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Methodology of initial training of young volleyball players aged 9-10 Based on the use of biomimetic exercises

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Abstract

Background and purpose

At the current stage of volleyball development, special attention is paid to the initial training of young athletes, as the 9–10 age group is considered a sensitive period for developing coordination, speed, speed-strength abilities and flexibility. The objective is to develop and experimentally substantiate a methodology for the initial training of young volleyball players aged 9–10, using biomimetic exercises to improve the effectiveness of the training process.

Material and methods

The study was conducted at the Children's and Youth Sports School No. 12 of the Kharkiv City Council with the participation of 16 young volleyball players aged 9-10, divided into a control group (n=8) and an experimental group (n=8). The control group was instructed using traditional teaching methods, which were recommended by the volleyball training programme for youth sports schools. The experimental group was given a methodology that had been specially developed, involving biomimetic exercises. These were integrated into the preparatory, main, and final parts of the training sessions. Research methods: It is recommended that the following methods be considered: analysis of scientific and methodological literature, pedagogical observation, pedagogical experiment, pedagogical testing, and methods of mathematical statistics.

Results

A comparative analysis of the rates of improvement demonstrated that the experimental group exhibited higher rates of motor performance enhancement in comparison to the control group. The experimental technique, which integrated biomimetic exercises into training combinations with technical elements of volleyball, provided a statistically significant improvement in most indicators of technical preparedness of young volleyball players aged 9–10 years compared to the traditional technique of technical training.

Conclusions

The methodology developed for the initial training of young volleyball players aged 9-10 using biomimetic exercises has been shown to be effective in the development of motor skills and the mastery of technical skills. It has been demonstrated that this approach contributes to a more dynamic increase in physical fitness indicators, increased motivation, and more effective mastery of basic technical and tactical game techniques when compared to traditional methods. The results obtained confirm the feasibility of using a biomimetic approach in the training process of young volleyball players.

Keywords

volleyball, young athletes, biomimetic exercises, technical training and motor skills.

Анотація

Ігор Гринченко, Денис Філяєв. Анатолій Денисовець, Олена Пантус, Сергій Колій. Методика початкової підготовки юних волейболістів 9-10 років на основі застосування біоміметичних вправ

Обґрунтування і мета

На сучасному етапі розвитку волейболу особливу увагу приділено початковій підготовці юних спортсменів, оскільки вік 9-10 років є сенситивним періодом для розвитку координаційних, швидкісних, швидкісно-силових здібностей та гнучкості. Мета: розробити та експериментально обґрунтувати методику початкової підготовки юних волейболістів 9-10 років із застосуванням біоміметичних вправ для підвищення ефективності навчально-тренувального процесу.

Матеріал і методи

Дослідження проводилося на базі КЗ «КДЮСШ №12 ХМР» за участю 16 юних волейболістів 9-10 років, розподілених на контрольну (n=8) та експериментальну (n=8) групи. У контрольній групі застосовувалися традиційні методи навчання техніки гри, рекомендовані навчальною програмою з волейболу для ДЮСШ. В експериментальній групі використовувалася спеціально розроблена методика із застосуванням біоміметичних вправ, які інтегрувалися в підготовчу, основну та завершальну частини тренувань. Методи дослідження: аналіз науково-методичної літератури, педагогічне спостереження, педагогічний експеримент, педагогічне тестування, методи математичної статистики.

Результати

Покращення в експериментальній групі мали тенденцію до більшої вираженості, проте ці відмінності за усіма тестами не досягли рівня статистичної значущості ($p>0,05$). При порівняльному аналізі темпів приросту було виявлено, що в експериментальній групі темпи покращення рухових показників були вищими, ніж у контрольній. Експериментальна методика, що інтегрувала біоміметичні вправи у тренувальні комбінації з технічними елементами волейболу, забезпечила статистично значуще покращення більшості показників технічної підготовленості юних волейболістів вікової групи 9–10 років порівняно з традиційною методикою технічної підготовки

Висновки

Розроблена методика початкової підготовки юних волейболістів 9-10 років із застосуванням біоміметичних вправ є ефективною для розвитку рухових здібностей і опанування технічних навичок. Вона сприяє більш динамічному приросту показників фізичної підготовленості, підвищенню мотивації та ефективності засвоєння базових техніко-тактичних прийомів гри порівняно з традиційними методами. Отримані результати підтверджують доцільність використання біоміметичних вправ у навчально-тренувальному процесі юних волейболістів.

Ключові слова

волейбол, юні спортсмени, біоміметичні вправи, технічна підготовка, рухові здібності

Introduction

Volleyball is a popular sport that requires athletes to have a high level of physical fitness, technical skills and tactical thinking. The initial training stage is of particular importance, as it establishes the foundations for future sporting improvement. In this context, the problem of identifying effective methods for teaching and training young volleyball players is of the utmost importance.

A review of the scientific and methodological literature indicates the importance of taking age-sensitive periods into account in the training of young athletes. The developmental stage of 9-10 years is characterised by the acquisition of key competencies, including enhanced coordination, speed, speed-strength abilities, and flexibility. Furthermore, recent studies [1–4]. have emphasised the significant impact of physical activity on the neurocognitive development of children, in particular on neuroplasticity and the formation of new neural connections.

Conventional training methodologies predominantly emphasise the discrete cultivation of physical attributes and technical competencies. However, an integrated approach that combines these components into a single training process has recently become increasingly popular) [5–8].

