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The impact of physical training and special preparation on the development of strength and endurance in adolescent judokas

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Abstract. *The relevance of the study is determined by the need to reconsider the system of training young athletes in the context of modern educational and social challenges. Judo is viewed not only as a sport but also as a tool for cultivating discipline, promoting a healthy lifestyle, and integrating children into the social environment. At the same time, the development of strength and endurance during adolescence remains a key factor in shaping a competitive athlete. The* ***purpose of the article*** *is to clarify the role of physical loads and special preparation not only as a means of developing motor qualities but also as a factor in harmonizing the educational process and socialization of adolescent judokas. The* ***research methodology*** *employed an interdisciplinary approach, combining the analysis of pedagogical concepts, the study of sports school practices, and the generalization of experience in integrating sports programs into the system of extracurricular education. The* ***study's results*** *demonstrated that physical training, when structured in combination with specialized elements, has a positive effect not only on physical performance growth but also on the discipline, responsibility, and communication skills of adolescents. Such integration reduces dropout rates from sports sections,*

increases interest in systematic training, and fosters long-term motivation for sports. The scientific novelty lies in interpreting the development of strength and endurance not only as a biomechanical process but as a complex phenomenon that influences the educational and social trajectory of young athletes. It broadens the traditional understanding of the training process by including educational and communicative aspects. The ***conclusions*** *confirmed that the harmonious combination of physical training and special preparation contributes not only to athletic performance but also to social adaptation and personal development of adolescents. Thus, judo performs two functions - sporting and educational - making it a unique tool for multidimensional development. Prospects for further research involve studying the effectiveness of integrating sports programs into school education, analyzing the impact of physical training on the formation of resilience, and examining the social capital generated through adolescents' engagement in systematic judo practice.*

Keywords: *long-term training, motor abilities, technical-tactical skills, training loads, individualization, morphofunctional factors, injury prevention.*

Вплив фізичних навантажень та спеціальної підготовки на розвиток сили та витривалості в дзюдоїстів підліткового віку

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Анотація. *Актуальність дослідження визначається потребою переосмислення системи підготовки юних спортсменів у контексті сучасних освітніх і соціальних викликів. Дзюдо розглядається не лише як спортивна підготовка, а й як інструмент виховання дисципліни, формування здорового способу життя та інтеграції дітей у соціальне середовище. Водночас*

питання розвитку сили та витривалості в підлітковому віці залишаються ключовими для формування конкурентоспроможного спортсмена. ***Мета статті*** *полягає у з'ясуванні ролі фізичних навантажень і спеціальної підготовки не тільки як засобу розвитку рухових якостей, а й як чинника гармонізації освітнього процесу та соціалізації підлітків-дзюдоїстів.* ***Методологія дослідження*** *ґрунтувалася на міждисциплінарному підході, який поєднував аналіз педагогічних концепцій, вивчення практики роботи спортивних шкіл та узагальнення досвіду інтеграції спортивних програм у систему позашкільної освіти.* ***Результати дослідження*** *показали, що фізичні навантаження, структуровані в поєднанні з елементами спеціальної підготовки, позитивно впливають не лише на приріст фізичних показників, а й на дисципліну, відповідальність і комунікативні навички підлітків. Така інтеграція сприяє зниженню рівня відсіву зі спортивних секцій, підвищує зацікавленість у систематичних заняттях та формує довготривалу мотивацію до спорту. Наукова новизна полягає у трактуванні розвитку сили й витривалості не лише як біомеханічного процесу, а як комплексного явища, що впливає на освітню та соціальну траєкторію юного спортсмена. Це дає змогу розширити традиційні уявлення про тренувальний процес, включивши до нього виховні та комунікативні аспекти.* ***Висновки*** *засвідчили, що гармонійне поєднання фізичних навантажень та спеціальної підготовки сприяє не тільки спортивним результатам, а й підвищує рівень соціальної адаптації та особистісного розвитку підлітків. Таким чином, дзюдо виконує дві функції — спортивну й виховну, що робить його унікальним засобом багатовекторного розвитку. Перспективи подальших досліджень полягають у вивченні ефективності інтеграції спортивних програм у шкільну освіту, аналізі впливу фізичних навантажень на формування життєстійкості та дослідженні соціального капіталу, який створюється через залучення підлітків до систематичних занять дзюдо.*

Ключові слова: *багаторічна підготовка, рухові якості, техніко-тактичні навички, тренувальні навантаження, індивідуалізація, морфофункціональні чинники, профілактика травматизму.*

