STUDY OF THE PHYSICAL FITNESS IN PRE-ADOLESCENT FEMALE GYMNASTS

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ABSTRACT
Performance in artistic gymnastics depends on the optimal balance between the level of physical fitness and the complex technical skills required for each apparatus. Therefore, a high level of strength, flexibility, and muscular endurance, combined with speed and coordination, is essential in artistic gymnastics in order to successfully perform the large volume of complex exercises. The aim of the study is to determine the level of development of the motor qualities, strength, and endurance in 9-10-year-old female artistic gymnasts, according to the normative evaluation system in the Republic of Bulgaria. The research was carried out with 14 girls from a sports club in the town of Sofia. A cross-sectional study was conducted with 14 girls from a sports club in Sofia, who were examined on five indicators that provided information on different manifestations of strength and endurance: standing long jump, hanging pull-ups, hanging leg lifts, straddle L-sit to press handstand on floor exercise, and 15 jumps from the occipital position. A statistical analysis was conducted using SPSS 25 through variation analysis. In addition, the sigma method for evaluation was applied. The conducted study demonstrated that the gymnasts achieved an average level of performance in the tests assessing upper limb strength, abdominal muscle strength, and muscular endurance. Better results were observed in the indicators of explosive lower limb strength and speed-strength endurance. These findings are of particular importance given the demands associated with the increasing difficulty of high-level gymnastics practice.

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INTRODUCTION

The content of sports training has those structural elements that, based on functional and methodological rules, determine sports performance (Forminte et al., 2021). Artistic gymnastics requires extraordinary levels of physical fitness and strength to train and compete at the highest levels (Readhead, 2011).

To achieve a high level of complex motor performance in various sports disciplines, it is essential to initiate training in early childhood (Boraczyński et al., 2013). Artistic gymnastics training leads to the development of a natural body posture in most gymnasts who start their training at an early age, typically between 6 and 7 years (Kochanowicz et al., 2009; Garcia et al., 2011).

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

Performance in artistic gymnastics depends on the perfect balance between the physical fitness level and the complex technical skills required for each apparatus (Minganti et al., 2010). Therefore, a high level of strength, flexibility, and muscular endurance, combined with speed and coordination are required for artistic gymnastics to successfully perform the large volume of complex exercises (Chu, 1994; Bencke et al., 2002; French et al., 2004; Jemni et al., 2006).

A study conducted with young elite male gymnasts showed that muscle power is paramount in identifying talents in gymnastics (Mkaouer et al., 2010). Developing various physical qualities (i.e., speed, power, strength, endurance, etc.) is essential for building the elite gymnastics profile. Therefore, an objective assessment of young gymnasts is necessary to identify potential future champions.

Aim And Objectives

The aim of the study is to determine the level of development of the motor qualities, strength, and endurance in 9-10-year-old female artistic gymnasts, according to the normative evaluation sys-

tem in the Republic of Bulgaria.
The study makes it possible to assess the actual state of physical fitness and will assist in optimizing the training process of the gymnasts during the subsequent stages of preparation.

METHODOLOGY

The current study was carried out in March 2025.

Participants

Fourteen girls from a sports club in Sofia were studying. The study focused on examining the motor abilities of strength and endurance in 9- to 10-year-old female gymnasts.

Measurement and indexes

For the purposes of the study, a sports-pedagogical test was conducted with the participants. A validated and standardized test battery was applied, including five indicators that carry information about the different manifestations of strength and endurance, as presented in Table 1 (Dimova et al., 1988; Dobreva et al., 2019).

