analysis was used on the Tanita MC-780MAP body composition analyser (Japan). Measurements were performed in a standing position, barefoot, with contact of the feet and hands with the electrodes of the device; before the procedure, the participant's age, gender, and height (cm) were entered into the system, after which the device automatically calculated body composition indicators based on the electrical resistance of the tissues. Body weight (kg) was determined by the analyser's built-in scales, and the percentage of adipose tissue (%), lean mass (kg) and skeletal muscle mass (kg) were recorded according to the device's protocol without additional manual formulae. Before the measurement, the participants did not perform intensive physical activity for 24 h, did not drink a large amount of fluid immediately before the procedure, did not eat for at least 3 h before testing, and were measured at the same time of day, which reduced the error associated with fluctuations in water balance.

Anthropometric measurements included shoulder, chest, waist, and hip circumferences, which were recorded in centimetres using a flexible inelastic anthropometric tape with an accuracy of 0.5 cm. Upper arm circumference was measured in the middle third of the shoulder with the biceps tense; chest circumference – at the level of the nipple line after a calm exhalation; waist circumference – at the level of the smallest torso circumference; hip circumference – in the upper third of the thigh. During the measurement, the tape was placed horizontally, without excessive compression of soft tissues. Each measurement was performed three times, after which the average value was used for analysis.

Strength training was assessed based on the results of 1RM in three basic exercises: bench press, barbell squat, and deadlift. Testing was performed after a 10-minute general warm-up and a special warm-up in the corresponding exercise, which included 2-3 sets of approaches with a gradual increase in load. After each attempt, the participant rested for 3-5 minutes, which allowed reducing the impact of acute fatigue on the result of the next attempt. The maximum result was recorded as the largest weight that the athlete performed technically correctly in one repetition with a full range of motion. In the bench press, an attempt was counted if the barbell was lowered to the chest in a controlled manner and the arms were fully extended; in the squat, if the required squat depth was reached and the body was returned to the starting position independently; in the deadlift, if the body was fully straightened and the barbell was fixed without losing technique. If the athlete violated the technique, performed the movement with incomplete amplitude or needed outside assistance, the attempt was not counted. For a generalised assessment of strength training, the total strength index (SSI, kg) was calculated as the sum of the maximum results in three basic exercises:

$$TSI = 1RM \text{ bench press} + 1RM \text{ squat} + 1RM \text{ deadlift}, \quad (1)$$

where TSI – total strength index (kg); 1RM – the largest weight (kg) lifted by an athlete in one technically correct repetition. TSI was previously defined as an integral criterion of general strength fitness, since it summarised the results of three basic multijoint exercises and reflected functional changes in the main muscle groups after training intervention. This indicator was used to compare the general dynamics of strength fitness and functional efficiency of the studied training methods.

Methods of statistical analysis of results. Statistical analysis was performed in the Statistica 10.0 programme (USA). For each indicator, the arithmetic mean (M), standard deviation (SD), absolute (Δ) and relative (Δ%) change were determined; the results were presented in the format M ± SD. Normality of distribution was checked using the Shapiro-Wilk test. Intragroup dynamics of indicators were assessed using paired Student's t-test, intergroup differences were assessed using one-way ANOVA with a posteriori comparison using Tukey HSD. Pearson correlation analysis was used to establish relationships between changes in skeletal muscle mass, adipose tissue, girth parameters, and TSI. Pairs of indicators for correlation analysis were formed according to the principle of functional-morphological interdependence: the increase in skeletal muscle mass was compared with the change in TSI to assess the relationship between hypertrophic and strength adaptation; the decrease in the proportion of adipose tissue and waist circumference were analysed as interrelated markers of improved body composition and muscle relief; changes in shoulder, chest, and hip girths were considered in connection with the increase in lean and skeletal muscle mass as an anthropometric reflection of local muscle hypertrophy. The strength of the relationship was interpreted by the absolute value of r: up to 0.30 – low, 0.30-0.69 – medium, 0.70 and above – high. The level of statistical significance was set at $p < 0.05$.

Results

Dynamics of body composition indicators of bodybuilders. Before the start of the experiment, no statistically significant differences were found between the groups in terms of body composition indicators ($p > 0.05$), which confirmed the comparability of the initial data. After an 8-week training cycle, an increase in lean and skeletal muscle mass was recorded in all groups against the background of a decrease in the proportion of adipose tissue, however, the magnitude of these changes differed depending on the method used. The quantitative dynamics of body composition indicators in each experimental group are presented in Tables 5-7.