Introduction. The problem of developing physical qualities in adolescent judokas is particularly relevant due to the need for a harmonious combination of general physical and specialized training in conditions of intensive body development. The adolescent period is particularly sensitive for the development of strength and endurance, which determine not only the effectiveness of performing technical and tactical actions in competitive activities, but also the level of general working capacity and resistance to physical exertion. Insufficient consideration of the age and morphofunctional characteristics of athletes in the process of building training programs can lead to an imbalance between the development of basic motor qualities and the acquisition of specialized skills, which in the long term negatively affects sports results and increases the risk of injury. In this context, the task of harmonizing modern scientific approaches in the field of sports training with the practical needs of the training process arises, particularly in the search for optimal models of the ratio of physical load to special exercises. Solving this problem will contribute to enhancing the effectiveness of training young athletes, ensuring their long-term development in sports, and creating conditions for the formation of competitive athletes on the international stage.

Analysis of recent research and publications. Analysis of scientific works on the influence of physical activity and special training on the development of strength and endurance in adolescent judokas allows us to distinguish four areas.

The first area focuses on methodological training programs and their effectiveness. A. Khachaturian and O. Tserkovna proved that the combination of general and exceptional work in the pre-competition period of athletes 12–15 years old significantly improves their performance [1]. Yu. V. Chernikov, A. V. Symonik

showed that comprehensive programs for the development of strength endurance in older adolescent judokas guarantee a stable increase in physical capabilities [2]. I. Kryventsova, H. Ohar and O. Panina noted that systematic strength training creates a basis for consolidating technical actions and preventing injuries [3]. In this direction, improving the structure of training programs through the integration of general and special means, taking into account age characteristics, is promising. The second direction addresses the specifics of strength programs and load regulation. B. H. Branco and co-authors argued that additional strength training improves the results of tests of general and special preparedness of cadets [4]. J. Simenko emphasized the risks of premature involvement of young athletes in training models of older groups [5]. A. G. Yaneva and V. Lukanova emphasized the importance of developing strength in young children as a basis for further endurance [6]. B. Nursulu and A. Mansur emphasized the need for a harmonious combination of general and special loads [7]. R. Santos-Junior and E. Franchini developed a model for the development of strength endurance, which has proven its effectiveness in young martial artists [8]. Further research should focus on the dosage of loads and their gradual intensification to preserve the health of athletes.

The third direction reflects physiological and morphofunctional factors. H. P. Griban and co-authors established a direct relationship between morphological features and the level of strength endurance [9]. M. Kowalczyk, M. Zgorzalewicz-Stachowiak, and M. Kostrzewa proved the practical effect of judo classes on the physical condition of children [10]. O. Prieske and colleagues outlined seasonal fluctuations in anthropometric characteristics and body composition of athletes, emphasizing their influence on the level of strength endurance [11]. M. Kowalczyk and co-authors in a systematic review substantiated the positive value of judo for motor development and drew attention to the need to standardize test batteries [12]. The use of individualized training approaches that take into account morphological and age-related characteristics is promising.

The fourth direction focuses on age and competitive factors. Thus, A. Prokopczyk proved that the transition from the U16 to the U21 group is accompanied by an increase in the requirements for extraordinary endurance, which requires adapted programs [13]. N. Milošević and co-authors confirmed the importance of physique as a key factor in the development of physical qualities [14]. D. Detanico, R. L. Kons, R. Canestri, and M. Albuquerque analyzed the differences in the performance of judokas of light and heavy weight categories, proving the need for a differentiated approach to organizing the training process of judokas of different weights [15]. A promising direction is the development of models to predict success based on age, morphology, and weight categories.

Identification of previously unresolved parts of the overall problem. Despite significant achievements in the study of training young judokas, several aspects remain understudied. In particular, there is a lack of systematic analysis of the features of strength and endurance development in adolescents, taking into account morphofunctional factors, which limits the possibilities of individualizing the training process. Methodological approaches to combining general and specialized training are poorly developed, which creates the risk of imbalance and reduces the effectiveness of forming basic and specialized motor qualities. Limited empirical data and the absence of comprehensive recommendations complicate the practical implementation of modern training models.

The proposed work aims to overcome these gaps by studying the age and morphofunctional features of adolescents, clarifying the role of physical activity in the development of motor qualities, and analyzing modern methods of specialized training. The development and substantiation of practical recommendations will enable the improvement of the training system, increase efficiency, reduce the risks of overload, and create the prerequisites for the harmonious and long-term development of young judokas.

