PAIRED-CONNECTED DEVELOPMENT OF MOTOR QUALITIES IN AESTHETIC GYMNASTICS

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Abstract

Intensification of training and competitive activity in sports creates the need to search and develop new training methods. This study was conducted with the aim to study the influence of the author's methodology of paired-connected development (PCD) of physical qualities on the level of technical readiness and performing skills in aesthetic gymnastics (AG). For 13 girls - gymnasts (12±1.2 years old), training according to the standard method (control group), and 12 gymnasts of the same age and qualifications, using PSD in the training cycle (main group), the level of development of flexibility, strength, speed, coordination, endurance, technical readiness and success of competitive activity was studied. It was shown that the use of PCD improves the flexibility in the hip joints by 4.24% and 2.28% for the right and left legs, respectively, and the flexibility of the spine by 7.04%. Coordination indicators improved by 32.66-41.25%, strength by 10.02%. The increase in speed indicators was 18.71-21.09%, the indicators of special endurance increased by 11.13-25.16%. For balance, the marks increased by 25.75%, for turns by 19.38%, for jumps by 24.58% and for the flexibility movements they increased by 15.47%. The average scores for the technical value of the composition increased from 4.5±0.07 to 5.45±0.06 points (21.1%), and the average indicators of the final competitive scores increased from 14.49±0.04 to 15.73±0.08 (8.56%). As a result of the experiment, the positive influence of the developed PCD methodology on the level of physical and technical readiness of female gymnasts, as well as on the final competitive result, was confirmed.

Keywords: *aesthetic gymnastics, coupled method, flexibility, strength, speed, coordination, endurance.*

INTRODUCTION

Today in AG there is a steady increase in the number of competitions during the year, which leads to a longer competitive period and a shorter preparatory period in the annual training cycle, the main task of which is to increase the technical readiness of female athletes (Tsepelevich, 2007). In this regard, coaches, athletes, and specialists are in constant search for new means and methods of special physical training (SPP) of athletes, that would, on one hand, have a complex effect on the physical qualities and technique of performing competitive elements, while on the other, it would not contradict the

principles of sports training (Tarabrina, 2018).

Karpenko and Rumba (2010) suggested that in AG the motor qualities do not appear separately, they are closely interconnected with each other and are manifested in different forms. Vishnyakova (2011) confirmed that in the situation of shorter time for the preparation of competitive compositions, it is necessary to include complex impact exercises in the SPP program that include elements of acrobatics, choreography, and, to a greater extent, competitive exercises.

Sports science introduced into practice the so-called method of connected impact (Dyachkov, 1960), based on the principles of redundancy, connection and advanced development. This means that while performing special exercises that develop any physical abilities, coordination is simultaneously developed and this forms the basis of a competitive exercise. In this way, it is possible to significantly increase the effectiveness of the training process (Tsepelevich, 2007). Simmons (2000) has proven the effectiveness of PCD in strength training for powerlifters and Epov (2018) has shown its positive effect on the development of leg strength in highly skilled taekwondo athletes. There are very few studies that experimentally prove the effectiveness of PCD of motor qualities in AG.

The aim of this research was to study the influence of the author's methodology of PCD on the level of technical readiness and performing skills in AG.

METHODS

The study involved 25 girls aged 12±1.2 years, engaged in AG in the team of "Vestalia" in Simferopol, with the experience of sports training from 5 to 7 years. Informed parental consent was obtained for the participation of children in the experiment. All sportswomen, according to the Unified Sports Classification System (Federal law of the Russian Federation, 2007; Unified Sports Classification System, 2017) had the same sports qualification (sports category I); therefore, the difference in sports experience was not considered in the statistical analysis. They were divided into two groups: the first (control – CG) group consisted of 12 female gymnasts (10 girls (83.3%) had 7 years of sports experience and 2 (16.7%) had 6) and trained according to the standard method. The second (main – MG) group consisted of 13 gymnasts (11 girls (84.6%) with 7 years of sports experience, 1 with 6 and 1 with 5 (7.7%)) who, for four months in the preparatory period of the training cycle, performed a set of exercises developed at the Department of Medical and Biological Foundations of Physical Culture and Sports of V.I. Vernadsky Crimean Federal University (Tarabrina, Chernaya, 2018). This set was used in the general and special preparatory stages. The effectiveness of the developed sets was studied by looking at the following indicators:

- level of development of motor qualities according to the results of pedagogical testing;
- level of technical readiness based on the results of expert assessment for the performance of competitive elements by gymnasts;
- results of competitive activity at control competitions: regional stage: October, 2017; municipal stage: March, 2018.