Table 5. Dynamics of body composition of the first experimental group

Indicator	Before the experiment	After the experiment	Δ	Δ%
Body weight, kg	82.3 ± 5.7	83.0 ± 5.6	+0.7	+0.9
Adipose tissue, %	14.9 ± 2.0	13.8 ± 1.8	-1.1	-7.4
Fat-free mass, kg	70.0 ± 4.8	71.3 ± 4.7	+1.3	+1.9
Skeletal muscle mass, kg	39.0 ± 3.1	40.1 ± 3.0	+1.1	+2.8

Note: Δ – absolute change in the indicator; Δ% – relative change from baseline; data are presented as M ± SD
Source: data obtained during the research

In the first group, after the application of the traditional hypertrophic method, a moderate improvement in body composition was established. Body weight increased by 0.7 kg, but this increase was not accompanied by an increase in the fat component, since the proportion of adipose tissue decreased from 14.9 ± 2.0% to 13.8 ± 1.8%. This indicates that the increase in body weight in athletes of this group was associated mainly with an increase in active tissue mass, and not with the accumulation of adipose tissue. Fat-free mass increased by 1.3 kg, and skeletal muscle mass by 1.1 kg. Such dynamics indicate the presence of a hypertrophic response to the traditional strength training regimen, built on the performance of 8-12 repetitions with moderately high intensity. At the same time, the relative increase in skeletal muscle mass was 2.8%, which characterises the method as stable, but gradual in terms of the pace of morphological adaptation. A 1.1 percentage point reduction in adipose tissue further indicates an improvement in the ratio between muscle and fat components, which is a necessary condition for the formation of muscle relief.

Table 6. Dynamics of body composition in the second experimental group

Indicator	Before the experiment	After the experiment	Δ	Δ%
Body weight, kg	82.0 ± 5.9	82.9 ± 5.7	+0.9	+1.1
Adipose tissue, %	14.8 ± 2.1	13.1 ± 1.9	-1.7	-11.5
Fat-free mass, kg	69.9 ± 4.9	71.6 ± 4.8	+1.7	+2.4
Skeletal muscle mass, kg	38.9 ± 3.2	40.4 ± 3.1	+1.5	+3.9

Note: Δ – absolute change in the indicator; Δ% – relative change from baseline; data are presented as M ± SD
Source: data obtained during the research

The data in Table 6 demonstrated that in the second group, after 8 weeks of using the drop-set technique, positive dynamics of body composition were also recorded. Body weight increased by 0.9 kg, while the proportion of adipose tissue decreased by 1.7 percentage points. This result indicates a simultaneous improvement in two components of physique: an increase in the mass of tissues associated with training adaptation and a decrease in relative fat content. Fat-free mass in this group increased by 1.7 kg, and skeletal muscle mass by 1.5 kg. This can be explained by the specificity of drop-sets, which increase the duration of muscle work within one approach, increase local fatigue and create higher metabolic stress. Under these conditions, muscle groups receive an additional stimulus to adapt not only through mechanical stress, but also through the accumulation of metabolites at the end of the work set. The 11.5% reduction in adipose tissue from baseline may be associated with a higher training load density and higher energy expenditure during training.

Table 7. Dynamics of body composition of the third experimental group

Indicator	Before the experiment	After the experiment	Δ	Δ%
Body weight, kg	82.5 ± 5.6	84.1 ± 5.4	+1.6	+1.9
Adipose tissue, %	15.0 ± 2.0	12.7 ± 1.7	-2.3	-15.3
Fat-free mass, kg	70.1 ± 4.7	72.7 ± 4.6	+2.6	+3.7
Skeletal muscle mass, kg	39.1 ± 3.0	41.5 ± 2.9	+2.4	+6.1

Note: Δ – absolute change in the indicator; Δ% – relative change from baseline; data are presented as M ± SD
Source: data obtained during the research

In the third group, where the periodised strength-hypertrophic technique was used, the most pronounced intragroup dynamics of body composition indicators were established. Body weight increased by 1.6 kg, but at the same time the proportion of adipose tissue decreased from 15.0 ± 2.0% to 12.7 ± 1.7%. This means that the increase in total body weight occurred against the background of a decrease in the fat component, i.e. morphological changes had a favourable direction for the formation of muscle relief. Fat-free mass increased by 2.6 kg, and skeletal muscle mass by 2.4 kg, which indicates a pronounced hypertrophic response. This nature of the changes may be associated with the combination of two training stimuli: strength approaches with higher intensity, which increased mechanical stress, and hypertrophic approaches in auxiliary exercises, which provided a sufficient amount of local muscle work. The 2.3 percentage point decrease in adipose tissue further indicates an improvement in the ratio between active and fat body mass. Thus, within this group, the periodised load structure provided a combination of muscle gains with a decrease in the relative fat content.