In view of the aforementioned points, the utilisation of biomimetic exercises, which emulate the natural movements of animals, is a particularly salient area of interest. It has been demonstrated that the execution of these exercises has a beneficial effect on the development of physical qualities in young athletes. Furthermore, research has shown that these exercises also have a positive effect on the motivation, emotional involvement, adaptive abilities and cognitive functions of young athletes.

The relevance of this study is determined by the necessity to develop and scientifically substantiate an effective methodology for the initial training of young volleyball players aged 9-10, combining the development of physical qualities and the mastery of technical skills based on the use of biomimetic exercises. Such an approach, taking into account the age characteristics, physiological mechanisms and psychological needs of children, will contribute to the optimisation of the training process and increase its effectiveness.

Material and Methods

Participants

The present study was conducted at the Children's and Youth Sports School No. 12 of the Kharkiv City Council. The present study was conducted on a sample of sixteen pupils, aged between nine and ten, who were enrolled in the beginner training group. Training sessions were held on three occasions per week.

The following research methods were utilised to achieve the set goal: analysis of scientific and methodological literature, pedagogical observation, pedagogical experiment, pedagogical testing, and methods of mathematical statistics.

In order to implement the research tasks, two groups were formed at the Children's and Youth Sports School No. 12 of the Kharkiv City Council – a control group and an experimental group – from among the pupils of the initial training group. Each group comprised eight individuals. The groups were formed by random sampling, based on age criteria and the available list of children in the specified beginner training group.

The training programme for the control group was based on conventional methods, forms and means of developing motor skills and mastering technical and tactical game techniques recommended by the volleyball training programme for youth sports [9].

A bespoke set of biomimetic exercises was developed for the experimental group, which were applied in stages: first in the preparatory part of the training, then in the final part, and later they were combined with exercises for mastering the technique of the game in the main part of the training session. In order to test the developed methodology, a pedagogical experiment was conducted.

Testing was conducted at the commencement and conclusion of the experiment (October 2024 – May 2025). The standard test programme for the initial training group in the 1st-3rd years of study was taken as a basis [9].

Ethical committee statement

The Ethics Committee of H.S. Skovoroda Kharkiv National Pedagogical University was granted approval to conduct this research, as it is in accordance with the Declaration of Helsinki of the World Medical Association - ethical principles of medical research involving human subjects (No. KhNPU/PhES/EC/1/2/2023.

Method of analysis of literary sources

A review of the scientific and methodological literature on optimising the training process for 9–10 year-old volleyball players was conducted. This finding serves to underscore the significance of sensitive periods in childhood for the development of fundamental physical qualities, including coordination, speed, speed-strength, and flexibility. Furthermore, it highlights the neurophysiological mechanisms through which physical activity exerts its impact on the brain. Furthermore, analogies were drawn between animal movements and technical volleyball skills, and the effectiveness of biomimetic exercises in developing physical qualities, cognitive functions, motivation and adaptive abilities was noted. The significance of a training structure that fosters physiological soundness to prevent overtraining and ensure the harmonious development of young athletes was also emphasised.

This analysis of scientific and methodological literature underscores the significance of a scientifically robust approach to the development of training methods for young athletes. Such an approach must consider the age-related characteristics of athletes, as well as their physiological and psychological needs.

Methodology of Measurements and Assessment

Tests were conducted at the beginning (October 2024) and at the end (May 2025) of the experiment to objectively assess the dynamics of motor skills development and technical preparedness levels of the studied groups. Test procedures adhered to the normative requirements of the Training Programme for Children's and Youth Sports Schools.

Assessment of Motor Skills Development

The following tests were utilized to determine the level of motor skills development:

30-meter sprint from a high start: Participants performed a timed sprint from a high start over a distance of 30 meters. Time was recorded with an accuracy of 0.01 s. The best of two attempts was recorded.

5-minute run: The test was conducted for 5 minutes. The maximum distance covered by the participant within the allotted time was measured in meters.

92-meter «Herringbone» Run: This test assessed a complex manifestation of speed-strength and coordination abilities. The participant started from a high start at the center of the front line (marked by a 40 cm diameter circle, denoted by figure 7 in the diagram – the start and finish point). The task involved rapidly moving sequentially to each medicine ball (located along the course), touching one with one hand, and then instantly returning to the starting position (stepping over or onto the starting line) after each reverse run. An attempt was considered successful if the participant touched all balls and, after each reverse run, stepped over (or onto) the starting line. The test was performed twice with full recovery between attempts. The best result was recorded in seconds (with an accuracy of 0.1 s).

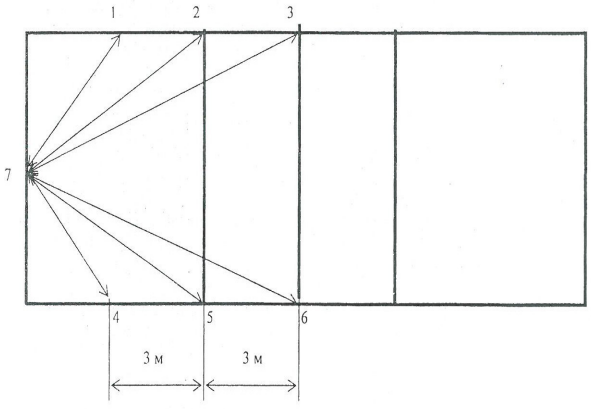

Fig. 1. Herringbone Run" Test Diagram for Volleyball Players (Arrows indicate the sequential running direction to designated points)

3x10m Shuttle Run: Participants performed a run over a 10-meter distance with three changes of direction (touching a line or object). Time was recorded with an accuracy of

0.1 s. The best of two attempts was recorded.

