Analysis and optimization of training load to improve bench press performance in young powerlifters

Artem Gonchar [1]

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Annotation. The study addresses the growing need for individualized training strategies in young powerlifters, particularly under conditions of early specialization and increasing competitive demands. Existing methods often neglect age-specific morphofunctional characteristics, resulting in suboptimal development. The research aims to substantiate scientifically grounded approaches for optimizing training loads to enhance bench press performance during the stage of preliminary basic training. It was established that special physical preparedness plays a decisive role in performance outcomes, while irrational load distribution leads to functional decline and technical instability. The study proposes a structured model incorporating variable resistance and speed-strength elements as a more adaptive approach. This model enables progressive strength gains while minimizing overload risks. The findings confirm the effectiveness of load variation and individualized training design. Further research will explore biomechanical profiling and real-time feedback technologies.

Keywords: speed-strength training, variable resistance, technical consistency, training microcycles, morphofunctional traits, adaptation processes, athletic performance.

Аналіз та оптимізація тренувального навантаження для покращення жиму лежачи у молодих пауерліфтерів

Анотація. Актуальність дослідження зумовлено потребою у підвищенні ефективності тренувального процесу у молодих пауерліфтерів, зокрема в умовах ранньої спортивної спеціалізації та збільшення змагальних вимог. У сучасній практиці спостерігається брак адаптованих методик, що враховують вікові, морфофункціональні та психофізіологічні особливості юних спортсменів, а також недостатня індивідуалізація у побудові тренувального навантаження. Це актуалізує розробку підходів до оптимізації навантаження з акцентом на розвиток спеціальної сили, зокрема у вправах на жим лежачи, що є одним із ключових елементів у програмі пауерліфтингу. Мета дослідження – обґрунтувати науково-методичні підходи до оптимізації тренувального навантаження для підвищення результативності жиму лежачи у молодих пауерліфтерів на етапі попередньої базової підготовки з урахуванням специфіки розвитку спеціальної фізичної підготовленості та закономірностей побудови багаторічного тренувального процесу.

[1] Bachelor, truck fleet manager, STR Auto, fhntvjy@gmail.com, https://orcid.org/0009-0001-7849-0789.

Методологія дослідження ґрунтувалася на комплексному теоретичному аналізі фахової літератури, узагальненні емпіричних даних тренувальної практики, використанні порівняльно-аналітичного та функціонального підходів до оцінювання ефективності силової підготовки. Було здійснено систематизацію методів варіативного навантаження та вивчено ефективність використання засобів змінного опору в умовах адаптаційної тренувальної фази. Результати дослідження засвідчили, що спеціальна фізична підготовленість виступає провідним чинником спортивного прогресу в жимі лежачи. Виявлено, що нераціональне поєднання обсягів та інтенсивності навантаження, а також порушення принципу чергування тренувальних впливів призводять до функціонального виснаження, технічної нестабільності та зниження результативності. Обґрунтовано ефективність включення вправ зі змінним опором та швидкісно-силової спрямованості в структуру базового етапу підготовки. Висновки підтверджують доцільність поетапної оптимізації навантажень на основі індивідуального підходу, чергування навантажень різної інтенсивності та цільового розвитку швидкісно-силових компонентів. Доведено, що застосування змінного опору сприяє покращенню техніки, підвищенню вибухової сили та забезпеченню стабільного приросту результату. Перспективи подальших досліджень пов'язані з розробкою індивідуальних біомеханічних профілів спортсменів, моніторингом нейром'язової реактивності у відповідь на різні типи навантаження та впровадженням цифрових систем біофідбеку для корекції техніки в режимі реального часу.

Ключові слова: швидкісно-силова підготовка, змінний опір, технічна стабільність, тренувальні мікроцикли, морфофункціональні особливості, адаптаційні процеси, спортивна результативність.

