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Original Article

The effect of training with a multifunctional adaptive device on mastering elements performed on gymnastic rings: A comparative study of pre- and post-training routines

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Abstract
Auxiliary devices are used to enhance gymnastics training. Following the principle of training specificity, this study aimed to improve the efficiency in mastering vibration and strength training techniques on rings by incorporating a multifunctional adaptive device. The study involved 40 gymnasts – 10 pre-junior, 13 junior, and 17 senior ranging in age from 14–27 years. The control group followed a traditional training program, while the experimental group trained with a program integrating exercises using a multifunctional adaptive device developed by the researchers. The results showed a 15% improvement in general physical fitness indicators among gymnasts ($p < 0.001$). Specific strength qualities increased by 18%, and the total number of elements performed on the rings also increased by 18%. First-category element indicators remained unchanged, while second-category elements increased from 0.1 to 0.6 points (600% improvement). Third-category elements increased from 0.2 to 0.6 points (300% increase), and fourth-category elements increased from 0.3 to 0.5 points (67% improvement). In the pedagogical experiment, the proposed multifunctional adaptive device and the exercise complex developed from it were scientifically validated. This training approach effectively improved athletes' physical qualities and technical skills.
Keywords: artistic gymnastics, strength exercise, gymnastics rings, still rings, multifunctional adaptive device

Introduction

Elite athletes must use specific training to achieve optimal performance. Optimizing specific physical prerequisites—such as strength, power, and muscular endurance—is essential across many sports (Wilmore, et al., 2008). However, the high volume of sport-specific and preparatory training (e.g., resistance training) increases the risk of overuse injuries. In gymnastics, where mastering technical skills is the primary training goal, exceptionally high training loads have been reported (Sands, 2000).

In modern competitive programs, top gymnasts exhibit exceptional technical skill, seamlessly integrating peak physical qualities into original sequences and combinations (Mullagildina, et al., 2014). The effectiveness of training depends directly on the methods used, aligning with athletes' physiological characteristics (Deineko, 2017). Rings are the only gymnastic apparatus with a mobile support, which influences the nature of exercises performed on them. These exercises combine pronounced dynamic movements, high demands for accuracy, balance in static positions, and specialized strength training for gymnasts (Gaverdovskiy, 2014a, b; Smolevskiy, 1999). When performing exercises on mobile support, gymnasts experience a sudden increase in shock-type load on the musculoskeletal system, requiring a high level of specialized physical conditioning. Analysis of literature and video materials revealed that since the early 1980s, there has been a considerable advancement in the development of this type of all-around performance. Forgotten strength exercises were revived and integrated with flight elements, requiring gymnasts to develop muscle strength, speed–strength abilities, flexibility, spatial awareness, balance, and other critical skills (Zhuravin, et al., 2002; Gaverdovskiy, 2014a, b; Smolevskiy, 1999). Although various approaches and methods exist for addressing the challenges of teaching exercises on dynamic supports, the teaching of promising and efficient techniques for performing swinging and static elements on the rings, as well as the selection of methods and tools to expressively link these movements with equipment featuring adaptive structures, remains underexplored. This gap highlights the need for innovative training tools that consider the unique characteristics of exercises performed on the rings, thus facilitating their mastery.

Training on the still rings begins early in sports participation, training, and competition. It starts with less challenging static strength elements and swinging movements from long hangs (Fink, et al., 2021; Hart, et al., 2018), progressing to more difficult elements that place greater demands on technical skills and physical prerequisites, such as muscle strength, which must be developed. The high demands of training increase the

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weight-bearing load on the upper extremities, particularly the shoulder joints. Properly mastering the technique requires a well-structured training process supported by effective diagnostic methods to assess the mechanical loading on the gymnast's body (Malíř, et al., 2023).

