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Original Article

The relationship between the indicators of physical preparation and the scores attained in competitions by the junior female gymnasts

VALERIAN NICOLAE FORMINTE[1], RAMONA MICU[2], VLADIMIR POTOP[3], EMILIA FLORINA GROSU[4]
[1]PhD. Student, "Babes-Bolyai" University of Cluj-Napoca, Faculty of Physical Education and Sport, "Farul Constanta" Sports Club, ROMANIA.
[2]LPS "Cetate" Deva, ROMANIA
[3]Department of Physical Education and Sport, University of Pitesti, ROMANIA
[4]"Babes-Bolyai" University of Cluj-Napoca, Faculty of Physical Education and Sport, Cluj-Napoca, ROMANIA

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Abstract
This paper examines the relationship between the indicators of physical preparation and the scores attained in competition by the junior female gymnasts aged 13-15 years. ***Materials and methods.*** 6 junior gymnasts of 13-15 years old, selected from the national team of Deva, participated in this study. The physical training was assessed by 10 fitness tests. The competition results were recorded in three national competitions (C1-3). The statistical analysis used the following descriptive parameters: mean, standard deviation, nonparametric tests, namely: Z - Wilcoxon Signed Rank Test for Paired Data, Chi-Square Kruskal-Wallis test and *R* - nonparametric correlation coefficient – Spearman. ***Results.*** The assessment of the junior female gymnasts' physical training highlights an increased segmental strength of the arms, abdomen, scapular belt and legs (spring). There were also noticed higher specific endurance and better balance sense. The results obtained in competitions reveal the following elements: in handspring vaults event, they present an increase by 0.27 points in C3, $p > 0.05$; on uneven bars, the final score (FS) increases by 3.19 points in C3, $p < 0.05$; on balance beam, the FS is higher by 0.10 points in C3, $p > 0.05$; on the floor, the FS increases by 0.25 points in C3, $p > 0.05$. The correlative results analysis between indicators of physical preparation and the results obtained in competitions shows strong and very strong connections in the intervals ($R = .60$-$.79$; $R = .80$-1.0) on each apparatus in C1 and C3. ***Conclusions.*** The correlative analysis of the relationship of physical preparation means and the scores attained in competition by junior female gymnasts highlights strong connections between indicators.
Keywords: gymnastics, physical fitness, competition results, statistical analysis, juniors

Introduction

Artistic gymnastics keeps making significant progress even though the international technical regulations underwent changes in terms of difficulty, content and composition of the exercises on apparatus (Bale & Goodway, 1990; FIG, 2017).

According to Grigore, V. (2001) "artistic gymnastics is characterized by motor coordination, vestibular and emotional balance, resistance to stress, focused attention etc.; from a somatic point of view: small-medium size, underweight, well-developed muscular strength".

The content of sports training has those structural elements that, based on functional and methodological rules and laws, determine sports performance.

Physical preparation is the basis for all the training factors on which the pyramid of high performance is supported (Bompa, 2001). This component of the training has a special role in the preparation process, materialized in the results got in competitions (Niculescu, 2003).

Artistic gymnastics requires extraordinary levels of physical fitness and strength to train and compete at the highest levels (Readhead, 2011).

According to Smolevskij and Gaverdovskij (1999), the physical and functional training includes several methodological aspects, highlighting the individual features of the gymnast's training. It refers to the physical and functional skills and to the requirements for their development. The success in artistic gymnastics largely depends on the special skills related to the athlete's sensory and motor development.

The valorization and evaluation of the artistic gymnastics' exercises are done according to the FIG norms provided in the Code of Points. Two types of scores are given: difficulty (D) and execution (E) and the final score is calculated by the sum of the two, resulting the final score (FIG, 2017).

The analysis of the specialized literature on ensuring the relationship between the factors of sports training in artistic gymnastics highlights interdependent connections between physical, technical, mental preparation and the performances achieved in competitions (Forminte, et al., 2020).

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

The paper goal was to show the relationship between the indicators of physical preparation and the scores obtained in competitions at the level of junior gymnasts aged 13-15.

Materials and methods

The study involved 6 junior gymnasts of 13-15 years old, selected from the whole group of the national women's artistic gymnastics team of Romania.

