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Correlation analysis of the integral preparedness of 12-17 years-old gymnasts

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Abstract

Purpose: Consider a mathematical model of correlation and factor analysis of the readiness of promising young gymnasts and the level of its significance in determining the model characteristics of young athletes

Methods: In this work, methods of mathematical statistics were used, in particular, correlation and factor analysis of the results.

Results: The validity of individual tests changes with age, both with the result in the types of gymnastic all-around, and with the volume of mastered and included in the combination of elements of the highest difficulty group. It turned out to be quite difficult to choose which test is more valid and at what age. But there is still a tendency to increase the significance of these links with increasing age, especially in tests related to the strength training of gymnasts.

Conclusion: In the course of the study, it was determined that integral indicators for the types of fitness of gymnasts have the greatest informativeness. Also, the use of factor analysis allows you to purposefully build a training process in gymnastics.

Keywords: Model, correlation analysis, factor analysis, physical development, testing, physical fitness, technical training, control tests, sports and technical skills.

Introduction

In recent years, modeling of the main aspects of skill and training methods has become widespread in the athletes' training management system. L. Y. Arkaev, Y. K. Gaverdovsky, V. N. Platonov, V. S. Cheburaev believe that at the present stage of the development of high-performance sports in order to optimize the training process, it is time to create stage-by-stage intermediate models of athletes of various qualifications and training impact programs necessary to achieve a certain level of sports and technical skill (Arkaev, 1994; Gaverdovskij et al., 2005; Gaverdovskij, 2008; Platonov, 2019; Cheburaev, 1997).

A model is a set of basic parameters that determine the achievement of a certain level of sportsmanship and predictable results (Arkaev, 1994; Gaverdovskij, 2008; Platonov, 2019; Eshtaev, 2018). Individual indicators included in the model are considered as model characteristics (Gaverdovskij et al., 2005; Platonov, 2019; Umarov et al., 2009; Eshtaev, 20182,4,5,7). Qualitative and quantitative indicators necessary for modeling are obtained by examination, testing, various experiments, expert assessments of specialists and others (Arkaev, 1994; Umarov et al., 2009; Eshtaev, 2018).

Depending on the purpose of management, the following types of models are distinguished: basic, perspective, theoretical and mathematical.

Basic models are requirements that must be met by the preparedness of athletes by a certain time.

A prospective model is a forecast of the possible results of winners.

A theoretical model is a system of knowledge that describes and explains the totality of phenomena of some aspects of athletes' fitness from a single point of view.

A mathematical model is equations, graphs, etcetera. They are based mainly on the results of correlation, factorial, regression and variance analyses.

In the course of research, a mathematical model of correlation and factor analysis of the fitness of promising young gymnasts will be considered.

Research objectives.

1. To determine the factor structure of the preparedness of young gymnasts of various ages and qualifications.

2. To identify the influence of various aspects of preparedness on the success of competitive activity of gymnasts.

Methods

The research was conducted in a centralized form of training for promising gymnasts of the I category, candidates for masters of sports

(CMS) and masters of sports (MS) aged 13-18 years, respectively, who passed the prospective and pre-Olympic selection and are at the stage of in-depth sports training and sports improvement.

The gymnasts were divided into three groups by age: 13-14, 15-16 and 17-18 years. The complex of tests included exercises and tests recommended by YK Gaverdovsky, characterizing physical, technical training, physical development and performance (Gaverdovskij et al., 2005).

Results and discussion

At the first stage, motor tests were checked for informativity, objectivity and reliability. The check showed their authenticity (quality). All tests on special physical (SPT) and technical (TT) training have good and excellent assessments of objectivity and reliability. The values of the correlation coefficients were in the range of 0.910 - 0.990.

The validity of individual indicators and tests by types of fitness of gymnasts varies significantly in different age periods. At the same time, their correlation with sports and technical results in the types of gymnastic all-around, the specifics of which they reflect, is higher than in the all-around. Integral indicators of relative strength, physical and technical fitness and training loads are the most informative, which, in general, speaks in favor of an integrated approach in assessing any fitness of gymnasts (see table 1):

tionship between the various aspects of gymnasts' fitness (physical development, physical and technical fitness and training loads) and their sports and technical skills. The athletic and technical skills (ATS) of promising gymnasts were evaluated by two indicators (two components):

the first part is the sports result (scores obtained during the competition);

the second part was technical readiness, which was assessed by the number of learned elements of the highest difficulty group, support jumps and by the number of similar exercises included in arbitrary programs at competitions, that is, implemented in competitive combinations.