6x5m Shuttle Run: Participants performed a run over a 5-meter distance with six changes of direction. Time was recorded with an accuracy of 0.1 s. The best of two attempts was recorded.

Standing Vertical Jump: This test assessed the explosive power of the lower limb muscles, utilizing an Abalakov device to determine the height of the overall center of gravity lift during the jump. Standing with the entire foot on the ground, the participant extended one arm upwards to fix the initial reach height (the mark touched by the fingertips on the device's scale). A vertical jump was then performed, initiated by a push-off with both feet from a preliminary squat with an arm swing. At the highest point of the jump, a mark was registered on the device's indicators. Jump height was calculated as the difference between the highest point reached and the initial reach height. Take-off and landing were to be executed within a 50x50 cm square. Two attempts were given, and the best result was recorded in centimeters.

Running Vertical Jump: This test assessed the height of a vertical jump with an approach run. Measurement was conducted using specialized equipment known as the "Slanted Screen" (Figure 2.), which features marked height levels and a target for hand contact. The participant performed a jump with a 2-3 step approach run, pushing off with both feet and an arm swing. The test result was defined as the difference between the height mark recorded in a standing position (with an arm raised upwards) and the height mark left by the participant at the highest point of the jump. The best result from two attempts was recorded in centimeters.

Standing Long Jump: Participants performed a long jump from a standing position, pushing off with both feet. The distance from the take-off line to the nearest imprint of the participant's body part (usually heels) was measured in centimeters. The best of three attempts was recorded.

Pull-ups on horizontal bar: Participants performed pull-ups from a hang on a horizontal bar until the chin was above the bar. The total number of correctly performed pull-ups was recorded.

Medicine ball throw (1 kg) overhead from standing: The participant stood on a line, throwing a 1 kg medicine ball with both hands from behind the head. The throwing distance from the line was measured in centimeters. The best of three attempts was recorded.

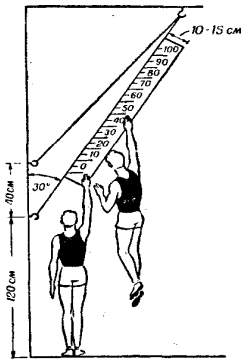

Fig. 2. Equipment for Measuring Running Vertical Jump Height

Assessment of Volleyball Technical Preparedness

To evaluate the level of technical preparedness of volleyball players in initial training groups, the following tests were employed:

- **Overhead Two-Hand Set Accuracy**: The participant performed 10 attempts of an overhead two-hand set, aiming for a zone near the net (3-3.5 m long, 3-4 m high). The number of accurate sets was assessed.
- **Overhead Two-Hand Set Accuracy Through a Hoop**: The participant performed 10 attempts of an overhead two-hand set through a hoop, positioned near the volleyball net at a height of 30-40 cm above it, from a specified zone to a target zone (4-4.5 m). The number of successful hits was assessed.
- **Jump Set Execution (Overhead Two-Hand)**: The participant performed 5 attempts of an overhead two-hand set while jumping, aiming for a length of 3-4 m and a height of 1-2 m. The number of successful sets was assessed.
- **Underhand Two-Hand Pass Accuracy (in pairs)**: Two participants stood 4-5 m apart. They performed 8-10 underhand two-hand

passes, aiming to maintain a height of 1-2 m. The number of accurate passes within the pair was assessed.

- **Forearm Pass Reception Accuracy from a Targeted Serve**: The participant performed 5 attempts of an underhand two-hand reception after a targeted serve (from a coach/partner). The ball was to be directed towards the net (1.5 m from the net) at a height up to 3 m. The number of successful receptions was assessed.
- **Serve Accuracy**: The participant performed serves, aiming for four 3x3 m zones: right, left, near, and far parts of the court (2 attempts per zone). The number of accurate serves into the designated zones of the volleyball court was assessed.

Intervention Technology

Methodology for Applying Biomimetic Exercises in the Training Process of Young Volleyball Players Aged 9-10 Years and its Scientific Justification

The term "biomimetic exercises" originates from the concept of "biomimetics" (or biomimicry), defined as the imitation or borrowing of principles and elements from natural systems and living organisms to solve applied problems [10]. Prior to the official introduction of the term "biomimetic exercises" into scientific discourse (in relation to physical activity), in 1998, a young Ukrainian researcher from Kharkiv, Zhaneta Kozina, put forward an innovative proposal for applying this approach to prepare pregnant women for childbirth [11]. She was the first to develop a complex of physical exercises by integrating principles and elements borrowed from natural systems and living organisms, particularly plants and animals. Later, these biomimetic principles, developed by Zh. Kozina, were successfully implemented in her original imitative exercises for younger children, forming a unique program [12].

The developed intervention technology integrated biomimetic exercises into the training regimen for young volleyball players aged 9-10 years. This approach aligns with contemporary integral preparation concepts [5-7, 13], particularly relevant for this age group's psychological characteristics and sensitive developmental periods [14, 15]. The methodology was implemented using a phased approach.