The level of physical preparation development was evaluated by means of 10 fitness tests used at the beginning (initial testing - IT - 20.03.2017) and at the end (final testing - FT - 15.12.2017): Fitness test (FT1) – arms strength, climbing on the rope with the help of the arms, (sec); FT2 – abdominal strength, rib stall hanging leg raises, reps maximum number (N.R.); FT3- specific endurance, holding a handstand, (sec); FT4 – combined strength of scapular joint and back, power handstand, (N.R.); FT5 – strength of lower limbs, single-leg squats (left and right), N.R.; FT6 – back strength, torso extensions from prone position with arms up, maximum (N.R.); FT7 – arms strength, pull-ups, maximum (N.R.); FT8 - strength of lower limbs (spring), standing long jump, (cm); FT9 - strength of lower limbs, standing high jump, (cm) and FT10 – arms strength, push-ups from the prone position (N.R.).

Remark: FT2, FT4, FT5, FT6, FT7, FT8 and FT12 were executed in 60 seconds.

The performance level on the competitive apparatus was evaluated when the junior female gymnasts participated in three national competitions: C1- Team and Individual National Championships for Junior II Level 4 (CNEIJ), Onești, 03 - 04.06.2017; C2 - Open Individual National Championships and National Championships of Club Representative Teams (CNIO), men and women, Ploiești, 1 – 3.09.2017 and C3 - Individual National Championships of Junior II Level 4 (CNIJ), Deva, 09 - 11.11.2017.

The statistical-mathematical calculation and graphical representation method was applied with the help of KyPlot and Microsoft Excel programs, using the following statistical indicators: M - mean, ±SD – standard deviation; the differences between tests concerning the physical training indicators were analyzed using Z - Nonparametric test and Wilcoxon Signed Rank Test for Paired Data. The differences between the performances obtained in competitions were analyzed using the non-parametric test: Chi-Square – Kruskal-Wallis; the correlative analysis of the physical training indicators and the performance ones in C1 and C3 was made with the help of R – non-parametric correlation coefficient – Spearman.

Results

Table 1 presents the physical preparation results of the junior gymnasts in initial testing (IT) and final testing (FT).

Table no 1. Results of the indicators of physical preparation in junior gymnasts aged 13 to 15, n = 6

Statist. Indic.	Test	FT1, sec.	FT2, N.R.	FT3, sec.	FT4, N.R.	FT5, N.R.		FT6, N.R.	FT7, N.R.	FT8, cm	FT9, cm	FT10, N.R.
						left	right					
Mean	initial	23.94	33.7	39.5	8.17	28.00	27.83	44.33	10.00	192.5	38.17	35,17
	final	22.08	36.33	45.50	11.67	30.50	31.33	47.33	13.50	197.17	41.67	40,33
±SD	initial	1.92	2.58	30.07	2.48	2.09	2.14	2.73	3.34	17.69	2.48	4,16
	final	2.44	2.34	32.54	2.94	2.26	2.42	2.65	3.67	17.33	1.51	4,13
Z		2.201	-2.271	-2.214	-2.212	-2.251	-2.232	-2.264	-2.264	-2.219	-2.226	-2.232
P- values		0.036	0.031	0.035	0.027	0.032	0.033	0.031	0.031	0.034	0.034	0.031

Note. N.R. – number of reps, ±SD –standard deviation, PF – fitness test (described in "Material and Methods"), Z – non-parametric test, Wilcoxon Signed Rank Test for Paired Data.

The results of the comparative analysis of physical preparation indicators highlight the following elements: FT1 – decrease (improvement) by 1.86 sec in FT (22.08 sec.), $p < 0.001$; FT2 - increase by 2.83 reps in FT (36.33 reps), $p < 0.01$; FT3 - increase by 6.0 sec in FT (45.50 sec), $p < 0.01$; FT4 - increase by 3.5 reps in FT, $p < 0.001$; FT5 with the left leg had - increase by 2.50 reps in FT (30.50 reps), $p < 0.001$; with the right leg – increase 3.5 reps in FT, $p < 0.001$; FT6 - increase by 3.0 reps in FT, $p < 0.001$; FT7 - increase by 3.50 reps in FT (13.50 reps), $p < 0.001$; FT8 - increase by 4.67 cm in FT (197.17 cm), $p < 0.001$; FT9 - increase by 3.5 cm in FT (41.67 cm), $p < 0.01$; FT10 - increase by 5.16 reps in the FT (40.33 reps), $p < 0.001$.