The data on 67 parameters obtained in the course of preliminary studies on promising gymnasts served as the material for correlation analysis.

Correlation analysis showed that gymnasts aged 12-17 years have a reliable relationship between physical development indicators and sports results observed only in certain types of gymnastic all-around:

- at 12-13 years of age, the length of the body with the result on the uneven bars,
- at the age of 14-15, the result is on a horse with a body length and a Broca's index,
- at the age of 16-17, the result is on a horse with body weight.

In connection with age-related changes and the impact of regular gymnastics, there are periods of decrease and increase in the correlation coefficient between indicators of physical

Table 1. Integral indicators of relative strength.

Integral indicators	Sports and technical result		
	13-14 years old	15-16 years old	17-18 years old
Relative strength	0.630	0.719	0.684
Physical preparedness	0.946	0.518	0.873
Technical preparedness	0.783	0.867	0.807
Training loads	0.661	0.715	0.767

The empirical (calculated) informativity of the tests we used to assess physical and technical fitness is supplemented by meaningful (logical) informativity, since these tests are exercises included in the competitive program of gymnasts, that is, they are part of those motor actions that an athlete performs at competitions. Correlation analysis was used to study the rela-

development and sports and technical results. The most significant relationship between indicators of physical development and technical readiness of gymnasts is observed at the age of 13-14. With age, the tightness of the connection decreases.

The analysis of the research materials showed that the number of mastered elements

of the highest difficulty group (a group of super complicated elements were not taken into account in the analysis due to their small number in the arsenal of gymnasts) reliably correlates with almost all results on shells in all age groups (0.576-0.897), with the exception of estimates on the support jump (0.127), moreover, there is a noticeable tendency to increase the correlation coefficient with the age and qualifications of gymnasts: at 12-13 years - on the crossbar and horse, at 14-15 and 16-17 years - on the crossbar and rings.

The number of elements of the highest difficulty group included in the combination significantly correlates mainly with the scores in floor exercises, on horseback and rings in all age groups, and the number of support jumps mastered and included in competitive programs is only with the score on jumps. All four types of technical readiness indicators have a reliable relationship with the sum of points in the all-around. A higher relationship was revealed between the integral indicator of technical readiness both with the result in the all-around and on individual shells, and with the age of gymnasts, this relationship becomes closer.

Thus, it has been established that there is a rather significant relationship between the sports and technical result from the level of technical preparedness, that is, from the number of complex elements of the highest difficulty group mastered and included in competitive combinations. This relationship can be regarded as follows: the greater the margin of difficulty of gymnasts, the better they perform at competitions, and the more complex their competitive programs, the higher the competitive results. However, the difficulty of mastered elements in young gymnasts often comes at the expense of the quality of their performance, especially at the stage of the formation of sportsmanship, since young gymnasts must constantly increase the number of elements in combinations and increase their complexity. The instability of competitive combinations, both in complexity and in the number of elements, can be explained by a not very high level of correlation coefficients. The integral result is a unified indicator and when determining the level of technical readiness of gymnasts, it is necessary to focus on it.

Analysis of the relationship between the results of control exercises (tests) on special physical fitness and sports and technical results both in individual types of gymnastic all-around and in all-around, revealed that those tests that reflect the specifics of working on the projectile have higher correlation coefficients with this type of all-around. Speed-strength tests (20m running, rope climbing, and standing long jump) have a higher correlation with floor exercise, vault, and ring exercises. Tests for dynamic and static strength have a fairly close relationship with the results in exercises on the rings, parallel bars and pommel horse; flexibility indicators (the sum of deductions for performance errors in seven exercises) - with floor exercises and on pommel horse; indicators of special endurance (the number of circles on the pommel horse) - with the results of exercises on the pommel horse.

The indicators of the relationship of individual tests with the sum of scores in the multiathlon are somewhat lower, but in most cases this relationship is reliable or tends to be reliable. The highest correlation coefficients are observed between the integral indicator of special physical fitness and the sum of all-around scores in 12-13 years (0.946); in 14-15 years (0.918) and in 16-17 years (0.873).

More than half of the tests used have a reliable relationship with both the number of mastered and included in the combination of elements of the highest difficulty group. The integral indicator of special physical fitness has a close relationship with both the number of mastered and included in the combination of elements of the highest difficulty group.