To develop the necessary maximum strength specific to ring training, athletes have traditionally used concentric or static exercises with barbells or dumbbells targeting the relevant muscle groups. They may also use facilitated versions of the elements themselves, employing counterweights, devices that shorten the lever arm (herdos), or the assistance of a spotter (Hübner & Schärer, 2015; Bernasconi, et al., 2009; Bernasconi, et al., 2006; Gorosito, 2013). However, previous studies have indicated that not all of these methods elicit similar muscle activation patterns as the elements themselves (Bernasconi, et al., 2009; Bernasconi, et al., 2006; Bernasconi, et al., 2004). Additionally, the maximum strength achieved in these traditional exercises does not always correlate closely with the ring-specific strength required to perform the elements (Hübner & Schärer, 2015; Gorosito, 2013).Leading international researchers in the field of artistic gymnastics have identified various methods for developing basic skills and abilities in gymnasts during the sports specialization phase. However, the scientific basis for using training equipment to develop stable skills for performing swinging exercises on the rings, maintaining static positions, and executing transitions (such as swing-to-swing, swing-to-static-to-swing, and strength-to-movement-to-strength) is largely unexplored. This study aims to improve the effectiveness of mastering swinging and strength techniques on the rings through the integration of adaptive equipment into the training regimen.

Materials and methods

Pedagogical experience

The experimental research included participants from the Tashkent Specialized Sports School for Gymnastics (14), the Republican School of Higher Sports Mastery in Gymnastics (20), and the Fergana Specialized Sports School for Gymnastics (6). In total, 40 gymnasts aged 14–27 were divided into experimental and control groups, categorized into pre-junior (10 participants), junior (13 participants), and senior (17 participants) levels. Both groups trained six times a week, with each session lasting three academic hours (2 h and 25 min). The control group followed a traditional training program, while the experimental group implemented the program developed by us. The results obtained during the experimental research were subjected to statistical analysis.

Pedagogical testing

Pedagogical test trials were performed to assess the physical and technical preparedness of gymnasts during the training phase. The tests were administered twice—once at the beginning and once at the end of the experiment—under the same conditions, with the same specialists evaluating technical preparedness. The testing protocol was developed based on specialized gymnastics programs and relevant literature. The selection of test tasks was informed by research by Y.K. Gaverdovskiy, V.N. Platonov, and V.A. Solodyannikova.

Assessment tests for general physical fitness in gymnasts

- "6 × 10 m running" exercise
- Jump rope
- Dips on parallel bars
- Pull-ups

Assessment of specific strength indicators in gymnastic athletes

- On the rings, hand-supported, powerful rise from an angle (number of repetitions)
- From a hanging position on the rings, backward horizontal hang (s)
- From a hanging position on the rings, forward horizontal hang (s)
- Transitions between forward horizontal hang and backward hang (number of repetitions)
- Powerful rise on the rings (stemme) (number of repetitions)

Technical parameters of a multifunctional adaptive device

This study examined the potential for expanding the use of adaptive training equipment in the methodology for teaching gymnasts to perform ring elements, with an emphasis on mastering and improving complex skills. The research aimed not only to explore the use of training devices but also to optimize training protocols by reducing unnecessary exertion, increasing lesson efficiency, enhancing learning outcomes, and preventing errors and shortcomings.

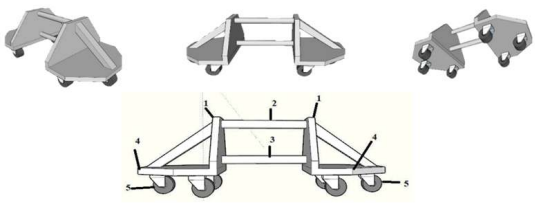


Fig 1. 1. Right and left vertical metal walls. 2. Upper ball-shaped handle for footrest. 3. Lower vertical support. 4. Right and left horizontal metal walls. 5. Casters

Fig. 2. Range of actions that can be performed with a multifunctional adaptive device

The athletes' training session was structured into three phases: a 20–25 min warm-up, an 80–90 min main training period, and a 20–25 min cool-down. During this session, athletes participated in warm-up activities, practiced basic skills, and focused on acquiring or improving specific technical elements. The training device developed in this study can be incorporated into all phases of the training process (Table 1). Both the athlete and coach can modify the resistance offered by the training equipment. The session begins with low-intensity exercises, while the main focus is on repetitively practicing the target skill on the rings. In the final phase, the intensity of the exercises is increased by adding external resistance.