In total, seven SPP sets of combined orientation were developed: three sets aimed at developing balance and flexibility (abbreviated in Table 1, Figure 1, Figure 2 and Figure 3, respectively), three sets to develop jumping ability (leg muscle strength and jumping special endurance) (J.1, J.2, J.3, respectively), as well as a set of

acrobatic exercises which include competitive elements of increased complexity (A).

Each set of exercises provides three levels of dosage, which varies by 10-30% depending on the microcycle and is designated by letters a, d, c (respectively). The sets are distributed in the preparatory period of the training process by days of the week (Table 1).

The entire program of the experiment was conditionally divided into four mesocycles (Table 1). In the retraction, basic and control mesocycles and Set F were performed, aiming to develop flexibility and balance, as well as Set J that aimed to develop the jumping ability, jumping special endurance and strength of the leg muscles. Set A was performed in the grinding mesocycle. The sets were included in microcycles as follows: on Monday, Wednesday and Friday, at the end of the preparatory part of the training, the athletes performed Set F; on Tuesday, Thursday and Saturday at the end of the main part of the training, the gymnasts performed Set J.

In the grinding mesocycle of a special preparatory stage, which is aimed at eliminating shortcomings, improving the technique of competitive elements, and correcting mistakes, MG gymnasts were offered Set A three times a week, characterized by increased intensity.

Exercises (A) have a conjugate character and include technically complex competitive elements, repeated several times in a series (up to eight movements in a series), and represent preset combinations connected by acrobatic elements. In the future, gymnasts can use combinations from the acrobatic set as a part of their competitive program. To perform these exercises, gymnasts must simultaneously show such physical qualities as flexibility, strength, special endurance and coordination.

Children's flexibility was assessed using an indirect, scientifically proven method, (Kamaev & Osadchyieva, 2018) which involves linear measurement of the distance between segments or to an external object. Thus, to assess the flexibility of the spine in the frontal plane, we used the following test: "bend-forward-from-a-standing-position". The gymnast stands on the edge of a bench with legs together and straight knees. How much the fingers extend below the edge of the bench is noted. If the fingers do not reach the edge, the distance is recorded using the "-" sign (Romanenko, 1999).

To assess the flexibility of the shoulder joints, the test "twist-back-with-a-grip-for-a-centimeter-tape" was used. The subject transfers straight arms over the head from the front to the back position; the grip width is fixed (Romanenko, 1999).

The mobility of the hip joints was assessed by measuring the distance to the floor while performing the split. In this case, a gymnastic bench 60cm high was used (Kamaev & Osadchyieva, 2018).

To assess the mobility of the spine, a test exercise "box" was used: from the initial position, lying on the stomach, it is necessary to grab the legs with the hands, while measuring the distance from the feet to the floor (Romanenko, 1999).

Coordination abilities were assessed using the Romberg test (Galán-Mercant & Cuesta-Vargas, 2014). The subject stands in such a way that her legs are on the same line while the heel of one leg touches the other leg, eyes closed, arms extended forward and fingers spread. The indicators of Romberg test in children depend on their age (Table 2) (Galán-Mercant, Cuesta-Vargas, 2014).

The Firileva test, confirmed by scientific and experimental data (Firileva, 1981), was used to assess the ability to coordinate movements. Under

the test conditions, the subjects learn control exercises for 2-5 minutes. They include multidirectional movements of the legs, the arms, and the head. When performing these exercises, it is necessary to take into account the quality (score in points) and the execution time (s). Further, by dividing the indicators of the time spent on the exercise by the mark (between 1 and 5), a coefficient is derived, which is an indicator of the level of development of the ability to coordinate movements. Thus, the shorter the time and the higher the score, the lower the coefficient of the level of coordination development.

The results are interpreted as follows:

- "excellent": 0.1–2.0, conventional unit;
- "good": 2.1–4.0, conventional unit;
- "satisfactory": 4.1-6.0, conventional unit;
- "unsatisfactory": 6.1 and higher, conventional unit.