Concerning the results of the scores attained in the national competitions by the junior gymnasts, they are presented in table no 2, which shows the value of the mean and ±SD and the sense of the differences of the means between tests.

The comparative analysis of the statistical indicators shows the following: in Handspring Vaults event, the Mean of the vaults had the value of 12.82 points in C1, a decrease by 0.10 points in C2, an increase by 0.27 points in C3 and insignificant differences at $p > 0.05$; Uneven Bars event – the Final Score (FS) had a value of 11.63 points in C1, a decrease by 1.65 points in C2 and an increase by 3.19 points in C3 ($p < 0.05$), due to the increase of the difficulty by 0.53 points ($p > 0.05$) and the decrease of the execution by 0.101 points ($p < 0.05$); Balance Beam event – the FS had a value of 13.99 points in C1, a decrease by 0.92 points in C2 and an increase by 0.10 points in C3 ($p > 0.05$), due to the decrease of the difficulty by 0.54 points ($p > 0.05$) and execution by

0.282 points (p > 0.05); Floor event - the FS had a value of 13.54 points in C1 (p > 0.05), a decrease by 0.67 points in C2 and an increase by 0.25 points in C3 (p > 0.05), due to the decrease of the difficulty by 0.15 in C3 (p > 0.05) and execution by 0.282 points (p > 0.05).

Table 2. Results of the scores attained in national competitions of junior gymnasts 13–15-year-old

Contest apparatus		Mean			±SD			Kruskal-Wallis	
		C1	C2	C3	C1	C2	C3	Chi	P-value
Vaults	Score 1	12.83	-	13.11	0.78	-	0.69	0.24	0.624
	Score 2	12.98	-	12.97	0.69	-	0.78	0.00	1.000
	Mean	12.82	12.72	13.09	0.73	0.61	0.64	0.756	0.685
Uneven bars	D	3.33	2.93	3.86	0.68	0.80	0.60	2.935	0.230
	E	8.29	7.06	7.96	0.37	0.46	0.36	8.561	0.014*
	FS	11.63	9.98	11.82	0.50	0.58	0.48	6.469	0.039*
Balance beam	D	5.52	4.98	4.98	0.48	0.29	0.30	3.369	0.186
	E	8.48	8.09	8.186	0.39	0.19	0.44	1.347	0.51
	FS	13.99	13.07	13.17	0.73	0.29	0.62	3.869	0.144
Floor	D	5.07	4.78	4.92	0.49	0.34	0.39	0.591	0.743
	E	8.48	7.09	8.198	0.58	0.52	0.23	4.827	0.089
	FS	13.54	12.87	13.12	0.69	0.83	0.49	4.179	0.124

Note. D - difficulty; E – execution, FS – Final score; C1 (n=6) - CNEIJ; C2 (n=4) - CNIO, men and women, C3 (n=5) - CNIJ; Non-parametric test: Chi-Square – Kruskal-Wallis test (difference between C1, C2 and C3); * - $p < 0.05$.

In figure no 1 are presented the results of the correlation between the indicators of physical preparation and the scores obtained in competitions (final score) in vaults and uneven bars events obtained in Competition 1 (IT) and Competition 3 (FT).

