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Original Article

Strength training of young gymnasts using non-standardized means

ANVAR ESHTAYEV[1], VLADIMIR POTOP[2], SERGEY ESHTAYEV[3], XURSHID UMAROV[4], MIRJALOL BEKMIRZAYEV[5], MUHAMMADAMIN SULEYMANOV[6]
[1,3,4,5,6] Uzbek State University of Physical Culture and Sports, UZBEKISTAN
[2] National University of Science and Technology *Politehnica* Bucharest, University Center Pitesti, ROMANIA
[2] Moldova State University, Institute of Physical Education and Sport, REPUBLIC OF MOLDOVA

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Abstract:
Background and Aim: This study aimed to identify the biomechanical characteristics of motor actions, focusing on the manifestation of muscle force during adduction and abduction in both supinated and pronated arm positions in the frontal plane. It also explored how these factors influenced technical mastery and performance in competitions. The primary objective of the research was to develop and scientifically justify a specialized strength training program for gymnasts aged 14–15, using weights and resistance exercises. *Material and Methods.* The study included 24 gymnasts aged 14–15, divided into an experimental group and a control group. Strength tests were performed using a patented belt transmission dynamometer, assessing the strength of adduction movements (top to bottom) and abduction movements (bottom to top) in three arm positions (left and right). Specific training programs incorporating weights and resistance were developed for each apparatus used in men's gymnastics polyathlon. They were tailored to the training stages and the age of athletes. The loads, repetitions and training regimens were optimized so that to enhance performance. *Results.* Absolute strength indicators recorded before the experiment showed no significant differences between the experimental and control groups (P>0.05). Pedagogical observations indicated that 75% of the strength abilities demonstrated by gymnasts were dynamic, while 25% were static. Analyzing shoulder muscle strength indicators for adduction and abduction revealed the statistical significance between the control group and the experimental one. Highly significant differences (6.25%, p<0.001) were observed in the supinated adduction test for the right arm. Other significant differences (56.25%, p<0.01) were found during the arm adduction and abduction tests in various positions. These different values in supination and pronation for both arms - right and left - confirm the impact of training on the specific strength of scapular girdle. Moderately significant differences (6.25%, p<0.05) were observed in the adduction test with the hand moving inward (right arm) Non-significant differences (31.25%, p>0.05) were identified in the following tests: pronated adduction - right arm; pronated abduction from bottom - right arm; inward abduction from bottom - right arm; pronated adduction from bottom - left arm; supinated abduction of the right arm from the side. The technical evaluation of gymnasts was carried out according to the rules of the International Gymnastics Federation. It emphasized the connection between specific strength levels and performance in the execution of elements. The evaluation underlines the importance of developing adduction and abduction strength of the scapular girdle to enhance competitiveness. *Conclusions*. This study highlighted the considerable influence of developing specific adduction and abduction strength of the scapular girdle on technical mastery and competitive performance in gymnasts aged 14-15. The implementation of a specialized exercise program, using weights and resistance, led to statistically significant improvements in both dynamic and static strength. Thus, this program demonstrated the effectiveness of the proposed methodology.
Key Words*:* **biomechanics, adduction, abduction, scapular girdle, performance enhancement**

Introduction

This research was needed due to the developmental particularities of 14-15-year-old gymnasts who reached an advanced stage of sports specialization. That particular stage is characterized by rapid physical growth and high demands in terms of technical training. Performance in artistic gymnastics is deeply influenced by the level of strength qualities, especially the specific strength of the scapular girdle muscles (adductors and abductors of the shoulder). These muscles have a considerable contribution to the correct execution of complex technical elements.

The context of the paper was generated by the necessity to balance the strength development between the muscle groups involved in shoulder adduction and abduction movements, in order to prevent functional imbalances and improve technical performance. Specialized literature and also current sports practice identify deficiencies in the development of this specific strength, which lead to loss of points in competitions and an increased risk of injury. The lack of customized training programs adapted to motor requirements in men's gymnastics revealed the need for a structured intervention, based on scientific data and practical experience.

Corresponding authors: VLADIMIR POTOP, E-mail: vladimir_potop@yahoo.com

Technical training of gymnasts largely depends on their strength capabilities. It was demonstrated that specific strength training significantly improves the execution quality of gymnastic elements, particularly in the case of young gymnasts (Zasada et al., 2016). Strength has a considerable influence on the technique of performing the elements: the longer the support-free phase is maintained, the more precise the required final body posture must be (Andreeva, 2013; Biegajlo et al., 2022).

Particular attention is given in gymnastics to the development of static and dynamic strength, speed-strength skills and strength endurance. All these attributes play a critical role in increasing performance. The relationship between isokinetic leg muscle strength and dynamic balance highlights gymnastics-specific differences, particularly in adolescent girls (Kyselovičová et al., 2023). Innovative training methods have proven effective in boosting the special physical fitness of athletes in aerobic gymnastics (Kokarev et al., 2023). Integrating health fitness elements has been shown to enhance the physical and functional fitness of young gymnasts (Romanova et al., 2023). Also, physical education classes aim at developing the speed-strength skills, contributing to the overall athletic performance of gymnasts (Dudka, 2022).