We used coordination Set 1: initial position - normal stand position (n.s.p.); 1 - left leg back to toe, left arm bent at the elbow joint, elbows at shoulder height, wrist to shoulder, right arm up, head to the left; 2 - n.s.p.; 3 - repeat 1; 4 - n.s.p.; 5 - turn right; 6 - n.s.p.; 7 - half-squat, arms forward; 8 - n.s.p.. The combination must be repeated four times for the best score and for the best mark (Firileva, 1981).

To measure the gymnasts' strength of the muscles in the hands and the back of the wrist, dynamometers (hand-held flat-spring dynamometers, DRP-90, Russia) were used.

Strength indicators were determined for the muscles of the arms and shoulder girdle using the test exercise "flexion-and-extension-of-the arms-in-the-lying-position". In this case, the maximum number of repetitions of the test exercise, performed technically correctly, was counted: lying position, arms shoulder-width apart, angle at the elbow joint of at least 90° and straight arms to full extension (Romanenko, 1999).

The "angle" test was used to determine the strength of the trunk muscles: initial position - sitting on the floor, holding the legs at an angle of 135°, holding time is measured; boat test - from the initial position lying on the stomach, raised arms and legs up and hold the position, the holding time is recorded (Romanenko, 1999).

Strength indicators of the muscles of the lower extremities were assessed by using the "lifting-and-holding-the-pelvis-in-a-split" test (Romanenko, 1999).

To determine the speed and stability of the motor-sensory response, we measured the parameters of the time of a simple sensorimotor response using light and sound stimuli from the BioMouse software package (NeuroLab, Russia) (Kulakov, 2020).

The "fifteen-second-squat" test was used to assess the frequency of movements; the number of squats performed technically correctly is recorded (the legs should be shoulder-width apart, the angle at the knee joints is 90°, the heels do not come off the floor) (Tarabrina & Chernaya, 2018).

Special speed abilities were assessed using the "jumping-with-double-rope-rotation" test. The number of speed jumps in 10 seconds was assessed (Romanenko, 1999).

The level of high-speed special endurance was judged by the indicators of the number of jumps on the rope with alternating legs (running) for 1 minute and by the indicators of the maximum number of double jumps in the rope performed in a row (Romanenko, 1999) (Kamaev & Osadchyieva, 2018).

To determine the level of technical readiness of the female gymnasts, the method to expertly assess the fulfillment of competitive elements in all structural

groups of the exercise was used in the stage of in-depth training (IFAGG, 2020).

Competitive elements were performed by gymnasts in the main part of the training session and were assessed by three experts, coaches of the Federation of Aesthetic Gymnastics of the Republic of Crimea and "Vestalia" teams, and judges: one top category judge and two category II judges.

Twenty basic elements from the current competition rules were selected.

The following compulsory elements were evaluated: balance, turns, jumps and flexibility movements. The gymnasts were asked to perform the elements, and the experts were asked to give marks for the technique of each performed element. For this, the evaluation criteria presented in Table 3 have been developed. The final result was the average score from the sum of the marks for the performed elements in each structural group of the exercise.

The success of the competitive activity of gymnasts (SCAG) was assessed by adding together three assessments: for the technical value of the composition, for the artistic value, and for the performance (IFAGG, 2020).

The marks in each group are displayed as the arithmetic mean with or without dropping the highest and lowest marks, depending on the number of judges.

The maximum score for the technical value of the composition is 5.9+0.1 points - bonus increase; for the artistic value 3.9+0.1 points - bonus increase; for performance 9.8+0.2 points - bonus increase (Klyuchinskaya, 2012; IFAGG, 2020).

SCAG was judged on the basis of the results from two competitions: October 8-10, 2017 (Championship of Crimea in AG, Alushta) and March 11, 2018 (Championship of Simferopol in AG, Simferopol).

Thus, it was possible to compare the results of the competitive activity of gymnasts before and after the introduction of the sets.

The calculations and graphic design of the data obtained in the work were carried out using the Microsoft Excel program and the STATISTICA - 10.0 software package. The choice of the criterion for testing statistical hypotheses and measures of central tendencies that serve to describe the data was carried out depending on the results of the distribution test, which was carried out using the Shapiro-Wilk test. Pairwise comparison of groups was performed using the parametric Student's test. In this case, the arithmetic mean (M) was used as a measure of the central tendency, and the standard error of the arithmetic mean (m) was used as a scattering measure.

Table 1
Distribution of sets of conjugate exercises in the preparatory stage of gymnasts' training.

