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Analysis of the Dynamics of the Basic Technical and Physical Training on Uneven Bars in Women's Artistic Gymnastics

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Abstract

Purpose. This paper makes an analysis of the basic technical and physical training on uneven bars in women's artistic gymnastics. **Methods.** A study was carried out in the Romanian national team of women's artistic gymnastics, with a group of 14 gymnasts aged 13-16. The study was conducted from 2017 (initial testing) to 2018 (final testing). The physical training (PT) was assessed by means of 10 physical tests and the basic technical training (TT) by 8 tests. Performance capacity (PC) on uneven bars was monitored in competitions too. Statistical analysis was made with KyPlot program, using descriptive indicators and the parametric method Paired Comparison for Means, at $p<0.05$. **Results.** The comparative analysis of PT indicators highlights an improvement of muscle strength development and significant differences at $p<0.05$ in holding a handstand (physical test - PT3), power handstand (PT4), alternating one-legged squats (PT5), long jump (PT8) and push-ups

(PT10). The comparative analysis results of basic TT indicators reveal an improved execution in final testing at p<0.001, p<0.01 and <0.05, except for elements with flight phase on the same bar (technical test - TT4) - p>0.05. The PC results highlight the elements difficulty increase (p<0.05), the execution decrease, the final score increase and p>0.05. **Conclusions.** The use of a physical training program (per muscle groups, both in the first and the second training) and preparatory exercises for each technical requirement on uneven bars showed the dynamics of muscle groups strength development according to the results obtained in competitions.

Keywords: artistic gymnastics, assessment, muscle strength, technical requirements, performance

Introduction

Contemporary artistic gymnastics develops in accordance with the laws and trends of world sport. The present-day stage is characterized by the development in depth and width, by higher difficulty of the competitive programs, increase of the technical mastery and widening of the geographical area (Arkaev & Suchilin, 2004).

The main goal of athletes' training in artistic gymnastics (high performance-oriented sport) is the successful participation in major competitions, with great achievements in terms of sports technical results, which are planned in advance (Atiković et al., 2017). One of the basic tasks in the training of elite female gymnasts from many teams in the world is to improve the accomplished technical execution of the competitive routines; the mastery criterion is the accurate and faultless performance required for obtaining the best results in competitions (Crețu, 2004).

The analysis of the method-scientific literature and the practical experience point out that the normative documents that ensure efficiency in the basic and special technical training, resting on the systemic materials, are not sufficient or lack totally. At the same time, the study of young gymnasts' training highlights that the coaches, in the conditions of "running" after sports results, teach the gymnastics elements in an accelerated manner, when the motor skills are not yet sufficiently developed; also, the individual style of

execution is created against the background of the mistakes omitted during the training process (Grigore, 2001; Potop, 2015).

The theory and methods of learning the women's artistic gymnastics exercises was studied for analyzing the process of improving the sports technical mastery; thus it was possible to set the bases of the macro-methods for teaching material assimilation in the basic specialization stage. As a dynamic system, this implies the unity of the long-term programs for learning the exercises of the movement school, basic level and specialization, the improvement of the routines on apparatus, respecting the requirements of didactic principles and learning rules (Boloban, 2013; Potop, 2015).

Based on the classic didactic principles, the concept of highly skilled gymnasts' preparation meets the requirements of complex training. This means that in the comparative learning of a simple element (layout salto, for example) it is necessary not only to learn an execution level without mistakes from judges' point of view, but also to pay attention to the parameters that allow the gymnast to learn faster and in due order the elements of higher difficulty (e.g. double or triple salto), in other words to use the horizontal and vertical transfer in learning (Potop et al., 2014).