Thus, the validity of individual tests changes with age, both with the result in the types of gymnastic multiathlon, and with the volume of mastered and included in the combination of elements of the highest difficulty group. It turned out to be quite difficult to choose which test is more valid and at what age. Both in terms of the number of reliable connections and their level, all age groups are approximately the same, but there is still a tendency to increase the significance of these connections with increasing age, especially in tests related to the strength training of gymnasts.
It should also be noted that not all the tests we used were end-to-end, so it is somewhat difficult to compare gymnasts by age.

Summing up all the above, it can be stated that the technical skill of gymnasts largely depends on the general level of special physical training.

Also, the study revealed a close relationship of sports and technical results with indica-

tors of relative strength. With age and advanced training, the number of reliable correlation coefficients increases. The most significant correlation coefficients were found between athletic performance and the relative strength of the muscles (0.727) carrying gymnastics-specific loads (shoulder extensors, adductors, hip extensors and foot flexors). The significance level of these correlation coefficients also increases with age. This increase is probably due to the fact that strength training has an increasing impact on the level of technical skill of gymnasts.

The highest correlation with the technical skill of gymnasts was also revealed by integral indicators of relative and absolute muscle strength.

The total amount of training loads correlates reliably with the results on all the gymnastic multiathlon equipment (0.575-0.889), with the exception of the result on the support jump, here the observed relationship is unreliable in all age groups. In turn, the sum of points in the multiathlon in all age groups also has a reliable relationship with the amount of work performed on individual training equipment. The exception is also the support jump. It is characteristic that with increasing age and qualifications, the value of the correlation coefficient between the amount of training load and sports performance also increases, especially on equipment with a power nature of work.

Higher correlation coefficients are observed between the load performed in a particular type of gymnastic all-around and the assessment in this type. A cross (indirect) correlation was also revealed between the amount of load when working on one projectile and the result on another projectile.

Thus, the volume of the load performed on the bars affects the result in the exercises on the pommel horse and rings; the volume of the load in the floor exercises on the support jump; the volume of the load in the exercises on the crossbar - on the result in the exercises on the rings.

The volume of the performed load in special physical training (SPT) significantly correlates with the results in almost all types of all-around, excluding the crossbar and jump. The most significant relationship was revealed between the training load and the sum of points in the all-around (0.797).

The technical readiness of gymnasts aged 14-17 (in terms of the number of elements of the highest difficulty group mastered and included in combinations) mainly correlates with the volume of training loads on such shells as rings at the age of 12-13; and with the volume of training loads on rings, bars and crossbar at 14-17 years. The number of support jumps mastered and included in competitive programs correlates only with the amount of load in this form.

In addition, in the course of the study, the principal component method was applied with the rotation of the reference axes according to the Varimax criterion. Initially, 17-19 factors were identified in each group, then derivative and duplicate indicators were excluded based on the results of correlation analysis. Of the 67 indicators, only 20 were left in each age group. By the method of principal components, a matrix of the 20th order has now been analyzed, including, in our opinion, the main of the above indicators.

The analysis showed that the morpho-motor structure of promising gymnasts can be represented by four orthogonal factors; i.e., an intercorrelation matrix with leading factors was obtained.

These factors account for 74-78% of the total variance sample. Each age group and sports qualification is characterized by a specific morpho-motor structure with the presence of a certain correlation between factors with physical qualities and motor abilities and sports and technical readiness of promising gymnasts. Significant indicators have been established that must be taken into account in sports orientation and which can be used in the development of model characteristics (see table 2).

The contribution of the first factor (technical skill or preparedness) to the generalized dispersion sample of gymnasts aged 13-14 years is 26.9%. This includes high factor weights of technical fitness indicators of gymnasts (the number of mastered and included in the combination of elements of the highest group of difficulties and sports results both in the types of multiathlon). In addition, a significant connection with strength training was revealed.

The first factor in gymnasts aged 14-15 is named by us as a factor of relative strength. Its contribution to the variance was 32.9%. High factor weights here have indicators of the relative strength of the main muscle groups, significant speed and strength qualities (running for 20 meters and others) and loads for special physical training.

