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Original Research Article

The impact of experimental strength training on selected morphological parameters and physical fitness in recreational bodybuilding practitioners

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Abstract

Background: Strength training plays a key role in improving morphological parameters and physical fitness; however, the optimal intensity and volume of training remain the subject of ongoing research. The aim of this study was to assess the impact of an experimental strength training program with varying intensity on selected morphological parameters and physical fitness in men who engage in recreational bodybuilding. **Material and Methods:** The study included 40 men (aged 20–30) who were randomly assigned to two groups. Group A performed training with a submaximal load (80% 1RM), while Group B trained with a moderate load (40–60% 1RM). After eight weeks, the groups switched training protocols. Somatic parameters (lean body mass, BMI) and physical fitness test results (strength, endurance, VO_2max) were assessed. **Results:** Both groups showed a significant increase in lean body mass ($p<0.05$) and improvements in strength and endurance test results. The greatest increase in muscle mass and strength was observed in the group that trained with higher loads. **Conclusions:** Both moderate and submaximal load training effectively improve morphological parameters and physical fitness. The increase in lean body mass is strongly correlated with improvements in aerobic capacity and muscle strength.

Keywords: general population, health, fitness, strength training

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Introduction

Recreational exercise and strength training are gaining significance in the modern world [1]. Participation in recreational activities has a positive impact on both mental and physical well-being. Regular physical activity during leisure time provides numerous health benefits. When performed methodically, it can prevent or treat various diseases or mitigate the effects of conditions such as heart disease, hypertension, diabetes, and osteoporosis [2].

Strength training has been recognized in preventive medicine and geriatrics. Research has shown that after 10 weeks of resistance training, lean body mass can increase by approximately 1.4 kg, resting metabolism can rise by 7%, and body mass can decrease by 1.8 kg [3]. Additionally, strength training reduces the risk of muscle strength loss, decreased mobility, and worsening symptoms of chronic diseases, while enhancing psychological well-being, quality of life, and life expectancy [4]. Geriatrics is not the only medical field that incorporates strength training [5]. According to the American College of Sports Medicine (ACSM), strength training should be performed at least twice a week with an intensity of 60–70% of 1RM.

In recreational bodybuilding, various strength training concepts allow individuals to achieve better physique, health, and well-being. One popular concept is interval training, which involves performing high-intensity exercises with short rest periods. Another approach is full range-of-motion training, which focuses on exercises that engage the entire range of motion in a given joint, helping to prevent injuries and overuse [6]. A complementary training concept also plays a crucial role, emphasizing the strengthening of weak body areas, improving muscular balance, and reducing pain and excessive muscle tension. Strength training concepts in recreational bodybuilding are diverse and tailored to different goals and skill levels, with their application depending on individual needs and preferences.

Classical strength training focuses on muscle mass development (hypertrophy). This goal can be achieved by performing exercises targeting specific muscle groups. The appropriate selection of weights, adjusted to the individual's strength, is crucial. Excessive or insufficient loads may lead to injury or fail to produce the desired results. Proper movement quality during exercises is essential, as correct technique prevents injuries and enhances training effectiveness. After training, muscle stretching is recommended to minimize soreness and stiffness. Additionally, protein-rich meals play a vital role in post-training recovery and muscle growth [7].

Different repetition ranges are recommended depending on the training objective and type of exercise. To increase muscle strength, 3–5 sets of exercises with loads at 85–100% 1RM, consisting of 1–5 repetitions per set, are suggested. For muscle hypertrophy, 3–5 sets with 65–85% 1RM, performing 6–12 repetitions per set, are recommended. To improve muscular endurance, 3–5 sets with 50–65% 1RM, performing 13–20 repetitions per set, are advised [7,8].

Strength training with lower external resistance is an integral part of modern recreational strength training. A review of the literature indicates that strength and muscle mass can be increased by performing exercises with lighter weights but a higher number of repetitions over an extended duration. The key element in training with lighter loads is executing exercises through a full range of motion and achieving complete muscle contraction. It is important to avoid excessive strain on the body and to start with lighter loads, gradually increasing them as training progresses [8,9].

Muscle hypertrophy, particularly in individuals engaging in recreational bodybuilding, has been a subject of research for 30 years. The impact of various strength training methods on body composition is especially intriguing in the context of overall health. Amateur bodybuilding is becoming increasingly popular. Training with lighter weights and higher repetitions can lead to muscle volume expansion while aligning with the concept of health-related fitness. Such an approach may also be safer due to the reduced load distributed over a longer period.