Physical training is a process of education of the motor skills necessary for the correct acquisition of elements, connections and combinations, as well as of the entire routines in artistic gymnastics. Physical training is carried out in close connection with the technical, psychological, artistic, tactical and theoretical training. In practical activity, the physical training includes the following forms: *general* and *specific*. Throughout an annual training cycle, depending on the qualification level of the gymnasts and the training stage, there are two aspects of the physical training: *development of the motor skills* (preparatory period) and *maintaining the reached level,* even improving it (competitive period). Learning the routines and their execution, consistent with the requirements of the Code of Points (FIG, 2017), supposes the existence of a higher level of development of the coordinative capacity, strength, mobility-flexibility, speed, endurance and the combined qualities too (Grigore, 2001; Irwin et al., 2005; Readhead, 2011).

Uneven bars - women's artistic gymnastics event – has enriched its content lately with new technical procedures whose names are not yet to be found in the specialized literature. The main directions of development for this apparatus are: derivation, composition, concentration and loan (transfer) (Grosu, 2004).

The content and construction of the routines on uneven bars must present a variety of movements, namely: rotation and momentum, elements near the bar, flights from the high bar to the low bar and vice versa, flight on the same bar, elements with turn on the longitudinal axis and descents (FIG, 2017). From biomechanical point of view, the female gymnast must control her body in unusual conditions, to overcome her own weight – by segments and whole body – and also the effects of the gravity (external and internal forces) (Prassas, 2006).

Methods

The purpose of the study is to analyze the level of basic physical and technical training on uneven bars in women's artistic gymnastics.

Hypothesis of the study: we consider that the use of a physical training program, correlated per muscle groups, both in the first and the second training session and preparatory exercises for each technical requirement on uneven bars will highlight the dynamics of muscle groups strength development and their learning in conformity with the results achieved in competition.

This scientific approach led to the organization of an experimental study in the Romania national team of women's artistic gymnastics, with a group of 14 gymnasts of 13-16 years old. All investigations were conducted in conformity with the Code of Ethics of the World Medical Association (Declaration of Helsinki). The study was carried out during two annual training cycles: 2017 (initial testing) and 2018 (final testing). The physical training level was assessed in the beginning of each annual training cycle in the preparatory period.

The following fitness tests were used to assess the physical training: physical test 1 (PT1), rope climbing by means of the arms, from straddled position, 5m/sec; PT2, rib stall hanging leg raise in 60 sec, (max rep no); PT3, holding a handstand on the floor, (sec); PT4, power handstand – straddle press to handstand 60 sec, (max rep no); PT5, alternating one-legged squat with forward roll on the floor in 60 sec, (max rep no); PT6, torso extensions with arms up from prone position in 60 sec, (max rep no); PT7, pull-ups in 60 sec, (max rep no); PT8, standing long jump (cm); PT9, standing high jump (cm); PT10, push-ups from prone position in 60 sec., (max rep no).

Table no 1. Program of physical training used during the study

A1	**ABDOMEN + BACK + ABDOMEN - SIDE**	**Distribution**
1	Abdomen: from supine position / upside down on the rib stall, torso raises holding a 5 kg plate in the hands.	5 – 7 sets x 20 reps / 20-30 sec pause between sets
2	Back: torso extensions will be performed from prone position on the balance beam, arms forwards.	5 - 7 sets x 20 reps / 20-30 sec pause between sets
3	Abdomen - side: lying on the side, with one arm in the extension of the trunk and the other supported on the floor, lateral trunk extensions will be performed.	5 – 7 sets x 50 reps / alternating the sides
A2	**LEGS + ARMS**	
1	Legs: - squats	5 sets x 70 reps / pause 20 – 30sec
	- high jumps over 10 fences, knees to the chest	10 sets x 10 reps / pause 20 – 30 sec
	- high jumps will be performed on two inclined trampolines, with alternative change of the legs	3-4 sets x 100 reps / pause 20-30 sec

2	Arms: - handstand push-ups	5 sets x 13 reps / pause 20-30 sec
	- strength handstand (from rollover or on the beam)	5 sets x 7-10 reps / pause 20-30 sec
	- in standing position, the back supported on the rib stall - arms raises with a 5 kg plate in the hands.	5 sets x 20 reps / pause 20-30 sec

Note: A1 – training session 1 - a.m., A2 – training session 2 - p.m.