Table 2. **Factor structure of fitness of gymnasts aged 13-18.**

Factor №	Factors	The contribution of the factor to the variance	Overall contribution
12-13 years old (I category)			
I	Technical preparedness	26.9	75.0
II	Physical development	16.5	
III	Training load	16.4	
IV	SPT (+ endurance, proportions)	15.0	
14-15 years old (CMS)			
I	Relative strength	32.9	
II	Technical preparedness	20.4	
II	Physical development	11.3	
IV	SPT (+ loads, proportions)	9.5	
16-17 years old (MS)			
I	Training load	28.4	77.7
II	Technical preparedness	20.2	
III	Relative strength	14.9	
IV	SPT (+ flexibility, proportions)	14.4	

The share of the first factor in athletes aged 16-17 accounts for 28.4%. This is a load or performance factor. In addition, this factor with high correlations included indicators of physical development and absolute strength.
The share of the second factor among gymnasts of the first category falls 16.5%. This is a factor of physical development of gymnasts, its basis is weight and height indicators.

Among the candidates for the master of sports, the second factor is called by us the factor of technical preparedness and skill. Its weight is 20.4%. As mentioned above, by technical skill we mean the volume of technically complex motor skills by types of multiathlon and the number of support jumps, as well as the sports results shown by gymnasts in the multiathlon and in its individual types.

The contribution of the second factor to the generalized variance among masters of sports was 20.2%. The highest factor weights are also indicators of technical skill of gymnasts, this factor is similar to the second factor identified in the training of gymnasts aged 14-15 years. (candidates for master of sports).

The third factor with a weight of 16.4 in the total sample of gymnasts of the I category aged 12-13 is more associated with training loads by types of all-around and the total load of gymnasts. In addition, it includes indicators that indirectly characterize athletic performance, such as lung capacity, chest circumference, and others.

At the age of 14-15, the third factor is interpreted by us as physical development. His contribution was 11.3%. These are the weight and height indicators and body proportions of gymnasts of this age. A significant connection in this case was revealed with physical fitness, namely with test indicators of strength, flexibility and speed-strength qualities.

The contribution of the third factor to the generalized sample of masters of sports is 14.9%. We called it the relative strength factor of gymnasts. This includes statistically significant correlations (correlation coefficients) with the relative strength of all major muscle groups and the integral index.

The significance of the fourth factor among gymnasts of the I category was 15.0%. This is a generalized factor of special physical training with a tendency to endurance and strength of the arms and shoulder girdle. A significant connection was revealed with the proportions of the gymnasts' bodies.

The share of the fourth factor in 14-15-year-old gymnasts, candidates for master of sports, accounts for 9.5%. We have also gener-

Table 3. Factor structure of physical fitness of gymnasts aged 12-I7.

Physical qualities	Factor numbers		
	12-13 years old I category	14-15 years of CMS	16-17 years old MS
Absolute strength	5	3	2
Relative strength	5	4	3
Static strength	4	I	I
Dynamic strength	т	I	3
Speed strength	3	3	4
Flexibility, mobility in joints	4	2	4
Endurance (special)	3	2	I

alized it as a factor of special physical training, although it is quite diverse. However, it is dominated by endurance, torso strength and training loads according to SPT. Indicators of athletes' body proportions reach a significant level.

The contribution of the fourth factor in highly qualified gymnasts aged 16-17 to the generalized variance sample was 14.4%. This factor can be called a factor of special physical training, but with the predominance of the weight of flexibility. There is also a significant relationship with the proportions of the body.

As we can see, the fourth factor in all three age groups of athletes of different qualifications is common. This is a factor of special physical fitness and body proportions. The latter, as is known, affect the indicators of the physical qualities of gymnasts. The length of the arms and torso are interconnected with the strength of the gymnast.

Similarly, the factor structure of physical fitness of young gymnasts was revealed, the main content of which were tests aimed at strength training. The factor structure of the physical fitness of gymnasts aged 12-I7 years is shown in table 3.

In the table, instead of factor weights, the movement of factor numbers (places) is shown or a change in the significance of each factor with an increase in the age and qualifications of gymnasts.

Conclusion

Thus, the factor structure of the fitness of gymnasts aged 12-17 years (I category, CMS, MS) is determined by a set of the following main factors:

- physical development factor;
- relative strength factor;
- the factor of technical preparedness;
- physical preparedness factor;
- load factor (working capacity).

The most informative are the integral indicators of the types of fitness of gymnasts.

For each age group and various qualifications of gymnasts, their own "model" of the morpho-motor (factor) structure of physical (strength) and general fitness and the correlation of correlations were revealed. The use of factor analysis allows you to purposefully build a training process in gymnastics.

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