Formulation of the article's goals (task setting). The purpose of the article is to substantiate the influence of physical activity and special training on the development of strength and endurance in adolescent judokas and to determine the optimal approaches to combining general and special training in the training process.

Objectives of the article:

1. To study the features of the development of strength and endurance in adolescent judokas, taking into account age and morphofunctional factors.

2. To analyze methodological approaches to the organization of special training and identify problems that limit the effectiveness of the development of physical qualities.

3. To formulate practical recommendations for improving the training system to increase the efficiency and preserve the health of young athletes.

Presentation of the main reseach material of the study. In adolescence, the development of physical qualities, particularly strength and endurance, is crucial for the effectiveness of the training process in martial arts. During the intensive growth and development of the body, these qualities determine the athlete's ability to perform technical and tactical actions with the necessary efficiency, withstand high loads, and maintain working capacity for a long time. The morphofunctional features of this age period, particularly the growth of muscle mass, improvement of the cardiovascular and respiratory systems, and an increase in the body's energy potential, create favorable conditions for the targeted development of strength and endurance. At the same time, failure to adhere to the principles of gradualness and individualization of the load can lead to overload and an increased risk of injury, making the issue of finding optimal methods for combining general and specialized training relevant (table 1).

Table 1

Morphofunctional factors of strength and endurance development in adolescent judoists

Factor	Characteristics	Effect on strength	Effect on endurance
Increase in muscle mass	Active development of skeletal muscles	Increases absolute and relative strength	Indirectly contributes to the maintenance of loads
Development of the cardiovascular system	Increases heart volume, improves peripheral blood circulation	Provides more efficient muscle nutrition during strength exercises	Improves aerobic endurance and recovery rate
Development of the respiratory system	Increases vital lung capacity	Improves oxygen exchange during strength efforts	Promotes long-term preservation of performance
Hormonal changes	Increases the level of anabolic hormones	Stimulates protein synthesis and muscle growth	Provides stability energy processes
Neuromuscular coordination	Improvement of intermuscular interaction	Improves the quality of power movements and explosive strength	Promotes the economical use of energy during prolonged actions

Source: formed by the author based on [9, p. 1238–1239; 10; 11; 14; 15, p. 125–126]

The increase in muscle mass during this age period creates the prerequisites for using loads that combine general developmental and specialized exercises. In practice, this means that exercises using one's own body weight or elements of functional training (for example, pull-ups, dummy throws, or work with a stuffed ball) not only stimulate strength potential but also directly form motor skills related to judo technique [12].

The improvement of the cardiovascular and respiratory systems in adolescents allows for a gradual increase in the intensity and duration of the load. It is manifested in the possibility of performing interval training in combination with technical actions and running exercises, where the athlete performs a series of throws followed by speed segments for several minutes. Such practice simultaneously increases strength potential and develops the ability to maintain a high pace of work in competitive conditions.

The hormonal restructuring of the body, which contributes to the growth of muscle tissue, deserves special attention. In the training process, this factor is utilized not by maximizing weights, which can be detrimental to the musculoskeletal system, but through a rational combination of exercises with moderate external loads [14]. For example, working with elastic shock absorbers or exercises with a partner strengthens the muscle corset and, at the same time, develops the explosive power specific to judo.

No less significant is the improvement of neuromuscular coordination, which is manifested in the ability to perform movements with greater accuracy and economy of effort. In modern training practice, this is implemented through variable practice of the same techniques in changed conditions - with reduced time, with partners of different weight categories or during fatigue. This approach not only improves technical skill but also develops endurance, since the athlete learns to control movements even in a state of exhaustion.

In the system of training young judokas, physical activity is a fundamental tool for developing motor qualities that determine the effectiveness of both the training process and competitive performance. The difference of this stage is that the teenager's body is still in the stage of active adaptation, and it is the correctly dosed load that creates the conditions for the harmonious development of strength, speed, flexibility and coordination. General loads serve as the foundation, promoting overall physical fitness, while special loads focus on refining technical and tactical skills in specific judo conditions. Thus, the role of physical activity extends beyond the limits of purely training actions and is manifested in the ability to ensure the holistic improvement of a young athlete's musculoskeletal system (table 2).