The preparatory exercises used to learn the content of the routine on uneven bars are the basic technical requirements presented in the given fitness tests. The following tests were used: technical test 1 (TT1), handstand on the floor (points); TT2, mount by strengthening, on the low bar or on the high bar (points); TT3, elements with flight and transition from the high bar to the low bar (Pak salto / transition with 180° twist), (points); TT4, elements with flight phase on the same bar (points); TT5, elements with different grip, except for mount and dismount (points); TT6, element with 360° twist on longitudinal axis (points); TT7, element next to the bar – clear hip circle to handstand (SPM) / toe circles in SPM / Stalder in SPM, (points); PT8, double salto tucked dismount (DST) / double salto piked (DSP) / double salto tucked with 360° twist (Tsukahara) / double salto stretched (DSS) / double salto forward (DSfwd), (points).

The results achieved on uneven bars by the gymnasts in 5 national and international competitions in 2017 and 5 competitions in 2018 (according to the competition calendar of the Romanian Gymnastics Federation) were used to assess the performance capacity (Difficulty (D), score; Execution (E), score; Final score (FS).

The statistical analysis was made by means of the computerized statistical calculation program ”KyPlot”, using the most common indicators: mean, standard errors mean (SEM), standard deviation (SD), coefficient of variability (CV%); parametric method, t -test, Paired Comparison for Means; all data were reported at the significance threshold $p < 0.05$.

Results

The level of basic physical and technical training on uneven bars was assessed in two stages at the end of the preparatory period of the annual cycle 2017 (initial testing) and 2018 (final testing). The performances of the gymnasts in the uneven bars events in both training cycles were also monitored. The results of the study were statistically analyzed and compared at $p<0.05$. The dynamics of the physical training is shown in table no 2.

Table no 2. Results of physical training, n =14.

Indicators	Testing	mean	SEM	SD	Cv (%)	t	p
PT 1 (sec)	final	9.60	0.20	0.76	7.94	-0.03	>0.05
	initial	9.61	0.19	0.74	7.72		
PT 2 (reps no)	final	35.36	0.29	1.08	3.06	1.10	>0.05
	initial	34.93	0.32	1.21	3.45		
PT 3 (sec)	final	46.84	3.52	13.18	28.14	2.81	<0.05
	initial	40.28	3.59	13.43	33.34		
PT 4 (reps no)	final	11.36	0.48	1.78	15.68	3.51	<0.01
	initial	9.43	0.71	2.65	28.13		
PT 5 (reps no)	final	24.71	0.69	2.61	10.58	2.99	<0.05
	initial	23.28	0.56	2.09	8.98		
PT 6 (reps no)	final	45.21	1.22	4.58	10.12	0.38	>0.05
	initial	45.00	1.34	5.02	11.16		
PT 7 (reps no)	final	15.57	0.62	2.31	14.84	-0.45	>0.05
	initial	15.78	0.74	2.78	17.60		
PT 8 (cm)	final	212.5	4.04	15.13	7.12	2.27	<0.05
	initial	208.21	4.05	15.17	7.28		
PT 9 (cm)	final	48.86	1.16	4.35	8.89	1.97	>0.05
	initial	47.28	1.14	4.25	8.98		
PT 10 (reps no)	final	36.21	2.00	7.49	20.69	2.50	<0.05
	initial	33.86	2.48	9.28	27.41		

The comparative analysis of the physical training indicators highlights differences in final testing at physical test 1 (PT1) - keeping the level of arms strength at both tests - and insignificant differences at $p>0.05$; in PT2 , the abdominal strength (legs raise) was improved by 0.43 reps, with insignificant differences at $p>0.05$; PT3 (holding a handstand) shows an improvement of the sense of balance by 6.56 sec with significant differences at $p<0.05$; in PT4 there was an increase of the number of power handstand mounts by 1.93 reps and significant differences at $p<0.01$; PT5 shows the improvement of legs strength by the increase of the number of alternating one-legged squats by 1.43 reps and significant differences at $p<0.05$; PT 6 highlights the maintaining of back muscles strength at 45.20 sec and insignificant differences at $p>0.05$; in PT 7 there is a decrease of arms strength by 0. 21 reps and insignificant differences at $p>0.05$; PT 8 reveals the increase of legs strength by the increase of long jump value by 4.29 cm and significant differences at $p<0.05$; in PT 9, the legs strength at high jump increases by 1.58 cm, with insignificant differences at $p>0.05$; PT10 (push-ups) shows the increase of arms strength by 2.35 reps and significant differences at $p<0.05$.