Table 1. *Indicators examined*

Indexes	Measure unit	Measurement direction
Standing long jump	1,0 cm	+
Hanging pull-ups	1,0 pcs	+
Hanging leg lifts	1,0 pcs	+
Straddle L-sit to press handstand on floor exercise	1,0 pcs	+
15 jumps from occipital position	0,01 sec	-

Research methods

To achieve the study's aim, the following methods were employed: a review of *specialized literature and sports-pedagogical testing.*

Procedure

The research was conducted in the gymnastics hall during the regular artistic gymnastics training sessions. The testing was carried out by our research team with the active participation of the children's coaches. Prior to the study, permission and informed consent were obtained from the parents regarding its purpose and the use of the collected data. Gymnasts' anonymity was guaranteed, as all of them were registered under different numbers. All participants took part in the study voluntarily and did not receive any monetary or financial compensation for their contribution. Before the testing, brief instructions, a video, and a demonstration of the test battery were provided. For the implementation of the tests, the necessary equipment was used: a stopwatch and a measuring tape. Each participant performed only one trial of the test.

Study design

For the purposes of the study, we assessed the level of motor qualities, strength, and endurance according to the normative table for evaluating physical preparedness in women's artistic gymnastics (Dimova et al., 1988; Dobreva et al., 2019). The following sequence was observed in the assessment process:

- Determination of the score corresponding to the achieved test result, taking into account the age of the gymnasts (e.g., for a result of 124 cm in the standing long jump, the gymnast is awarded 16 points).
- Normalization of the score within a six-grade evaluation system (e.g., 16 points correspond to a "Satisfactory" grade) (Table 2).

Table 2. *Normalization of the score to a six-grade evaluation system*

Evaluation	Excellent	Very good	Good	Satisfactory	Weak
Points for 1 test	41-50	31-40	21-30	11-20	1-10
Total points (5 tests)	201-250	151-200	101-150	51-100	1-50

Data analysis

The results of the study were subjected to mathematical-statistical processing with SPSS 25 and illustrated with Excel 365. Depending on the tasks of the study, the following statistical methods were applied:

- *variation analysis* – for defining average values, normality of distribution, and variety of indicators under study;
- *sigma method* – for the quantitative assessment

of the condition of the measured signs. Based on the average level of the measured characteristics for a given age group, evaluations are calculated as normalized values presented within a 50-point system, which allows for comparing the achievements in different dimensions of tests and indicators – number, time, meters (Gigova, 2009; Dimova et al., 1988; Dobreva et al., 2019).

RESULTS

The main parameters of the variation analysis are presented in Table 3. The data indicate that the distribution of values is normal or close to normal for most of the strength and endurance indicators. An exception was observed for the "Standing long jump," where the skewness (As) values exceed 1.00. This may be attributed to the small sample size ($n \leq 15$). The group consisted of 10 nine-year-old and 4 ten-year-old gymnasts, with most values concentrated in the lower range, reflecting lower performance outcomes. This concentration may explain the presence of an asymmetric distribution for this indicator.

Table 3. *Average values and variability of physical fitness indicators*

Indicators	*n*	X min	X max	R	*Mean*	*SD*	V	As	Ex
Standing long jump	14	121	168	47	135,71	14,12	10,40	1,233 *	1,02
Hanging pull-ups	14	3	8	5	5,21	1,42	27,31	0,495	-0,445
Hanging leg lifts	14	3	8	5	5,43	1,70	31,26	0,088	-1,153
Straddle L-sit to press handstand on floor exercise	14	0	4	4	1,50	1,16	77,35	0,862	0,203
15 jumps from occipital position	14	26,63	41,74	15,11	34,47	4,13	11,98	-0,373	-0,095

Note: The critical values of the coefficients of skewness and kurtosis: at n=10 (As=1.374; Ex=2.668); at n=15 (As=1.160; Ex=2.242)

To verify the normality of the data distribution for the individual indicators, the nonparametric Shapiro–Wilk test was additionally applied at a significance level of $\alpha = .05$ (Table 4). The results show that the data distribution differs from the normal in the "Standing long jump" and "Straddle L-sit to press handstand on floor exercise" – $p \leq .05$. For the remaining indicators, $p > .05$, which confirms the null hypothesis that the data distribution is normal.