Recreational bodybuilding is not focused on competitive performance but rather on achieving an aesthetic physique and maintaining psychophysical well-being. Therefore, the rate of hypertrophy is not as crucial. Studies suggest that training with lighter loads (40–60% 1RM) compared to submaximal loads (80% 1RM) is more widely promoted by international expert groups in the field of strength training. Moreover, it is effective for muscle development and overall health improvement.

The cognitive objective of this study is to examine the impact of experimental strength training on selected morphological and functional parameters in individuals practicing recreational bodybuilding and to compare the effectiveness of strength training at different intensities in shaping morphological and functional parameters.

Material and Methods

Participants

The study was conducted on a group of 40 men aged between 20 and 30 years (X=26.1, SD ±2.1 years) who practiced recreational bodybuilding. Participants were selected for the experiment through random allocation using block randomization, dividing them into two separate groups. The inclusion criterion was the level of training experience:

- Training experience of two years or less.
- Previous training was conducted a maximum of three times per week.

Detailed data on the basic anthropometric statistics for participants in each group are presented below (Table 1).

Table 1. Characteristics of the Study Groups

	Group A N=20			Group B N=20			U	P
Variable	Min-Max	Mean	Standard Deviation	Min-Max	Mean	Standard Deviation		
Body Height (m)	1,77-1,91	1,83	0,06	1,73-1,96	1,82	7,66	6,11	0,686
Body Mass (kg)	71,6-92	80,5	7,69	71,6-92	80,4	8,74	8,13	0,94
BMI (kg/m^2)	23,4-24,94	23,99	0,68	23,3-25,5	24,2	0,91	7,618	0,88

U - Mann-Whitney Test, p - Significance Level

Research Program and Methodology

According to the assumptions of the pedagogical experiment protocol, the research intervention involved the introduction of two independent training programs that differed in their execution. This approach led to the division of the study group into two subgroups, each following a distinct training program. The participants were assigned using block randomization.

One group performed training with a low external resistance (40–60% 1RM) but with a relatively high number of repetitions. The second group trained with a submaximal load (80% 1RM) and a lower number of repetitions. The 1RM level was assessed in major compound exercises.

After a warm-up, participants selected a weight with which they could perform a maximum of five repetitions. This result, recorded in kilograms, was then used in Charles Poliquin's table (which illustrates the relationship between the maximum number of repetitions and maximal weight) to estimate the potential load for a one-repetition maximum using proportional calculations.

Next, participants were tested to determine whether they could successfully complete one repetition with the estimated weight. If the repetition was successfully performed, the result was recorded. If the attempt was unsuccessful, the load was reduced by 5%, and after a rest period, another attempt was made.

Once the individual 1RM values were established for each participant, 40%, 60%, and 80% 1RM were calculated. These values were then used for the experimental training sessions.

The study was conducted between March and May 2023. The experiment was carried out using a technique involving two equal-sized groups of participants qualified for the study (Figure 1). The training program lasted for 16 weeks. The first 8 weeks of training followed these guidelines:

- 4 weeks of full-body training, performed three times per week on alternating days,
- 4 weeks of split training (split system).

After the first 8 weeks, Group A was renamed Group A2 and followed the training program initially assigned to Group B. Similarly, Group B was renamed Group B2 and switched to the training program originally assigned to Group A.

Training sessions were scheduled with a repetitive structure:

Group A and B: Monday – Thursday and Tuesday – Friday.

After 8 weeks, a crossover switch was implemented, where both groups exchanged their training protocols, continuing the new program for an additional 8 weeks.