Analyzing the scientific and methodological literature on strength training, three primary methods meant to develop strength qualities have been identified: exercises with external resistance, exercises utilizing body weight and isometric exercises. Resistance training with external loads is widely acknowledged as a cornerstone for building muscular strength. Progression and specificity in this type of training are highly important in optimizing the results (Kraemer & Ratamess, 2004; Zatsiorsky et al., 2020). Exercises using body weight are also effective, ensuring versatility and accessibility for athletes of various levels (Fleck & Kraemer, 2014; Brown, 2007). As for the isometric exercises, they help to gain strength by improving muscular activation and force generation, especially when integrated into targeted training programs (Suchomel et al., 2018; Stone et al., 2007). The effectiveness of these methods was demonstrated across different people, including younger and older athletes. Their adaptability and significance in strength development was pointed out (Van Roie et al., 2013; Morrissey et al., 1995).

Modern requirements for performing gymnastic elements involve the execution of movements with straight arms. That means strength and coordination of the adductor and abductor muscles of the shoulder girdle are highly important. This approach not only enhances the aesthetic quality of routines but also ensures biomechanical efficiency and reduces the risk of injury (Mandroukas et al., 2023; Potop et al., 2019; Ramsbottom, 2018). Proper training and rehabilitation techniques are critical in meeting these demands, as they address both physical conditioning and recovery needs of gymnasts (Tilley & James, 2020). Developing fundamental skills through structured and progressive training programs is essential for preparing gymnasts to meet these high technical standards (Mitchell et al., 2002; Sleeper, 2012). The historical and theoretical foundations of gymnastics further underline the importance of strict shape and muscle engagement in achieving optimal performance (Lindhard, 2018).

Preliminary research shows that specialists in artistic gymnastics pay special attention to physical training through the use of weights and resistances. However, methods for developing strength skills with the help of weights and resistances are insufficiently studied or not scientifically substantiated in a proper way by the specialized literature.

To solve the identified problem, a specific training program focusing on the development of the scapular girdle strength (particularly the adductor and abductor muscles of the shoulder) was created and implemented. The program integrated various exercises: with external resistance, with body weight, isometric exercises, and also modern methods, including devices with gyroscopic movements.

The study was conducted as part of a pedagogical experiment, in which the subjects were separated in experimental groups and control ones. Initial and final testing allowed for a comparison between the two groups in terms of muscle strength development. The results were statistically analyzed to highlight significant differences following the application of the program, demonstrating the effectiveness of the intervention. Analysis was completed with the theoretical correlation of the results with the specialized literature and the recent studies in strength training and sports medicine fields.

The *main purpose* of the research is to develop and validate scientifically a technology of specialized strength exercises for gymnasts aged 14-15, based on the use of weights and resistance. This, in turn, will have a positive influence on the quality of strength-demanding gymnastics elements and enhance success in performing competitive routines. To study this problem, the biomechanical characteristics of motor actions were identified. These include adduction and abduction strength manifested in supinated and pronated arm positions across various planes, reflecting the distinctive features of technical mastery and their impact on competitive activity.

Material & methods

Participants

The study was carried out throughout the 2023-2024 academic year in a specialized gymnastics school. The research involved 24 gymnasts aged 14 to 15, divided into two groups: an experimental group from Tashkent and a control group from the Children's and Youth Sports School in Fergana. Participants were informed in advance about the conditions of the experiment and gave written consent. The study was approved by the Ethics Committee of the Uzbek State University of Physical Education and Sport.

Test protocol

The research was conducted according to the plan authorized by the Scientific Department of the Uzbek State University of Physical Education and Sport. The tests were performed using a patented belt transmission dynamometer (No. 007929). Strength of adduction movements (top to bottom) and abduction movements (bottom to top) of both arms was evaluated in three positions: pronation, supination and inward turned hand. The subject was sitting on a gymnastics bench with the back against the Swedish ladder, with the dynamometer fixed at the top for adduction movements and at the bottom for abduction movements.

- *Adduction and abduction in the sagittal plane*: Test no.1: Adduction movement of the right arm in pronation; Test no. 2: Adduction movement of the right arm in supination; Test no. 3: Adduction movement of the right arm with the hand oriented inward; Tests no. 4-6:indicators for the left arm (adduction in pronation, supination and hand oriented inward); Tests no.7-9: indicators for the right arm from bottom to top (abduction in pronation, supination and hand oriented inward); Tests no.10-12: indicators for the left arm from bottom to top (abduction in pronation, supination and hand oriented inward).
- *Adduction and abduction in the frontal plane*: Test no. 13: Adduction movement of the right arm in pronation from the side; Test no. 14: Adduction movement of the left arm in pronation from the side; Test no. 15: Abduction movement of the right arm in supination from the side; Test no. 16: Abduction movement of the left arm in supination from the side.

Data collection and analysis

Workout complexes using weights and resistance were developed for each apparatus in men's gymnastics polyathlon. The preparatory period was divided into two stages:

- The first stage aimed at developing strength skills through traction. Coaches intensively used additional weights during this phase.
- The second stage concentrated on the development of overall strength.

Stages were differentiated by the methods used: in the first stage, weights and resistance were actively employed, whereas in the second stage, exercises were performed without weights or using only the body weight. Within the developed methodology, gymnasts practiced various training regimens with weights and resistance. Optimal loads, number of repetitions and weights were determined for each age group, tailored to the objectives and training phase.

In the control group, exercises were performed using only body weight, while in the experimental group, additional weights were used.

Fundamental elements requiring motor actions in supinated and pronated arm positions:

Floor exercises: front hold (plank), turnovers, high angle holds, circles.