The intergroup comparison showed that all three methods contributed to the improvement of body composition, but the severity of the changes was different. In the first group, the traditional hypertrophic method provided an increase in skeletal muscle mass by 1.1 kg and fat-free mass by 1.3 kg, reflecting a gradual morphological adaptation. In the second group, drop sets provided a greater increase in skeletal muscle mass – 1.5 kg – and a more noticeable decrease in adipose tissue by 1.7 percentage points, which may be associated with a higher load density and more pronounced local fatigue. The largest changes were recorded in the third group: skeletal muscle mass increased by 2.4 kg, fat-free mass – by 2.6 kg, the proportion of adipose tissue decreased by 2.3 percentage points. The obtained dynamics indicate that for the formation of muscle relief, not only an increase in the volume of work performed was decisive, but also the method of its organisation. The most favourable result was provided by the programme in which strength approaches with greater intensity were combined with a hypertrophic mode of auxiliary exercises, since such a structure simultaneously maintained mechanical tension, sufficient local volume of load and fatigue control.

Changes in anthropometric parameters of the formation of muscle relief. After an 8-week experiment, changes in anthropometric parameters confirmed the different orientation of the athletes' adaptation to the three methods of strength training. In all groups, an increase in shoulder, chest and hip girths was observed, however, the rate of growth of muscle segments was not the same. Simultaneous reduction of waist circumference showed improvement of body proportions, and the most pronounced combination of increase of peripheral circumferences and decrease of central circumference was characteristic of periodised power-hypertrophic technique. Quantitative dynamics of anthropometric parameters of bodybuilders is given in Table 8.

Table 8. Dynamics of anthropometric parameters of bodybuilder athletes

Indicator	Group	Before the experiment	After the experiment	Δ	Δ%
Upper arm circumference, cm	Group 1	39.3 ± 1.9	40.2 ± 1.8	+0.9	+2.3
	Group 2	39.1 ± 2.0	40.4 ± 1.9	+1.3	+3.3
	Group 3	39.4 ± 1.8	41.0 ± 1.7	+1.6	+4.1
Chest circumference, cm	Group 1	105.2 ± 4.7	106.6 ± 4.6	+1.4	+1.3
	Group 2	105.0 ± 4.9	106.8 ± 4.7	+1.8	+1.7
	Group 3	105.5 ± 4.6	108.0 ± 4.4	+2.5	+2.4
Waist circumference, cm	Group 1	82.4 ± 4.1	81.0 ± 3.9	-1.4	-1.7
	Group 2	82.1 ± 4.3	80.2 ± 4.0	-1.9	-2.3
	Group 3	82.6 ± 4.0	79.7 ± 3.8	-2.9	-3.5

Table 8, Continued

Indicator	Group	Before the experiment	After the experiment	Δ	Δ%
Hip girth, cm	Group 1	61.7 ± 3.0	62.8 ± 2.9	+1.1	+1.8
	Group 2	61.6 ± 3.2	63.2 ± 3.0	+1.6	+2.6
	Group 3	61.8 ± 3.1	64.1 ± 3.0	+2.3	+3.7

Note: Δ – absolute change in the indicator; Δ% – relative change from baseline; data are presented as M ± SD
Source: data obtained during the research

The results presented in Table 8 showed that anthropometric dynamics had not only quantitative but also structural differences between the groups. In the first group, the increase in girths was uniform but moderate: the shoulder increased by 0.9 cm, the chest – by 1.4 cm, the thigh – by 1.1 cm. This pattern of changes corresponded to the traditional hypertrophic method, in which muscle groups received a stable training stimulus without a sharp increase in work density or change in intensity within the microcycle. The 1.4 cm waist reduction complemented the increase in peripheral girths, but the overall morphological effect in this group was mostly gradual.

In the second group, anthropometric changes were more pronounced, especially in shoulder and thigh girths. Compared to the first group, the increase in the shoulder was 0.4 cm greater, the hip – 0.5 cm, the chest – 0.4 cm, and the waist – 0.5 cm. This indicated that drop sets create a more intense local stimulus for muscle segments that perform work to pronounced fatigue after weight loss. This mode increases metabolic stress and the duration of muscle tension, so the increase in girth was greater than with the traditional method. At the same time, the advantage of drop sets remained moderate, since this method had a greater effect on local load density than on the systemic combination of strength, volume, and recovery.

The third group recorded the most pronounced change in the anthropometric profile. Compared to the first group, the increase in the shoulder was 0.7 cm greater, the chest – 1.1 cm, the hips – 1.2 cm, and the waist – 1.5 cm smaller; compared to the second group, the advantage was 0.3 cm, 0.7 cm, 0.7 cm, and 1.0 cm, respectively. This indicated that under the conditions of standardised training frequency, split microcycle structure, training duration, and number of basic exercises, the periodised strength-hypertrophic technique was associated with a greater increase in individual girths and a more pronounced improvement in body proportions. At the same time, since the detailed calculation of the total load volume according to the formula "weight × repetition × sets" was not a separate outcome indicator of this study, the advantage of the third group should be interpreted as the result of a comprehensive organisation of the training effect, and not in isolation as an effect of periodisation. This result can be explained by the fact that power approaches with higher intensity created sufficient mechanical stress for large muscle groups, and hypertrophic approaches in auxiliary exercises supported the local volume of work. Due to this, the increase in the shoulder, chest, and thigh was combined with the greatest decrease in the waist.