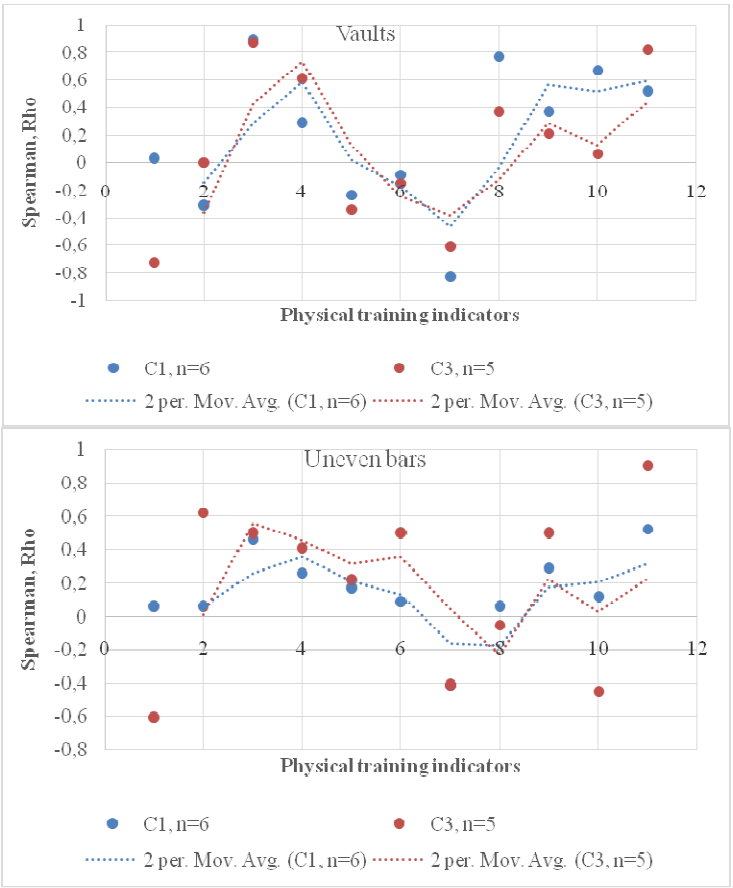

Fig. 1. Correlation of the indicators of physical preparation and the final score in vaults and uneven bars obtained in Competition 1 (IT) and Competition 3 (FT)

The correlative analysis highlights very strong correlations in C1 between the mean of performance in vaults and FT3, R = -.89, FT6, R = -.83) and in C3 with FT3, R = .87, with FT10, R = .82; strong correlations in C1 with FT7, R = .77 and with FT9, R = .67; in C3 with FT1, R = -.72, with FT4, R = .61 and with FT6, R = -.61. In uneven bars event there are not significantly correlations in C1 and in C3 there were significantly correlations

between the Final Score (FS) and FT10, R = .90 and strong correlations in C3 with FT1 R = -.60 and FT2 R = .62; the other correlations are moderate, weak and very weak (figure 1).
In figure no 2 are presented the results of the correlation between the indicators of physical preparation and the scores achieved in competitions (final score) on balance beam and on the floor in Competition 1 (initial test) and Competition 3 (final test).

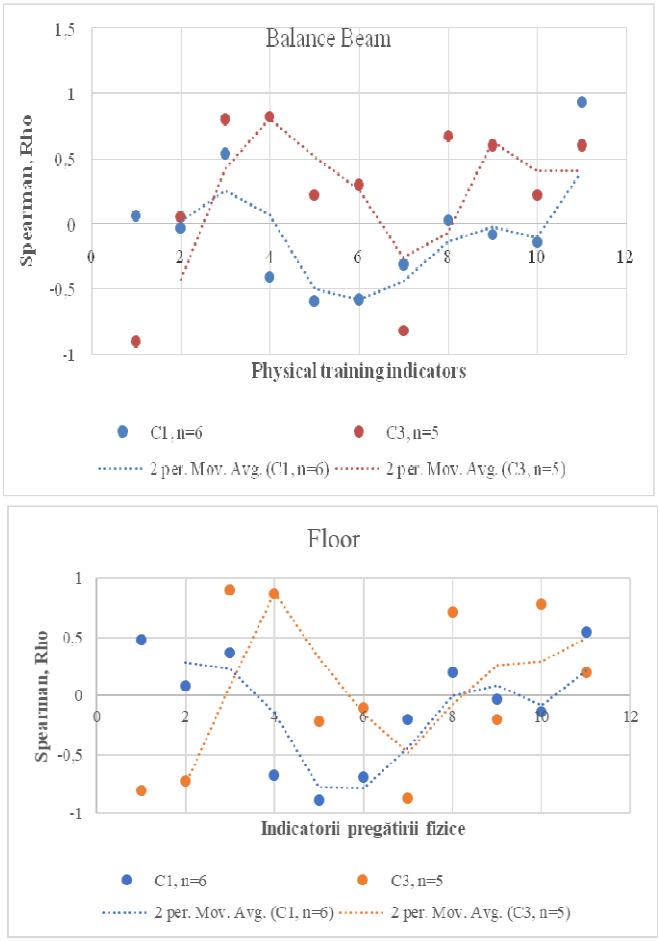

Fig. 2. Correlation between the indicators of physical preparation and the final score obtained on beam and on the floor in Competition 1 (IT) and Competition 3 (FT)