Pommel horse: circles, cross-circles, transitions, Flair - "Delasallo" circles, flares, power dismounts into a balanced position.

Still rings: twists, kips, forward and backward swings, extension raises, power balance holds, horizontal hanging positions, large forward and backward circles, iron cross.

Vaults: turnovers.

Parallel bars: swings, uprises, strength balances, transitions over the bars, under bar skills, dismounts.

High bar: various pull-ups with overhand and underhand grip, front and back giants, transitions, release-and-regrasp elements, reverse forward and backward giants.

Structure of the gymnasts' strength development program:

1. Trunk exercises:
- Raising the torso from supine or prone position;
- Focus on back extension and flexion, using additional weights.
2. Leg exercises:
- Leg raises while hanging from stall bars, with progressively increasing difficulty angles (90° and bar touch);
- Jumps onto elevated surfaces (**40-50 cm and 10 cm),** with additional weights on the back or arms.
3. Exercises on apparatus:
- Low bar and rings: jumps into support position with straight arms, using weights at the waist;
- Pommel horse: Cross- movements and circles, using weights on the legs.
4. Balance and plank exercises:
- Maintaining static and dynamic positions (plank, horizontal holds, transitions between positions).
- Inclusion of weights for additional difficulty.
5. Progression and adaptation:
- Exercises are performed in 3-5 sets, with 8-30 repetitions, depending on the movement type and intensity;
- Weights, apparatus height and difficulty levels are gradually adjusted every two weeks.

The training regimen included:

- For strengthening the arm muscles and shoulder girdle: 3-4 sets of 11-12 repetitions.
- For back and abdominal muscles: 3-4 sets of 10-12 repetitions.
- For leg muscles: 3-4 sets of 20-30 jumps.

The study analyzed the structure of motor actions and identified methods for developing strength skills through the use of weights and resistance. The strength development program was implemented. In the main (core) part of the training sessions, coaches organized strength exercises. In the preparatory part, gymnasts alternated stretching exercises with warm-up routines. During the final (cool-down) part, gymnasts performed a complex of exercises in circuit system, which increased the density and intensity of the training session.

Specific distribution of loads and weights used in training for the development of strength and strength-speed skills:

Exercises for developing strength:

• For arms: the load varies from 300 to 500 kg;
• For legs: the load ranges between 400-600 kg;
• For lumbar area: the load is the highest one, ranging from 500 to 800 kg.

Exercises for developing strength-speed:

• For arms: the weights used are smaller, ranging from 250 to 400 kg;
• For legs: the range is similar to the range for arms, namely 250-400 kg;
• For lumbar area: the load is 300-500 kg.

These distributions are modified according to training objectives, aiming to develop the specific strength of each muscle region, thus contributing to gymnasts' overall performance improvement.

The statistical analysis performed using Microsoft Excel included the calculation of the arithmetic mean, standard deviation (±SD), coefficient of variation (Cv, %) and the use of the t-test parametric test (both unpaired and paired), with a significance level of $P<0.05$. This analysis evaluated the initial homogeneity of the groups and the significant differences between the initial and final performance averages. Results highlighted significant differences between the experimental and control groups at the final testing ($P<0.05$). Thus, the effectiveness of the training method used in the experimental group was confirmed.

Results

The technology for specialized strength training was developed on the basis of the theoretical materials regarding the subject approached. At the beginning of the experiment, strength indicators were determined for the pronation and supination movements of the shoulder joint (Table 1).

Table 1. Comparison of the statistical characteristics of scapular girdle strength capacity in gymnasts aged 14-15 at the beginning of the experiment

Tests, kg	Control group, n=12		Experimental group, n=12		t	P
	mean ±SD	CV, %	mean ± SD	CV, %		
1	22.92 ± 2.89	12.61	22.33 ± 2.88	12.90	0.50	>0.05
2	21.08 ± 2.44	11.57	21.50 ± 2.54	11.81	0.41	>0.05
3	21.25 ± 2.67	12.56	21.75 ± 2.69	12.37	0.46	>0.05
4	20.17 ± 2.35	11.65	20.58 ± 2.46	11.95	0.42	>0.05
5	19.17 ± 2.23	11.63	18.83 ± 2.24	11.89	0.37	>0.05
6	18.08 ± 2.27	12.55	18.50 ± 2.37	12.81	0.44	>0.05
7	17.33 ± 2.19	12.63	17.00 ± 2.18	12.82	0.37	>0.05
8	16.50 ± 1.91	11.58	16.92 ± 2.02	11.94	0.52	>0.05
9	16.92 ± 2.27	13.42	16.58 ± 2.31	13.93	0.36	>0.05
10	15.83 ± 1.83	11.56	15.50 ± 1.82	11.74	0.45	>0.05
11	14.67 ± 1.85	12.61	14.92 ± 1.91	12.80	0.33	>0.05
12	13.75 ± 1.59	11.56	14.08 ± 1.68	11.93	0.50	>0.05
13	20.33 ± 2.36	11.61	20.75 ± 2.46	11.86	0.42	>0.05
14	19.33 ± 2.05	10.60	19.92 ± 2.17	10.90	0.68	>0.05
15	18.92 ± 2.19	11.58	18.50 ± 2.19	11.84	0.47	>0.05
16	17.42 ± 1.85	10.62	17.83 ± 1.93	10.82	0.54	>0.05

Note: description of material and methods; p = 0.05: critical t value = 2.074; p = 0.01: critical t value = 2.819; p = 0.001: critical t value = 3.693.