Table 4. *Shapiro–Wilk test for normality of distribution*

Indicators	*n*	*W*	*p*
Standing long jump	14	0.872	.045
Hanging pull-ups	14	0.936	.369
Hanging leg lifts	14	0.933	.332
Straddle L-sit to press handstand on floor exercise	14	0.865	.036
15 jumps from occipital position	14	0.965	.806

The values of the coefficient of variation showed that the group was highly homogeneous in terms of explosive power of the lower limbs – V1 = 10.40% - and speed-strength endurance – V5 = 11.98%. For two of the indicators characterizing the power of the abdominal muscles and strength endurance, the coefficient of variation was over 30%, indicating that the group was highly heterogeneous in the "Hanging leg lifts" and "Straddle L-sit to press handstand on floor exercise" tests. Only in the "Hanging pull-ups" test, the coefficient of variation was 27.31%, which showed that in terms of the strength of the upper limbs, the group is relatively homogeneous.

The analysis of the table showed larger differences between the minimum and maximum values in test 1, "Standing long jump" – R = 47 cm, and test 5, "15 jumps from occipital position" – R = 15.11 sec. Given the age of the children who are in the phase of prepubescent development, we consider this normal.

The results of the gymnasts' evaluation, according to the 50-point assessment system, are presented in Figure 1.

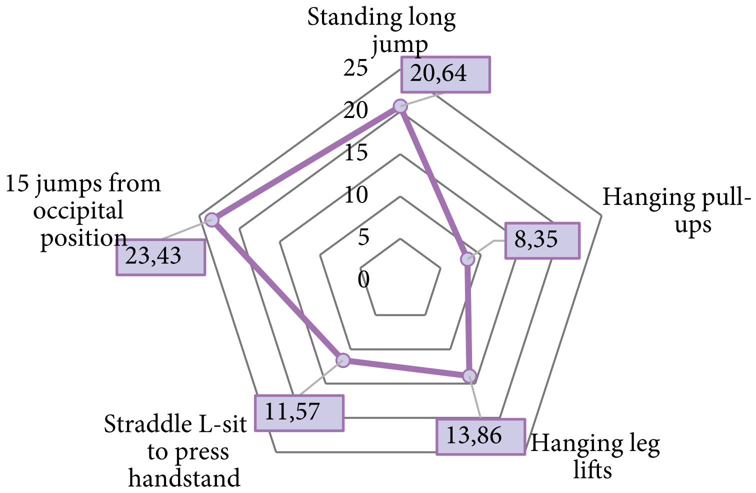

Figure 1. *Mean score of physical fitness of 9-10-year-old gymnasts*

The analysis of the figure showed that the highest mean score of 22.43 points was achieved by the gymnasts in test 5, "15 jumps from occipital position," corresponding to a "Good" evaluation (Figure 1). In Test 1, "Standing long jump", the result was 20.64 points, which can be interpreted as tending towards a "Good" evaluation. The average values obtained in two of the tests fall within the 11–20-point range, respectively 13.86 points for Test 3, "Hanging leg lifts", and 11.57 points for Test 4, "Straddle L-sit to press handstand on floor exercise", for which the group received a "Satisfactory" evaluation.

The lowest average score was recorded in Test 2, "Hanging pull-ups", amounting to 8.35 points. The corresponding evaluation for the group for this indicator was "Poor" (Figure 1).

Figure 2 presents the individual evaluations of the gymnasts' physical fitness. As shown in the figure, two gymnasts (No. 4 and No. 11, both aged 10) achieved higher total scores of 126 and 129 points, corresponding to a "Good" evaluation. The results of the remaining gymnasts fell within the range of 51 to 100 points, for which their evaluation was "Satisfactory." Only gymnast No. 2 recorded the lowest score of 46 points, corresponding to a "Poor" evaluation.