The correlative analysis reveals very strong associations in C1 between the mean of performance on balance beam and FT10, *R* = .93 and in C3 with FT1 *R* = -.90, FT3, *R* = .80, FT4, *R* = .82, FT6, *R* = -.82; there are no strong correlations in C1 – while in C3 there are correlations with FT8, R = .60 and FT10, *R* = .60. On the floor there were found out very strong correlations in C1 between the Final score (FS) and FT5a, R = -.88; in C3 with FT1, *R* = -.80, with FT3, *R* = .90, with FT4, *R* = .87, with FT6, *R* = -.87 and strong correlations in C1 with FT4, *R* = -.67, with FT5b, *R* = -.69 in C3 with FT2, *R* = -.72, with FT7, *R* = .72, with FT9, *R* = .78; the other correlations are moderate, weak and very weak (figure 2).

Discussion

The physical training level was assessed in two tests (initial and final); the performance level was evaluated during the participation of the junior gymnasts in three national competitions.
The review of the specialized literature reveals the existence of studies that have focused mainly on the levels of high-performance participation, with quantitative descriptions of the specific abilities (Takei et at., 2000). Determining the variability between the days of the scores in WAG competitions at high level proves that the consistency of the performance score of the Olympic gymnasts is higher than the superior national competitors. The consistency of performance score required from the female gymnasts who aspire to participate in the Olympics as competitors in the top-24 is better than 3% (Bradshaw, Hume, & Aisbett, 2012). Interested in the performance subject, Lee (1986) examines the relationship between self-sufficiency, performance both in training and competition in the WAG. The investigation of the most appropriate aptitudes for the elite sports

results in WAG and the determination of the physical profile reveals that the endurance, the strength and flexibility are important and essential for the achievement of elite performance (Nassib et al., 2020).

Referring to the training load in the artistic gymnastics' workouts (Burt et al., 2010), the effects of the participation level (international and national one), apparatus (balance beam and floor) and training stage (precompetitive and competitive) on the estimates of the training tasks are highlighted. A scientific study monitored the Danish elite female gymnasts in terms of bone density and the relationship with the maximum muscle force, the concentration of sexual hormones and the menstrual status (Helge, & Kanstrup, 2002). The influence of an intensive physical training on the pubertal development and growth in the athletes of rhythmic gymnastics and artistic gymnastics prolongs the pre-puberty stage and delays the pubertal development by regulating the hypothalamic-pituitary set point at puberty, without affecting the duration of the pubertal process (Georgopoulos et al., 2010). The study of the physiological indicators in women's artistic gymnastics on different apparatus characterizes the post-exercise heart rate, the oxygen uptake (VO2) and the maximum blood lactate concentration (Lmax) in a group of eight elite-oriented female gymnasts (Marina & Rodríguez, 2014).

The results obtained by the junior gymnasts aged 12 to 15 in the three national competitions reveal differences as for the difficulty of exercises and the decrease of the technical execution on apparatus. The higher final score in vaults and uneven bars was achieved by increasing the exercises difficulty level; the lower final score on balance beam and floor is explained by the non-fulfillment of the requirements regarding the exercise's difficulty and by a poor technical execution.

Conclusions

The results specific to physical training in the junior female gymnasts demonstrate the development of the segmental strength of arms, back, lower limbs, abdomen and scapular belt, the increase of legs strength (spring) and the enhancement of the specific endurance and balance sense.

The results of sports performances obtained by the junior gymnasts of 12-15 years old highlight some differences in the difficulty of the routines and the diminution of the technical execution and final score in the exercises on apparatus.

The correlative analysis between the indicators of physical preparation and the scores attained in competitions in the case of the 13-15-year-old female gymnasts proved the correlation level between indicators and their influence upon the performances in competition.

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