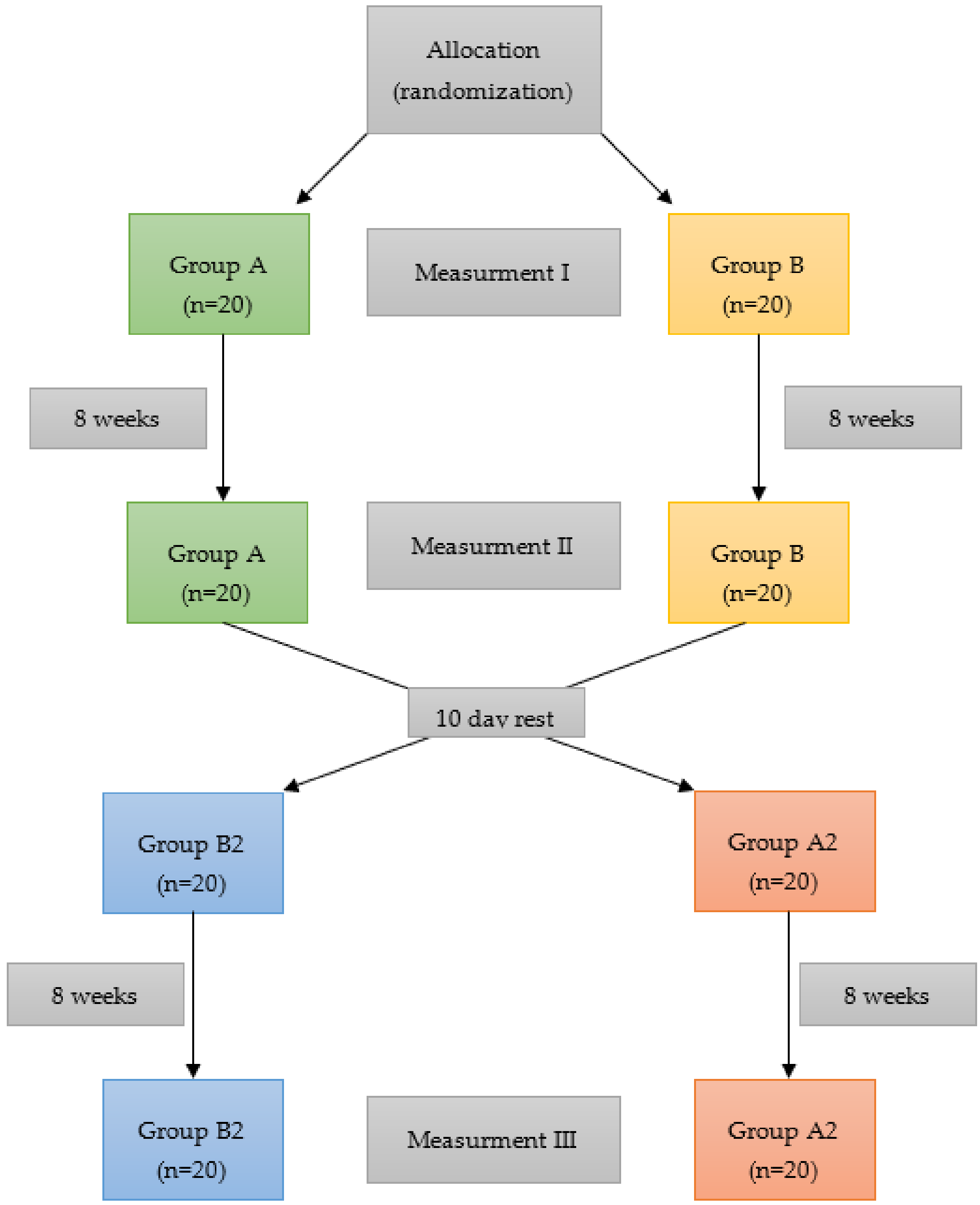

Figure 1. Study Design

Description of Exercises in the Experimental Program

The participants followed the program for 16 weeks. The training program of the studied groups changed after 8 weeks with a seven-day recovery break, during which the participants did not engage in any high-volume or high-intensity activities. Group A, in the first stage of the study (the first 8 weeks of training), performed submaximal strength exercises for the upper and lower limb muscles in a 70:30% proportion. This means that the upper limbs were trained more intensively than the lower limbs. The upper limbs were trained using the barbell bench press, bent-over barbell row, seated barbell overhead press behind the neck, and standing barbell bicep curl. The lower limbs were trained with the back squat, deadlift, and calf raises. Participants in Group A were instructed to achieve submaximal intensity in strength exercises (80% 1RM, 4 sets, 6–8 repetitions, 1-minute rest between sets). Participants in Group B performed the same set of exercises, but at moderate intensity (40–60% 1RM) with twice the number of repetitions (15–20 per set), also in four sets per exercise, with a 1-minute rest between sets.

An exception was made for the following exercises: transition from lying to sitting on an inclined bench, abdominal crunches in a lying position, calf raises, and leg raises in a supine position, where similarly, 4 sets were performed, the rest time was 1 minute, but the number of repetitions in each set was maximal (until muscle fatigue).