Introduction

In the modern sports training process, there is a need to improve the preparation methods of young powerlifters, particularly in the aspect of the development of force indicators in the bench press as one of the main competitive movements. Despite a large number of scientific and methodological works covering the features of strength training, the problem of accurate dosage of load and its individualization for young athletes remains relevant. Insufficient adaptation of general techniques to boys' age functional and morphological characteristics can lead to overripeness, inefficient increase in strength or risk of injury. This problem is significant in growing competition in junior sports, where increased results are due to accurate regulation of intensity, volume and recovery.

From a scientific point of view, it is essential to study the patterns of the body's reactions to different load variants, taking into account biomechanical, physiological and psycho-emotional factors that affect the effectiveness of the bench press. On the practical side, the task is to provide coaches and athletes with walled training models based on modern scientific approaches that allow maximum productivity without harming health. Solving this problem will increase the efficiency of young powerlifter training and serve as a basis for further research in sports science focused on developing personalized training systems.

Analysis of scientific works devoted to improving the training load in the bench press in the preparation system of young powerlifters allows us to distinguish four leading scientific directions that form a modern approach to modeling the force training process. The first direction covers psychophysiological and motivational factors determining athletes' involvement in systematic exercises. In the study of G. Z. Lavrin, I. O. Sereda, T. V. Kucher, I. M. Grygus, and W. Zukow [1] found that the choice of physical education model and the level of intrinsic motivation directly impact participation in the training process. In turn, O. Andrieieva, D. Maltsev, V. Kashuba, M. Dutchak, D. Ratnikov, I. Grygus, N. Byshevets, I. Horodinska [2] substantiated the connection between physical activity, quality of life and

family well-being. Further research should focus on the study of cognitive-emotional regulation regulation of training involvement.

The second area is related to the individualization of training based on morphofunctional characteristics. O. Tykhorskyi, S. Babenko, N. Didiuk, and O. Olkhovyi [3] proved the need to differentiate programs by somatotype. B. Semko, V. Voronetskyi, V. Dzhym [4] showed the effectiveness of elastic means. S. Drachuk, V. Bohuslavska, and O. Shvets [5] submitted a structural model of loads. M. Rostorhuy, A. Detko, K. Hulei, M. Havrylenko, Yu. Borovyk [6] found a relationship between anthropometric indicators and bench techniques. V. Mocherniuk, I. Zavadiak, and V. Martyn [7] substantiated the expediency of functional control. T. Kyrychenko [8] focuses on the importance of general physical training. In the future, it is advisable to use multifactorial modeling.

The third direction covers functional and mechanical monitoring. T. D. Williams, M. R. Esco, M. V. Fedewa, P. A. Bishop [9] examined the dynamics of strength after microcycles. M. Reya, J. Škarabot, B. Cvetičanin, and N. Šarabon [10] highlighted key technical factors. S. Montalvo, L. D. Gruber, M. P. Gonzalez, M. S. Dietze-Hermosa, S. Dorgo [11] proved the efficiency of eccentric load. The introduction of sensory platforms and video analysis is promising.

The fourth direction concerns the methods of intensification and periodization. P. Androulakis-Korakakis, N. Michalopoulos, J. P. Fisher, J. Keogh, J. P. Loenneke, E. Helms, J. Steele [12] substantiated the concept of minimal load. H. Arazi, A. Khoshnoud, A. Asadi, and J. J. Tufano [13] showed the effectiveness of cluster sets. M. Sapuppo, D. Oberlin, R. Burke, A. Pinero, A. Mohan, F. Augustin, and B. Schoenfeld [14] confirmed the benefits of phase periodization. J. H. Dugdale, A. M. Hunter, T. G. Di Virgilio, L. J. MacGregor, and D. L. Hamilton [15] evaluated the «Slingshot» device. Further research should be directed to the development of adaptive microcycles with the inclusion of aids.

