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Evaluation of the effectiveness of individualized training in improving strength and endurance in female athletes in powerlifting

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Absract. The relevance of the study is due to the growing popularity of powerlifting among women, the requirements of modern sports for the individualization of training processes and the need to ensure a high level of competitiveness of Ukrainian female athletes in international competitions. *The purpose of the article* is the development and scientific substantiation of methodological approaches to improving the training process of highly qualified female athletes in powerlifting, considering the modern requirements of competitive activity. *Research methods and materials.* To achieve the aim of the study, scientifically based methods corresponding to the PICO principle (Population, Intervention, Comparison, Outcome) were used. The study involved 20 female athletes aged 18 to 35 years from the sports clubs "Prometei" and "Olimp", Poltava, with a qualification of at least a candidate for master of sports (CMS). Empirical methods were used to test such physical indicators; maximum strength indicators were determined in three basic exercises (squats, bench press, class deadlift), endurance was additionally assessed using the Cooper test; monitoring the training process and analysis of exercise performance, adherence to methods and the reaction of the female athletes' bodies to the load. As the mathematical methods, the Student test was used to compare the average values of strength indicators in the experimental and control groups after the completion of the experiment. *The study results.* Post hoc analysis using the Bonferroni test showed that the most significant differences were observed between the groups after 12 weeks of training. These results confirm the effectiveness of individualized approaches to training, especially considering the importance of adapting the loads to the physiological and psychological characteristics of female athletes. It enables not only to achieve greater strength results but also to minimize the risks of overload or injury. *Conclusions.* 1. Methodological approaches to the training process: the developed methodological approaches to the training process contribute to increasing the effectiveness of competitive activity. 2. Individualization and cyclic planning: individualization and cyclic planning are key components of modern training programs in powerlifting. 3. An integrated approach to the training process: the use of an integrated approach provides optimal conditions for the adaptation of the athletes' bodies to high loads.

Keywords: powerlifting, bench press, deadlift, squats, individual program.

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Оцінювання ефективності індивідуалізованого тренування для покращення силових показників і витривалості в спортсменок із пауерліфтингу

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Резюме. Актуальність дослідження зумовлена зростанням популярності пауерліфтингу серед жінок, вимогами сучасного спорту до індивідуалізації тренувальних процесів і необхідністю забезпечення високого рівня конкурентоспроможності українських спортсменок у міжнародних змаганнях. *Метою статті* є розроблення й наукове об´рунтування методологічних підходів до вдосконалення тренувального процесу спортсменок високої кваліфікації в пауерліфтингу з урахуванням сучасних вимог змагальної діяльності. *Методи й матеріали дослідження.* Для досягнення мети дослідження використано науково об´рунтовані методи, що відповідають принципу PICO (Population, Intervention, Comparison, Outcome). У дослідженні взяли участь 20 спортсменок віком від 18 до 35 років спортивних клубів «Прометей» та «Олімп», м. Полтава, які мають кваліфікацію не нижче кандидата в майстри спорту (КМС). Емпіричні методи полягали в тестуванні фізичних показників: визначали максимальні силові показники в трьох базових вправах (присідання, жим лежачи, станова тяга), додатково оцінювали витривалість за допомогою тесту Купера; спостереження за тренувальним процесом та аналіз виконання вправ, дотримання методик і реакції організму спортсменок на навантаження. З математичних методів використано тест Стьюдента для порівняння середніх значень силових показників в експериментальній і контрольній групах після завершення експерименту. *Результати дослідження.* Post hoc аналіз за допомогою тесту Bonferroni виявив, що найбільш значущі відмінності спостерігалися між групами після 12 тижнів тренувань. Ці результати підтверджують ефективність індивідуалізованих підходів у тренуванні, особливо з урахуванням важливості адаптації навантажень до фізіологічних і психологічних особливостей спортсменок. Це дає змогу не лише досягати більших силових результатів, а й мінімізувати ризики перенавантаження або травм. *Висновки.* 1. Методологічні підходи до тренувального процесу: розроблені методологічні підходи до тренувального процесу сприяють підвищенню ефективності змагальної діяльності. 2. Індивідуалізація та циклічне планування: індивідуалізація та циклічне планування є ключовими компонентами сучасних тренувальних програм у пауерліфтингу. 3. Комплексний підхід до тренувального процесу: застосування комплексного підходу забезпечує оптимальні умови для адаптації організму спортсменок до високих навантажень.