The absolute strength indicators recorded before the experiment in standard conditions (Table 1) show that the experimental and control groups did not have significant differences at $P<0.05$ as for the maximum strength development of the shoulder adductor and abductor muscles. The average value of arm movements on frontal plane in terms of adductor muscles ranged between 20.33 and 20.75 kg, while for the abductor muscles it ranged between 18.9 and 18.5 kg. The average value of muscle strength on sagittal plane (antero-posterior) for both arms was 21.8 ± 2.6 kg. Analyzing the average strength value of the muscles during pronation movements showed a value of 22.6 ± 2.8 kg for the right arm, while the left arm had a value of 21.3 ± 2.5 kg. During supination movements, the average value for both arms was 18.6 ± 2.6 kg. Abduction strength of the arms during pronation movements was 16.9 ± 2.1 kg, whereas it was 14.3 ± 1.8 kg during supination movements. The difference between the adductor and abductor forces of the shoulder muscles was approximately 4.75 kg in favor of the adductor muscles. Statistical analysis revealed that there was no significant correlation between the results of the groups (P>0.05), which indicated the absence of significant differences and became the basis for further research.

Pedagogical observations on the competitive activity of 14-15-year-old gymnasts highlighted the manifestation of strength abilities: 75% of these are represented by dynamic efforts and 25% by static efforts. The expert evaluation of the elements related to strength abilities is presented in Figure 1.

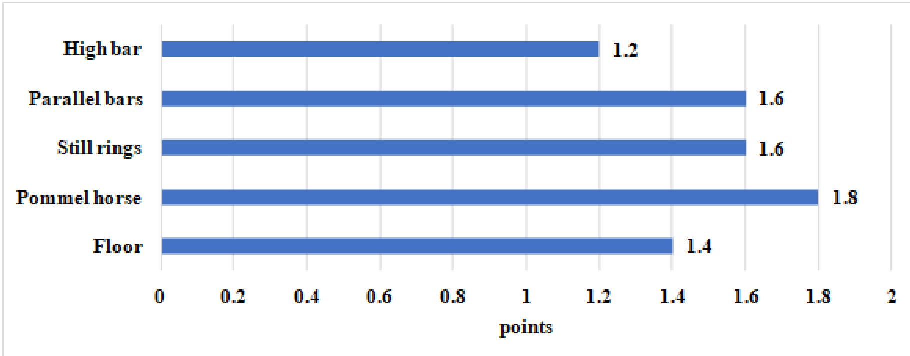

Fig. 1. *Faults in the compulsory elements execution*

The expert evaluations on the competitive exercises that include elements demonstrating the activity of abductor and adductor muscles were analyzed. The analysis identified significant deviations from the technical model required for the successful execution of these exercises. Most of the faults related to the strength manifestation of gymnasts, especially when the number of elements in combination increases, are typical ones, leading to a loss of 8.1 points. The more complex the requirements for competitive exercises, the more significant the athletes' special strength abilities become. Men's artistic gymnastics requires carefully selected exercises for the targeted development of strength, consistent with the motor actions structure in the elements. This research helped to establish priorities in choosing methods for developing the strength qualities of adductor and abductor muscles, leading to the development of a program based on the use of weights and resistances.

Table 2. Comparison of the statistical characteristics of scapular girdle strength capacity in the gymnasts aged 14-15 at the end of the experiment

Tests, kg	Control Group, n=12		Experimental Group, n=12		t	P
	Mean ±SD	CV%	Mean ±SD	CV%		
1	25.61 ± 3.19	12.46	26.98 ± 3.27	12.12	1.79	>0.05
2	23.52 ± 2.69	11.35	26.49 ± 2.95	11.14	4.16	<0.001
3	23.68 ± 2.93	12.37	25.79 ± 3.14	12.18	2.84	<0.05
4	21.94 ± 2.49	11.35	24.39 ± 2.72	11.15	3.56	<0.01
5	20.87 ± 2.39	11.45	22.29 ± 2.48	11.13	2.13	<0.01
6	20.35 ± 2.53	12.43	22.43 ± 2.72	12.13	3.01	<0.01
7	19.43 ± 2.39	12.30	20.59 ± 2.49	12.09	1.74	>0.05
8	18.23 ± 2.07	11.35	20.19 ± 2.25	11.14	3.13	<0.01
9	19.24 ± 2.55	13.25	20.41 ± 2.69	13.18	1.70	>0.05
10	17.21 ± 1.96	11.39	18.45 ± 2.05	11.11	2.05	>0.05
11	16.53 ± 2.06	12.46	18.63 ± 2.26	12.13	3.35	<0.01
12	15.34 ± 1.74	11.34	17.47 ± 1.94	11.10	3.68	<0.01
13	22.47 ± 2.56	11.39	24.98 ± 2.78	11.13	3.60	<0.01
14	21.23 ± 2.23	10.50	23.63 ± 2.42	10.24	3.69	<0.01
15	20.56 ± 2.35	11.43	21.79 ± 2.42	11.11	1.87	>0.05
16	19.07 ± 1.97	10.33	21.16 ± 2.15	10.16	3.42	<0.01

Note : df = 22; p = 0.05, t = 2.074; p = 0.01; t = 2.819; p = 0.001; t = 3.693.