In the second stage of the study, the groups switched training intensities. Participants from Group A trained with a moderate intensity of 40–60% 1RM. The number of sets was set at 4, with approximately 15–20 repetitions per set. The rest time was 1 minute. Group B trained with an intensity of 80% 1RM, in 4 sets, with 6–8 repetitions per set. The rest time was also 1 minute. The second stage of the study also lasted eight weeks. After this period, the participants in the experiment were re-evaluated.

Assessment of Basic Somatic Parameters

Assessment of basic somatic indicators included:

- Body Height (BH) – measured using a Martin-type anthropometer (USA) with a measurement accuracy of 1 mm.
- Body Mass (BM) – assessed using the TANITA BC-418 body composition analyzer.
- Body Mass Index (BMI) – calculated as the ratio of body mass to the square of height using a formula in an Excel spreadsheet.
- Fat Mass (FM) – fat tissue mass measured using the TANITA BC-418 body composition analyzer.

Body mass and composition were determined using bioelectrical impedance analysis (BIA) with the TANITA BC-418 body composition analyzer. Additionally, skinfold thickness measurements were conducted to verify the results obtained through the BIA method. The comparison did not reveal any significant differences.

Assessment of Aerobic Capacity

VO_2max was determined in the test. The test was performed on a treadmill (Technogym Run 700 Excite). The effort began with a 4-minute warm-up performed at a speed of 8 $km*h^{-1}$, with a ground incline angle of 10. When the heart rate frequency approached the maximum value (understood as 220 - age), the achieved running speed was maintained, and the load increased by raising the incline angle by 1 degree per minute. The trial was performed until the participant refused to continue due to extreme exhaustion. Heart rate (HR) was measured during the test using a sports tester (Polar H10).

Physical Fitness Tests

During the experiment (before the training cycle, midway, and after the training cycle), motor ability assessments were conducted. Using the Eurofit Fitness Tests [10] and the International Physical Fitness Test [11], the following control trials were selected:

Strength Tests:

- Dynamic abdominal strength – sit-ups from a supine position in 30 seconds
- Arm strength – pull-ups on a bar
- Additional Strength Tests:
- Maximal strength – barbell bench press 1RM (kg)

- Strength endurance – barbell bench press with a 30 kg load on a flat bench (number of repetitions)
- Maximal strength – classic barbell squat 1RM (kg)

Speed Tests:

- Explosive lower limb strength – standing long jump
- Agility – shuttle run (10 × 5 m)
- Flexibility Test:
- Sit-and-reach test
- Endurance Test:
- Upper body muscular endurance – hang time on a bar

Bioethics Committee

Prior to participation in the tests, the participants were informed about the research procedures, which were in accordance with the ethical principles of the Declaration of Helsinki WMADH (2000). The participant's written consent was the inclusion criterion. The research was approved by the Bioethics Committee at the Regional Medical Chamber (No. 83/KBL/OIL/2023).

Statistical Analysis

The statistical analysis of the collected data was conducted using Statistica v.13.1 software from Statsoft (Tibco). Basic descriptive statistics were calculated, including the mean, minimum and maximum values, and standard deviation. Differences between groups were assessed using the Mann-Whitney U test. Differences depending on the measurement point and group were analyzed using the Kruskal-Wallis ANOVA test with post-hoc Kruskal-Wallis analysis. A significance level of $p<0.05$ was adopted for statistically significant differences.

Results

Difference Between the Results of Study I and II in Group A

Statistically significant differences were observed in the results of physical fitness measurements at different stages of the study in the sit-up test, pull-ups on a bar, hanging time on a bar, 1RM barbell squat, shuttle run, and sit-and-reach test ($p<0.05$). After the intervention, participants performed three more pull-ups, increased their hanging time by six seconds, improved their 1RM squat by 4 kg, enhanced their shuttle run time by six seconds, and increased their sit-and-reach test result by 1 cm. On average, participants improved by 8.9%. The greatest improvement was observed in pull-ups (30%) and the sit-and-reach test (20.4%). Additionally, a statistically significant difference in lean body mass was identified between measurement points. In Group A, a statistically significant increase in lean body mass by 2.1% was observed ($p<0.05$) (Table 2).