Table 1. Analysis of time allocation in gymnasts' training schedules

Primary	Main	Final	Total
20–25	80–90	20–25	135 min
Warm-up exercises	Working with equipment	Stretching and focusing on specific physical qualities	Proper distribution of training loads

To ensure the research was both theoretically and practically sound, we designed a specialized exercise complex for the experimental group. This complex was incorporated into the study, with the training regimen and skill acquisition process divided into specific phases to address the specific needs of each workout segment. This approach allowed athletes in the experimental group to use the complex during their entire training session.

Results

The muscle activation patterns during exercise on a multifunctional adaptive device—including the degree of muscle contraction and relaxation, the sequential recruitment of muscle groups, and the synergistic action of various muscles—should closely align with the biomechanical demands of the target sport. Training devices designed with these principles enhance the automation and stabilization of motor skills.

A broader foundation of fundamental movement skills enhances the effectiveness of technical skill development. A diverse range of general and specific exercises, incorporating bodyweight, external implements, and specialized training equipment, should be used to enhance this motor skill repertoire. It is essential to acknowledge the strong connection between physical development and the acquisition of technical proficiency.

Training devices that control the performance conditions for specific exercises in motor skill acquisition allow the selection of key movement parameters, highlight critical phases of movement, and support targeted development and reinforcement, demonstrating considerable potential.

Indicators of general physical fitness

At the beginning of our study, we evaluated the general physical preparedness (GPP) levels of both the control and experimental groups. Statistical analysis indicated no significant differences between the groups, justifying the initiation of the research. In selecting the GPP assessment exercises, we focused on those that

targeted the muscle groups and body segments most heavily engaged during ring exercises, ensuring alignment with the requirements of competitive ring routines.

Before the study began, we selected specific exercises to assess the athletes' physical fitness levels. The chosen assessment exercises were divided into two categories: GPP exercises and specific physical preparation (SPP) exercises (Table 5).

Table 5. Indicators of general physical fitness of gymnasts

№	Test exercises		Control group			Experimental group			t	p
			$\bar{x}$	σ	V%	$\bar{x}$	σ	V%		
1	"6×10 m running" exercise interval	Pre	53.461	1.2	2.04	53.007	1.7	3.24	1.87	<0.1
		Post	52.07	1.7	3.29	51.28	0.9	1.76	5.63	<0.001
2	Jumping rope	Pre	140	8.7	6.27	140	8.2	5.89	2.10	<0.1
		Post	144.8	9.4	6.47	154.1	7.2	4.65	5.77	<0.001
3	Dips on parallel bars	Pre	34.7	4.2	12.1	34.9	4.1	11.6	1.79	<0.1
		Post	36.9	3.5	9.42	40.4	4.0	9.87	4.34	<0.001
4	Pull-ups	Pre	13.45	1.7	12.41	13.25	1.3	10.06	1.47	<0.1
		Post	14.2	1.5	10.86	14.7	1.0	6.87	3.87	<0.001

Table 2. Exercise complex for teaching swinging movements on gymnastic rings

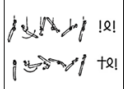
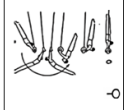
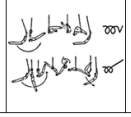
Element names	Element appearance	Technical preparedness	Standard	Exercises performed on an adaptive device			Standard
				Light	Medium	Heavy	
From support or cross, backward felge piked or straight with bent arms to support		The oscillation level should exceed the height of the rings, with the body maintaining a straight line in both forward and backward movements.	8–10 sets, 4–5 repetitions	Support on the arms, arms extended upward, starting position	Lying on the back with arms at the sides, hands supporting, starting position	Weight-bearing position while lying on the back, arms at the sides, hands supporting, starting position	The load weight is 15% less than the athlete's body weight. 10 × 3, 3 repetitions
Forward swing to handstand or backward giant swing to handstand (2 s)		Handstand on the rings with forward and backward fall. Rise from a large swing to 45°	6–8 sets, 3–4 repetitions	Support on the arms, arms extended to the sides and held, starting position	Lying on the back, lift 10 cm off the ground, arms extended overhead, starting position	Weight-bearing while lying on the back, lift 10 cm off the ground, arms extended overhead, starting position	The load weight is 12% less than the athlete's body weight. 10 × 3, 3 repetitions
Double forward tucked somersault to hang		Opening and snapping shut during the rise from a swing, transitioning to a support	6–8 sets, 3–4 repetitions	Support on the hands from a lying position, lowering to 45°, starting position	From a lying position, swing the legs up and transition to support on the hands	Weight-bearing while lying on the back, swing the legs up and transition to support on the hands	The load weight is 18% less than the athlete's body weight. 10 × 3, 3 repetitions
Double forward somersault, piked or straight, to hang		Opening and snapping shut while rising from a swing, transitioning into a support	6–8 sets, 3–4 repetitions	Handstand with a straight body, lowering into a support	From support, spring up to a handstand with the legs and perform a forward roll	Weight-bearing from a support, spring up to a handstand with the legs and perform a forward roll	The load weight is 20% less than the athlete's body weight. 10 × 3, 3 repetitions