The workout complexes created for the development of strength skills in gymnasts must take into account the kinematic structure of the gymnastics exercises for each apparatus. Problems in training affect competitive performance and entail a low level of technical performance of motor actions. A repeated test of shoulder adduction and abduction strength indicators was made at the end of the experiment. The analysis of the shoulder adduction and abduction strength indicators (Table 2) showed the statistical significance level between the control and experimental groups. Very significant differences (6.25%, $p<0.001$) were observed in Test 2 (adduction in supination, right arm). Significant differences (56.25%, $p<0.01$) were found in the following tests: no.4 (adduction in supination, left arm), no.5 (adduction inward, left arm), 6 (adduction, left arm inward), no. 8 (abduction in supination from bottom, right arm), no. 11 (abduction in supination from bottom, left arm), no. 12 (abduction from bottom, left arm inward), no. 13 (adduction in pronation, right arm from the side), no. 14 (adduction in pronation, left arm from the side) and no.16 (abduction in supination, left arm from the side). Moderate significant differences (6.25%, $p<0.05$) were noted in Test 3 (adduction with hand inward, right arm). Insignificant differences (31.25%, $p>0.05$) were found in Tests: no. 1 (adduction in pronation, right arm), no. 7 (abduction in pronation from bottom, right arm), no. 9 (abduction from bottom inward, right arm), no.10 (adduction in pronation from bottom, left arm) and no. 15 (abduction in supination, right arm from the side).

The relative increase in shoulder joint strength in the control group was 12.05%, while in the experimental group it was 25.33%.

The technical training evaluation of the gymnasts have characteristic results for this stage of training. The evaluation carried out by the expert committee was based on the judging rules approved by the International Gymnastics Federation (FIG), expressed in points, with the following scoring: minor faults – 0.1–0.3 points, medium faults – 0.3 points, major faults – 0.5 points. The evaluation of the technical training elements allows confirmation of the connection with the strength training indicators. As shown in the graph, following the experiment, the errors made by gymnasts at Candidate Master of Sports (CMS) and Category I (CI) levels ranged up to 3 points. Thus, the overall evaluation of execution faults in the gymnasts' technical training influences their competitiveness when performing technical elements (Fig. 2).

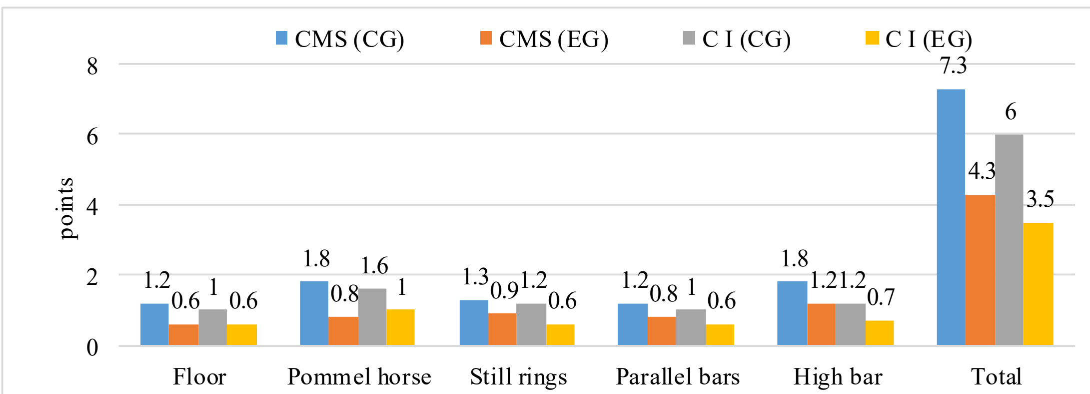

Fig. 2. Results of the Execution Score for the technical elements of Men's Gymnastics Polyathlon

Note. CMS – Candidate Master of Sport, C I – category I, CG – control group, EG – experimental group

The development of abduction and adduction strength in the upper scapular girdle has a direct impact on the score achieved. Therefore, in the development of special strength skills, it is necessary to take into account the structure of the movements in gymnastics competitive routines, as well as to select the appropriate means influencing the nature and sequence of these movements.

Discussion

This study focuses on the group of gymnasts aged 14-15 who reached the stage of advanced specialization and sports improvement during their rapid physical growth. The technical training of gymnasts largely depends on their strength skills level. Strength significantly influences the technique of performing the elements: the longer the support-free phase is maintained, the more precise the required final body posture must be. In gymnastics, special attention is also given to the development of static and dynamic strength, speed-strength qualities and strength endurance. Based on the analysis of scientific and methodological literature on strength training, three main methods for developing strength qualities can be identified: exercises with external resistance, exercises using body weight and isometric exercises.

The effectiveness of these methods is related to a more rational distribution of training means, which considerably improved the functional capabilities of gymnasts' bodies consistent with various strength indicators. Thus, a high level of development in both special physical and technical training was reached. All these aspects are the basis for obtaining remarkable sports results within the pedagogical experiment. The effectiveness of the proposed program is confirmed by the main materials of the pedagogical experiment. This program is grounded on the synthesis of theoretical data and practical experience, also on the use of additional unconventional tools.

The results obtained before the experiment highlight an initial uniformity in the absolute strength level between the experimental and control groups. This uniformity is confirmed by the absence of significant differences (P>0.05), which ensures fair conditions for investigating the impact of the intervention. This also emphasizes the predominance of the adductor muscles strength compared to the abductors, and the need for further analysis to achieve the functional balancing of these muscles (Table 1).

