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SPECIAL ENDURANCE AND MORPHO-FUNCTIONAL CHARACTERISTICS OF YOUNG GYMNASTS IN THE CONTEXT OF A LONG-TERM TRAINING PROCESS

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Abstract: The increasing intricacy of competition routines and the considerable intensity of training loads in modern artistic gymnastics are placing greater demands on athletes' physical fitness and functional reserves. The objective of this study is threefold: firstly, to analyse the physiological determinants of specific endurance; secondly, to determine the contribution of aerobic and anaerobic capacity to maintaining the coordinative stability of motor actions; and thirdly, to systematise current methodological approaches to sports selection and functional monitoring.

The methodological basis of the study comprised a systematic review of the relevant literature, modelling of gymnasts' functional profiles, and the assessment of biomechanical parameters. It has been established that the execution of full-scale competitive combinations in the all-around event is associated with a sharp increase in the activity of the cardiorespiratory system. During this period, heart rate (HR) reaches critical values comparable to those seen in cyclic sports. Scientific evidence has demonstrated the pivotal function of aerobic capacity (maximum oxygen uptake) in the expedited resynthesis of energy substrates and in counteracting the deterioration of complex coordination structures in the context of fatigue.

Moreover, a systematisation and comparative analysis of standardised international protocols for sports selection and functional testing of gymnasts has been conducted. It has been determined that the effective development of specific endurance is predicated on the concept of 'energy surplus', which involves the formation of an excess functional reserve. This approach precludes the possibility of systematic training whilst in a state of profound physiological fatigue.

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Consequently, this ensures a high degree of reliability and consistency in the execution of competitive elements on the vaulting table.

Keywords: artistic gymnastics, special endurance, morphofunctional profile, aerobic capacity, anaerobic power, coordinational stability, multi-year training process, energy surplus concept.

Introduction: It is an irrefutable fact that specific endurance is a fundamental component of physical fitness. Indeed, it is the determining factor in the dynamics of growth and improvement in sporting performance across various sports. Contemporary research in the theory and methodology of sports training demonstrates significant progress in conceptualising specific endurance as the basis for technical and sporting improvement, as well as in differentiating the body's physiological responses to competitive stress factors.

The process of developing specific endurance in sports involving complex coordination and a multi-event structure of competitive activity presents a particular scientific and practical challenge. These disciplines impose a range of demands on the biomechanical characteristics of motor actions and the functioning of energy supply systems. This necessitates the sustained maintenance of high precision and the coordinative structure of movements under conditions of progressive fatigue. Artistic gymnastics serves as a paradigmatic exemplar of this group of sporting disciplines.

Methods: The findings of scientific research provide confirmation that the execution of complex competitive routines in the all-around gymnastics event is associated with a significant increase in cardiovascular activity, which manifests itself in the attainment of maximum heart rates (HR). Following the conclusion of the exercises, it has been demonstrated that the chronotropic response of the myocardium in gymnasts is comparable to the haemodynamic parameters of athletes participating in cyclic endurance sports. Consequently, in specialised scientific and educational literature, changes in heart rate are interpreted not merely as an objective indicator of physical exertion, but also as an informative marker of an athlete's general and specific fitness levels.

A sufficient level of physical fitness contributes to the optimisation of the body's adaptive responses and increases tolerance to exertion of varying intensity and nature. Whilst the conventional interpretation of work capacity is as the ability to perform a given volume of work per unit of time (which reflects the limits of anaerobic and aerobic power), the maximum oxygen uptake (VO_2 max) is widely regarded as a universal and comprehensive criterion of aerobic performance. In the

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context of cyclic sports, a robust correlation has been observed between VO2max values and competitive outcomes. However, in the domain of artistic gymnastics, the contribution of aerobic potential and oxygen supply systems is distinct in nature, necessitating their differentiated assessment, taking into account the structure of competitive activity.

The increasing intricacy of the technical elements and competition routines in contemporary artistic gymnastics poses substantial scientific and methodological challenges in the design of training loads and the selection of the most suitable pedagogical approaches. In order to ensure a high level of technical and tactical proficiency, as well as the effective development of specific endurance in gymnasts, it is essential to establish a fundamental basis that enables the varied mastery and consistent execution of a wide range of structurally diverse exercises in the competitive all-around.

In the domain of artistic gymnastics, specific endurance is not regarded as an isolated physical attribute, but rather as a pivotal element in the effective realisation of coordinative potential and the maintenance of kinematic precision in technique throughout all stages of the training and competition cycles. A high level of aerobic capacity optimises the metabolic processes involved in energy supply, reduces the physiological cost of the work performed, and increases tolerance to variable-intensity loads. Concurrently, indicators of maximum power output per unit of time serve as the most significant criterion for an athlete's overall physical fitness.

In the context of the temporal constraints imposed on the development of complex competitive routines, the individual trainability of gymnasts and a scientifically grounded methodology for developing specific endurance become of decisive importance. The most significant methodological principle is that it is unacceptable to systematically perform specific training volumes when the body's physiological reserves have been exhausted, as severe fatigue inevitably leads to the breakdown of subtle coordinative links, even when a technical element has been highly automated. In this regard, it is imperative to cultivate an 'energy surplus' (excess functional potential) in athletes, which ensures the reliability and stability of element execution during both intensive training programmes and on the competition floor.