Table 3. Exercise complex for teaching static elements performed on gymnastic rings

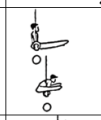
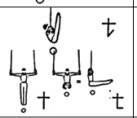
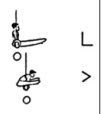
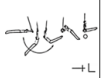
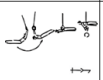
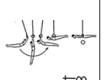
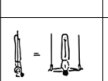
Element names	Element appearance	Technical preparedness	Standard	Exercises performed on an adaptive device			Standard
				Light	Medium	Heavy	
Hanging front scale (front lever) (2 s)		From a hanging position, grasping the corner, with a swing, hold the front horizontal	8 × 10 sets, 3 repetitions	From hand support, perform an arm flexion followed by abduction (or lateral raise), starting position	From hand support, perform arm abduction to overhead and return to the starting position	Weighted handstand arm abduction to overhead and return, starting position	The load weight is 15% less than the athlete's body weight. 10 × 3, 3 repetitions
L-sit (2 s) or straddled L-sit (2 s) hold		Transitions on the parallel bars from corner to corner with legs extended	6–8 × 10 sets, 2 repetitions	Angled grip with supination and pronation movements during a supported position	From a support, hold a 45-degree angle (or pike position)	Weighted support hold, 45-degree pike (or weighted support hold, 45-degree angle)	The load weight is 25% less than the athlete's body weight. 10 × 3, 3 repetitions
Any cross (2 s) or V cross (2 s)		On the small rings, jump from a bridge to a cross position	15–20 × 10 sets, 2 repetitions	Reaching arms out to the sides and lifting them overhead.	From hand support, hold a high pike (or L-sit) at 90 degrees and lower to a 45-degree pike position	Weighted handstand hold, 90-degree pike (or L-sit), and lower to a 45-degree pike	The load weight is 22% less than the athlete's body weight. 10 × 3, 3 repetitions
Support scale at ring height (swallow or Maltese cross) (2 s)		On the small rings, supported at a height, extend the arms to the sides downward	5 × 10 sets, 2 repetitions	Maintaining hand support while opening the arms downward from the sides.	From hand support, perform an arm abduction and return to the starting position	Weighted hand support arm abduction and lowering, starting position	The load weight is 14% less than the athlete's body weight. 10 × 3, 3 repetitions
Forward somersault, piked or straight, also with a ½ twist		From a supine position, perform a backward roll to a handstand	5 × 2 sets, 2 repetitions	Raising to an upright position by swinging the legs upward while maintaining a hand support	From hand support, perform a swinging motion to a handstand, followed by a front fall	Weighted hand support swing to handstand and forward roll, starting position	The load weight is 10% less than the athlete's body weight. 10 × 3, 3 repetitions

Table 4. A complex of exercises for teaching the transition from dynamic movements (swings) to static holds on the rings