The most indicative for assessing muscle relief was not an isolated increase in individual girth, but the ratio between the increase in muscle segments and the decrease in the central girth of the trunk. In the first group, this ratio changed moderately, which corresponded to the gradual adaptation to the standard hypertrophic load. In the second group, the relief increased mainly due to greater local fatigue and work density, which contributed to better dynamics of the shoulder, hip, and waist. In the third group, the changes were the most balanced, since the development of the upper and lower muscle segments was accompanied by the most noticeable reduction in the waist. Therefore, within the framework of the applied programme, the periodised approach was associated with the most favourable combination of muscle girth growth and improvement of body proportions, however, the interpretation of this advantage should take into account the lack of a separate quantitative comparison of the total training volume between the groups.

Dynamics of strength training of athletes of the experimental groups. Strength indicators after an 8-week training cycle increased in all experimental groups, however, the greatest differences between the methods were manifested not in the fact of the increase itself, but in its scale and distribution between basic exercises. The traditional hypertrophic programme provided a gradual increase in results, drop sets gave similar but slightly higher dynamics, while the periodised power-hypertrophic technique provided the greatest increase in bench press, squat, deadlift and TSI. Throughout the experiment, the technical stability of the basic exercises was monitored during training sessions and repeated strength testing. No systematic technical violations were recorded in any of the groups that would require the removal of test results or changes in the load programme. In the drop sets group, local fatigue at the end of the working approaches required more frequent coaching control of the amplitude and pace of movement, but did not lead to a loss of technical suitability for performing the basic exercises. To summarise these changes, TSI was calculated using formula (1). The obtained TSI values were used to compare the integral strength dynamics between the experimental groups. Quantitative changes in the strength training of athletes are given in Table 9.

Table 9. Dynamics of strength training of athletes of experimental groups

Indicator	Group	Before the experiment	After the experiment	Δ	Δ%
Bench press, kg	Group 1	108.4 ± 11.8	116.1 ± 11.5	+7.7	+7.1
	Group 2	108.0 ± 12.0	116.4 ± 11.6	+8.4	+7.8
	Group 3	108.7 ± 11.7	123.5 ± 11.2	+14.8	+13.6

Table 9, Continued

Indicator	Group	Before the experiment	After the experiment	Δ	Δ%
Squats with a barbell, kg	Group 1	142.1 ± 15.9	152.8 ± 15.4	+10.7	+7.5
	Group 2	141.9 ± 16.1	153.0 ± 15.6	+11.1	+7.8
	Group 3	142.6 ± 15.7	162.9 ± 15.1	+20.3	+14.2
Deadlift, kg	Group 1	166.2 ± 17.6	177.7 ± 17.1	+11.5	+6.9
	Group 2	165.8 ± 17.9	178.0 ± 17.2	+12.2	+7.4
	Group 3	166.7 ± 17.4	188.8 ± 16.8	+22.1	+13.3
Total power index, kg	Group 1	416.7 ± 41.8	446.6 ± 40.7	+29.9	+7.2
	Group 2	415.7 ± 42.4	447.4 ± 40.9	+31.7	+7.6
	Group 3	418.0 ± 41.2	475.2 ± 39.8	+57.2	+13.7

Note: Δ – absolute change in the indicator; Δ% – relative change from baseline; data are presented as M ± SD
Source: data obtained during the research

In the bench press, the gains in the first and second groups were similar: 7.7 kg and 8.4 kg, respectively. This indicates that the traditional hypertrophic regimen and drop sets provided a similar level of adaptation in the bench press movement, although the gains were slightly higher in the drop sets group. The additional weight reduction in the last approach increased the local load on the pectoral muscles, triceps and anterior deltoids, but did not create the neuromuscular stimulus that is characteristic of regular work with higher percentages of the one-repetition maximum. That is why the third group demonstrated a significantly greater gain in the bench press – 14.8 kg, which was almost twice the result of the first group.

In the barbell squat, the difference between the methods was even more pronounced. In the first group, the result increased by 10.7 kg, in the second – by 11.1 kg, while in the third – by 20.3 kg. Such dynamics show that the lower limbs responded better to the programme, where the basic exercise was performed in the power block with greater intensity. For the squat, this is explained by the fact that the exercise requires not only muscle hypertrophy, but also effective intermuscular coordination, stabilisation of the trunk and the ability to maintain technique under high load. The periodised technique, unlike the other two, combined a strength stimulus with a subsequent hypertrophic load on the muscles of the lower limbs, which explains the greater increase in the result.