Table no 3 presents the results of the indicators of basic technical training on uneven bars, according to the technical requirements for this apparatus (FIG, 2017).

Table no 3. Results of the basic technical training on uneven bars, n=14

Indicators	Testing	mean	SEM	SD	Cv (%)	t	p
TT 1 (points)	final	7.00	0.10	0.39	5.60	10.94	<0.001
	initial	4.50	0.25	0.94	20.9		
TT 2 (points)	final	8.57	0.14	0.51	6.78	-3.12	<0.01
	initial	8.00	0.00	0.00	0.00		
TT 3 (points)	final	7.57	0.13	0.51	6.78	2.51	<0.05
	initial	7.00	0.28	1.04	14.83		
TT 4 (points)	final	7.28	0.16	0.61	8.39	1.71	>0.05
	initial	6.78	0.32	1.19	17.51		
TT 5 (points)	final	7.36	0.19	0.74	10.13	3.31	<0.01
	initial	6.78	0.26	0.97	14.37		
TT 6 (points)	final	7.57	0.14	0.51	6.78	2.48	<0.05
	initial	7.14	0.21	0.77	10.78		
TT 7 (points)	final	7.50	0.14	0.52	6.91	3.12	<0.01
	initial	7.07	0.19	0.73	10.32		
TT 8 (points)	final	7.43	0.14	0.51	6.91	4.77	<0.001
	initial	6.42	0.23	0.85	13.24		

The comparative analysis of the indicators of basic technical training reveals the following matters: the technical test 1 (TT1) shows differences in final testing, improvement of the handstand on the floor by 2.50 points and significant differences at $p<0.001$; TT2 highlights the improvement of the supported mount by 0.57 points and significant differences at $p<0.01$; in TT3 – the final test - there is an improvement by 0.57 points of the elements with flight phase and transition from high bar to low bar (Pak salto / transition with 180° twist) and significant differences at $p<0.05$; TT4 – initial testing has a low level of 6.78 points and a final improvement by 0.5 points of the elements with flight phase on the same bar (releases) and insignificant differences at $p> 0.05$; at TT5, there is an

improvement by 0.58 points in final testing as for the elements with different grip, excepting the mount and the dismount, and significant differences at p< 0.01; TT6 has a mean of 7.14 points in initial testing and an improvement by 0.43 points in final testing at the elements with 360° twist in longitudinal axis, with significant differences at p <0.05; TT7 highlights an improvement by 0.43 points in the final testing (7.50 points) at the elements close to the bar - clear hip circle to handstand (SPM) / toe circles in SPM / Stalder in SPM, with significant differences in p<0.01; TT8 has an improvement by 1.01 points in final testing (7.43 points) at double salto dismount (DST / DSP) / DST 360º (Tsukahara) / (DSS) / (DSfwd) and significant differences at p<0.001.

