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EFFICACY OF A FOUR-BLOCK PLYOMETRIC EXERCISE COMPLEX IN DEVELOPING JUMPING ABILITIES OF 7-10-YEAR-OLD RHYTHMIC GYMNASTS

Shahnoza Rakhmatova
PhD Researcher
Scientific Research Institute of Physical Culture and Sports under the Uzbekistan State Sports Academy
E-mail: (shahnozaraxmatova21@gmail.com
Jizzakh, Uzbekistan

ABOUT ARTICLE

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Abstract: This study scientifically evaluates the efficacy of a developed four-block plyometric exercise complex on the general jumping abilities of rhythmic gymnasts at the training stage. The research was conducted over 12 weeks involving 60 athletes aged 7-10, randomly divided into experimental and control groups. Pedagogical testing methods were applied, including horizontal and vertical jumps, a jumping endurance test, and the Abalakova test to assess asymmetry. Statistical analysis revealed that the experimental group demonstrated significant improvements: horizontal jump increased by 10.0% ($p < 0.001$), vertical jump by 19.6% ($p < 0.001$), and asymmetry decreased by 56.2% ($p < 0.001$). Changes in the control group were marginal. The results confirm the high effectiveness of the proposed complex, which accounts for age-related physiological characteristics, the principle of allometric scaling of loads, and the integration of apparatus manipulation (dual-task), making it highly recommended for implementation in sports school training processes.

Introduction. Modern rhythmic gymnastics is characterized by increasingly complex competition rules and high physical demands placed on athletes. According to the Code of Points 2025-2028 of the International Gymnastics Federation (FIG), jumping elements in the competition program require not only exceptional height and distance but also execution in complex asymmetric leg positions (e.g., split leap, attitude) [1]. This demands not only high explosive power from the athlete but also perfect dynamic balance and spatial orientation. Consequently, jumping ability is one of the primary factors determining a rhythmic gymnast's overall competitive result.

The selection and recruitment process for rhythmic gymnastics begins at an early age, typically 4-5 years. As a result, girls engaged in the crucial “training stage” of professional sports preparation are usually between 7 and 10 years old. From the perspective of sports pedagogy and youth physiology, this specific age range (7-10 years) is considered a “sensitive period” for the development of speed-coordination abilities, including jumping capacity [2, 3]. During this period, the plasticity of the central nervous system (CNS) is high, and the myelination of motor cortices occurs actively. However, the musculoskeletal system of 7-10-year-old girls, particularly the epiphyseal plates (growth zones), is not yet fully formed; therefore, physical loads must be strictly scientifically grounded and carefully dosed [4].

Currently, plyometric exercises used in youth training are mostly aimed at general strength and are predominantly performed symmetrically on both legs. However, according to rhythmic gymnastics rules, jumps must be executed asymmetrically. A discrepancy in strength between the leading and trailing legs (asymmetry) can lead not only to technical deductions but also to severe sports injuries in the future [5]. Furthermore, existing exercises often lack a systematic approach to integrating apparatus manipulation (dual-task) and cognitive-motor functions specific to rhythmic gymnastics.

The above analysis indicates that developing a systematic, step-by-step exercise complex aimed at improving jumping abilities, while considering the age and gender characteristics, musculoskeletal safety, and competition requirements (asymmetry and apparatus handling) of 7-10-year-old rhythmic gymnasts, is a pressing scientific and practical issue.

The aim of the study is to experimentally evaluate the efficacy of a four-block plyometric exercise complex developed to enhance the jumping abilities of 7-10-year-old rhythmic gymnasts.

Materials and methods

The study was conducted over a 12-week period. Sixty rhythmic gymnasts at the training stage were randomly assigned, using a computer random number generator, to either an Experimental Group (EG, n=30) or a Control Group (CG, n=30).

Inclusion criteria: regular training for at least 2 years, absence of acute injuries or chronic diseases, and written informed consent from parents. Exclusion criteria: sustaining an injury during the study or missing more than 3 training sessions.

The age and anthropometric characteristics (height, body weight, leg length, and foot length) of the participants were measured (Table 1). In accordance with FIG rules requiring asymmetric execution of jumps, leg lengths were measured separately. Considering that jumping ability is a complex physical quality dependent on the explosive power of lower limb muscles, neuromuscular coordination, and the efficiency of biomechanical levers, foot lengths were also measured [6, 7].

Table 1.

Age and anthropometric characteristics of the study participants

Indicators	**Experimental Group (n=30)** X± **S**	**Control Group (n=30) X± S**	**p (significance)**
Age (years)	8.5 ± 0.8	8.6 ± 0.7	> 0.05
Height (cm)	131.2 ± 4.5	130.8 ± 4.8	> 0.05
Body weight (kg)	28.5 ± 3.2	28.8 ± 3.4	> 0.05
Leg length (cm) - Right	72.4 ± 3.1	72.1 ± 3.2	> 0.05
Leg length (cm) - Left	72.3 ± 3.0	72.2 ± 3.1	> 0.05
Foot length (cm) - Right	21.2 ± 0.8	21.3 ± 0.9	> 0.05
Foot length (cm) - Left	21.1 ± 0.8	21.2 ± 0.8	> 0.05

Data from Table 1 indicate no statistically significant differences in anthropometric indicators between the two groups at the beginning of the study ($p > 0.05$), ensuring the homogeneity of the sample and the validity of the research.