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Table 2. Physical Fitness Measurement Results in Group A Depending on the Study Stage

	Group A Before the Intervention			Group A After the Intervention			F	P
Variable	Min-Max	Mean	Standard Deviation	Min-Max	Mean	Standard Deviation		
VO_{2max}	26,21-42,25	30,53	7,82	26,6-43,1	31,29	7,83	0,323	0,78

Sit-ups from a Supine Position (nx)	18-28	23,25	4,11	21-31	26,75	4,5	2,672	0,041
Pull-ups on a Bar (nx)	2-12	5,75	4,5	4-16	8,25	5,43	3,891	0,031
Hanging Time on a Bar (s)	23-80	48,5	29,84	28-86	54,25	29,64	6,082	0,026
Barbell Bench Press on a Flat Bench 1RM (nx)	65-105	77,5	18,59	68-110	80,25	20,1	5,781	0,031
Barbell Bench Press in a Supine Position on a Flat Bench 30 kg (nx)	22-52	31,5	13,82	22-56	33,25	15,5	0,517	0,07
Classic Barbell Squat 1RM (kg)	72,5-122,5	87,5	23,54	75-136	91	23,6	7,79	0,021
Shuttle Run (s)	17,82-21,37	19,24	1,53	16,99-20	18,61	1,25	6,891	0,031
Sit-and-Reach Test (cm)	1-8	4	3,16	2-93	5,025	3,27	7,823	0,035
Standing Long Jump (cm)	181-215	199,8	14,1	192-221	206,5	11,84	12,991	0,51
Body Fat Percentage (%)	13,3-21,4	17,8	3,9	14,1-21,9	17,78	3,81	15,009	0,180
Fat Mass (kg)	10,74-16,88	13,85	2,9	12,1-20,3	16,6	3,09	17,045	0,169
Lean Body Mass (kg)	10,67-16,78	12,9	8,2	11,81-17,91	15,01	2,3	6,81	0,003

Difference Between the Results of Study I and II in Group B

Physical fitness results improved in all tests ($p<0.05$). After the intervention, participants achieved statistically significant better results in barbell bench press 1RM (by 4 kg), pull-ups on a bar (by 3 times), had a longer hanging time on a bar (by 7 seconds), better result in classic barbell squat 1RM (by 3 kg), improved shuttle run performance (by 3 seconds), and the sit-and-reach test also changed (by 1 cm). On average, participants improved their results by 7.5%. The percentage change ranged from 2% (VO_2max) to 29.4% (pull-ups on a bar). After the intervention, a statistically significant increase in lean body mass of approximately 2% was also observed ($p=0.037$) (Table 3).

Table 3. Physical Fitness Measurement Results of Group B Before and After the Intervention

	Group B Before the Intervention			Group B After the Intervention			F	P
Variable	Min-Max	Mean	Standard Deviation	Min-Max	Mean	Standard Deviation		
VO_{2max}	25,86-41,75	30,63	7,46	26,3-43,4	31,31	8,1	6,781	0,041

Sit-ups from a Supine Position (nx)	17-26	23	4,08	20-30	26,75	4,57	10,551	0,002
Pull-ups on a Bar (nx)	3-11	6	3,56	6-14	8,5	3,87	6,81	0,03
Hanging Time on a Bar (s)	23-80	47,5	29,84	28-86	54,25	29,64	7,661	0,041
Barbell Bench Press on a Flat Bench 1RM (nx)	63-102	76,75	17,4	67-110	80,75	19,85	7,781	0,039
Barbell Bench Press in a Supine Position on a Flat Bench 30 kg (nx)	21-50	31	13,1	24-54	33,75	13,82	9,15	0,003
Classic Barbell Squat 1RM (kg)	70,6-121	87,4	22,76	74-125	90,5	23,27	7,981	0,042
Shuttle Run (s)	17,99-22,4	19,43	2,02	12,75-18,35	16,41	2,56	8,168	0,037
Sit-and-Reach Test (cm)	2-9	5,25	3,3	2,9-10,4	6,23	3,5	7,31	0,029
Standing Long Jump (cm)	184-212	198	11,5	189,19-218,9	205,7	12,29	7,19	0,022
Body Fat Percentage (%)	13,6-19,9	15,32	3,05	14,40-20,6	16,13	2,99	21,081	0,325
Fat Mass (kg)	10,73-16,61	13,75	2,58	11-16,43	13,93	2,38	19,667	0,259
Lean Body Mass (kg)	61,18-76,99	65,93	7,47	62,6-77,9	67,53	7,04	8,913	0,037

Difference Between the Results of Study II and III in Group A2

The physical fitness measurement results in Group A2 improved in all assessed parameters ($p<0.05$). After the intervention, participants achieved statistically significant better results in barbell bench press 1RM (by 4 kg), pull-ups on a bar (by 4 times), hanging time on a bar (by 6 seconds), classic barbell squat 1RM (by 3 kg), improved shuttle run performance (by 3 seconds), and the sit-and-reach test also improved (by 2 cm).On average, participants improved their results by 9.9%. The percentage change ranged from 2% (classic barbell squat 1RM) to 22.7% (pull-ups on a bar). In Group A2, a statistically significant increase in lean body mass of 4 kg was observed ($p<0.034$). Detailed data are presented in Table 4.