A similar pattern was observed in the deadlift. The increase in the first group was 11.5 kg, in the second – 12.2 kg, and in the third – 22.1 kg. The difference between the traditional method and drop sets was small, indicating a limited effect of additional local fatigue on the development of maximum strength in a complex pulling movement. Deadlift depends on the ability to mobilise large muscle masses, maintain tension in the back and lower limbs, and effectively coordinate movement throughout the kinematic link. Therefore, the greatest increase in the third group can be explained by the regular performance of basic exercises in a higher intensity mode and controlled load progression.

The TSI showed an integral advantage of the periodised approach. In the first group, it increased by 29.9 kg, in the second – by 31.7 kg, and in the third – by 57.2 kg. Thus, drop sets only slightly exceeded the traditional method in terms of overall strength gain, while the periodised programme provided almost double the increase compared to the first group. This indicates that for the development of strength training in bodybuilders, it is not enough to simply increase the volume or density of the load; it is necessary to systematically include strength approaches with a higher relative weight that stimulate neuromuscular adaptation.

The generalisation of the strength results showed that all methods provided positive dynamics, but the training effect had a different direction. The traditional hypertrophic programme formed a stable increase in strength due to an increase in muscle volume and repetition of the load. Drop sets increased local muscle fatigue and could maintain strength gains due to greater training stress at the end of the approach, but the impact on maximum results was limited. The periodised strength-hypertrophic technique provided the best strength dynamics, as it combined mechanical stress, work with higher intensity, sufficient hypertrophic volume and recovery control during the microcycle.

Correlations of morphological and strength changes in athletes. Correlation analysis made it possible to clarify which morphological changes were most closely associated with the increase in strength training after an 8-week training cycle. The closest relationships were established between the increase in skeletal muscle mass and the increase in TSI, as well as between the increase in hip circumference and the results in squat and deadlift. In contrast, the decrease in adipose tissue had a weaker, but statistically significant relationship with strength indicators, which indicated its greater role in the formation of relief than in the direct increase in maximum strength (Table 10).

Table 10. Correlations of compositional, anthropometric and strength indicators

A pair of indicators	r	p	Interpretation
Skeletal muscle mass gain – total strength index gain	0.74	<0.001	high direct connection
Gain in lean mass – gain in total strength index	0.69	<0.001	medium direct connection
Reduction of adipose tissue – increase in total strength index	0.38	0.002	medium direct connection
Shoulder girth gain – bench press gain	0.58	<0.001	medium direct connection
Chest girth gain – bench press gain	0.61	<0.001	medium direct connection
Hip circumference gain – squat gain	0.67	<0.001	medium direct connection

Table 10, Continued

A pair of indicators	r	p	Interpretation
Hip circumference increase – deadlift increase	0.63	<0.001	medium direct connection
Waist reduction – reduction of adipose tissue	0.72	<0.001	high direct connection
Decrease in waist circumference – increase in skeletal muscle mass	0.41	0.001	medium direct connection

Note: r – Pearson correlation coefficient; p – statistical significance level; analysis performed on 66 bodybuilders
Source: data obtained during the study

The closest correlation was established between the increase in skeletal muscle mass and the increase in TSI ($r = 0.74$; $p < 0.001$). This result showed a pronounced association between the growth of the muscle component and the improvement of results in basic strength exercises, but did not give grounds to interpret it as a direct cause-and-effect effect. The performance of bench press, squat and deadlift depends not only on the volume of active muscle tissue, but also on the movement technique, intermuscular coordination, the ability to stabilise the body under load and the efficiency of neuromuscular regulation. Thus, the increase in skeletal muscle mass created a morphological basis for strength progress, but the realisation of this potential was also determined by the quality of motor control.

The increase in lean mass also had a pronounced direct relationship with the increase in TSI ($r = 0.69$; $p < 0.001$). This indicator confirmed the general direction of adaptation to the training load, but was less specific compared to skeletal muscle mass, since fat-free mass includes not only muscle tissue, but also other components of the body. Therefore, its connection with force dynamics reflected a broader morphofunctional effect of training, but less accurately characterised the hypertrophic response. A decrease in the proportion of adipose tissue correlated with an increase in TSI weaker ($r = 0.38$; $p = 0.002$), which indicated a different functional content of this indicator. A decrease in the fat component primarily reflected an improvement in body composition and conditions for visualisation of the relief, while its contribution to an increase in maximum strength was indirect.

The correlations between girth parameters and the results of individual strength exercises had an anatomically justified direction. Increases in shoulder and chest girth were associated with improved bench press performance ($r = 0.58$ and $r = 0.61$; $p < 0.001$), indicating a relationship between upper body muscle segment development and bench press strength. Changes in hip girth were correlated with increases in squat ($r = 0.67$; $p < 0.001$) and deadlift ($r = 0.63$; $p < 0.001$), as these exercises involve the lower limb muscles, gluteal region, and posterior chain. This confirmed that local anthropometric changes were not isolated morphological manifestations, but reflected functional strengthening of those muscle groups involved in the execution of basic movements.