Testing Procedures.

To determine the general jumping indicators, the following tests were administered before and after the experiment:

1. Horizontal jump: Standing long jump (cm).

2. Vertical jump: Jumping height measured using the “SPORK” device (cm).

3. Jumping endurance: 30-second speed rope jumping (reps).

4. Asymmetry test: Based on the Abalakova test, jumping results on the right and left legs were recorded on a special measuring tape mounted on the wall, and the absolute difference (cm) between them was calculated.

Intervention Protocol (Exercise Complex)

A four-block exercise complex was developed considering modern rhythmic gymnastics demands, structured from simple to complex:

Table 2.

Structure and methodological characteristics of the four-block plyometric complex

Block	No. of Exercises	Main Focus	Safety and Methodological Principle
I. Two-legged jumps	9	General explosive power and amortization	Controlling knee valgus, soft landing
II. One-legged jumps	9	Eliminating asymmetry, dynamic balance	Equal execution on both legs, spatial orientation
III. Apparatus jumps	10	Cognitive-motor integration (Dual-task)	Synchronizing apparatus rhythm and jumping
IV. Leg strength (Resistance)	10	Specific strength and proprioceptive control	Allometric scaling (0.5-1% of body weight)
Note: *The detailed protocol of all 38 exercises is available from the author upon request.*			

The 38-exercise complex is not performed entirely in a single session. Aligned with modern sports pedagogy, it functions as an "exercise bank" rationally distributed across the weekly microcycle. In the main part of a single session, 15-20 minutes (25-30% of the main part) are allocated for jumping development. Athletes perform 2-3 exercises from each block (8-10 total) in 3 sets. This maintains optimal CNS excitability, ensures high-quality and fast movement execution, and prevents injuries.

Safety and Allometric Scaling.

The additional resistance (sand-filled pouches) used in the study was determined based on the principle of allometric scaling in children's sports. While international literature applies loads of 2.5% of body weight for 16-year-old adolescents [8], this indicator was significantly reduced for our younger athletes: no more than 1% of body weight when placed on the thigh (proximal part), and no more than 0.5% when placed on the ankle (distal part). Biomechanically, placing the weight on the thigh reduces the torque applied to the knee and ankle joints, which is the most effective method for injury prevention in 7-10-year-old girls [9].

Statistical Analysis.

Data were analyzed using SPSS (version 27.0). Normal distribution was checked via the Shapiro-Wilk test. Differences within groups were calculated using the Paired t-test, and between groups using the Independent t-test. Effect size was evaluated using Cohen's d. The significance level was set at $p < 0.05$.

Results

According to the pedagogical experiment conducted over 12 weeks, significant positive changes were observed in the Experimental Group (EG) compared to the Control Group (CG) across all four test types (Table 3 and

Chart 1).

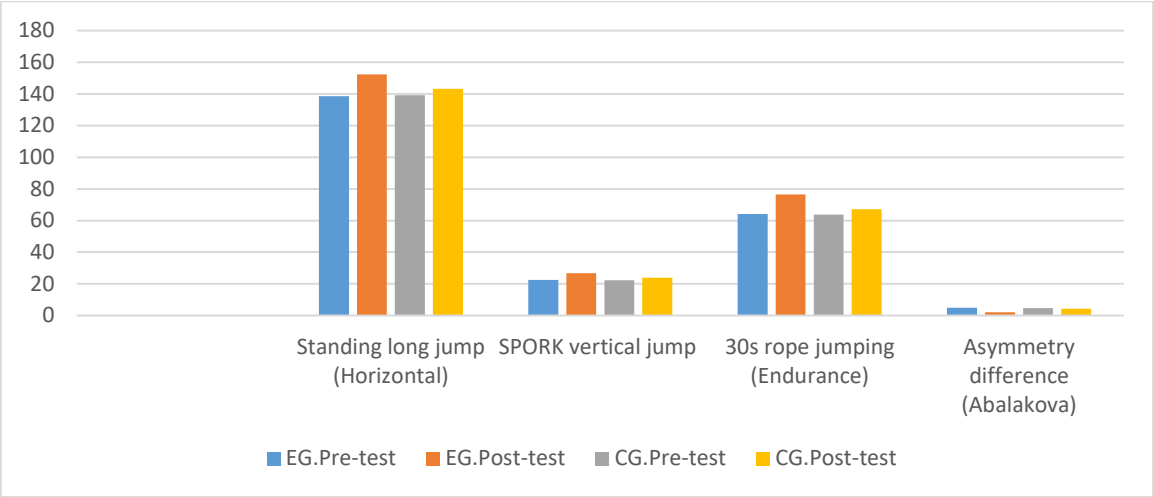
Table 3.