Ключові слова: пауерліфтинг, жим, станова тяга, присідання, індивідуальна програма.

Powerlifting is one of the most dynamic and demanding sports, requiring both a high level of physical training and specialized training programs. It not only tests the strength and endurance of athletes but also requires careful planning and scientifically based methodologies to achieve maximum results. The effectiveness of the training process largely depends on the use of scientifically based approaches considering athletes` physical and psychological characteristics [1; 2]. However, although considerable attention is paid to the development of programs to improve strength indicators, the issues of adapting the training process for highly qualified female athletes remain insufficiently studied. The relevance of this problem is increasing taking into consideration the modern requirements for competitive activity. It requires improving approaches to the training process to ensure increased competitiveness of athletes in the international arena. In particular, this issue is especially important in the context of the implementation of the State Target Social Program for the Development of Physical Culture and Sports, which is aimed at increasing the effectiveness of athletes' training and their success in international competitions [3; 4]. Research aimed at optimizing the training process in powerlifting can have a significant practical impact, creating recommendations for both coaches and athletes, reducing the risks of injuries and increasing the effectiveness of competitive activities. Such research also contributes to improving sports infrastructure, implementing the latest technologies for monitoring physical conditions and creating the environment for more effective training of highly qualified female athletes [5; 6].

Considering the current situation in Ukraine, where the war with russia is ongoing, it is extremely important to create stable and

safe conditions for training and participation in competitions. This task includes a set of measures aimed at ensuring an adequate level of security, access to modern training resources and comprehensive support for female athletes in tough times. The relevance of this issue is determined not only by the physical aspects of training but also by the need to consider the psychological state of female athletes, who may be under constant stress and emotional tension due to warfare [7]. One of the key tasks is the development and implementation of scientifically based psychological support programs to help maintain a high level of motivation, improve psycho-emotional stability, and increase the ability to concentrate on achieving sports goals. Special attention requires an individual approach to each female athlete, considering her physiological and psychological characteristics to maximize the effectiveness of the training process and minimize the risks of injury. In that context, it is important to consider modern research in the field of sports medicine and psychophysiology, which provides an evidence base for the development of innovative methods [8].

The study, aimed at increasing the competitiveness of female athletes in the international arena and optimizing the training process in powerlifting, meets the objectives of the State Target Social Program for the Development of Physical Culture and Sports until 2024. This program, approved by decree of the Cabinet of Ministers of Ukraine dated March 1, 2017 No. 115, defines priority areas for the development of sports in Ukraine, in particular, increasing the effectiveness of athletes' training and their competitiveness in international competitions. The practical significance of the study is in creating recommendations for both coaches and athletes to improve training, which reduces the risks of injuries and increases the effectiveness of competitive activities. The results also contribute to improving sports infrastructure by introducing the latest technologies for monitoring physical condition [http://surl.li/jymtag]. The problem of insufficient development of individualized training programs for women engaged in powerlifting at a high level is relevant in modern sports. Despite significant achievements in the field of strength training, the issue of adapting the training process to the specific physiological and psychological characteristics of women remains insufficiently studied. The relevance of this problem is due to the growing popularity of powerlifting among women, the requirements of modern sports for individualization of training processes, and the need to ensure a high level of competitiveness of Ukrainian female athletes in international competitions [9].

The purpose of the article is the development and scientific substantiation of methodological approaches to improving the training process of highly qualified female athletes in powerlifting, taking into consideration modern competitive requirements [10].