	General preparatory stage						Special preparatory stage					
	Retracting mesocycle			Base mesocycle			Control mesocycle			Grinding mesocycle		
	Microcycle											
	1	2	3	4	5	6	7	8	9	10	11	12
Monday	F.1a	F.1b	F.1c	F.2a	F.2b	F.2c	F.3a	F.3b	F.3c	A.a	A.b	A.c
Tuesday	J.1a	J.1b	J.1c	J.2a	J.2b	J.2c	J.3a	J.3b	J.3c			
Wednesday	F.1a	F.1b	F.1c	F.2a	F.2b	F.2c	F.3a	F.3b	F.3c	A.a	A.b	A.c
Thursday	J.1a	J.1b	J.1c	J.2a	J.2b	J.2c	J.3a	J.3b	J.3c			
Friday	F.1a	F.1b	F.1c	F.2a	F.2b	F.2c	F.3a	F.3b	F.3c	A.a	A.b	A.c
Saturday	J.1a	J.1b	J.1c	J.2a	J.2b	J.2c	J.3a	J.3b	J.3c			
Sunday	Day of rest			Day of rest			Day of rest			Day of rest		

Table 2
Average time of stability (s) in the Romberg position for children, adolescents and young men (according to A.F. Sinyakov).

Age (years)	6	7	8	9	10	11	12	13	14	15	16	17	18
Stability time (s)	13	16	21	24	28	30	36	44	48	50	52	51	53

Table 3
Criteria for assessing the technical readiness of gymnasts.

Assessment (score)	Description
1.0	element executed without errors
0.9	item executed with one minor error
0.8	average error in the technique of performing an element or two small errors while maintaining the amplitude of movement
0.7	slight decrease in the range of motion and minor error in the technique of performing the element
0.6	preservation of the shape of the element with the assumption of average error in technique
0.5	element made with significant technical error; in a competitive combination it cannot be scored
0.4	broken shape of the element, insufficient range of motion
0.3	the required form of the element is missing with several minor errors in the basic movement technique
0.2	gross error in the basic technique of performed movement
0.1	crash on element execution
0	refusal to execute an element

RESULTS

Figure 1 shows that in CG, the increase in flexibility indicators is insignificant, and in MG, improvement is observed only in such indicators as "split on the right leg", "split on the left leg" and "box" (4.24%, 2.28% and 7.04% ($p<0.05$), respectively). In gymnasts, the most developed of all physical qualities are passive and active flexibility in joints and the spine. Before the start of the study, these indicators in athletes of both groups were at a high level, therefore, the sets could only slightly affect their change. Coordination tests improved in CG (21.33-25.21%) ($p<0.05$-0.01) and in MG (32.66-41.25%) ($p<0.01$-0.001). The most striking changes were observed in Romberg test: 41.25% ($p<0.001$) (Figure 2).

As a result of training according to the standard method, the strength indicators of CG gymnasts did not change significantly, and the strength of the muscles of the upper shoulder girdle decreased by 2.5%. In MG, the strength of the back muscles increased between 8.74% to 10.02% ($p<0.01$). The greatest results were achieved in the development of the strength in the adductor muscle group which lift and hold the body and pelvis from a position sitting on a split. This indicator increased by 31.38% ($p<0.01$) (Figure 3).

Indicators of a simple sensorimotor reaction where light and sound signals were used as stimuli did not change significantly. The number of squats and double rope jumping in 10 seconds in MG improved by 18.71% ($p<0.05$) and 21.09% ($p<0.01$), respectively (Figure 4). Special working capacity was significantly improved only in MG gymnasts (Figure 5). Double and alternate rope jumping increased by 11.11-11.13% ($p<0.05$-0.01), respectively. At the same time, the expert assessments for the performance of the competitive elements of the gymnasts in both groups changed after the experiment. A statistically significant ($p<0.05$) increase is observed in the assessments of CG gymnasts for turns (9.66%), for jumping performance (9.49%), and for flexibility elements (3.48%). In MG gymnasts, the increase in the score for the fulfillment of balances was 25.75% ($p<0.05$), for the performance of turns 19.38% ($p<0.01$), for jumping 24.58% ($p<0.05$), and movements for flexibility: 18.71% ($p<0.05$) (Figure 6).

The average scores for the technical value of the composition of CG gymnasts increased by 4.35%, while in the MG these indicators increased by 21.1% ($p<0.05$). The final competitive result for the exercise performance of CG athletes remained practically unchanged and was 14.74±0.02 points (increased by 2.01%) after the experiment. In the MG, the increase occurred from 14.49±0.04 points before the experiment to 15.73±0.08 points after (increased by 8.56% ($p<0.05$)).