Table 4. Physical Fitness Measurement Results of Group A2 Before and After the Intervention

	Group A2 Before the Intervention			Group A2 After the Intervention			F	P
Value	Min-Max	Mean	Standard Deviation	Min-Max	Mean	Standard Deviation		
VO_{2max}	26,3-43,4	31,31	8,1	28,04-44,2	33,23	7,4	3,11	0,392
Sit-ups from a Supine Position (nx)	20-30	26,75	4,57	25-37	31,25	4,9	14,11	0,0091
Pull-ups on a Bar (nx)	6-14	8,5	3,87	7-19	11	5,5	12,91	0,001
Hanging Time on a Bar (s)	28-86	54,25	29,64	31-98	60,75	32,6	11,67	0,041
Barbell Bench Press on a Flat Bench 1RM (nx)	67-110	80,73	19,85	70-117	84,25	21,97	161,91	0,023
Barbell Bench Press in a Supine Position on a Flat Bench 30 kg (nx)	24-54	33,75	13,82	23-58	35,5	15,67	51,81	0,001
Classic Barbell Squat 1RM (kg)	74-125	90,5	23,27	77-129	93,25	24,15	8,91	0,024
Shuttle Run (s)	12,75-18,35	18,14	2,56	16,45-19,6	16,41	1,29	11,88	0,021
Sit-and-Reach Test (cm)	2,9-10,4	6,23	3,5	2,9-10,1	7,815	3,3	9,91	0,03
Standing Long Jump (cm)	189,19-218,9	205,7	12,29	198,9-230	213,4	12,76	8,141	0,001
Body Fat Percentage (%)	13,3-21,4	17,8	3,9	13,6-21,8	17,8	4,1	41,91	0,91
Fat Mass (kg)	10,74-16,88	13,85	2,9	11,6-17,5	14,75	2,65	18,11	0,234
Lean Body Mass (kg)	61,85-78,89	66,66	8,2	64,5-82,3	70,025	8,24	9,167	0,034

Difference Between the Results of Study II and III in Group B2

The physical fitness measurement results in Group B2 showed a statistically significant improvement in 8 out of 10 assessed parameters. After the intervention, participants achieved better results in barbell bench press 1RM (by 5 kg), pull-ups on a bar (by 3 times), hanging time on a bar (by 5 seconds), improved shuttle run performance (by 3 seconds), and the sit-and-reach test also changed (by 2 cm). In Group B2, a statistically significant increase in lean body mass of 2 kg was observed ($p<0.044$). Detailed data are presented in Table 5.

Table 5. Physical Fitness Measurement Results of Group B2 Before and After the Intervention

	Group B2 Before the Intervention			Group B2 After the Intervention			F	P
Value	Min-Max	Mean	Standard Deviation	Min-Max	Mean	Standard Deviation		
VO_{2max}	26,6-43,1	31,29	7,83	27-44,1	32,16	8,1	7,81	0,033
Sit-ups from a Supine Position (nx)	21-31	26,75	4,5	20-30	32,1	4,57	11,871	0,001
Pull-ups on a Bar (nx)	4-16	8,25	5,43	9-18	11,75	4,27	5,99	0,043
Hanging Time on a Bar (s)	28-86	54,25	29,64	35-92	59,77	29,22	7,918	0,033
Barbell Bench Press on a Flat Bench 1RM (nx)	68-110	80,25	20,1	71-115	85	20,34	7,891	0,037
Barbell Bench Press in a Supine Position on a Flat Bench 30 kg (nx)	22-56	33,25	15,5	27-57	36,25	14,08	2,10	0,059
Classic Barbell Squat 1RM (kg)	75-136	91	23,6	79-128	94,5	22,54	3,371	0,0591
Shuttle Run (s)	16,99-20	18,61	1,25	12,1-17,87	15,8	2,54	8,228	0,0481
Sit-and-Reach Test (cm)	2-9,3	5,025	3,27	3,8-12,01	7,23	3,94	8,193	0,021
Standing Long Jump (cm)	192-221	206,5	11,84	194,8-225,9	211,15	12,75	8,119	0,0321
Body Fat Percentage (%)	14,40-20,6	16,13	2,99	14,9-20,9	16,65	2,85	3,98	0,171
Fat Mass (kg)	11-16,43	13,93	2,38	11,4-16,22	14,36	2,28	5,71	0,054
Lean Body Mass (kg)	62,6-77,9	67,53	7,04	63,9-78,8	69,075	6,67	11,77	0,044