The findings are consistent with the principles outlined by Haff and Triplett (2015) regarding the role of targeted strength training in addressing muscle imbalances and optimizing performance. Furthermore, research conducted by Small (2024) shows the importance of challenging motor tasks in improving balance control, a key factor in achieving functional equilibrium in gymnastics. Specialists such as Wise (1996) analyzed the differentiated muscle activity in various tasks, emphasizing the necessity of tailored interventions. Adaptive sports medicine insights provided by McMullen et al. (2021) also stress the importance of functional muscle balance in enhancing technical execution. Lately, Güzel and Kurcan (2024) demonstrate the effectiveness of structured training programs (Pilates, for example) in improving body composition and overall muscle balance, further supporting the need for specific conditioning in artistic gymnastics.

Specialists underline the importance of prioritizing exercises that develop the specific strength of the adductor and abductor muscles. These exercises are highly necessary considering that deficiencies in the manifestation of this specific strength, exacerbated by the complexity of technical combinations, significantly contribute to the loss of competition points. This fact underscores the need for a special training program adapted to meet the motor requirements of men's artistic gymnastics (Fig. 1).

Other specialists like Jha, Bajpai and Mishra (2023) proved that this program is absolutely necessary. The authors analyzed the effects of active physical training compared with active resistance training in the case of groin pain in young gymnasts, highlighting the positive impact of targeted exercises on performance. Also, Outevsky and Martin (2015) point out the relevance of applying conditioning methodologies inspired by gymnastics and artistic dance to improve specific physical capacities. Sleeper (2012) developed a reliable method for measuring the physical abilities of young gymnasts, providing a valuable framework for evaluating progress. Furthermore, Manning (2014) investigated the biomechanics of technique selection in women's artistic gymnastics, offering perspectives that can be extended and adapted to the requirements of men's gymnastics. Ranieri, Potter, Mascaro and Grant-Ford (2020) detailed the process of returning to competitions, demonstrating the importance of developing specific musculature to support gymnastics performance.

The results of the repeated testing reflect significant and very significant differences in the development of shoulder adduction and abduction strength between the experimental and control groups. These differences validate the effectiveness of the training program especially tailored to the specific requirements of men's artistic gymnastics, stressing on complex exercises which involve supination and pronation movements (Table 2). However, the absence of significant differences in certain tests points to an area that requires adjustments and refinement in methodology to optimize physical training in these deficient areas (Campos, 2010; RM & CE, 2017).

In the context of rehabilitation and shoulder strength development, recent research reveals the role of training programs that include specialized devices, like those based on gyroscopic movements. These training methods have already been successfully used to treat impingement syndrome and lateral epicondylitis (Babaei-Mobarakeh et al., 2018). Also, the integration of moderate to high resistance exercises is recommended in managing biceps injuries, according to recent studies that point out the effectiveness of this type of exercises in athlete recovery (Borms et al., 2017). Other studies, investigating the impact of physical exercises on the elderly, suggest that applying such methods can significantly improve strength and functional performance for wheelchair users. A potential adaptation of these techniques of gymnastics could enhance shoulder adduction and abduction strength (Wołoszyn et al., 2021).

Results demonstrate the correlation between the specific strength training of the muscles involved in abduction and adduction movements at scapular girdle level and the considerable diminution of technical mistakes. Thus, the importance of using exercises adapted to the specific motor structure of gymnastics is emphasized.

These exercises contribute to improved performance and increased competitiveness for elite athletes (Fig. 2). So, the studies mentioned above reveal the importance of training programs focused on the specific strength of the scapular girdle for injury prevention and technique optimization (Malíř et al., 2023; Concannon et al., 2020; Sleeper, 2012).

In our opinion, integrating a specific training program based on exercises consistent with the technical and motor requirements of gymnastics is key to optimizing the performance of young gymnasts. We believe that a balanced approach, combining strength training technologies with innovative methods and non-standardized tools, will significantly contribute to developing functional muscular balance and preventing injuries. All these will support the progress of athletes during their advanced specialization phase.

Conclusions

1. The results obtained confirm the effectiveness of the specific training program for gymnasts, particularly in the development of adduction and abduction strength at scapular girdle level. Complex exercises involving supination and pronation movements are essential for optimizing technique and preventing injuries, demonstrating the effectiveness of the proposed training regimen for gymnasts aged 14-15.
2. Despite the progress made in developing muscular strength, studies highlighted the need to adjust the methodology to achieve an optimal functional balance between adductor and abductor muscles. Deficiencies identified in certain areas suggest a more targeted approach to exercises in order to correct imbalances and support high-level athletic performance.
3. Integration of non-standardized tools in training: the use of non-standardized tools, such as devices based on gyroscopic movements or active resistance methods, has demonstrated a significant positive impact on increasing strength and functional performance. These innovative techniques are crucial for improving endurance and supporting the progress of 14-15-year-old gymnasts.
4. The research contributed to the development and scientific foundation of specialized strength exercise technologies for young gymnasts, based on the use of weights and resistance. These technologies are fundamental for the development of athletes during their advanced specialization phase, ensuring adequate physical training for top-level performance and injury prevention.