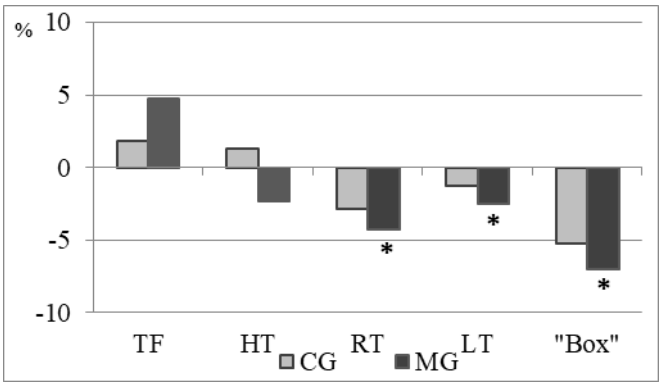

Figure 1. Changes in indicators of flexibility development in gymnasts of the control (n=12) and the main (n=13) group (%). Here and further: statistically significant differences at 0.05 level between the two groups at each assessment are denoted by asterisks: * – p<0,05; ** – p<0,01; *** – p<0,001; T is the Student criterion. TF is Tilt Forward, HT is Hands Twist, RT are Right Splits, LT are Left Splits.

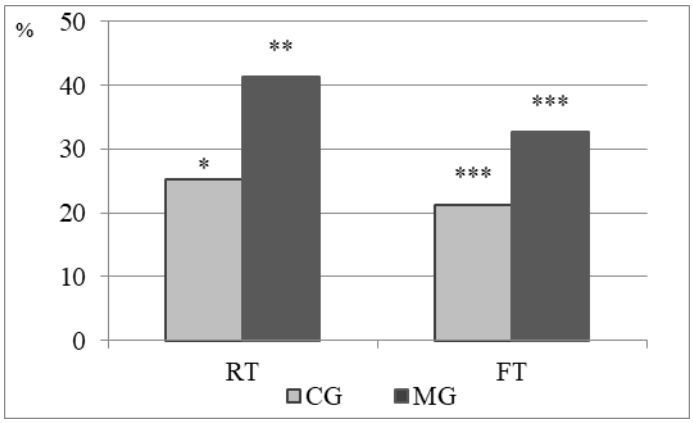

Figure 2. Changes in the indices of the coordination development in gymnasts of the control (n=12) and the main (n = 13) groups (%). RT is Romberg Test, FT is Firileva Test.

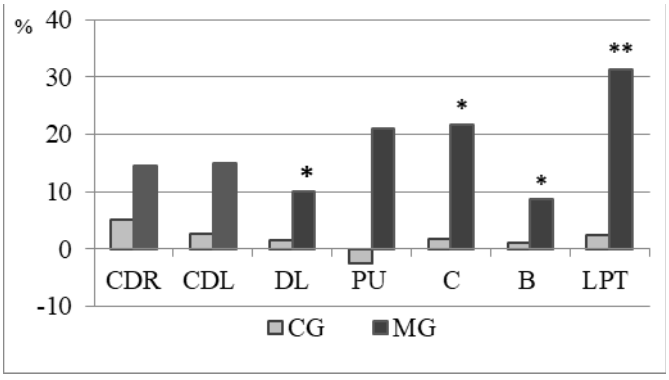

Figure 3. Changes in the strength indicators of gymnasts in the control (n=12) and the main (n=13) group (%). CDR is carpal dynamometry of the right hand, CDL is carpal dynamometry of the left hand, DL is deadlift, PU are push-ups, C is “Conner”, B is “Boat”, LPT is Lifting the pelvis in the twine.

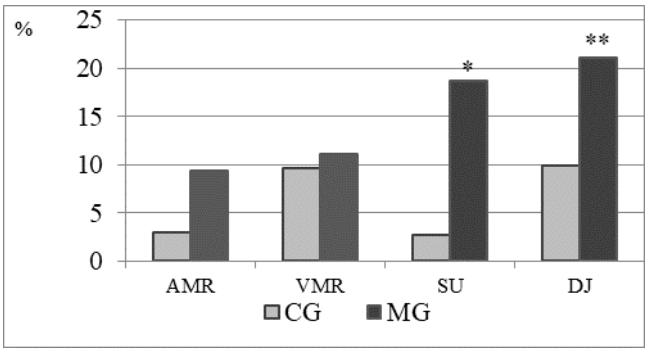

Figure 4. Changes in indicators of speed development in gymnasts of the control (n=12) and the main (n=13) group (%). AMR is audio-motor response, VMR is Visio-Motor Response, SU are Sit-Ups, DSR is Double Skipping Rope.