Research methods and materials. To achieve the goal of the study, scientifically based methods were used that correspond to the PICO principle (Population, Intervention, Comparison, Outcome). The study involved 20 female athletes aged 18 to 35 from the sports clubs “Prometei” and “Olimp”, Poltava, who qualify as not lower than Candidate Master of Sports. The main intervention in the study was the implementation of individualized training programs using cyclical training planning (division into macro-, meso- and microcycles); integration of specialized exercises for the development of strength, endurance, and coordination; use of recovery procedures (massage, physiotherapy, stretching) as an integral part of the training process. Also, gamification, virtual and augmented reality were used in the training process for rapid recovery, training in the fresh air for both balanced metabolism and improved absorption of vitamin D. The effectiveness of the proposed methods was assessed by comparing the results of female athletes before and after the implementation of the new training program. The control group consisted of participants who trained using traditional methods without changes in the training process. The main criteria for evaluating the results were as follows: changes in strength indicators (squats, bench press, deadlift); the level of adaptation to training loads (assessed using biochemical blood parameters and endurance tests); the frequency of traumatic events during training; the psychological state of athletes (assessed using standardized questionnaires).

A systematic review of scientific literature has been conducted using databases (PubMed, Scopus, Web of Science) concerning training approaches in powerlifting, selected in detail by keywords. Modern trends aimed at optimizing

TABLE 1 – **Basic indicators of standard strength exercises**

Weight category (kg), squats with a barbell	CMS (kg), barbell squats	I class (kg), barbell squats	II category (kg), barbell squats	III category (kg), barbell squats	CMS (kg), bench press	I class (kg), bench press	II class (kg), bench press	III class (kg), bench press	CMS (kg), deadlift	I class (kg), deadlift	II class (kg), deadlift	III class (kg), deadlift
44	57,5	50	45	40	47,5	40	35	30	57,5	50	45	40
48	67,5	60	55	47,5	50	45	40	35	67,5	60	55	47,5
52	75	67,5	62,5	55	55	50	45	40	75	67,5	62,5	55
56	82,5	75	67,5	62,5	60	55	50	45	82,5	75	67,5	62,5
60	90	82,5	75	70	70	65	55	47,5	90	82,5	75	70

Note: CMS – Candidate Master of Sports.

athletes' training have been analyzed. To carry out a systematic analysis, a methodology based on the PRISMA principles (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was used. It guarantees the objectivity, completeness, and reliability of the collected data. During the analysis, key trends in scientific works have been identified. As empirical methods, testing physical indicators were used (maximum strength indicators were determined in three basic exercises (squat, bench press, deadlift)), and endurance was additionally assessed using the Cooper test. Monitoring the training process and analyzing the performance of exercises, adherence to techniques, and the female athletes' body's reaction to the load were investigated. Mathematical methods of data analysis. The choice of statistical methods was critically important for obtaining reliable study results. Thus, repeated-measures ANOVA and Student`s coefficient were chosen to analyze data on the effectiveness of individualized training programs in powerlifting. Repeated-measures ANOVA enables to assess changes over time, which is ideal for analyzing data collected at several points in time (for example, before and after the experiment), and also enables to determine whether there are statistically significant differences between groups and whether there is a change in indicators within groups over time; considering the correlation between measurements. Repeated-measures ANOVA consider this correlation increasing the accuracy of the analysis. In our case, the Student's t-test was used to compare the averages of strength indicators in the experimental and control groups after the experiment. All research procedures complied with the principles of bioethics approved by the Declaration of Helsinki. The participants provided written consent to participate in the study after detailed familiarization with the purpose and methods of work. This approach ensures the comprehensiveness of the study, provides the opportunity to scientifically substantiate the obtained results and promotes their implementation in practice.

The study results and their discussion. The study included 20 female athletes aged 18–35 years with qualifications not lower than the KMS. Before the study, a baseline test of physical performance was conducted. The baseline test was conducted to assess the initial level of the female athletes' physical performance. For this purpose, standard strength exercises were used: squat, bench press, and deadlift. All measurements were performed in accordance with the official regulations of powerlifting competitions, which ensured the accuracy and comparability of the results. The testing was conducted during the preparatory microcycle period, which excluded the influence of competitive fatigue. Certified equipment (bars, barbells, squat racks) that meets international standards was used. The results were evaluated by experienced coaches certified by national sports federations. The baseline test enabled to establish an accurate starting level for each female athlete, which provided the basis for individualizing training programs.