Phase 1: Introduction to Biomimetic Exercises (First 2–3 Sessions)

The initial phase focused on familiarising participants with biomimetic exercise techniques. These were incorporated into the preparatory part of the sessions and performed without strict regulation of repetitions, duration or rest. The primary objective was to ensure the participants assimilated the specific movements qualitatively.

Phase 2: Development of Motor Qualities (Subsequent 3 Sessions)

Biomimetic exercises were then utilised in the concluding part of training. This phase aimed to develop general and leading motor qualities [16], which are essential for mastering fundamental volleyball techniques.

Phase 3: Integration with Technical Elements (From the third week onward**s)**

From the third week onwards, biomimetic exercises were integrated with drills focused on mastering specific game techniques. Two weekly sessions were dedicated to performing combined biomimetic and technical drills, primarily in the main part of the session. This combined approach was aimed at significantly enhancing the effectiveness of acquiring basic volleyball technical skills. It also fostered the development of general motor qualities, improved coordinative abilities [17, 18], enhanced intermuscular interaction, cultivated sport-specific movement amplitude and strength, and developed conscious bodily control. The experimental group trained using this methodology for the first three months, covering all fundamental game techniques.

Key Biomimetic Exercises Utilized: The methodology incorporated a set of biomimetic exercises, each designed to enhance specific physical qualities with direct transfer to volleyball performance:

- "Bear": Optimizes shoulder girdle stability critical for dynamic movements (blocking, attacking). Enhances proprioception and spatial body control.
- "Crab": Develops core strength and stability, crucial for balance and

effective force transmission in ball reception, passing, and jumping. Improves proprioception and body control.

• "Frog": Optimizes powerful vertical jumping ability for effective blocking and attacking. Fosters speed and coordinative movements for quick court transitions.

• "Sparrow": Improves precise, controlled movement and body stability during jumps, vital for blocking, attacking, and other technical elements.

• "Monkey": Develops speed and agility in lateral movements, necessary for effective defense and net play. Aids in maintaining low stance and balance.

• "Lizard": Optimizes body control and stability during rapid changes in direction, critical for court movement, especially in defensive actions. Enhances proprioception and adaptability.

• "Horse": Improves rhythmic coordination and movement speed, vital for efficient court movement and rapid transitions between zones.

• "Duck": Enhances leg strength and endurance for repetitive squatting and low-stance movements typical of ball reception and defense. Improves body control and coordination.

• "Goose": Boosts static and dynamic balance, spatiotemporal coordination for precise court movements, changes in direction, and effective passing. Enhances proprioception and dynamic body control.

• "Snake": Optimizes upper body strength and stability, important for passing, blocking, and attacking (e.g., chest roll).

• "Spider": Provides comprehensive core, shoulder girdle, and lower limb strength development. Improves coordination for quick, agile movements.

• "Cheetah": Develops explosive power, speed of movement switching, and ability to maintain power after initial load.

• "Kangaroo": Optimizes powerful vertical jumping ability, crucial for effective blocking, attacking, and powerful serves.

• "Penguin": Develops lower limb stability, ability to quickly regain optimal stance after unaccustomed loading.

Integrated Complexes of Biomimetic Exercises with Game Technique Acquisition: To enhance learning and development, biomimetic exercises were directly integrated with corresponding technical elements. Examples of these combinations included:

• "Bear" + overhead two-hand pass: Perform "Bear" movement (4-5m), then quickly stand to execute 6-8 overhead passes (self or partner). Develops shoulder girdle strength, coordination, and pass accuracy. Emphasize hand relaxation while maintaining pass accuracy.

• "Crab" + two-hand underhand reception: After 3-4m "Crab" movement, quickly assume mid/low stance for 6-8 underhand receptions from partner/coach. Develops stabilizer muscle strength, accuracy of initial receiving position (hand placement). Focus on proper hand position.

• "Frog" + blocking: After 5-6 "Frog" jumps, quickly approach the net and perform 3-4 blocks with lateral movements (zones 2-3-4). Enhances explosive leg power, dynamic balance, and jump coordination for effective blocking.

• "Sparrow" + attack hit from coach toss: Following single-leg "Sparrow" jumps, immediately perform a run-up and attack hit on a coach-tossed ball. Develops explosive power, balance, general coordination, and hitting accuracy post-imbalance.

• "Monkey" + movement and second pass: After "Monkey" movement, quickly stand and assume setter's role, moving under high passes to execute second passes for attack. Develops upper limb agility, pass accuracy post-unconventional loading, and game intelligence.

• "Lizard" + defensive actions on back line: After 3-4m "Lizard" movement, perform a series of defensive actions (dives for balls tossed by coach

into various zones). Develops trunk and arm strength, reaction speed, agility, ability to rapidly change direction/body position.

• "Horse" + serve: After galloping along the sideline, execute a series of targeted serves. Develops coordination and serving accuracy after physical exertion.

• "Duck" + low-stance reception: After "Duck" movement, perform reception of low balls tossed by coach into various zones. Develops leg strength, flexibility, and quick reaction ability from a low stance.

• "Goose" + overhead jump pass: After "Goose" steps, perform a series of overhead two-hand jump passes. Develops balance, coordination, and jump pass accuracy.

• "Snake" + net play (finishing actions): After "Snake" movement, execute finishing actions near the net: tips, drops, deceptive hits. Develops upper body strength, finger tactile sensitivity, and tactical thinking.