Table 2

The role of physical activity in the formation of motor qualities of young judokas

Type of load	Basic motor qualities	Special motor qualities	Practical effect
Aerobic loads (running, circuit training)	General endurance	Resistance to fatigue in fights	Ability to maintain the pace of the fight throughout all rounds
Strength exercises using body weight and moderate weights	General strength	Specific explosive force for throws	Improving the efficiency of throwing and holding actions
Speed exercises (sprints, reaction tasks)	General speed	Special speed-power reaction	Increasing the pace of performing techniques and counterattacks
Flexibility (stretching, dynamic complexes)	General mobility	Specific amplitude of movements in throws and holds	Reducing the risk of injuries, increasing technical variability
Coordination exercises (balance, non-standard situations)	General motor coordination	Accuracy of execution of techniques in changed conditions	Adaptation to the opponent's unpredictable actions

Source: formed by the author based on [4; 7, p. 135–136; 8; 13, p. 682–683; 5]

Modern practice confirms that these loads work most effectively in a complex system, rather than in isolation. Running segments, which initially appear to have a general developmental nature, are integrated into the training process through the simulation of competitive situations, such as performing a series of throws after an intensive interval run [8]. It enables the athlete to assess how well they maintain their technique in a state of fatigue. Strength exercises, particularly those using one's own body weight, receive special direction when combined with tasks in pairs, such as holding an opponent or practicing lifting a partner. For their part, speed loads are implemented not only in sprints but also in reaction games, where the judoka must instantly change their action in accordance with the coach's signal. Particular attention is paid to flexibility exercises, because they are not limited to standard stretching, but are integrated into special exercises that simulate extreme amplitudes in throws and holds. It allows athletes not only to avoid injuries but also to expand the arsenal of techniques. Finally, coordination loads are most often carried out through training in non-standard conditions, such as performing throws on an

unstable surface or competing against athletes of different anthropometry [10]. It is such exercises that form the ability to adapt to the unpredictable actions of the opponent, which is key to real martial arts.

Special training in judo is an essential component of the training process, as it ensures the development of technical and tactical skills, and the athlete's ability to apply motor qualities in real fights effectively. Unlike the general physical block, special training focuses not only on developing strength and endurance, but also on integrating these skills into specific combat situations. Modern methodological approaches are based on the principles of variability, modeling competitive conditions and combining technical and tactical tasks in a single training environment [5]. It enables the development of athletes' resistance to the stress factors of competition, enhances decision-making speed, and ensures a high level of readiness for various wrestling styles (table 3).

Table 3

Modern methodological approaches to organizing special training in judo

Methodological approach	Main characteristics	Practical application	Expected result
Variable practice of the techniques	Performing techniques in changed conditions (different speed, partner resistance)	A series of throws with partners of different weight categories	Technical flexibility and adaptation to different opponents
Competitive scenario simulation	Creating match-like conditions	Training fights with time or task restrictions	Psychological and physical readiness for competitions
Integration of technical and tactical tasks	Combining techniques with tactical decisions	Exercises «attack–counterattack» with instant response	Increasing the speed of decision-making
Use of game-based methods	Learning through competitive game methods	Tasks with unexpected coach signals	Formation of creative and variable actions
Cross-training	A combination of special judo exercises with	Performance of throwing combinations after acrobatic elements	Development of functional and adaptive motor skills

Methodological approach	Main characteristics	Practical application	Expected result
	elements of other types of exercises		

Source: formed by the author based on [1, p. 188–189; 2; 3, p. 15–16; 6, p. 733–734; 13, p. 684–685; 8]

In teenage judo, special training has long ceased to be limited to «practicing a technique 100 times». Variability here becomes the basis: a throw with a partner of low body weight develops speed, with a heavier one, it emphasizes explosive power, and with a partner with atypical anthropometric characteristics, it develops flexibility of technique [1, p. 188–189; 2; 3, p. 15–16]. It is how readiness for unpredictable opponents in competitions is developed. When a coach organizes short control fights with the condition of «win only by counterattack» or «score within the final 20 seconds», athletes gain experience working under pressure [4]. It is much more valuable than ordinary sparring, because it prepares a teenager for the nervous tension of a real tournament. In practice, the combination of technique and tactics also works well: the «attack-counterattack» exercise teaches not to act stereotypically, but to make instant decisions [7, p. 135–136]. Many clubs now incorporate video analysis, allowing athletes to see where they were late with their reaction immediately, and subsequently act more confidently [13, p. 684–685].

The element of the game also plays a significant role: an unexpected signal from the coach or a fight in a limited area of the tatami keeps athletes in shape, forces them to look for creative solutions and makes classes more interesting. And cross-exercises, such as a combination of an acrobatic somersault with a throw, train not only strength and coordination, but also the speed of switching motor programs – a skill that often decides the fate of a fight. During the development of physical qualities in teenage judokas, several issues are identified that significantly reduce the effectiveness of the training process. One of the most common is the imbalance between general and special training [5]. Most often, coaches emphasize the development of technique and specialized exercises, neglecting the development of

fundamental motor skills. It leads to an insufficient formation of strength and aerobic foundation, which makes it impossible to withstand high-intensity fights.