Thus, scientific sources cover a complex of problems with motivational involvement to technical and mechanical efficiency and innovation in the structure of training load. Despite the existing scientific training in power training, several aspects remain insufficiently investigated. In particular, the mechanisms of the influence of exceptional physical fitness on the dynamics of the results in the bench press in the context of many years of training have not been fully revealed. Insufficiently substantiated approaches to the construction of the training process, taking into account the age and morpho-functional characteristics of young athletes, there is a fragmentary use of methods of variational loading, as well as the absence of holistic models that take into account the patterns of adaptation at the stage of preliminary basic training. Insufficient methodological support for correcting the training load based on athletes' individual technical and physiological needs remains a significant problem.

The proposed research allows for the partial elimination of these gaps by comprehensive analysis of effectiveness factors in the bench press, systematization of modern methods of speed-power training, and development of adapted methodology using variable resistance. Due to the combination of theoretical provisions and practical empirical analysis, solutions are proposed to increase the efficiency of the training process in young powerlifters and, at the same time, expand the scientific idea of optimization of strength training in early specialization.

The purpose of the study is to substantiate approaches to optimization of training load to increase the efficiency of bench press in young powerlifters at the stage of preliminary basic training, taking into account modern ideas about the development of special physical qualities and patterns of construction of the training process.

Objective of the study:

1. Analyze the impact of exceptional physical fitness on the effectiveness of the bench press and determine the features of the construction of the training process, considering the age and morphofunctional characteristics of young athletes.

2. Systematize modern means of development of strength and speed-power qualities and identify the main problems of loading loads in bench press training.

3. To substantiate and propose a method of correction of special training using variable resistance at the stage of preliminary basic training.

The study uses theoretical and structural-analytical approaches. The basis of the source base was the generalized materials of the training documentation of young powerlifters (13-18 years old), which specialize in lying, provided for analytical processing.

The following research methods were used to solve these tasks: theoretical analysis of scientific and methodological literature on problems of power training and age-related adaptation of athletes; content analysis and comparative characteristics of different approaches to the construction of training load; systematization of training tools and load modes used in the practice of preparing young athletes; graphoanalytic processing of training schemes and distribution of loads.

The study is based on generalizing typical training models adapted to the preliminary bare training stage to identify effective planning structures, methodological errors and the potential to optimize physical activity.

Results

In the system of many years of training of athletes in strength sports, exceptional physical fitness is considered one of the key factors ensuring high sports results. In powerlifting, in particular, in the exercise of the bench press, it is the level of development of special strength qualities that determines the efficiency of technical performance of competitive movement, the ability to overcome maximum loads, as well as resistance to fatigue in conditions of high intensity of the training process. Special physical training is the final link in the structure of physical fitness, which forms targeted motor qualities by modeling competitive conditions. Its role is especially increased at the stage of preliminary basic training, where the basics of specialized functional adaptation are laid, and the technical and power base of the athlete is formed.

Below is a generalization of key components of exceptional physical fitness in the bench press and their functional role in the system of training of powerlifters (table 1).

Table 1

Components of exceptional physical fitness in the bench press and their functional significance

Component	Characteristics	Functional significance in the bench press
Maximum pectoral muscle strength	Ability to overcome significant resistance due to isometric and concentric work	The main driving force when lifting the barbell in the main effort phase
Triceps strength	Concentrated effort in the final phase of the movement	Completion of the lift, overcoming the «dead point»
Power of the shoulder girdle muscles	Speed-strength characteristics when including muscles large groups	Ensuring dynamics and stability of movement
Strength of stabilizers (scapulae, cortex)	Control of body position, maintaining the arc	Increasing technical efficiency and preventing injuries
Functional muscle endurance	Ability to perform efforts without reducing amplitude and speed	Maintaining the quality of repetitions in series

Source: formed by the author based on [3; 5; 6; 8; 10; 11]

Table 1 systematizes the main components of special physical fitness, which is critical for achieving high efficiency in bench press. Each component performs a specific function in the technical and power exercise process and should be purposefully developed in the training process. The maximum strength of the pectoral muscles is a dominant factor in the phase of the main effort. This group of muscles assumes the main load in the middle of the movement amplitude, where the highest mechanical tension is formed. The triceps' force ensures the movement's completion - overcoming the so-called «dead point», which is often critical for young athletes with insufficiently developed dynamic abilities.