• "Spider" + accurate passing under time/space constraints: Perform "Spider" movement (4-5m), then immediately execute accurate passes with time/space limitations. Develops overall strength, coordination, and precision under pressure.

• "Cheetah" + attack hit after run-up: After 3-4 quick steps with an explosive jump, immediately perform a full run-up and attack hit from a coach-designated spot. Develops explosive power, rapid transition ability between movements, and power retention after prior exertion.

• "Penguin" + serve reception after movement: Move as "Penguin" with a ball between legs for 4-5m, then release the ball and immediately perform serve reception with required movement to a specified zone. Develops lower limb stability and ability to quickly regain optimal stance post-unusual loading.

• "Kangaroo" + group blocking: After a series of "Kangaroo" jumps, players approach the net and perform group blocking drills based on coach signals. Enhances explosive jumping power and coordinated group blocking.

This comprehensive and phased approach aimed at a holistic development of physical qualities and technical skills, leveraging the inherent advantages of biomimetic movements for young athletes. This is further supported by research on neurocognitive development and exercise [1, 19, 20], emphasizing how innovative motor patterns stimulate cognitive functions vital for game intelligence. The approach is also particularly important at the initial stage of training, where the foundations of technical mastery are laid [21], and aligns with longitudinal studies showing integrated training leads to robust motor skill development in children and adolescents [22, 23].

Methods of mathematical statistics

For the mathematical-statistical processing of the obtained data, generally accepted methods of variation statistics were used: arithmetic mean (M), standard deviation (σ), standard error of the mean (m), Student's t-criterion (t), and significance level (p). The conformity of the sample data distribution to the normal law was confirmed by the Kolmogorov-Smirnov criterion. These methods allowed for the identification of significant differences in the indicators of physical qualities and technical preparedness of the pupils of KZ "KDYuSSh №12 KhMR". All digital data processing was carried out using Microsoft Excel (Microsoft Office 2022 package).

Results

The effectiveness of the developed methodology for organizing the training process for young volleyball players aged 9-10 years, based on the application of biomimetic exercises, was evaluated by analyzing the dynamics of their motor abilities and technical-tactical preparedness at the beginning and end of the study.

To establish the baseline level of motor abilities, initial testing was conducted in both the control (CG) and experimental (EG) groups. The testing utilized ten standardized assessments, allowing for a comprehensive evaluation of leading motor qualities: strength,

speed, endurance, and agility. Analysis of the initial testing results (Table.1) revealed no statistically significant differences ($p>0.05$) between the indicators of the control and experimental groups. This confirms the homogeneity of the sample at the outset of the study, thereby establishing equal conditions for subsequent comparison of methodological effectiveness.

At the initial stage of the study, technical preparedness testing was not conducted, as participants in both groups had not yet acquired the necessary fundamental game techniques.

The subsequent phase of the study involved conducting a formative experiment aimed at verifying the effectiveness of the developed methodology, which focused on the development of fundamental physical qualities and the acquisition of basic game techniques through the use of biomimetic exercises. The control group trained according to the generally accepted methodology, consistent with the official Curriculum for Youth Sports Schools in volleyball. The absence of changes in the CG's training process ensured an objective comparison of results.

After seven months of training, in May 2025, final control and pedagogical measurements were conducted using the same standardized tests. Additionally, the technical preparedness of both groups was assessed using six standard tests recommended by the Curriculum for evaluating the assimilation of basic technical skills.

A comparison of the obtained results (Table.2) revealed that after seven months of training, both the CG and EG showed improvement in all ten indicators of motor abilities. However, the changes in the CG were not statistically significant ($p>0.05$), which may be attributed to natural age-related development. In the EG, a clear tendency towards improved results across all investigated tests was observed, though these differences did not reach statistical significance between the groups ($p>0.05$).

A deeper analysis of intragroup changes in motor indicators (Table 3) revealed significant differences in the rates of improvement between the groups (Fig. 1). The EG demonstrated a pronounced improvement in results across all tests, and the rates of increase (or decrease in time) were higher compared to the CG. Particularly significant progress in the EG was recorded in tests for explosive strength (jumping) and strength endurance of the upper shoulder girdle and arms (pull-ups).

The observed tendencies towards greater improvement in the EG can be attributed to several factors inherent in the biomimetic approach. Firstly, the integration of biomimetic exercises, encompassing motor, cognitive, and perceptual components, fosters holistic development. Secondly, these exercises engage a wider range of muscle fibres and promote more efficient intermuscular coordination. Thirdly, the novel and often more engaging nature of biomimetic movements may enhance motivation and adherence among young athletes. Finally, the variability and adaptability of biomimetic exercises offer a rich motor learning environment, which has the potential to lead to more robust skill acquisition.

Furthermore, post-experimental testing revealed distinct differences in the technical preparedness of the groups (Table 4.). The experimental methodology was found to have a statistically significant impact on the majority of fundamental technical skills in the EG, in contrast to the CG. This finding was confirmed by statistical analysis.