Element names	Element appearance	Technical preparedness	Standard	Exercises performed on an adaptive device			Standard
				Light	Medium	Heavy	
L-sit (2 s.) or straddled L-sit (2 s) hold		Pullover on the high bar with a shoulder kip, transitioning from a layout back lever on the ladder to the bar	10 × 3 sets, 3 repetitions	From a supported position with knees bent, perform an arm abduction (or lateral raise), hold for 0.3 s, and then return to the starting position	From hand support (or handstand), perform arm abduction to overhead, followed by a lateral raise and lowering, starting with arms extended at the sides	Weighted hand support arm abduction to overhead, lateral raise and lowering, starting position	The weight of the load is 15% less than the athlete's weight. 10 × 3, 3 repetitions.
Forward uprise to L-sit (2 s)		High swings, transitioning to an inverted hang (or support), followed by a free fall dismount	10 × 2 sets, 2 repetitions	From a handstand, perform controlled shoulder movements (or scapular rotations) up to 30° while maintaining balance	From a standing position on a 30 cm elevation, with arms extended overhead, starting position	Standing on a 30 cm elevation, feet together, arms extended overhead, starting position	The weight of the load is 10% less than the athlete's weight. 10 × 3, 3 repetitions.
Backward uprise to straddled support scale (2 s)		On the parallel bars, from a swing, perform a straddled press to horizontal (or straddled press to L-sit position)	8 × 3 sets, 3 repetitions	From a lying position, perform a swing and press to a straddled L-sit (or straddled horizontal position)	From a supine position, perform a forceful press to a straddled L-sit (or straddled horizontal)	Weighted, from a supine position, perform a forceful press to a straddled L-sit (or straddled horizontal)	The weight of the load is 12% less than the athlete's weight. 10 × 3, 3 repetitions.
Backward uprise to swallow (2 s)		From a swing, perform a straddled press to horizontal (or straddled L-sit) and, using a push-off (or kick-out), transition into a front lever	5 × 4 sets, 3 repetitions	From a handstand with legs extended, perform a swallow dive descent followed by a kick-out (or press-up) to return to the handstand	From a handstand with legs extended, perform a controlled descent to a front lever in 0.5 s and a kick-out (or press-up) back to the handstand	Weighted handstand, transitioning to and holding a weighted swallow (or weighted planche)	The weight of the load is 7% less than the athlete's weight. 10 × 3, 3 repetitions.
Inverted cross (2 s)		On the rings, perform a handstand with a forceful arm abduction (or lateral raise) while maintaining stability	5 × 2 sets, 2 repetitions	From hand support (or handstand), perform arm abduction (or lateral raise), starting from arms extended at the sides	Handstand against the wall, arms abducted (or in a lateral raise position), starting position	Weighted handstand against the wall, arms abducted (or in a lateral raise position), starting position	The weight of the load is 9% less than the athlete's weight. 10 × 3, 3 repetitions.

Technical training results

The level of mastery of elements performed on the rings, in accordance with specific requirements, was evaluated (Table 6).

Table 6. Indicators of the development of gymnasts' specific strength qualities

№	Test exercises		Control group			Experimental group			AG	t	P
			$\bar{x}$	σ	V%	$\bar{x}$	σ	V%			
1	On the rings, supporting on the hands, powerful rise from an angle, 3 seconds (number of repetitions)	Pre	5.61	0.9	16.53	5.48	0.7	12.30	0.13	0.52	>0.1
		Post	5.61	0.9	16.53	7.21	0.8	10.73	1.60	7.09	<0.001
2	From a hanging position on the rings, backward horizontal hang (s)	Pre	9.45	1.2	12.54	9.32	1.4	14.66	0.13	0.41	>0.1
		Post	10.47	0.7	6.97	14.74	0.7	4.05	4.27	14.65	<0.001
3	From a hanging position on the rings, forward horizontal hang (seconds)	Pre	6.61	1.1	16.05	6.56	0.9	13.51	0.05	0.57	>0.1
		Post	7.10	0.9	12.46	7.63	0.7	9.48	0.53	3.47	<0.001
4	Transitions from forward horizontal hang to backward and forward hang (number of repetitions)	Pre	7.48	0.7	9.73	7.67	0.8	10.1	0.19	0.80	>0.1
		Post	9.66	0.8	8.7	12.66	1.2	10.0	3.0	3.22	<0.001
5	Powerful rise on the rings (stemme) (number of repetitions)	Pre	9.06	0.7	8.07	9.35	0.9	10.10	0.29	1.08	>0.1
		Post	9.93	0.7	8.07	11.57	0.8	7.83	1.64	2.02	<0.01

Statistical analysis of survey data concerning the training duration for the prescribed exercises, performed without specialized equipment, resulted in average values. We identified the most commonly performed ring elements among gymnasts and integrated them into the training protocol for our study.