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References

Andreeva, N. O. (2013). Key elements of sports techniques of ball throwing and catching by those engaged in rhythmic gymnastics at the stage of preliminary basic preparation. *Journal of Physical Education and Sport*, 13(1), 46 – 52. https://doi.org/10.7752/jpes.2013.01008

Babaei-Mobarakeh, M., Letafatkar, A., Barati, A. H., & Khosrokiani, Z. (2018). Effects of eight-week “gyroscopic device” mediated resistance training exercise on participants with impingement syndrome or tennis elbow. *Journal of bodywork and movement therapies*, 22(4), 1013-1021. https://doi.org/10.1016/j.jbmt.2017.12.002

Baechle, T. R., & Earle, R. W. (Eds.). (2008). *Essentials of strength training and conditioning*. Human kinetics.

Biegajlo, M., Nogal, M., Niźnikowska, E., Mastalerz, A., Wiśniowski, W., & Niznikowski, T. (2022). Key elements of sports technique in the phase structure of acrobatic exercise that connects moves performed on a beam. *Journal of Physical Education and Sport*, 22(4), 1061-1071. https://doi.org/10.7752/jpes.2022.04134

Borms, D., Ackerman, I., Smets, P., Van den Berge, G., & Cools, A. M. (2017). Biceps disorder rehabilitation for the athlete: a continuum of moderate-to high-load exercises. *The American Journal of Sports Medicine*, 45(3), 642-650. https://doi.org/10.1177/0363546516674190

Brown, L. E. (2007). *Strength training*. Human Kinetics.

Campos, M. J. A. (2010). *Swallow Element and Training Perspectives in Men's Artistic Gymnastics: An Electromyographic Study Case* (Master's thesis, Universidade do Porto (Portugal)).

Concannon, L. G., Loveless, M. S., & Matsuwaka, S. T. (2020). *Upper extremity injuries in gymnasts*. In Gymnastics Medicine: Evaluation, Management and Rehabilitation, 177-208. https://doi.org/10.1007/978-3-030-26288-4_9

Dudka, V. I. (2022). Development of speed-strength qualities in physical lessons. Coursework development of strength abilities in high school students in physical education lessons. Development. https://shkolyariki.ru/en/geografiya/razvitie-skorostno-silovyh-kachestv-na-urokah-fizicheskoi-kursovaya-rabota.html

Fleck, S. J., & Kraemer, W. (2014). *Designing resistance training programs*, 4E. Human Kinetics.

Güzel, S., & Kurcan, K. (2024). The Effect of Pilates Training on Body Composition. *International Journal of Health, Exercise, and Sport Sciences*, 1 (1), 25- 32. https://www.ijoss.org/Archive/ijoss-Volume1-issue1-05.pdf

Haff, G. G., & Triplett, N. T. (Eds.). (2015). *Essentials of strength training and conditioning*, 4th edition. Human kinetics.

Hodorcă, R. M., Moraru, C. E., & Albu, A. (2017). Reeducation of the upper limb using adapted means from rhythmic gymnastics. *Sport & Society/Sport si Societate*, 17(2), 61.

Jha, S., Bajpai, S., & Mishra, R. (2023). The Comparative Study between Active Physical Training versus Active Resistance Training in Groin Pain among Young Gymnasts. *Central India Journal of Medical Research*, 2(01), 8-12.

Kokarev, B., Kokareva, S., Atamanuk, S., Terehina, O., & Putrov, S. (2023). Effectiveness of innovative methods in improving the special physical fitness of qualified athletes in aerobic gymnastics. *Journal of Physical Education and Sport,* 23(3), 622-630. https://doi.org/10.7752/jpes.2023.03077

Kraemer, W. J., & Ratamess, N. A. (2004). Fundamentals of resistance training: progression and exercise prescription. *Medicine & science in sports & exercise*, 36(4), 674-688. https://doi.org/10.1249/01.mss.0000121945.36635.61

Kyselovičová, O., Zemková, E., Péliová, K., & Matejová, L. (2023). Isokinetic leg muscle strength relationship to dynamic balance reflects gymnast-specific differences in adolescent females. *Frontiers in Physiology*, 13, 1084019. https://doi.org/10.3389/fphys.2022.1084019

Lindhard, J. (2018). *The theory of gymnastics*. Routledge.

Malina, R. M., Baxter-Jones, A. D., Armstrong, N., Beunen, G. P., Caine, D., Daly, R. M., ... & Russell, K. (2013). Role of intensive training in the growth and maturation of artistic gymnasts. *Sports Medicine*, 43, 783-802. https://doi.org/10.1007/s40279-013-0058-5

Malíř, R., Chrudimský, J., Šteffl, M., & Stastny, P. (2023). A systematic review of dynamic, kinematic, and muscle activity during Gymnastic still rings elements. *Sports*, 11(3), 50. https://doi.org/10.3390/sports11030050

Mandroukas, A., Metaxas, I., Michailidis, Y., & Metaxas, T. (2023). Muscle Strength and Joint Range of Motion of the Spine and Lower Extremities in Female Prepubertal Elite Rhythmic and Artistic Gymnasts. *Journal of Functional Morphology and Kinesiology*, 8(4), 153. https://doi.org/10.3390/jfmk8040153

Manning, M. L. (2014). *Biomechanics of technique selection in womens' artistic gymnastics* (Doctoral dissertation, Cardiff Metropolitan University).

Mcmullen, C. W., Latzka, E. W., Laker, S. R., De Luigi, A. J., & Harrast, M. A. (2021). Sports medicine and adaptive sports. In *Braddom's Physical Medicine and Rehabilitation* (pp. 789-819). Elsevier. https://doi.org/10.1016/B978-0-323-62539-5.00039-4

Mitchell, D., Davis, B., & Lopez, R. (2002). *Teaching fundamental gymnastics skills*. Human kinetics.