Table 1

Indicators of Motor Abilities Development in Young Volleyball Players Aged 9-10 Years at the Beginning of the Pedagogical Experiment

Control Tests	CG (n=8)	EG (n=8)	(t)	(P)
Motor Abilities				
30 m sprint from high start (s)	5,56±0,26	5,64±0,29	0,21	P>0,05
92 m "herringbone" run (s)	23,50±1,60	24,14±1,04	0,34	P>0,05
5 min run (m)	714,25±38,63	690,12±42,14	0,42	P>0,05

3x10 m shuttle run (s)	10,65±0,41	10,92±0,43	0,45	P>0,05
5x6 m shuttle run (s)	13,20±0,65	13,87±0,72	0,69	P>0,05
Standing vertical jump (Abalakov device) (cm)	19,25±1,48	18,19±1,52	0,50	P>0,05
Running vertical jump ("Slanted Screen") (cm)	38,34±2,14	39,52±2,23	0,38	P>0,05
Standing long jump (cm)	117,63±6,21	114,69±5,42	0,36	P>0,05
Pull-ups on horizontal bar (reps)	1,25±1,03	1,18±0,94	0,05	P>0,05
Medicine ball throw (1 kg) overhead from standing (m)	5,98±0,79	6,11 ±0,63	0,13	P>0,05

Note: CG – Control Group; EG – Experimental Group
Critical t-value = 2.145 at significance level α = 0.05

Table 2
Indicators of Motor Abilities Development in Young Volleyball Players Aged9-10 Years at the End of the Pedagogical Experiment

Control Tests	CG (n=8)	EG (n=8)	(t)	(P)
Motor Abilities				
30 m sprint from high start (s)	5,42±0,22	5,14±0,25	0,84	P>0,05
92 m "herringbone" run (s)	22,70±1,49	21,82±1,50	0,42	P>0,05
5 min run (m)	737,19±32,59	786,5±42,0	0,93	P>0,05
3x10 m shuttle run (s)	10,97±0,41	12,13±0,60	1,60	P>0,05
5x6 m shuttle run (s)	12,80±0,65	13,19±0,67	0,42	P>0,05
Standing vertical jump (Abalakov device) (cm)	19,83±1,48	22,07±1,65	1,01	P>0,05
Running vertical jump ("Slanted Screen") (cm)	39,49±2,21	42,91±2,35	1,06	P>0,05
Standing long jump (cm)	121,16±5,87	131,62±6,90	1,15	P>0,05
Pull-ups on horizontal bar (reps)	1,72±1,14	2,36±1,20	0,39	P>0,05
Medicine ball throw (1 kg) overhead from standing (m)	6,16±0,77	6,92±0,80	0,68	P>0,05

Table 3
Comparative Indicators of Motor Abilities Development Dynamics (CG – Control Group, EG – Experimental Group)

Control Tests	CG (Start)	CG (End)	ΔCG (%)	EG (Start)	EG (Finish)	ΔEG (%)
Motor Abilities						
30 m sprint from high start (s)	5,56 ± 0,26	5,42 ± 0,25	-2,5%	5,53 ± 0,27	5,17 ± 0,24	-6,5%
92 m “herringbone” run (s)	23,50 ± 1,60	22,90 ± 1,52	-2,6%	23,46 ± 1,62	21,80 ± 1,49	-7,1%
5 min run (m)	714,25 ± 38,63	739,25 ± 39,53	+3,5%	715,00 ± 39,03	786,50 ± 41,90	+10,0%
3x10 m shuttle run (s)	10,95 ± 0,57	10,72 ± 0,54	-2,1%	10,94 ± 0,58	10,19 ± 0,51	-6,9%
5x6 m shuttle run (s)	13,20 ± 0,65	12,87 ± 0,61	-2,5%	13,19 ± 0,67	12,13 ± 0,60	-8,0%
Standing vertical jump (Abalakov device) (cm)	19,25 ± 1,48	19,91 ± 1,56	+3,4%	19,19 ± 1,49	22,13 ± 1,65	+15,3%
Running vertical jump (cm)	38,34 ± 2,14	39,92 ± 2,21	+4,1%	38,31 ± 2,13	42,91 ± 2,35	+12,0%
Standing long jump (cm)	117,63 ± 6,21	121,34 ± 6,54	+3,2%	117,52 ± 6,23	131,62 ± 6,90	+12,0%
Pull-ups on horizontal bar (reps)	1,25 ± 1,03	1,52 ± 1,08	+21,6%	1,31 ± 1,07	2,28 ± 1,19	+74,0%
Medicine ball throw (1 kg) overhead from standing (m)	5,98 ± 0,79	6,18 ± 0,80	+3,3%	5,97 ± 0,77	6,95 ± 0,80	+16,4%