Discussion

Based on the researchers' experience as trainers and former athletes, their participation in monitoring youth gymnastics tournaments at the national level and their training programs, it was observed that young gymnasts struggle with weak handstand performance on the still rings. This is reflected in frequent disputes from the execution (E) committee, often owing to tuck flyaways and instability, which lead to score deductions. The researchers believed that the low artistic performance, according to trainers' views, is largely attributed to inadequate physical preparation related to the technical aspect of gymnastics. Many gymnastics training skills depend on experience and self-assessment, further hindered by the limited availability of devices and assistive

training tools. This gap led us to incorporate training devices and design exercises to enhance physical and motor abilities, along with artistic performance, using the still rings apparatus.

At the end of the study, correlational analyses were performed to assess the differences between the pre- and post-test results for both the experimental and control groups. Table 5 shows the overall findings from the correlational analysis for GPP and SPP assessments. Subsequently, the results from the GPP assessments were analyzed using Student's t-tests. The shuttle run performance averaged 52.07 s for the control group and 51.28 s for the experimental group ($t = 5.63$; $p < 0.001$). The jump rope exercise averaged 144.8 repetitions for the control group and 154.1 repetitions for the experimental group ($t = 5.77$; $p < 0.001$). For parallel bar dips, the control group averaged 36.9 repetitions, while the experimental group averaged 40.4 repetitions ($t = 4.34$; $p < 0.001$). In the pull-up performance, the control group averaged 14.2 repetitions, compared to 14.8 repetitions for the experimental group ($t = 3.95$; $p < 0.001$).

A biomechanical analysis was performed to evaluate the sequencing and complexity of ring elements, as well as to assess the effective use of strength resources during their execution (Table 5). The GPP assessment exercises were chosen based on the physical qualities and movement patterns relevant to ring routines. Notably, the study spanned a one-year macrocycle, with data collection occurring at both the beginning and the end of the training year.

The study examined the learning process and error analysis of ring skills performed by gymnasts. A set of ring skills performed by the athletes was categorized according to the four difficulty levels outlined in the Code of Points (or Specific Requirements IGF) and analyzed (Table 6).

In the study, the evaluation focused on the accuracy of gymnasts' technical skills, the physical qualities developed through specific exercises, and their ability to effectively use these capabilities. The average duration of the weighted handstand hold on the rings, transitioning from a pike position, was 5.61 s for the control group and 7.21 s for the experimental group ($t = 7.09$; $p < 0.001$). For the back lever hold on the rings, the control group averaged 10.47 s, while the experimental group averaged 14.74 s ($t = 16.65$; $p < 0.001$). The average duration of the front lever hold on the rings was 7.10 s for the control group and 7.63 s for the experimental group ($t = 3.47$; $p < 0.001$). The control group achieved an average of 9.66 repetitions in transitions between the front lever and back lever, while the experimental group averaged 12.66 repetitions ($t = 3.22$; $p < 0.001$). For muscle-ups on the rings, the control group averaged 9.93 repetitions, compared to 11.57 repetitions for the experimental group ($t = 2.02$; $p < 0.001$).

Basic exercises were chosen and used in the study to enhance the learning and teaching of ring skills by developing fundamental movement patterns. The research showed that these movements considerably improved athletes' performance and led to more technically proficient execution of skills.

An analysis was performed on the construction of ring exercises, focusing on skill combinations to explore methods for optimizing workload, increasing difficulty, clarifying coach-controlled variables, and finding similar solutions. Ring skills were classified into four categories based on the requirements of the Code of Points (or specific technical regulations): swings, static holds, static–dynamic–static skills, and dismounts. Although these skills are expected to be performed competently by our athletes, they differ in terms of execution, difficulty level, technical proficiency, and relative ease of performance. Athletes must demonstrate a high level of performance when evaluated by officials and experts. The skill combinations performed by the athletes in our study were analyzed (Table 7).