The relationship between the decrease in waist circumference and the decrease in the percentage of adipose tissue ($r = 0.72$; $p < 0.001$) had a separate interpretative value. The high value of the correlation coefficient showed that the decrease in waist circumference did not reflect random fluctuations in measurement, but a real improvement in body composition associated with a decrease in the fat component. The moderate correlation between the decrease in waist circumference and the increase in skeletal muscle mass ($r = 0.41$; $p = 0.001$) additionally demonstrated the complex nature of the formation of the relief: the visual result was determined not only by muscle hypertrophy, but also by a decrease in the central girth of the trunk. Thus, the correlation analysis showed that the effectiveness of training methods should be assessed by a combination of three blocks of indicators: the increase in skeletal muscle mass, changes in local girths and a decrease in the fat component. It is this set of parameters that most fully reflects both the strength and visual-morphological results of bodybuilders' training.

Discussion

The results obtained showed that all the studied strength training methods contributed to positive changes in body composition, anthropometric parameters and strength training of bodybuilders, but the effectiveness was not the same. The traditional hypertrophic method provided a moderate but stable adaptation. Drop sets enhanced the growth of individual muscle girths and the reduction of the fat component due to a higher work density. The most pronounced changes were observed after periodised strength-hypertrophic training, which combined the growth of skeletal muscle mass, a decrease in the proportion of adipose tissue, an improvement in body proportions and the greatest increase in strength indicators.

The most pronounced positive dynamics of body composition were recorded after the use of the periodised strength-hypertrophic technique: skeletal muscle mass increased by 2.4 kg, lean mass by 2.6 kg, and the fat component decreased by 2.3%. In the drop-set group, the increase in skeletal muscle mass was 1.5 kg, lean mass by 1.7 kg, and the reduction in the fat component by 1.7%, while with the traditional hypertrophic technique, the corresponding changes were less pronounced – 1.1 kg, 1.3 kg, and 1.1%. The results obtained are consistent with the conclusions of A.J. Graybeal *et al.* (2020), who showed that the assessment of body composition in bodybuilders requires precise methodological control due to possible discrepancies between multicomponent models and impedance devices. This confirms the feasibility of interpreting changes in fat, lean and skeletal muscle mass together with anthropometric and strength indicators. Changes in body composition and strength abilities in fitness and bodybuilding athletes were analysed by J. Caha *et al.* (2021). The authors' results coincide with the identified trend, since the increase in the muscle component was accompanied by an improvement in strength indicators. In the work of B.J. Schoenfeld *et al.* (2020), changes in body composition, strength and metabolic characteristics during the training of a natural bodybuilder were described. The difference is that the mentioned study had a clinical case format and covered eating behaviour, while in this experiment, nutrition was only controlled as an external factor and had a recommendatory nature. The possibility of simultaneous increase in muscle mass and decrease in adipose tissue in trained individuals was substantiated by C. Barakat *et al.* (2020). This is consistent with the data, as body composition recomposition occurred in all groups, but the magnitude of this was greatest with the periodised method. Additional context is provided by N. Piakaew *et al.* (2025), who compared body composition, energy, and macronutrient intake of recreational bodybuilders and healthy adults. The findings are partially consistent with the results, but direct comparison is limited by the fact that nutrient intake was not a separate subject of analysis.

Anthropometric changes most clearly reflected the advantage of periodised strength-hypertrophic training: shoulder girth increased by 1.6 cm, chest girth by 2.5 cm, hip girth by 2.3 cm, while waist girth decreased by 2.9 cm. In the drop-set group, the corresponding changes were more moderate – 1.3 cm, 1.8 cm, 1.6 cm, and 1.9 cm, while with the traditional method the changes were 0.9 cm, 1.4 cm, 1.1 cm, and 1.4 cm, indicating a gradation of the effect depending on the load structure. The obtained dynamics are consistent with the conclusions of R.C. Alves *et al.* (2020), who noted that hypertrophic programmes in bodybuilding should provide not only an overall increase in muscle mass, but also a targeted load on individual muscle groups. In this context, the greater increase in the shoulder, chest, and thigh in the third group confirms the effectiveness of combining basic strength movements with auxiliary exercises aimed at local processing of body segments. The results also coincide with the positions of D. Souza *et al.* (2020), who linked the increase in muscle size and lean mass with training volume. At the same time, the obtained data clarify this position: the largest girth changes occurred not only due to volume, but when combined with higher intensity and wave-like progression. The interpretation of local changes also correlates with the approach of H. Lukaski & C. Raymond-Pope (2021), who substantiated the need for a comprehensive assessment of morphological indicators in sports. Comparison of girths with body composition data showed that the increase in peripheral parameters was not an isolated phenomenon, but was accompanied by a reduction in the central fat component. The position of A. Gonzalez *et al.* (2022) on the feasibility of using advanced strength training strategies in bodybuilding are consistent with the advantage of drop sets and periodised methods over the traditional programme. However, the best result was obtained precisely by periodisation, which indicates a greater effectiveness of the systematic alternation of strength and hypertrophic stimuli compared to an isolated increase in work density. The data of A. Falih (2025), obtained when using drop sets in young bodybuilders, confirmed the positive effect of this technique on bodybuilding indicators, but only partially coincide with the results presented. The discrepancy is that in adult trained athletes, drop sets improved girth parameters, but did not exceed periodised strength-hypertrophic training in terms of the effect on proportionality and expressiveness of the relief.