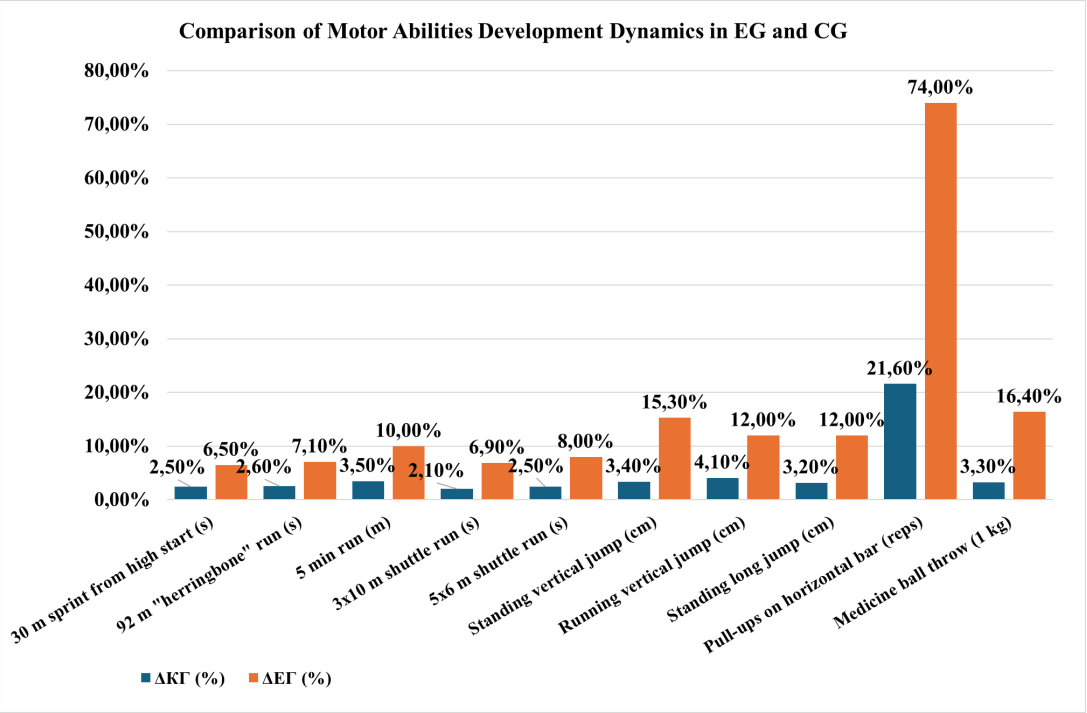

Fig. 3. Comparison of Motor Abilities Development Dynamics in EG and CG

Table 4

Indicators of Technical Preparedness Level in Young Volleyball Players Aged 9-10 Years at the End of the Pedagogical Experiment

Control Tests	CG (n=8)	EG (n=8)	(t)	(P)
Technical Preparedness of Young Volleyball Players				
Accuracy of overhead pass (second pass) with two hands overhead - length 3-3.5 m, height 3-4 m (near the net, 10 attempts)	6,25±1,04	8,90±0,64	2,17	P<0,05
Accuracy of overhead pass with two hands overhead through a hoop near the volleyball net (30-40 cm above the net) from zone to zone at 4-4.5 m (10 attempts)	5,77±1,19	8,75±0,62	2,22	P<0,05
Execution of overhead pass with two hands overhead in a jump – length 3-4 m, height 1-2 m (5 attempts)	3,16±0,84	5,00±0,00	2,19	P<0,05
Accuracy of underhand pass with two hands while standing in pairs at a distance of 4-5 m from each other (10 passes to a height of 1-2 m)	7,75±0,89	8,27±0,65	0,47	P>0,05
Accuracy of receiving-passing from below with two hands from a targeted serve. Receiving-passing is directed to the net (1.5 m from the net) up to 3 m high (5 attempts)	3,10±0,70	4,90±0,10	2,55	P<0,05
Accuracy of serving the ball into the right, left, near, far parts of the court in a 3 x 3 m zone (2 attempts in each part of the court)	4,88±0,83	6,80±0,32	2,16	P<0,05

Pacifically, statistically significant improvements were recorded in the EG for the following tests:

"Accuracy of the second overhead two-hand pass" (distance 3-3.5 m, height 3-4 m). The experimental group demonstrated significantly higher accuracy indicators compared to the control group ($t=2.17$; $p<0.05$). This indicates a substantial enhancement in repetitive passing ability and ball control.

"Accuracy of overhead two-hand pass through a hoop near the volleyball net" (located 30-40 cm above the net) from zone to zone at a distance of 4-4.5 m. The experimental group showed a statistically significant improvement in the accuracy of this technical action ($t=2.22$; $p<0.05$). This underscores the improved precision of targeted passes over the net.

"Execution of overhead two-hand pass in a jump" (distance 3-4 m, height 1-2 m). Test results confirmed a statistically significant improvement in indicators within the experimental group ($t=2.19$; $p<0.05$). This points to excellent execution of advanced passing techniques.

"Accuracy of underhand two-hand reception-pass from a targeted serve". The experimental group demonstrated a statistically significant improvement in the accuracy of executing the underhand reception-pass from a targeted serve ($t=2.55$; $p<0.05$). This confirms enhanced serve reception skills.

"Accuracy of serving the ball into the right, left, near, and far parts of the court". Analysis of the results revealed statistically significant positive shifts in serving accuracy within the experimental group ($t=2.16$; $p<0.05$). This indicates a notable increase in serving precision.

Regarding the test for "accuracy of underhand two-hand pass while standing in pairs" (at a distance of 4-5 m from each other), no statistically significant differences were found between the control and experimental groups ($t=0.47$; $p>0.05$). The absence of statistically significant differences in this specific test may have several interpretations. Firstly, it is possible that this technical skill is relatively straightforward for the 9–10 year age group to master and can be effectively acquired through both traditional and experimental methodologies. Secondly, the influence of biomimetic exercises might be less pronounced on this particular technical element compared to others that demand greater coordination or require higher precision of movements.

The obtained results conclusively demonstrate a statistically significant advantage of the experimental methodology, which integrated biomimetic exercises with game technical elements, in fostering the accuracy of performing most fundamental technical skills in young volleyball players aged 9–10 years. The application of non-standard, game-oriented, and imitative exercises likely contributed to a more effective and engaging learning process, leading to a superior level of technical proficiency.