Table 7. The cumulative score of the competitive routine elements performed in the study

№	Exercises	Group	Pre			Post			t	P
			$\bar{x}$	σ	V%	$\bar{x}$	σ	V%		
1	Competitive routine composition (or set of competitive routine elements) (D)	Experimental group	4.15	0.2	5.08	4.69	0.2	4.64	7,89	<0,001
		Control group	4.11	0.3	6.50	4.22	0.2	4.90		
2	Execution score (or score of the routine with deductions for errors) (E)	Experimental group	7.04	0.2	5.52	7.48	0.4	4.77	4,45	<0,001
		Control group	7.00	0.3	4.91	7.26	0.4	5.00		

The skills assessed by judges, along with the techniques used to perform them, must be performed with precision and clarity. During the study, the ability of the experimental group's gymnasts to perform elements of competitive routines, both in isolation and in combination, highlighted the effectiveness of complex exercises in enhancing their overall skill proficiency.

In the ring exercises (E) performed by the gymnasts, we analyzed the number of countable elements and the scores achieved (out of a possible 10.0). The findings of our study, which aimed to evaluate the effectiveness of the complex exercises and the adaptive device (training apparatus) used in this experiment, clearly demonstrated their effectiveness.

Table 8. The average difficulty score (or total difficulty values) of the competitive routines in the experimental group post-intervention (n = 20)

Sum of D points and bonuses	Combination	Errors	
D-0.4	Swinging back from a hanging position, rising, and holding a "swallow" position with the arms extended at the sides.	During the swing, the legs should remain straight and must not dip below the horizontal plane	0.1 0.3 0.5
D-0.4	Cast to iron cross (or weighted iron cross), with arms at the sides	Arms straight, with shoulders level to the rings	0.1 0.3 0.5
A-0.1	Forward shoulder roll on the rings	Arms straight, the body must reach a position above ring level	0.1 0.3 0.5
C-0.3	Forward tucked double somersault (or double tuck)	Seamless transition from support to a straddled (or open) position during rotation	0.1−0.3−0.5
D-0.4	Forward piked double somersault (or double tuck with pike)	Continuous transition from support to a straddled (or open) position during rotation, maintaining straight legs.	0.1−0.3−0.5
B-0.2	Straddled L-sit from a swing	Cast to handstand, with the swing reaching above 90 degrees before placing hands on the rings	0.1−0.3−0.5
B-0.2	Press handstand (or weighted press handstand)	Handstand on rings with arms extended (without rope contact)	0.3−0.5 and neutral deductions
C-0.3	Giant swing forward on the high bar	Stable and controlled handstand or other specified standing position	0.1−0.3−0.5 deductions for each skill
C-0.3	Back giant swing on the high bar	Stable and controlled handstand or other designated standing position	0.1−0.3−0.5 deductions for each skill
E-0.3	Double somersault with a 720° twist or double twisting somersault	Controlled landing with a full layout and an expressive finish	0.1−0.3−0.5 for each phase (of the routine)
1-category A+C+D+C+C 2-category D+B 3-category D+B 4-category E = 2.9 points without bonus	4 special requirements fulfilled: 0.5 + 0.5 + 0.5 + 0.5 = 2.0 points	Shortcomings are considered for each movement during evaluation.	−0.1−0.1−0.1−0.1−0.3−0.1 −0.1−0.1−0.3−0.1 = 1.9
Total final score	10.0 − 1.9 + 3.1 + 2.0 = 13.0		