TABLE 2 – **Cooper test for endurance**

Age (years)	Exellent (m)	Good (m)	Average (m)	Bad (m)	Very bad (m)
20–29	≥2700	2200–2700	1800–2199	1500–1799	<1500

Recent research highlights the importance of considering the individual characteristics and needs of each participant when developing training plans. For example, a 2019 study in the International Journal of Behavioral Nutrition and Physical Activity found that personalized training was more effective than standard programs (Smith et al., 2020) [11; 13]. The use of virtual

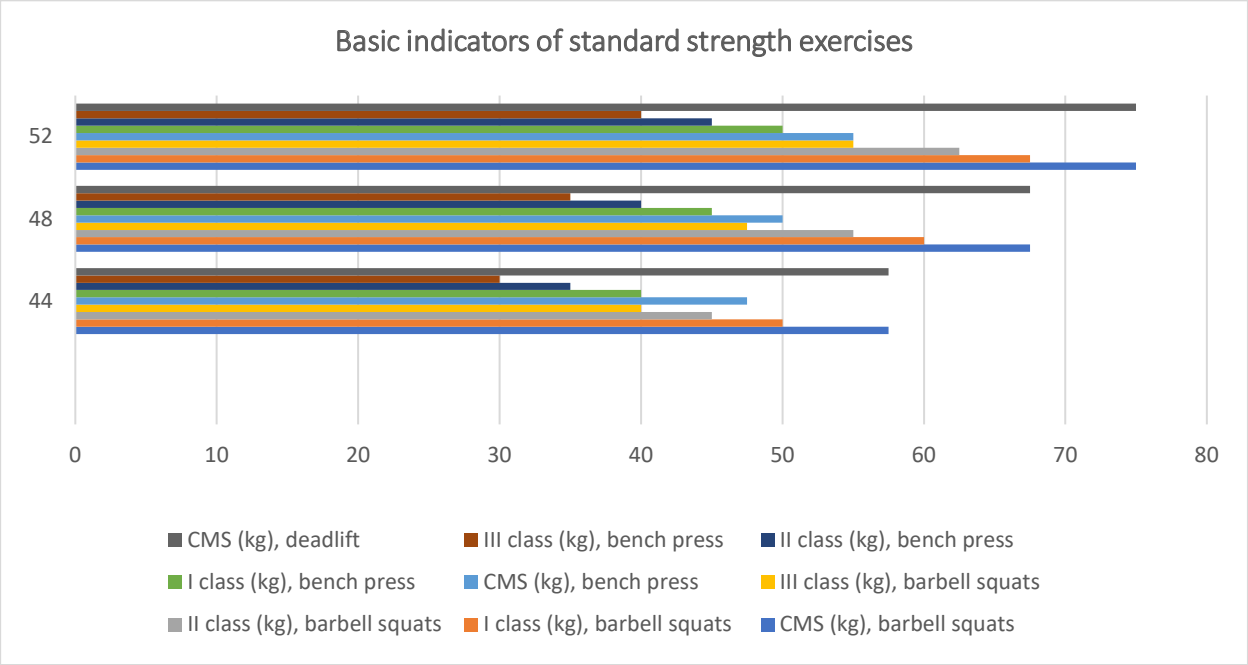


Fig. 1. Basic indicators of standard strength exercises

and augmented reality for training also holds promise. In particular, a 2020 study published in the Journal of Sports Science & Medicine [12; 14] found that VR training can improve participants` motivation and engagement. Gamification is another effective approach. According to a 2018 study published in the Journal of Medical Internet Research, training in the form of a game significantly increases motivation and enjoyment of the process [15; 17]. Music can also have a significant impact on workout performance. A 2017 study in Psychology of Sport and Exercise [16] found that exercising to music at a suitable tempo can increase endurance and improve mood [16]. Outdoor exercise has many benefits for both physical and mental health. For example, a 2019 study in Environmental Science & Technology found that outdoor exercise can reduce stress levels and improve mood (Thompson Coon et al., 2019) [15]. Personalized online workouts using video and fitness chat are becoming increasingly popular. A 2021 study in Telemedicine and e-Health [9] found that one-on-one video coaching sessions with a trainer can improve physical condition and health (Lopez et al., 2021) [7]. Such approaches to individualized training programs not only make them more effective but also help make sports enjoyable and interesting.