Discussion

The present study aimed to experimentally substantiate the effectiveness of applying biomimetic exercises at the initial stage of training young volleyball players aged 9-10 years. The obtained results demonstrate convincing evidence supporting the developed methodology, particularly in the context of forming technical proficiency.

A key defining result of the pedagogical experiment is the statistically significant improvement in most indicators of technical preparedness in the experimental group (EG) compared to the control group (CG) at the final stage of the study (Table 4). This applies to tests such as the accuracy of performing the second overhead pass, the accuracy of passing through a hoop, performing a pass in a jump, the accuracy of receiving-passing from below from a targeted serve, and the accuracy of serving the ball into court zones, which are fundamental at the initial stages of training.

Our data align with the modern concept of integral training [5, 6], which involves combining physical qualities and technical skills in a unified training process. The application of biomimetic exercises, which imitate animal movements, likely contributed not only to the comprehensive development of motor qualities but also created an environment closer to game conditions for mastering technical skills. Such integration, as Bernstein [18] notes, promotes the formation of deep motor stereotypes and the development of coordination abilities, as biomimetic exercises [11] engage a significant range of muscle groups and stimulate

neurocognitive processes. This is crucial for optimizing motor learning in this age period, which is also emphasized in studies by Ratey & Hagerman [11] and Kozina et al. [4] regarding the impact of motor activity on children's neurocognitive development."

Concurrently, the test for "accuracy of two-hand underhand passing standing in pairs" did not reveal statistically significant inter-group differences ($p>0.05$). This result can be interpreted in several ways.

Firstly, it is possible that this technical skill is relatively basic and less complex for young athletes aged 9-10 years to master, hence its effective acquisition can occur through both traditional and the proposed experimental methodologies [21].

Secondly, the influence of specific biomimetic exercises on the quality of performing this game technical skill might be less pronounced compared to those skills that require greater coordination complexity or specific adaptation of movements, which are better imitated by biomimetic prototypes. Generally, as Kozina and Zaichenko [3] note, the effectiveness of a methodology depends on its alignment with the psychophysiological characteristics of athletes, which may explain the varied reaction to individual exercises.

Regarding the development of motor abilities, the results of the final testing (Table 2) did not show statistically significant inter-group differences, despite a general improvement in indicators in both groups. However, intra-group analysis (Table 3 and Fig. 1) clearly demonstrated a tendency towards a more intensive increase in motor qualities in the experimental group. Specifically, a significant percentage of improvement was noted in pull-ups (+74.0%), standing high jump (+15.3%), running high jump (+12.0%), and medicine ball throws (+16.4%) in the EG, which is significantly higher compared to the CG. This tendency supports the assumption that biomimetic exercises, due to their novelty, high intensity, and focus on the development of coordination abilities and strength, contribute to a more dynamic development of physical qualities. The importance of developing coordination in early school age is also emphasized by Bakiko, Nosarchuk, and Sventsytska [17]. The absence of statistical significance between groups in this aspect, despite clear tendencies, may be explained by the relatively short duration of the experiment (seven months) and the sample size (n=8 in each group), which is a known limitation in pedagogical research [13]. For full statistical confirmation of these tendencies, studies with a larger sample size and a longer observation period are necessary.

Overall, the obtained data indicate that the biomimetic approach, which combines exercises imitating animal movements with technical elements of the game, is promising for the effective mastery of basic technical skills and has the potential for dynamic development of motor abilities in young volleyball players aged 9-10 years. This methodology corresponds to the age-sensitive periods of children's development [14, 15] contributes to increasing their motivation and interest in the training process, which is an important factor in working with primary school age children. As Tomporowski et al. [19, 20] note, physical activity significantly influences children's cognitive functions, which can enhance the effect of learning new, complex motor patterns characteristic of biomimetic exercises.

Conclusions

The conducted research experimentally substantiated the effectiveness of the developed methodology utilizing biomimetic exercises at the initial stage of training young volleyball players aged 9-10 years. The primary result is a statistically significant improvement in most indicators of technical preparedness in the experimental group, which confirms a more effective mastery of basic game techniques. Although no significant inter-group differences were found in the test for underhand passing accuracy, this may be related to the relative simplicity of the element or the specific nature of biomimetic exercises' influence. Regarding the development of motor abilities, intra-group analysis demonstrated a clear tendency towards a more intensive increase in physical qualities in the experimental group, despite the absence of statistical significance between groups, which may be explained by the relatively short duration of the experiment and sample size. Overall, the use of biomimetic exercises is promising for the initial training of young volleyball players, as it corresponds to age-sensitive periods of development, enhances

motivation, and has the potential to improve cognitive functions. Further long-term studies with larger samples are necessary for full confirmation of the identified tendencies and to reveal the full potential of the methodology.

Prospects for further research include

Conducting long-term experiments with larger samples to confirm and refine the identified tendencies in motor ability development; expanding the range of evaluated technical and tactical actions, including game situations [24], investigating the influence of biomimetic exercises on psychological aspects of preparation, such as cognitive functions, attention, and spatial thinking, which can further substantiate the effectiveness of the methodology. Taking these aspects into account can reveal the full potential of the biomimetic approach in the sports training of beginners.

Conflict of interest

The author declares no conflict of interest.

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