Power dynamics showed the advantage of periodised strength-hypertrophic training: the TSI increased by 57.2 kg, while the drop-set increase was 31.7 kg, and the traditional method – 29.9 kg. The most noticeable difference concerned the squat and deadlift, since these exercises depend not only on muscle volume, but also on the ability to coordinate the work of large muscle groups under high load. In the work of C.G. Vann *et al.* (2022), it was shown that high-volume and high-intensity training form different mechanisms of muscle adaptation. This explains the greater increase in strength in the third group, which regularly used a higher relative weight in basic exercises, which increased mechanical stress and neuromuscular mobilisation. In a systematic review, M. Lacio *et al.* (2021) found that different load ranges can stimulate both hypertrophy and maximum strength gains. The results presented concretise this position: the best strength effect was provided not by the isolated use of a certain repetition range, but by the combination of a strength block with a hypertrophic volume. Variable strength training, according to the conclusions of V. Andersen *et al.* (2022), contributes to the development of maximum strength and muscle power. The advantage of the third group confirms the importance of a wave-like change in intensity, which created conditions for load progression without excessive accumulation of fatigue. Data from the work by K. Keskin *et al.* (2025) on similar improvements in strength, endurance, and hypertrophy after traditional training, pre-exhaustion and drop sets with the same load volume help explain the moderate advantage of drop sets over the traditional method. In this study, drop sets did indeed produce a greater increase in total strength index than the traditional programme, but the effect remained lower than that of the periodised approach due to a smaller proportion of work with high relative weight. Adaptations of lean mass and muscle cross-section under block periodisation conditions were described by P.A. Moquin *et al.* (2021). These results strengthen the interpretation of the advantage of the periodised programme, since the increase in strength indicators in the third group was combined with the greatest increase in lean and skeletal muscle mass.

Correlation analysis showed a direct relationship between the increase in skeletal muscle mass and an increase in total strength index ($r = 0.74$; $p < 0.001$), as well as between a decrease in waist circumference and a reduction in the fat component ($r = 0.72$; $p < 0.001$). This confirmed that the formation of muscle relief was determined not by a single indicator, but by a combination of hypertrophy, improved body composition and increased strength. The relationship between body composition and strength and power was revealed in the study by G. Ben Mansour *et al.* (2021). The data obtained by the authors help to explain the identified correlations, however, the sample of students limits the direct transfer of these conclusions to bodybuilders with systematic strength training experience. Single and multi-stage drop sets were compared with traditional strength training by M. Fasihiyan *et al.* (2023), assessing muscle performance and body composition. This gives grounds to interpret drop sets as a technique capable of simultaneously influencing morphological and functional indicators, although in the results obtained the effect was inferior to the periodised approach. In a systematic review by E. Baz-Valle *et al.* (2022), the authors found that the effect of training volume on hypertrophy depends on the structure of the programme and the level of fitness. This approach explains why muscle mass gains were associated with strength progress, but could not be fully determined by the amount of work performed alone. The acute and chronic effects of drop sets, according to the conclusions of T. Havers *et al.* (2026), depend on the protocol, training volume and comparison regime. This makes it possible to explain the positive dynamics in the drop sets group without exaggerating the effectiveness compared to the periodised programme. The findings of L. Moesgaard *et al.* (2022) are closest to the revealed pattern, which showed that periodisation can affect strength and hypertrophy even with comparable training volume. That is why the connection between the increase in skeletal muscle mass, the increase in the strength index and the better results of the periodised method can be explained not only by the volume of training, but also by the rational alternation of intensity, recovery and hypertrophic stimulus.

Comparison of the obtained data with scientific sources made it possible to clarify the place of periodised strength-hypertrophic training among the methods aimed at the formation of muscle relief. Changes in body composition, anthropometric parameters and strength training correspond to the conclusions of studies that proved the importance of intensity, volume, load variability and recovery control. The advantage of the periodised method was manifested simultaneously in the increase in the muscle component, the reduction of adipose tissue, the improvement of body proportions and the increase in strength.