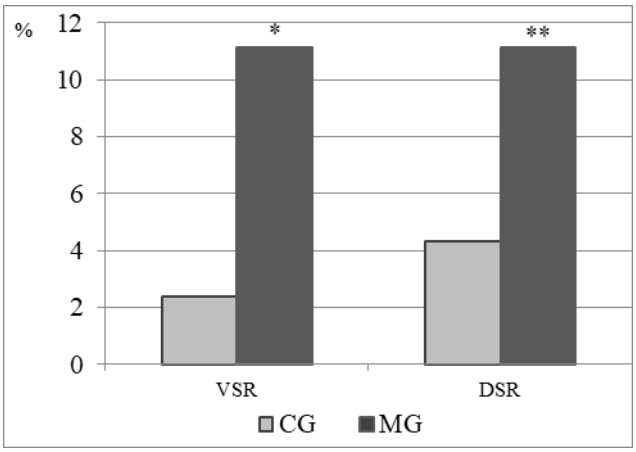

Figure 5. Changes in indicators of special endurance development in gymnasts of the control (n=12) and the main (n=13) group (%). VSR is variable skipping rope, DSR is double skipping rope.

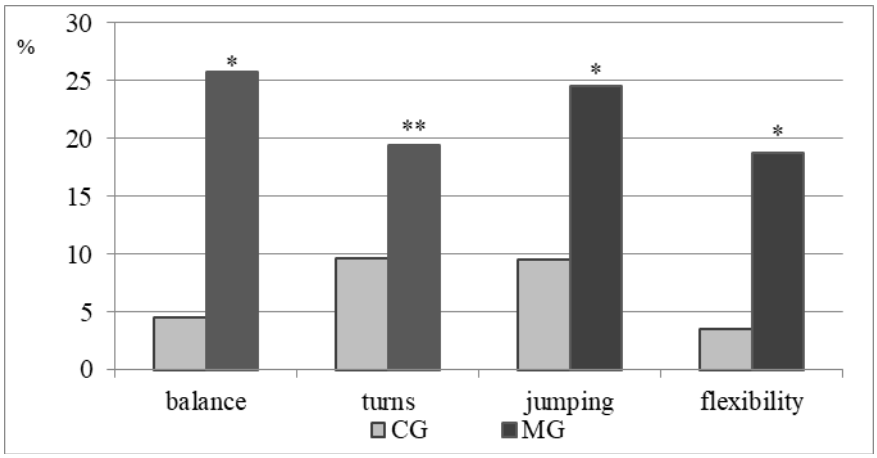

Figure 6. Changes in indicators of expert evaluations for the implementation of elements of gymnasts in the control (n=12) and the main (n=13) group (%).

DISCUSSION

In the system of sports training, there are various approaches to improving the technical skills of gymnasts. According to the authors, this can be realized by combining or conjugating various types of training: physical, technical, functional and theoretical. This pairing, especially of physical and technical training, in the general concept of integral training, has been successfully used for more than ten years at the national level in AG. The main provisions of the methodology were laid down in the concept of in-depth training for young gymnasts. In AG, this stage corresponds to the age of 12 years, when the athletes master and perform the program of the first sports category. The data presented here indicates its effectiveness.

The results obtained show that the indicators for coordination, speed, endurance, and strength statistically improved. However, the level of flexibility has not changed significantly. Tsepelevich (2007) believes that flexibility in gymnastics is the most developed and significant physical quality. This is confirmed by our data: the athletes participating in the study had a high level of flexibility before the introduction of the sets. This insignificant increase is explained by the Wilder-Leites rule or the “law of the initial level”, i.e., that the relative or absolute increase in the value of indicator is inversely related to its initial level (Plekhanov, Vasiliev, Kozlova, 1989). To improve the level of development of passive and active flexibility, it is recommended, in addition to the developed sets, to perform daily passive-static exercises (sitting in twine on a gymnastic bench), as well as active-dynamic (springing, swinging, jerking) exercises that can be performed with weights, shock absorbers or other resistance objects, or without them. It is important that the RCD sets, along with exercises for the development of flexibility, include exercises aimed at developing muscle strength. This helps to avoid injury to gymnasts and to achieve the best results (Tarabrina, Kraev & Tikhonov, 2020).