The strength of the shoulder girdle muscles and stabilizers (in particular, the bark and the interplot of the muscles) plays a key role in maintaining the right equipment, fixing the blades and maintaining the power arc position of the trunk on the bench. Insufficient development of these muscles leads to unbalanced equipment, stability loss and movement efficiency reduction [9]. That is why in modern practices, training young powerlifters is recommended to regularly include insulating exercises on stabilizers and tools that improve proprioceptive control.

Functional muscle endurance is significant when performing final series in training or working with subparaxial weights when the risk of reducing performance quality due to fatigue increases. In preparing young athletes, this component is often underestimated, leading to overloading of individual structures and increased risk of injury. Including exercises for the development of local muscular endurance, considering the pace, the amount of repetitions, and time under load ensures the stability of the equipment throughout the training volume.

The preliminary basic training stage is critical in forming a young powerlifter because it is at this stage that preconditions for further specialized training are formed. Considering the age and morpho-functional characteristics of athletes 13-18 years of age allows for adaptation to competitive loads without the risk of natural development. The construction of the training process should be aimed at gradually forming the power base, mastering the technique and developing coordination while maintaining functional equilibrium in the body (table 2).

Table 2

Characteristics of the training process at the stage of preliminary basic training, taking into account age and morphofunctional features

Component of the training process	Character of implementation in young powerlifters	Scientific justification of implementation
Training load	Mainly submaximal (60–85% of the 1RM), limited use of 1–3 RM	Ensuring adaptation to loads without overloading the central nervous system and joints
Frequency of training	3–4 times a week, with alternating accents (press, deadlift, squat)	Maintaining functional reserve and avoiding chronic fatigue
Dominant motor qualities	Strength, speed-strength endurance, coordination	Formation of neuromuscular connections and motor memory
Technical preparation	Teaching the technique of competitive exercises and variable auxiliary exercises	Creating a stereotype-correct movement at the early stage of specialization
Taking into account morphofunctional changes	Measured load on the spine, individual approach to deflections	Taking into account the unstable development of the skeleton and growth zone

Source: formed by the author based on [3; 4; 5; 7; 8]

In the modern practice of preparing young powerlifters, the effectiveness of the training process at this stage depends mainly on the ability of the trainer to combine gradual

specialization with multifaceted development. The results of perennial observations in strength sports show that excessive focus on the growth of results in exercises without the formation of the correct technical paternal and general motor background often leads to chronic overload of specific segments of the body - especially the shoulder joints and lumbar spine. A successful training model at this stage is based on the principles of volume load, cyclicity, and functional variability, considering the neuromuscular apparatus's maturation.

In practice, the alternation of «technical» and «power» days within the microcycle, where work on skills is performed with reduced weight. However, breathing and stabilization are effective in the conditions of maximum concentration at the trajectory. At the same time, a working series with a load of 70-85% of the single repetition maximum (1RM) is aimed at developing structural force without creating excess stress. The frequency of classes 3-4 times a week allows for the maintenance of high-quality exercise, especially if renewable measures are implemented [10]. Under real training conditions, this system contributes to more uniform athlete development and the formation of proper equipment without securing compensatory movements. It also provides a high potential for growth in future results within specialized preparation stages.

The development of strength and speed-power qualities in the bench press is the basic direction of special physical training in powerlifting. Increasing the effectiveness of this exercise is not only due to the increase in maximum force but also to the effective implementation of effort in a limited time to overcome «dead points», stabilization of equipment and optimization of motor coordination. Modern training methods involve many tools that affect synergistic muscles, stabilizers, neuromuscular conductivity, and the ability to activate motor units. It includes the main variants of bench press, auxiliary exercises on individual phases of movement, training with variable resistance, explosive effort, and special tempo and isometric load methods. Variability is the key to adapting the central nervous system and achieving a stable increase in force without overtraining (table 3).