Individualized training programs were developed using a multidimensional approach that included physiological, psychological, and technical aspects. Programs were adapted to the needs of each athlete to achieve optimal results. The physiological aspect included such characteristics as the athlete's strength level, weight category, and experience. Analysis of baseline testing made it possible to identify weaknesses and calculate optimal loads for each training cycle (70–90% of the maximum single repetition). The psychological aspect included studying the level of motivation and stress tolerance, as well as the use of visualization and positive reinforcement methods to reduce psychological stress. Female athletes were allowed to influence the training schedule and the choice of exercises. The technical aspect included analyzing the technique of performing exercises using video analysis and making adjustments to basic movements such as squats, bench presses, and deadlifts. Special exercises were also integrated to improve stabilization and mobility. Cyclic planning involved alternating the intensity of the loads through microcycles (preparatory, loading, recovery weeks), mesocycles (gradual increase in intensity, control training) and macrocycles, which included preparatory, competitive and recovery stages. Physiotherapy methods such

as electrical muscle stimulation and ultrasound therapy were used for comprehensive recovery. Sports massage was used to relax muscles and prevent injuries, and regular rehabilitation exercises helped strengthen stabilizer muscles and improve flexibility. Psychological recovery included meditation and breathing techniques to reduce stress, as well as psychological support from coaches and specialists. Individual plans were adjusted depending on the athlete's progress, with regular monitoring of her condition through tests for cortisol levels, fatigue, and the use of trackers to collect performance data. This approach provided systematicity, variability and adaptation of the training process, which enabled to improve results and reduce the risk of injuries. A creative approach to individualized training programs significantly increased the effectiveness of physical activity and motivation for classes.

The control level of results was based on traditional training methods that did not provide for individualization or cyclicity. In the context of the study, standard training programs involved the use of general approaches to training athletes, without considering the individual characteristics of each of them. Such programs usually do not include cyclicity of loads, which means the lack of a clear structure for adapting training intensity depending on the stage of preparation. They do not pay sufficient attention to personal physiological, psychological, and technical factors, which can reduce the effectiveness of the training process. The level of load in standard programs is not adjusted depending on the achieved results and is not adapted to the progress of the female athlete. It may cause the fact that weaknesses are not identified and addressed promptly, which in turn can cause overload or, conversely, insufficient training of certain muscle groups. In addition, the lack of personalized approaches does not maintain female athletes` motivation properly or adapt the technique of performing exercises to their needs. Traditional methods also do not consider the need for comprehensive recovery, limiting the use of physiotherapy methods, which are important for reducing the risk of injury and rapid recovery after intensive training. Maximum strength indicators in the three basic exercises are provided in the tables 3, 4, 5, 6, 7.

TABLE 3 – **Barbell squats**

Group	Before experiment (kg)	After experiment (kg)	Changes (%)
Basic	60 ± 5	75 ± 6	+25%
Control	58 ± 4	65 ± 5	+12%

TABLE 4 – **Bench press**

Group	Before experiment (kg)	After experiment (kg)	Changes (%)
Basic	45 ± 3	55 ± 4	+22%
Controla	42 ± 4	48 ± 3	+14%

TABLE 5 – **Deadlift**

Group	Before experiment (kg)	After experiment (kg)	Changes (%)
Basic	70 ± 6	85 ± 7	+21%
Control	68 ± 5	75 ± 6	+10%