Discussion

In bodybuilding training, there is a lack of clear guidelines regarding the optimal number of repetitions and load that most effectively influence morphological parameters. Moreover, as noted by Panasiewicz and Grochowicz, changes in these parameters, particularly in bodybuilding, depend on the motivation that drives individuals to engage in such physical activity [12]. Their studies indicate a wide range of motivations among recreational bodybuilding practitioners, with over 50% declaring their engagement in physical activity to improve physical performance or treating it as a hobby and a way to utilize free time [12].

In recent years, a dynamic growth in recreational bodybuilding has been observed, largely due to the increasing popularity of a healthy lifestyle promoted through social media [13]. Media, especially online platforms, have become one of the primary sources of knowledge and inspiration for engaging in physical activity. These platforms enable individuals not only to share their personal achievements but also to motivate each other to undertake training, which results in a growing number of people participating in recreational bodybuilding.

The findings of Skrzypczak and Wallas [14] confirm that social media serve as one of the most effective motivational tools, particularly in the context of amateur sports. They often become a space where users present their progress, which in turn inspires others to take similar actions. Social media also introduce an element of competition, which may further encourage individuals to increase their training effort and consistency.

However, as noted by Kromka [15], social media also have their darker aspects. They can promote unhealthy standards, create pressure for physical perfection, and impact the psychological aspects of those who train. On one hand, they offer positive motivation, but on the other, they can create problems related to unrealistic expectations and stress regarding body image.

Therefore, attention should be given to properly balancing the influence of social media on the development of physical activity. It is essential that the promoted content is credible and based on reliable knowledge, especially in the context of bodybuilding, where there is a significant need for education on proper training, nutrition, and recovery.

After completing the experimental strength training, changes were observed in only one morphological parameter in both study groups—an increase in lean body mass. These changes were significant in the context of physical performance and muscle strength, as confirmed by correlations with fitness and strength test results. Particularly interesting are the correlations between the increase in lean body mass and the results of the VO_2max test, hanging time on a bar, and barbell bench press. This indicates a relationship between muscle mass gain and overall physical fitness improvement, including both aerobic capacity and muscle strength.

Notable correlations, such as the strong relationship between the increase in lean body mass and the results of VO_2max and hanging time on a bar, suggest that muscle mass gain has a significant impact on improving physical performance. This is consistent with previous studies indicating that an increase in lean body mass is correlated with improved results in fitness tests such as VO_2max [16]. The increase in muscle strength, measured, among others, by the barbell bench press performance, also confirms this trend.

It is worth noting that the increase in lean body mass, combined with improved strength performance, suggests that proper adaptation to strength training may lead to more effective muscle strength development, which is consistent with studies indicating a significant impact of resistance training on muscle mass growth and the improvement of the body's functional capacity [17,18].

Summarizing, the study results demonstrate a strong relationship between the increase in lean body mass and the improvement in performance in endurance and strength tests, indicating the importance of strength training in the context of overall physical fitness enhancement. These changes may result both from the body's adaptation to training and from an appropriate training program that promotes muscle mass and strength development. In the future, it is worth considering how different training strategies, including training intensity and volume, may influence these relationships and what factors, such as diet and supplementation, may further support these processes [19].

Keenan et al. conducted a systematic review of the literature on maintaining and increasing body mass through resistance training. Eight scientific studies met the inclusion criteria, five of which indicated that fasting and strength training increase fat loss [17]. No dietary intervention was applied in the conducted study, so it can be indirectly stated that these results are consistent with Keenan et al.'s review. However, in the study group analyzed by the author of this work, the highest correlation was observed between changes in functional parameters and an increase in body mass, which means that strength training combined with appropriate nutritional intervention will be an effective tool for modifying other morphological parameters, as confirmed by the studies of Kisiel and Kozubowski [20].

Research conducted by Karpik et al. shows that about 40% of individuals engaged in recreational strength training use supplementation due to trends, while Escalante et al. indicate that proper nutrition can maximize muscle glycogen, minimize water retention in subcutaneous tissues, and reduce bloating [19,21]. These results suggest that education on nutrition and supplementation in recreational bodybuilding should take the form of a nationwide educational campaign, given the prevailing ignorance in this field.