Table 3

Systematization of means and methods for developing strength and speed-strength qualities in the bench press

Method	Characteristics of influence	Purpose of application in the training process
Classical bench press (60–95% of the 1RM)	Basic exercise with a variation of weight, repetitions and approaches	Development of maximum strength, improvement of technique
Press with a pause on the chest	Isometric delay at the bottom point	Overcoming the start phase, trajectory control, reducing inertia
Press with a stop at the «dead point»	Holding the barbell at the level of the weakest point	Activation of the triceps, local increase in strength
Press with chains or elastic bands	Variable resistance, increasing the load during lifting	Development of explosive strength, coordination and adaptation to tension
Tempo lifts (slow eccentric phase)	Controlled negative movement, sometimes with isometrics	Increasing muscular endurance, stabilizing movement
Exercises with dumbbells, narrow grip bench press	Variations for developing synergist muscles	Balancing the development of the pectorals, triceps and stabilizers
Explosive bench press (20–50% of the 1RM)	Maximum speed of movement with lightweight	Increasing speed-strength indicators and speed of effort

Source: formed by the author based on [9; 10; 11; 12; 15]

Thus, in the preparatory period, it is advisable to focus on bench presses with pauses and tempo variants to improve the technique and stabilization. In contrast, in the pre-rinsing period, preference is given to explosive lifting and circuits with chains to stimulate maximum muscle activation. The introduction of variable resistance is efficient for young athletes, as the body allows you to gradually adapt to the growing load in the final lifting phase - exactly where the classic bench press often breaks. The benchmark method with retention at the «dead point» allows you to overcome specific restrictions on the technique without overloading all amplitude [8].

In practical training, such a system allows you to create a functionally diverse and, at the same time, purposeful impact on key mechanisms of force work. The use of auxiliary exercises makes it possible to adapt flexible training for individual morphotypes, technical features, and functional restrictions of the athlete. Combining methods focusing on tempo, strength and speed generates a stable power potential without the risk of overtraining, which is especially important at a young age when the nervous system is most susceptible to multicomponent influence. This approach provides not only the increase in the result but also the quality construction of equipment, which will be stable in the face of competitive stress.

In the training process of powerlifters, one of the key threats to achieving a steady increase in force indicators is irrational planning of volume, intensity and alternation of loads, which leads to the imbalance of adaptation processes and reduces the efficiency of training [12]. The main problem is the absence of a clear systematization of micro- and mesocycles according to the individual level of readiness of the athlete, which causes either a chronic deduction or functional overload [3]. Excessive use of high weights without sufficient adaptive work leads to the depletion of functional reserves of the central nervous system and violation of the technical structure of movement, particularly in the phase of transition from the eccentric to the concentric part of the bench [9; 11]. At the same time, long-term use of low-intensity load without emphasis on maximum effort reduces the potential of explosive force, limits the activation of fast muscle fibers and does not stimulate hormonal mechanisms of force growth [12; 13]. Often, the lack of apparent logic in the alternation of load types, when the need for alternation of force, technical and restorative sessions is not taken into account, leads to the ineffective distribution of energy consumption and the blocking of restorative processes, which becomes an obstacle to super-compensation [5]. It is also problematic to underestimate the influence of individual morphofunctional parameters of the athlete on the recovery speed after lifting of varying intensity [8]. In adolescence, such errors threaten a temporary decrease in the result and disorders of the adaptation mechanism by the cardiovascular, neuroendocrine and musculoskeletal systems [7; 8]. In the conditions of insufficiently adapted technique, this manifests as a decrease in technical stability, unstable dynamics of forceful results, increased repetitions when working with submaximal weights and increased risk of overtraining [15]. Thus, the imperfection of load planning is a systemic restriction for the achievement of sports progress, which requires deep correction of the individual training module, taking into account the phase, the specifics of the impact of different intensity areas and the structure of recovery [12].