The greatest results were achieved in the development of the strength in the adductor muscle group (short and long adductor, square femoris, sartorius and comb muscles), gluteal muscles (large, middle and small), piriformis muscles, all of which are involved in lifting and holding the trunk and pelvis from a sitting position on a split. This indicator increased by 31.38% ($p<0.01$).

It was shown that due to the developed sets, the speed-power qualities of the gymnasts in general improved; however, the indicators of a simple sensorimotor reaction, where light and sound signals were used as stimuli, did not change significantly. The speed capabilities of a person (reflected in this indicator), especially in their motor part, are mostly natural and hardly changeable under the influence of sports training, which at the same time weaken with age (starting from adulthood) (Gardner & Moore, 2006). An increase in rope jumping with double rotation by 21.09% ($p<0.01$) testifies to the improvement of intermuscular coordination and coordination of movements, speed and high accuracy of the movement, as well as the efficiency of work.

The effectiveness of the developed methodology is confirmed by the competitive results of gymnasts. In the MG, not only the final results increased (by 8.56% ($p<0.05$)), but also indicators of the technical value of the compositions by 21.1% ($p<0.05$).

It should be noted that in the CG, the increase in the competitive result was not due to more difficult, technically valuable elements, but due to the higher-quality performance of the

elements, the technical value of which, according to the rules of the competition, is small: up to 0.5 points. This was achieved mainly by correcting minor errors and inaccuracies in technical details rather than by exercising physical ability. The results of MG gymnasts improved mainly due to the high-quality fulfillment of technically complex elements with a value of 0.6 points and more; their fulfillment requires a high degree of physical abilities that manifest in a specific complex motor action.

CONCLUSION

The theoretical analysis of scientific and methodological literature showed the need to search for directions to improve technical skills in gymnastic sports at all stages of training. This is associated with increased requirements for technical complexity and competitiveness at the international level. It is believed that ensuring a sufficiently high level of sportsmanship, as a necessary condition for achieving the highest results, is carried out as a result of fundamental, comprehensive and purposeful technical training. In this regard, it became necessary to develop the author's methodology of paired-conjugate development of motor qualities in 12-year-old female athletes engaged in AG at the stage of in-depth specialization in accordance with the methodological and didactic principles of sports training.

The author's methodology of paired-conjugate development of motor qualities was introduced into the educational-training process of a two-cycle annual training. It brought along the following improvements: use of methods and means of a practical and applied nature; development of seven sets for special physical training of a combined orientation: three sets of exercises mainly aimed at developing flexibility and balance; three sets mainly aimed at developing the jumping ability, leg muscle strength and jumping endurance, and a set that develops acrobatic exercises that include competitive elements of increased complexity. Each set of exercises provides three levels of dosage which varies by 10-30%, depending on the microcycle.

The analysis of the results obtained after the introduction of the author's method confirms the improvement of mobility in the hip joints by 4.24% and 2.28% for the right and left legs, respectively, and the flexibility of the spine by 7.04%. Coordination indicators improved by 32.66-41.25% ($p<0.001$), and strength indicators from 8.74% ($p<0.01$) to 10.77% ($p<0.05$). The increase in speed indicators was 18.71-21.09%, the indicators of special endurance increased from 11.13 ($p<0.01$) to 25.16% ($p<0.05$). The scores for balance increased by 25.75% ($p <0.05$), for the performance of turns - 19.38% ($p <0.01$), jumping - 24.58% ($p <0.05$), movements on flexibility - 18.71% ($p <0.05$). The average scores for the technical value of the composition increased from 4.5 ± 0.07 to 5.45 ± 0.06 points (21.1%) ($p <0.05$), and the average indicators of the final competitive scores increased from 14.49 ± 0.04 to 15.73 ± 0.08 points (8.56%) ($p <0.05$).

Thus, this study confirms our hypothesis and shows that in-depth training in AG as a method of PCD for motor qualities proved its effectiveness by making a difference to the physical and technical readiness of young gymnasts as well as their performing skills. This technique can be useful for both athletes and practicing trainers in AG. Some of its components can be used at different stages of sports training.

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