In gymnastics, the role of the ring apparatus is defined not only by the complexity of the skills performed but also by the limited range of support, which depends solely on the gymnast's physical and technical mastery. Consequently, it can be confidently stated that the overall quality of the routines performed during the study demonstrated substantial improvement. As shown in the table 8 above, based on the post-test results of the experimental group, the study aimed to assess the differences in the ring routines performed. The results demonstrate that the gymnasts successfully increased the overall difficulty score of their routines by proficiently performing advanced skills, including the special requirements from categories 3 and 4, which involve static holds and static–dynamic–static elements. Furthermore, they enhanced the execution of their ring routines, minimizing errors. The specific deductions for errors were as follows: cast to back uprise to swallow (planche) with arms at sides (SR D - difficulty value 0.4), 0.1 deduction; cast to iron cross (SR D - difficulty value 0.4), 0.1 deduction; forward shoulder roll (SR A - difficulty value 0.1), 0.1 deduction; forward tucked double somersault (SR C - difficulty value 0.3), 0.1 deduction; forward piked double somersault (SR D - difficulty value 0.4), 0.3 deduction; straddled L-sit from swing (SR B - difficulty value 0.2), 0.1 deduction; press handstand (SR B - difficulty value 0.2), 0.1 deduction. Forward giant swing (SR C - difficulty value 0.3), 0.3 deduction; backward giant swing (SR C - difficulty value 0.3), 0.1 deduction; double somersault with 720° twist (SR E - difficulty value 0.5), 0.3 and 0.1 deductions. Table 9 presents an analysis of the difficulty scores for the ring routines performed by the experimental and control groups before and after the study. Initially, the experimental group's routines included the following special requirements (SRs)—category 1: A+C+D+C+C+A; category 2: A; category 3: B; category 4: C, yielding a total difficulty score of 2.1. After the study, the experimental group's routines included the following SRs—category 1: A+C+D+C+C; category 2: D+B; category 3: D+B; category 4:

E, resulting in a total difficulty score of 3.1. This represents an increase of 1.0 point, or approximately 47%, compared to the pre-test results.

Table 9. The difficulty score (or total difficulty values) of the ring routines performed by the gymnasts post-intervention

Categories	Difficulty values (or value of elements)		Difference in difficulty values (or difference in element values)	Special requirements (SRs)
	Control group	Experimental group		
Category 1	A-0.1, C-0.3, D-0.4, C-0.3, C-0.3	A-0.1, C-0.3, D-0.4, C-0.3, C-0.3	1.4 = 1.4	+0.5
Category 2	A-0.1	D-0.4, B-0.2	0.1 < 0.6	+0.5
Category 3	B-0.2	D-0.4, B-0.2	0.2 < 0.6	+0.5
Category 4	C-0.3	E-0.5	0.3 < 0.5	+0.5

It is essential for ring routines to be performed not only accurately but also with expressiveness. The responsibility for calculating the execution score (E score) lies with the competition judges. An analysis of the E scores is shown in Table 9. The control group recorded an average E score of 2.99 before the test and 2.73 afterward, indicating an improvement of 0.26 points. In contrast, the experimental group had an average E score of 2.95 before the test, which decreased by 0.251 points post-test, resulting in a final score of 0.440.

An analysis of the increase in the Difficulty Score of ring routines alongside the improvement in gymnasts' skill levels is essential. During the skill acquisition process, simulating a competitive environment and emphasizing both the expressive quality and proper execution of the skills are crucial. Many ring skills require transitions from swinging movements to static holds, making it necessary for gymnasts to initially master these skills in isolation. However, it is advisable not to immediately incorporate newly mastered skills into complex combinations. The number of category 1 skills remained unchanged. Category 2 skills increased in difficulty value from 0.1 to 0.6, reflecting a 600% increase. Category 3 skills increased in difficulty value from 0.2 to 0.6, representing a 300% increase. Meanwhile, category 4 skills increased from a difficulty value of 0.3 to 0.5, marking a 67% increase (Table 9).

It is important to highlight that, as outlined in the training program for candidates pursuing a Master of Sport, Masters of Sport, and International Masters of Sport, gymnasts in the experimental group must gradually increase the difficulty value of their routines each academic year to advance their competitive level and qualify for international competitions.

Conclusions

The multifunctional adaptive apparatus and the corresponding exercise program we developed in this pedagogical experiment were scientifically validated. This training program effectively contributed to the development of the gymnasts' physical abilities and technical skills. The study demonstrated a significant improvement in the specific movement techniques involved in executing, increasing the difficulty, and mastering ring skills and routines. This progress was reflected in the improved performance of the experimental group, which successfully incorporated higher-level skills and met more complex SRs, resulting in an overall increase in difficulty scores. We successfully improved the gymnasts' overall and specific physical conditioning alongside their specialized technical skills. Highly skilled athletes and candidates for Master of Sport were able to significantly increase the difficulty value in their routines. In the experimental group, 20 gymnasts attained the scores required to qualify for the titles of Candidate for Master of Sport, Master of Sport, and International Master of Sport.

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