The method of correction of special physical training in bench press with the use of variable resistance and speed-power orientation, proposed for young powerlifters at the stage of preliminary basic preparation, is based on the results of the analysis of the dynamics of training load, the functional state of athletes and the efficiency of the traffic. The relevance of this technique is due to the need to increase specific training efficiency without excessive load on the musculoskeletal system and the central nervous system, which is especially important at the age of morphofunctional formation. It aims to increase the effectiveness of the bench press due to the variational targeted impact on the muscle-motor units, the improvement of equipment and the increase of explosive force.

Unlike traditional techniques focused mainly on the gradual weight gain in the basic exercise with fixed amplitude, this technique includes elements of variable resistance (rubber shock absorbers, chains), dynamic alternation of tempo and series at high speed. It is built on the principle of cyclic load variation, including power, high-speed technical and coordination blocks. This approach allows you to form multi-component adaptation and purposefully influence the phases of competitive movement, which is traditionally problematic - the start of the breast and the end in the upper amplitude (table 4).

Table 4

Methodology for correction of special physical training of young powerlifters in bench press

Method component	Content and form of implementation	Expected effect
Means of variable resistance	Bench press with elastic bands or chains in 2 out of 4 weekly training sessions	Increase in explosive strength, overcoming the «dead point», adaptation to increasing resistance
Tempo and pause repetitions	Exercises with pauses on the chest or in the «dead point», slow eccentric phase	Strengthening movement control, isometric strength, trajectory stabilization
Speed-strength sessions	Press with a weight of 40–60% of the 1RM with maximum speed, up to 6 repetitions	Activation of fast motor unit, stimulation of neuromuscular coordination
Variable auxiliary work	Triceps presses, narrow-grip presses with dumbbells, bench presses from an elevated platform	Local correction of weak muscle links, uniform development of muscles
Load control and recovery	Weekly monitoring of heart rate, well-being, subjective readiness	Avoiding overload, adapting the program to the athlete's condition

Source: author's development

In the practical training of young powerlifters, this technique can significantly increase the individuality of load due to the regulation of the resistance during the lift phase, which is not realized in the traditional bench. Variable resistance tools activate additional stabilizing muscles, train speed and amplitude control, and cause more purposeful adaptation close to the competition. Temporal exercises with pauses allow you to adjust the equipment, prevent inertial «rebound», and facilitate the formation of a stable pattern. The use of high-speed lifts activates the central nervous system. It develops the speed of recruitment of motor units, which is critically important against the background of slow development of pure maximum strength in adolescence.

The technique also involves introducing a self-control system - daily or weekly pulse measurements at rest and assessment of the subjective state on a readiness scale, which allows the adjustment of the volume and intensity by the athlete's functional state. This approach provides better adaptation, minimizes the risk of overtraining and contributes to long-term progress without reducing technical efficiency. Implementing this technique is expected to grow the benchmark, improve motor control, strengthen the musculoskeletal system, and increase the overall level of special readiness within the youth stage of long-term training.

Conclusions

The study found that exceptional physical fitness is a key factor in increasing effectiveness in bench press among young powerlifters. Individualized training programs considering athletes' morphofunctional features at the preliminary bare training stage are the most effective. It is determined that using variational means of force development, particularly

variable resistance, allows the influence of the weak links of technology and promotes the formation of explosive force.

The main problems identified are the irrational combination of volume and intensity of loads, insufficient individualization of the training process, and technical instability in the key phases of movement and transfer to the musculoskeletal system. It reduces adaptive capabilities and limits sports progress.

The developed technique for correcting special training using variable resistance tools has demonstrated high efficiency in improving equipment and increasing strength. It provides adaptive load within the permissible biomechanical and physiological boundaries, which is especially important in adolescence.

The prospects for further research are to create models of load based on individual biomechanical profiles, study neuromuscular reactions to variable resistance and the introduction of biofeedback technologies for real-time correction.

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