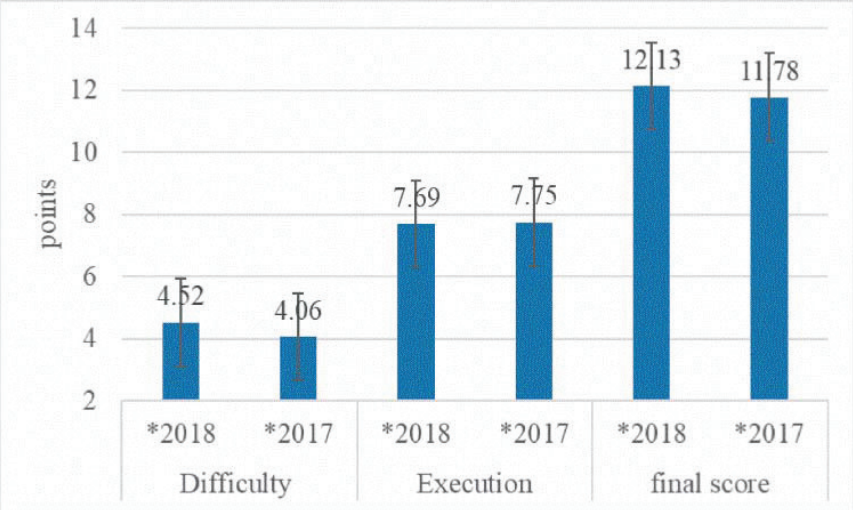

Fig. 1. Dynamics of the performance capacity on uneven bars, n =10

The results of the performance capacity are shown in figure 1, highlighting the mean of the scores obtained in 5 competitions of the training cycle 2017 and 5 competitions in 2018. The comparative analysis of the scores for Difficulty reveals an increase by 0.46 points (4.53 points) at the performances achieved in 2018; the scores for Execution have a decrease by 0.06 points and insignificant differences at p>0.05; the Final Score has an increase by 0.35

points in 2018 and insignificant differences at $p>0.05$. These differences are due to the introduction of some elements of great difficulty (such as transitions with flight phase, releases of the same bar and more difficult dismounts) in the content of the training plan.

Discussion

The basis of the contemporary artistic gymnastics is physical training. The high level of physical training is a prerequisite for achieving high results in artistic gymnastics. This condition is necessary but not sufficient. Finally, the main way to obtain sports technical result is the technical action, which can be found in the movements of athlete's body or its segments (Potop, 2011). If we consider the complete training of elite gymnasts from the systemic analysis angle and its description in terms of entry and exit, then the technical training could be seen as an exit and the physical training as an entry into the system (Arkaev & Suchilin, 2004).

The analysis of the specialized literature regarding the effort in training points out the correlation of training effort parameters with the average of the performances obtained in competitions (Cîmpeanu, 2014). An important approach within this study refers to the influence of physical training on the technical training on uneven bars (Potop & Cretu 2018). As for the basic technical training in accordance with the specific requirements on uneven bars, it was found out that improvements at the level of specific physical training and technical execution as well were still needed. This also implies the necessity of biomechanical study of the technical execution, for a deeper knowledge of the technique key elements. In this respect, we can mention some studies that focus on aspects like the optimization of the technique used in descents (Hiley & Yeadon, 2003, 2007; Forminte et al., 2020); the optimal kinematic model of the performance of the clear hip circle to handstand (Petkovic et al., 2018); biomechanical analysis of the double salto descent off the uneven bars (Potop, 2014); the mathematical modelling of the biomechanical characteristics of the dismounts off uneven bars

(Potop, Mihaila, & Urichianu, 2015). The study found out that the role and share of the special physical training increases in the training process. The volume of competitive training within an annual training cycle (5 competitions) also increases, at the same time as the number and level of the competitions. There are also studies that analyze the biomechanical characteristics and the performances obtained in the uneven bars events (Potop et al., 2014; Potop, Timnea, & Stanescu, 2017).

Conclusions

The comparative analysis of the physical training indicators following up the implementation of the training program between tests highlights the improvement of muscle strength development needed during the training, which was observed as a motor support in the learning of the specific requirements on uneven bars.

The results of the performance capacity reveal significant differences between the means of the scores obtained in the competitions of the training cycles 2017 and 2018, by increasing the elements difficulty, and insignificant differences at Execution by the decrease of the value and the increase of the Finale Score, as a result of their sum.

The use of a physical training program, correlated per muscle groups, both in the first and the second training session, and preparatory exercises for each technical requirement on uneven bars highlighted the dynamics of muscle groups strength development consistent with the results achieved in competitions; all this validates the hypothesis proposed in this study.

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