The initial conclusions from the conducted study suggest that the applied experimental training contributed to an increase in lean body mass and improved upper and lower limb strength, coordination abilities, and explosive leg strength. These results align with the literature, which indicates that training programs based on strength training can lead to significant improvements in muscle strength and muscle mass, particularly in individuals with a sedentary lifestyle [18,22].

The study group, consisting of amateur athletes working in a corporate environment, illustrates the impact of training on the physical condition of individuals leading a sedentary lifestyle, which is confirmed by research highlighting the importance of physical activity in preventing health issues resulting from prolonged sitting [23]. After completing the experimental training, the participants showed improvement in aerobic capacity (VO_2max), sit-up test performance, pull-ups, hanging time on a bar, barbell bench press (both 1RM and with 30 kg), classic barbell squats (1RM), shuttle run time, sit-and-reach test, and standing long jump performance. Similar results were obtained in studies indicating the positive impact of regular strength training on improvements in fitness and endurance test results [24]. It was observed that training with a higher number of repetitions and lower weight (40-60%) can lead to similar effects as training with heavier loads (80%) and fewer repetitions. These results are consistent with studies suggesting that both training volume and intensity can lead to similar improvements in strength, endurance, and explosive power [25]. It is worth noting that the key factor influencing differences in functional body parameters, such as strength, endurance, and fitness, is the increase in lean body mass. Moquin et al. emphasize that optimal strength and power gains require targeted training that promotes body composition changes while increasing metabolic capacity for exertion [26]. Empirical evidence indicates that gains in lean body mass and fat loss are effectively achieved with greater resistance training volume.

These conclusions are crucial because they emphasize that not only the type of load but also training volume can impact the effectiveness of body composition changes as well as improvements in strength and endurance performance. For recreational trainees, this means that there are multiple ways to achieve similar effects, allowing for better adaptation of training to individual preferences and goals. The study demonstrated that in both groups, the increase in lean body mass significantly correlated with endurance and strength test results, particularly concerning VO_2max and the hanging test on a bar.

Particularly interesting is the finding that in Group I, the increase in lean body mass showed a strong correlation with VO_2max test results ($r = 0.98$, $p < 0.001$), strength tests such as barbell bench press (1RM), and classic barbell squats (1RM). The correlation with tests such as hanging on a bar and sit-up test also indicates the significance of muscle mass gain in the context of strength and overall physical fitness improvements.

In Group II, the increase in lean body mass showed a significant correlation with VO_2max results ($r = 0.98$, $p = 0.033$) and the hanging test on a bar ($r = 0.79$, $p = 0.018$). This relationship fully confirms that lean body mass, especially muscle mass, plays a key role in improving both aerobic capacity and muscle strength.

These results highlight the fundamental role of lean body mass growth in improving the functional parameters of the body, including aerobic capacity and muscle strength. These changes may result from the body's adaptation to strength training, which leads to muscle mass gain, ultimately improving performance in endurance and strength tests.

However, fully confirming this relationship requires longer-term studies to obtain a more comprehensive picture of the impact of strength training on morphological and functional body parameters. Further research may also help in understanding the influence of other factors, such as diet, supplementation, and other nutritional interventions, which may support muscle mass development and improve aerobic capacity.

In summary, the results of this study provide strong evidence that strength training, leading to an increase in lean body mass, significantly improves performance in strength and endurance tests, which is particularly relevant in the context of recreational bodybuilding practitioners. Future studies may focus on the long-term effects of such training as well as potential interactions with diet and supplementation.

Limitations of the Study

The study did not include detailed control over the participants' diet, which may have influenced the results related to body mass and composition. Additionally, differences in training experience, lifestyle, and genetic predispositions of the participants could have affected the outcomes, making their interpretation more challenging.

Conclusions

The experimental strength training program, both at moderate and submaximal intensity, led to a significant increase in lean body mass and improvement in selected physical fitness parameters, including strength, endurance, and aerobic capacity. Additionally, training with lower loads and higher repetitions, as well as training with heavier loads and fewer repetitions, proved to be equally effective in the context of the aforementioned parameters.

Future studies should consider a longer observation period, a more diverse demographic of participants, and control over additional variables such as diet and supplementation.

Practical Implication

Training with lower loads and a higher number of repetitions may be a safer alternative for beginners and individuals with health limitations, directly contributing to greater training individualization. These findings may also have positive implications for promoting physical activity and a healthy lifestyle in the general population.

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