Mkaouer, B., Hammoudi-Nassib, S., Amara, S., & Chaabène, H. (2018). Evaluating the physical and basic gymnastics skills assessment for talent identification in men's artistic gymnastics proposed by the International Gymnastics. *Biology of sport*, 35(4), 383-392. https://doi.org/10.5114/biolsport.2018.78059

Moeskops, S., Oliver, J. L., Read, P. J., Cronin, J. B., Myer, G. D., & Lloyd, R. S. (2019). The physiological demands of youth artistic gymnastics: applications to strength and conditioning. *Strength & Conditioning Journal*, 41(1), 1-13. https://doi.org/10.1519/SSC.0000000000000404

Morrissey, M. C., Harman, E. A., & JOHNSON, M. J. (1995). Resistance training modes: specificity and effectiveness*. Medicine & Science in Sports & Exercise*, 27(5), 648-660.

Outevsky, D., & Martin, B. C. (2015). Conditioning methodologies for dancesport: lessons from gymnastics, figure skating, and concert dance research. *Medical problems of performing artists*, 30(4), 238-250. https://doi.org/10.21091/mppa.2015.4043

Prassas, S., Kwon, Y. H., & Sands, W. A. (2006). Biomechanical research in artistic gymnastics: a review. *Sports biomechanics,* 5(2), 261-291. https://doi.org/10.1080/14763140608522878

Potop, V., Grigore, V., Creţu, M., & Jurat, V. (2019). Analysis of the quantity and quality parameters in the high bar competitive routines. International Proceedings of Human Motricity/ ICPESK 2019. Supplementary Issue of *Discobolul – Physical Education, Sport and Kinetotherapy Journal*, зр. 202- 209. https://doi.org/10.35189/iphm.icpesk.2019.31

Ramsbottom, H. (2018). *Strength and Conditioning for Gymnastics*. Gymnast. BC. https://www.gymbc.org/media/lipd1gyc/strength-and-conditioning-manual-2020.pdf

Ranieri, M., Potter, M., Mascaro, M., & Grant-Ford, M. (2020). Return to Play in Gymnastics. *Gymnastics Medicine: Evaluation, Management and Rehabilitation*, 291-343. https://doi.org/10.1007/978-3-030-26288-4_12

Romanova, E., Vorozheikin, A., Bayankin, O., Limarenko, O., Bolotin, A., Tyupa, P., ... & Anisimov, M. (2023). Enhancing physical and functional fitness through the integration of health fitness elements in young gymnasts. *Journal of physical education and sport*, 23(10), 2685-2691. https://doi.org/10.7752/jpes.2023.10307

Sleeper, M. D. (2012). The Development of a Reliable and Valid Means to Measure the Physical Abilities of Young Male Gymnasts. Nova Southeastern University. https://nsuworks.nova.edu/hpd_pt_stuetd/10

Small, G. H. (2024). *The effect of increasingly challenging motor tasks on balance control in healthy adults and female gymnasts* (Doctoral dissertation). https://doi.org/10.26153/tsw/55504

Stone, M. H., Stone, M., & Sands, W. A. (2007). *Principles and practice of resistance training*. Human Kinetics.

Suchomel, T. J., Nimphius, S., Bellon, C. R., & Stone, M. H. (2018). The importance of muscular strength: training considerations. *Sports medicine*, 48, 765-785. https://doi.org/10.1007/s40279-018-0862-z

Tilley, D., & James, D. A. (2020). Rehabilitation of gymnasts. In: *Gymnastics Medicine: Evaluation, Management and Rehabilitation*, 233-290. https://doi.org/10.1007/978-3-030-26288-4_11

Van Roie, E., Delecluse, C., Coudyzer, W., Boonen, S., & Bautmans, I. (2013). Strength training at high versus low external resistance in older adults: effects on muscle volume, muscle strength, and force–velocity characteristics. *Experimental gerontology*, 48(11), 1351-1361. https://doi.org/10.1016/j.exger.2013.08.010

Vandorpe, B., Vandendriessche, J., Vaeyens, R., Pion, J., Lefevre, J., Philippaerts, R., & Lenoir, M. (2011). Factors discriminating gymnasts by competitive level. International journal of sports medicine, 32(08), 591-597.

Wise, D. D. (1996). *Muscle activity in tight hip and loose hip subjects during two different hip extension tasks*. Texas Woman's University.

Wołoszyn, N., Wiśniowska-Szurlej, A., Grzegorczyk, J., & Kwolek, A. (2021). The impact of physical exercises with elements of dance movement therapy on the upper limb grip strength and functional performance of elderly wheelchair users living in nursing homes–a randomized control trial. *BMC geriatrics*, 21, 1-14. https://doi.org/10.1186/s12877-021-02368-7

Zasada, S., Zasada, M., Kochanowicz, A., Niespodzinski, B., Sawczyn, M., & Mishchenko, V. (2016). The effect of specific strength training on the quality of gymnastic elements execution in young gymnasts. *Baltic journal of health and physical activity*, 8(4), 79-91. https://doi.org/10.29359/BJHPA.08.4.09

Zatsiorsky, V. M., Kraemer, W. J., & Fry, A. C. (2020). *Science and practice of strength training*. Human Kinetics.