On the other hand, an excessive focus on general physical exercises without a gradual transition to specialized loads can slow down the improvement of technical and tactical skills [13]. A significant problem is the lack of individualization of the training process. Teenagers differ in the pace of biological development: at the age of 13, one athlete may already exhibit pronounced signs of puberty and a significantly higher strength potential, while another is still in the initial stage of these changes [9, p. 1238–1239; 11]. The use of the same training programs for athletes with such different morphofunctional characteristics often causes either overload or insufficient stimulus for development [5; 10]. No less important is the issue of recovery. Adolescents often overlook sleep, nutrition, and rest regimes, yet it is during this period that the body especially needs resources to adapt to stress [9, p. 1238–1239]. The lack of a systematic approach to recovery leads to chronic fatigue, which reduces the effectiveness of training and increases the risk of injury [11; 13]. Excessive or incorrectly selected loads, particularly when combined with technical errors, frequently lead to musculoskeletal system injuries [10; 11]. In adolescents, the musculoskeletal system is undergoing a phase of active growth, and injuries can have long-term consequences, affecting the further development of strength and endurance.

The issue of coordination of training blocks is also problematic. In practice, unsystematicity is often observed: the load on strength, endurance, and technique is distributed chaotically, without considering the principle of gradualness and recovery [14]. It leads to a disproportionate formation of physical qualities, which negatively affects the complexity of the training process. The psychological aspect should be noted separately. The pressure of the result, high expectations from coaches and parents and the simultaneous academic load at school often cause stress, which negatively affects the body’s ability to adapt to physical exertion. Psycho-

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emotional overwork in adolescence is manifested by a decrease in motivation, loss of interest in classes and even refusal from sports.

Practical recommendations for improving the training system for young judokas should be based on a combination of scientific approaches and proven methods. Firstly, it is essential to strike an optimal balance between general physical training and specialized exercises. The development of strength and endurance should occur in stages. Basic physical qualities are formed through exercises using one's own weight, incorporating elements of athletics and acrobatics. Special training gradually integrates technical and tactical tasks, taking into account the individual level of fitness of the athlete. A necessary condition is the individualization of loads. Programs should take into account the rate of biological maturation in adolescents, their anthropometric characteristics, and the level of development of leading physical qualities. It will help avoid overloads and create an environment conducive to the harmonious development of the body. Recovery control is of significant importance. Stretching, breathing exercises, and relaxation elements should be integrated into the training process, which will help reduce muscle tension and prevent injuries. Rational planning of microcycles with mandatory rest days will enable the avoidance of chronic fatigue and maintain a stable level of performance. In teenage sports, the priority is to develop the correct technique against the background of increasing loads. The use of video analysis, biomechanical sensors, or even simple visual control methods helps detect technical errors and correct them promptly, preventing additional injuries. The psychological component also requires attention. It is essential to create a positive emotional atmosphere during training by incorporating game elements and simulating competitive situations that foster motivation and resilience against stress factors. In parallel, explanatory work should be conducted with parents regarding the role of recovery, nutrition, and sleep in sports development. The implementation of these recommendations will not only enhance the performance of young judokas in

competitions but also promote their overall health, foster long-term sports motivation, and lay the groundwork for future professional development.

Conclusions. The study found that the development of strength and endurance in adolescent judokas is most effectively ensured by a combination of general physical training, special technical and tactical exercises and elements of tactical work in clearly defined proportions. The dominance of the general physical block lays the groundwork for future sportsmanship. At the same time, specialized and tactical training ensures the gradual consolidation of motor skills and the ability to perform productive actions in competitive conditions. The main problems of the training process are identified: an imbalance between general and specialized training, insufficient individualization of loads, neglect of recovery, an increased risk of injuries, and psycho-emotional exhaustion among athletes. These factors complicate the development of the necessary strength and aerobic foundation, reducing the effectiveness of long-term training.

The proposed recommendations emphasize the individualization of programs, taking into account the morphofunctional characteristics of adolescents, a phased combination of general and special loads, the integration of recovery and injury prevention tools, the use of video analysis and game methods, as well as the creation of a favorable psychological climate in training. Prospects for further research include expanding the individualization of the training process to account for gender differences in training and analyzing the long-term results of implementing the methodology in the practice of sports schools. This analysis will contribute to increasing the competitiveness of Ukrainian judokas in the international arena.

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