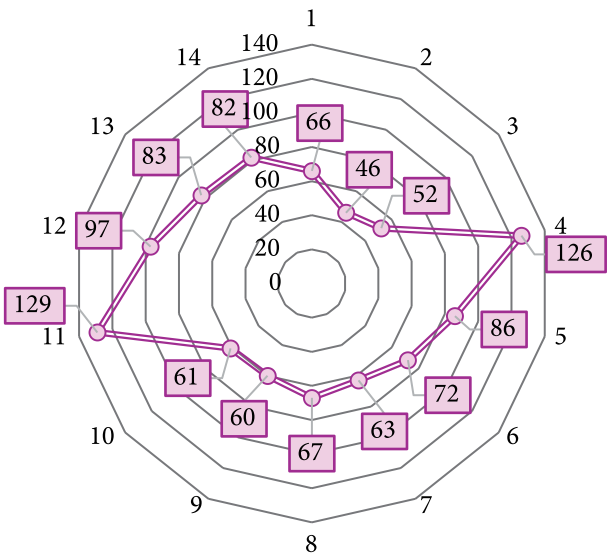

Figure 2. *Individual evaluation of the physical fitness of 9-10-year-old gymnasts*

DISCUSSION

The study's results provide insight into the developmental profiles of strength and endurance among the examined gymnasts. The comparatively better performance in the tests for speed-strength endurance and explosive strength of the lower limbs suggests that these qualities are relatively well developed at this age, which is consistent with the motor demands of gymnastics. Moreover, the low degree of variability in these tests indicates a relatively homogeneous level of performance across the group, reflecting a more uniform training effect.

In contrast, the lower results obtained in the tests for upper limb strength, abdominal muscle strength, and strength endurance point to weaker areas in the gymnasts' physical preparation. The greater variability in these indicators highlights substantial individual differences within the group, suggesting that some gymnasts experience difficulties in performing these tests. This unevenness in performance may be attributed to differences in training adaptation, growth, and maturation rates, or to the skills demonstrated during the execution of the tests. Additionally, the relatively small sample size (n = 14) may have contributed to the uneven results by amplifying individual differences within the group. Such findings emphasize the need for a more targeted approach in training, with a particular focus on improving the strength and endurance of the upper limbs and trunk, in order to achieve a higher level of development in the subsequent stages of long-term preparation. In turn, this is expected to positively influence the mastery of the technique of gymnastic exercises across the different apparatus.

In terms of qualitative assessment, the findings revealed that the gymnasts achieved a good level of development only in the test for speed-strength endurance ("15 jumps from occipital position"). For the remaining indicators of strength and endurance, the level of physical preparedness corresponded to the national average for this age group. However, when the results are compared with the standards proposed by the International Gymnastics Federation, a relatively low level of development of the different manifestations of strength and endurance becomes evident (Fink, Ortiz López, & Hofman, 2021).

The present findings, which highlight better performance in tests for explosive leg power and speed-strength endurance, are consistent with previous research emphasizing the central role of strength and explosive capacity in gymnastics. In their study, Jemni et al. (2006) established that strength and explosive power are the main determining factors of the physiological profile of gymnasts. According to the authors, the contribution of these qualities to performance has increased in recent years, as most elements are executed explosively within a very short time frame. This observation is supported by other researchers, who note that jumping ability is consistently identified as one of the most important skills for gymnasts (Bencke et al., 2002; Marina & Jemni, 2014). Moreover, Marina and Jemni (2014) emphasize that a gymnast's jumping capacity is closely linked to successful performance and may be considered a general indicator of gymnastic ability.

CONCLUSIONS

The conducted study revealed comparatively low results in the tests assessing upper limb strength, abdominal muscle strength, and strength endurance, most likely due to insufficient training emphasis on these components. Better results were observed in the indicators of explosive lower limb power and speed-strength endurance, which appear to reflect a more advanced level of development in some of the gymnasts.

The results of such a study are of importance, given the increasing demands of high-level gymnastic practice. In this context, it is essential to note that the rapidly growing difficulty in gymnasts' performances is largely a consequence of their advanced physical preparedness and the intensified training loads applied from an early age. Accordingly, a properly targeted and systematically applied physical preparation during the pre-adolescent period constitutes a prerequisite for achieving high sporting results.

Based on the findings of the present study, we propose the development of an example program aimed at enhancing the level of strength and endurance development, as well as monitoring the effects of its implementation, which will form the focus of our future research.

Limitations of the study

The desire of the research team was to cover a larger number of female gymnasts of the study age. Unfortunately, due to the refusal of some coaches, we had the opportunity to study only two teams.

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