Dynamics of jumping ability indicators in 7-10-year-old rhythmic gymnasts (12 weeks)

№	Tests (Indicator Type)	Groups	Pre-test (X±S)	Post-test (X±S)	Growth Rate (%)	t-criterion	p (significance)	Cohen's d
1	Standing long jump (Horizontal)	EG	138.5 ± 8.2 cm	152.4 ± 7.5 cm	+10.0%	t = 6.84	< 0.001	1.82
		CG	139.1 ± 7.9 cm	143.2 ± 7.8 cm	+2.9%	t = 2.05	< 0.05	0.52
2	SPORK vertical jump	EG	22.4 ± 1.5 cm	26.8 ± 1.3 cm	+19.6%	t = 12.45	< 0.001	3.15
		CG	22.3 ± 1.4 cm	23.9 ± 1.5 cm	+7.1%	t = 5.82	< 0.001	1.09
3	30s rope jumping (Endurance)	EG	64.2 ± 5.1 reps	76.5 ± 4.8 reps	+19.1%	t = 9.12	< 0.001	2.48
		CG	63.8 ± 4.9 reps	67.1 ± 5.0 reps	+5.1%	t = 2.58	< 0.05	0.66
4	Asymmetry difference (Abalakova)	EG	4.8 ± 1.2 cm	2.1 ± 0.8 cm	-56.2%	t = 10.35	< 0.001	2.64
		CG	4.7 ± 1.3 cm	4.2 ± 1.1 cm	-10.6%	t = 1.62	> 0.05	0.41

Chart 1.

Dynamics of jumping ability indicators in 7-10-year-old rhythmic gymnasts



Analysis of Table 3 shows that the Experimental Group achieved high reliability ($p < 0.001$) and a large effect size (Cohen's $d > 0.8$) across all indicators. Notably, the 19.6% increase in vertical jump and the 56.2% reduction in asymmetry demonstrate the high efficacy of the complex. In the Control Group, the asymmetry indicator did not change at a statistically significant level

($p > 0.05$).

Discussion

The results of this study prove the high efficacy of the specially designed four-block plyometric exercise complex in developing jumping abilities in 7-10-year-old rhythmic gymnasts. The 19.6% increase in vertical jump (Cohen's $d = 3.15$) and 10.0% increase in horizontal jump in the EG were significantly higher than the natural growth observed in the CG (7.1% and 2.9%, respectively). These findings align with research by Faigenbaum and Lloyd, who emphasize that plyometric exercises at the age of 7-10 accelerate the adaptation of the neuromuscular system and enhance the ability to synchronously activate motor units [10, 11].

One of the most crucial and scientifically novel findings of this study is the 56.2% reduction in the asymmetry indicator (dropping from 4.8 cm to 2.1 cm). In the CG, this difference decreased by only 10.6% and was not statistically significant ($p > 0.05$). In rhythmic gymnastics, jumps often require transitioning from one leg to another or maintaining asymmetric positions (split, attitude) in the air. The execution of Block II (One-legged jumps) exercises equally on both legs, combined with dynamic balance control through exercises like "Freeze jump" helped eliminate the strength and coordination discrepancies between the legs. This lays a solid foundation for future injury prevention [12].

The dual-task principle applied in Block III – simultaneously manipulating apparatuses (ball, ribbon, hoop) and jumping – ensured the integration of cognitive and motor functions.

Modern neurophysiological studies indicate that dual-tasks simultaneously activate the prefrontal and motor cortices of the brain, sharply improving movement accuracy and timing [13]. The 19.1% increase in rope jumping endurance is directly related to this factor.

The allometric scaling approach (0.5-1% of body weight) used for additional resistance also proved highly effective. While Hammami et al. (2020) found 2.5% of body weight effective for 16-year-old footballers [8], we reduced the load for 7-10-year-old girls, recommending no more than 0.5% for the distal part (ankle) considering their biomechanical specifics. This approach minimized pressure on the epiphyseal plates (growth zones), and no sports injuries were recorded during the 12 weeks. This demonstrates an optimal way to combine safety and efficacy in children's sports [14, 15].

As limitations of the study, the relatively small sample size (n=60) and the exclusive focus on girls can be noted. Future research is recommended to test this complex on boys and athletes in other sports requiring jumping abilities (e.g., artistic gymnastics, basketball).

Conclusion

1. The four-block exercise complex developed to enhance the jumping abilities of 7-10-year-old rhythmic gymnasts was experimentally proven to be highly effective. The EG showed a 19.6% increase in vertical jump and a 10.0% increase in horizontal jump.

2. The one-legged exercises in Block II reduced the asymmetry difference between legs by 56.2%, improving the athletes' dynamic balance, which fully meets the asymmetric jumping requirements of rhythmic gymnastics rules.

3. The integration of the dual-task principle (working with apparatuses) increased jumping endurance by 19.1% and developed cognitive-motor coordination.

4. The application of the allometric scaling principle (0.5-1% of body weight) for additional resistance ensured the safety of the musculoskeletal system in 7-10-year-old girls.

5. Coaches are advised to integrate this complex into the weekly training microcycle as an “exercise bank,” allocating 15-20 minutes of the main part of a single session for its execution.

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