Conclusions

Comparison of body composition indicators showed that all three strength training methods contributed to positive morphological dynamics, but the greatest changes were recorded after periodised strength-hypertrophic training. In this group, skeletal muscle mass increased by 2.4 kg, lean mass by 2.6 kg, and the fat component decreased by 2.3%. In the drop-set group, the corresponding changes were 1.5 kg, 1.7 kg, and 1.7%, and with the traditional hypertrophic method – 1.1 kg, 1.3 kg, and 1.1%. This indicates that the combination of strength and hypertrophic regimes provided a more pronounced body recomposition. Analysis of anthropometric parameters confirmed that the formation of muscle relief depended not only on the increase in muscle mass, but also on changes in body proportions. In the periodised training group, shoulder girth increased by 1.6 cm, chest girth by 2.5 cm, hip girth by 2.3 cm, while waist girth decreased by 2.9 cm. In the drop-set group, these changes were 1.3 cm, 1.8 cm, 1.6 cm, and 1.9 cm, respectively, and in the traditional method group, 0.9 cm, 1.4 cm, 1.1 cm, and 1.4 cm. Thus, the periodised programme provided a better combination of peripheral muscle segment development and central girth reduction. Strength training improved most significantly in the periodised strength-hypertrophic training group.

TSI increased by 57.2 kg, which exceeded the increase in the drop-set group by 25.5 kg and in the traditional method group by 27.3 kg. The greatest advantage of this technique was manifested in basic exercises that required high mechanical tension, stabilisation and coordinated work of large muscle groups. This confirmed that not only hypertrophic volume, but also the systematic inclusion of higher intensity approaches, is effective for strength gains in bodybuilders. Correlation analysis showed a relationship between morphological and strength changes. The increase in skeletal muscle mass was associated with an increase in TSI ($r = 0.74$; $p < 0.001$), and a decrease in waist circumference was associated with a decrease in the fat component ($r = 0.72$; $p < 0.001$). This proves that the formation of muscle relief was complex and was determined by a combination of hypertrophy, reduction of adipose tissue, improvement of anthropometric proportions and an increase in strength training. The limitation of the study is the formation of a sample of only men, which makes it impossible to assess the sexual characteristics of adaptation, as well as the 8-week duration of the experiment, which does not allow determining the long-term stability of morphological and strength changes. In future studies, it is advisable to involve bodybuilders of both sexes, and use a longer observation period to assess the preservation of muscle relief, compositional changes and strength indicators after several consecutive mesocycles of training.

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Порівняльний аналіз ефективності різних методик силового тренування для формування м'язового рельєфу у спортсменів-бодібілдерів

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Анотація. Метою дослідження було визначити, як різні варіанти організації силових навантажень впливають на розвиток м’язової маси, зміну композиції тіла та виразність рельєфу у спортсменів-бодібілдерів. Дослідження проведено на базі Уманського національного університету (Україна) з 20 жовтня до 12 грудня 2025 року за участю 66 спортсменів-бодібілдерів чоловічої статі, які виконували 8-тижневі програми традиційного гіпертрофічного тренування, дроп-сетів і періодизованого силово-гіпертрофічного тренування, а оцінювання їх ефективності здійснювали за допомогою педагогічного експерименту, біоімпедансного аналізу, антропометрії, тестування одноповторного максимуму, розрахунку сумарного силового індексу та статистичного аналізу. Найвиразніші зміни композиції тіла відбулися у групі періодизованого силово-гіпертрофічного тренування: скелетна м’язова маса зросла на 2,4 кг, безжирова маса – на 2,6 кг, а частка жирової тканини зменшилася на 2,3 %, що пояснюється поєднанням високого механічного напруження в базових вправах із достатнім гіпертрофічним обсягом у допоміжних рухах. Антропометричні показники підтвердили покращення рельєфу: обхват плеча збільшився на 1,6 см, грудної клітки – на 2,5 см, стегна – на 2,3 см, тоді як талія зменшилася на 2,9 см, що відображає покращення пропорцій тілобудови. Сумарний силовий індекс зріс на 57,2 кг проти 31,7 кг у групі дроп-сетів і 29,9 кг у групі традиційної методики, що підтверджує перевагу періодизації для розвитку максимальної сили. Кореляційний аналіз показав зв’язок приросту скелетної м’язової маси із силовим індексом ($r = 0{,}74$), а зменшення талії – зі зниженням жирової тканини ($r = 0{,}72$), що доводить взаємозалежність морфологічних і функціональних змін. Отже, періодизоване силово-гіпертрофічне тренування найефективніше поєднало приріст м’язової маси, зниження жирового компонента, покращення пропорцій і підвищення сили у бодібілдерів. Результати можуть бути використані тренерами з бодібілдингу, фахівцями з фізичної культури і спорту та спортсменами для планування тренувальних програм, спрямованих на формування м’язового рельєфу й контроль композиції тіла

Ключові слова: композиція тіла; безжирова маса; антропометричні параметри; адаптація; гіпертрофія; морфологічні зміни; дроп-сет