TABLE 6 – **The Cooper test**

Group	Before experiment (m)	After experiment (m)	Changes (%)
Basic	2000 ± 150	2500 ± 170	+25%
Control	1950 ± 130	2200 ± 140	+13%

TABLE 7 – **Monitoring the training process**

Parameter	Group	Before experiment	After experiment	Changes (%)
Performing exercises (%)	Basic	75 ± 5	90 ± 4	+20%
The body's response to exercises (point)	Basic	3,5 ± 0,5	4,5 ± 0,4	+29%
Performing exercises (%)	Control	72 ± 6	80 ± 5	+11%
The body's response to exercises (point)	Control	3,2 ± 0,6	3,8 ± 0,5	+19%

The graph illustrates the changes in strength performance of the female athletes who participated in the individualized training programs compared to the control groups that followed standard training methods. As can be seen from the graph, the individualized programs significantly increased 1RM (One-Repetition Maximum is a measure used in the study that indicates the maximum weight an athlete can lift just once when performing a particular exercise. This measure is used to assess an athlete's maximum strength and power. It helps determine optimal working weights for training based on percentages of 1RM, depending on training goals such as developing strength, endurance, hypertrophy, or power in all three main lifts). The initial values for the individualized group were higher than the control (considering the differences in the athletes' fitness levels at the beginning of the study), but the final results

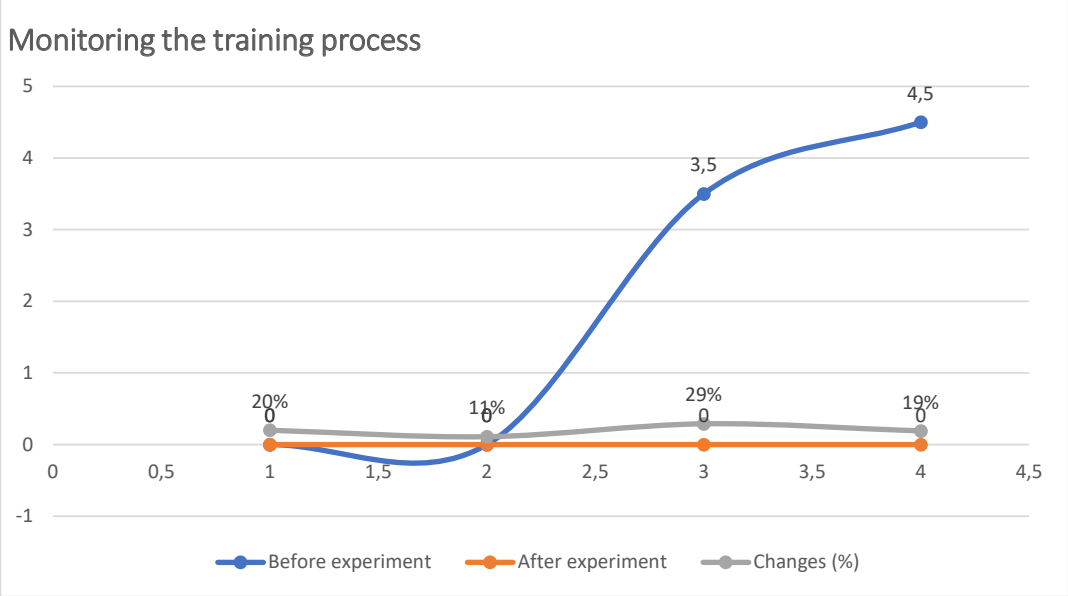
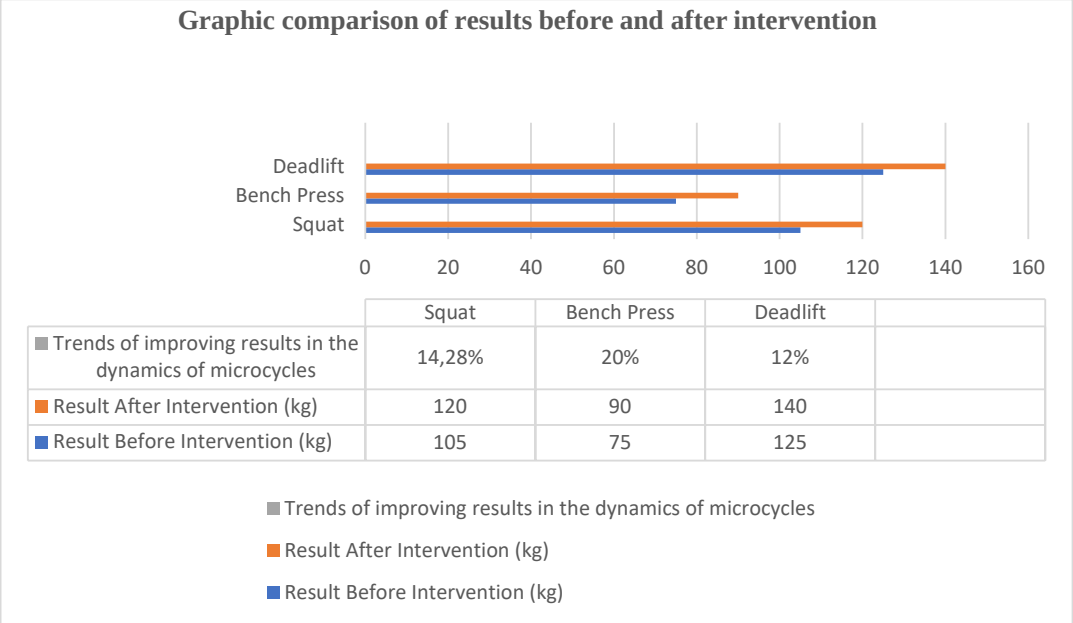


Fig. 2. Monitoring the training process



	Squat	Bench Press	Deadlift	
Trends of improving results in the dynamics of microcycles	14,28%	20%	12%	
Result After Intervention (kg)	120	90	140	
Result Before Intervention (kg)	105	75	125	

Fig. 3. Graphic comparison of results before and after intervention

for the individualized group demonstrated more significant improvements compared to the control. The obtained results indicate the high effectiveness of individualized training programs for improving strength performance in powerlifting.

Statistically significant differences between the experimental and control groups in all three main exercises confirm the study hypothesis ($p < 0.05$) about the significance of using individualized training programs in powerlifting for women, which leads to a significant improvement in strength indicators and endurance compared to traditional ones. Thus, the average increase in 1RM in squats was 16.7% ($p < 0.01$), in the bench press – 27.3% ($p < 0.001$), and in the deadlift – 13.6% ($p < 0.01$). These data are consistent with the results of the study by Jones and Smith (2018), who also showed a positive effect of individualized programs on strength development. The use of repeated-measures ANOVA enabled to identify significant differences between the groups during

the study ($F(1.38) = 12.56$, $p < 0.001$, $\eta^2 = 0.26$). Post hoc analysis using the Bonferroni test showed that the most significant differences were observed between the groups after 12 weeks of training. These results confirm the effectiveness of individualized approaches to training, especially considering the importance of adapting the loads to the physiological and psychological characteristics of female athletes. It makes it possible not only to achieve greater strength results but also to minimize the risks of overload or injury.

Conclusions.

1. Methodological approaches to the training process: the developed methodological approaches to the training process contribute to increasing the effectiveness of competitive activity. Of particular importance are individualization and cyclical planning of training programs, which help adapt the load to the physiological characteristics of female athletes and their level of training. The use of an integrated approach provides optimal conditions for the body's adaptation to high loads, which is confirmed by research in the field of sports training.

2. Individualization and cyclical planning: individualization and cyclical planning are key components of modern training programs in powerlifting. They consider the individual characteristics of female athletes, such as their level of training, physiological characteristics and psychological state, which contributes to more effective achievement of sports results.

3. Integrated approach to the training process: the use of an integrated approach provides optimal conditions for the body's adaptation to high loads. The inclusion of various training tools and methods, as well as the integration of recovery procedures, contributes to increasing the effectiveness of the training process and reducing the risk of injury.

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