Results and Discussion: Despite the evident pertinence of this issue, the process of specific training for the execution of complex motor skills within various structural exercise groups faces methodological limitations due to the inadequate study of the phenomenon of motor-coordination stability. At present, the range of methods available for developing specific endurance remains relatively limited,

whilst the mechanisms through which it indirectly influences the kinematic and dynamic structure of gymnastic elements require further fundamental and applied research.

Artistic gymnastics is a classic speed-strength discipline, the success of which depends on a high level of anaerobic capacity and joint mobility. The sport under discussion has been found to facilitate the comprehensive development of jumping ability, pushing and shoving efforts, explosive strength and the pulling capacity of the skeletal muscles. In addition, it has been found to engender a high level of static stability (balance) and expressive artistry when performing combinations on various gymnastic apparatus.

The attainment of success in the domain of competitive artistic gymnastics is contingent upon the establishment of an optimal equilibrium between an athlete's functional fitness and their proficiency in the intricate technical composition of movements that is unique to each apparatus within the comprehensive all-around competition.

In the field of men's artistic gymnastics (MAG), physical fitness is a critical factor in the successful learning and execution of a competition routine. It is imperative to note that the effective execution of a wide range of complex acrobatic elements necessitates the possession of an excellent level of absolute and relative muscle strength, joint mobility, and a high level of motor coordination by the athlete.

Empirical studies that adopt a longitudinal and comparative approach (Bencke et al.) have demonstrated that young gymnasts exhibit an earlier onset and more pronounced development of lower-limb muscle strength in comparison with athletes participating in other sports. The authors were able to experimentally confirm that 11-year-old athletes significantly outperform their peers who do not participate in regular sporting activities with regard to muscle strength. Concurrently, systematic, long-term gymnastics training exerts a heterochronic and differentiated effect, determined by the specific nature of strength manifestations and the targeted topographical muscle groups. In particular, relevant studies have recorded a higher rate of increase in muscular effort (force gradient) among young gymnasts compared with control groups of untrained peers of the same age, which indicates specific neuromuscular adaptation under the influence of specialised training loads.

The identification and selection of children with sporting talent (i.e. talent identification) constitutes a fundamental scientific and practical process that determines the effective implementation of a long-term system for training top-

level athletes. Concomitantly, despite the paramount importance of this issue, extant models for identifying sporting talent — in both team and individual sports — remain fragmented and are characterised by a number of methodological limitations. In the domain of artistic gymnastics, there is an ongoing development and systematic implementation of specialised programmes for the selection and monitoring of talent by leading international and national sports organisations (particularly the International Gymnastics Federation (FIG) and USA Gymnastics).

The 'FIG MAG Age Group Development Programme' model has been approved and occupies a special place within this framework. It has been established as a valid tool for identifying sporting potential and monitoring the physical development of gymnasts during the initial and specialised training stages. Achieving the elite level of competitive skill in the domain of artistic gymnastics necessitates a systematic training process that extends over a considerable number of years. This, in turn, necessitates an objective quantitative assessment of the dynamics of athletes' physical condition. Quantitative monitoring of physiological and coordination progress enables the identification of those gymnasts with the greatest potential for successfully adapting to the demands of international competition, even among those who are already achieving high results on the national stage.

In this context, the systematic collection and analysis of cross-cultural empirical data characterising the morphofunctional and motor parameters of young athletes in the early stages of sporting ontogenesis is of particular scientific and methodological value. A comprehensive, scientifically grounded assessment of gymnasts' physical capabilities from an early age is a critical determinant of the predictive accuracy in mapping out career trajectories in high-performance sport.

A substantial corpus of contemporary scientific and methodological literature features a number of foundational works devoted to the issue of identifying and selecting female athletes in the field of artistic gymnastics who demonstrate high aptitude for the sport. In particular, the research by Nassib et al., which focuses on the predictive modelling of gymnasts' physical fitness profiles based on the standardised international assessment programme 'FIG Age Group Development Programme', deserves special attention. The key findings of this study demonstrated that elite-level athletes exhibit a statistically significant advantage in terms of absolute and relative muscle strength (in isometric, explosive and dynamic modes), speed-strength power and joint mobility (flexibility) compared with the FIG normative standards. The authors established that these fitness parameters act

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as the determining limiting factors of physical fitness, which in turn determine success in competitive women's artistic gymnastics all-around events.

Concurrently, studies that aspire to differentiate and model the functional profile in men's artistic gymnastics (MAG) are considerably fewer in number and of a fragmentary nature. In particular, Sleeper et al. conducted a comprehensive analysis of athletes of various ages and abilities using the specialised diagnostic instrument, the Men's Gymnastic Functional Measurement Tool (MGFMT). Following the administration of 10 sets of MGFMT tests to a sample of gymnasts with varying levels of sporting proficiency, the researchers confirmed the high psychometric reliability and construct validity of the assessment system they had developed.

In a similar scientific and practical context, León-Prados et al. investigated the correlations between indicators of specific physical fitness and competitive performance among elite male gymnasts. The battery of tests was comprised of six in total, with four of these designed to assess parameters of joint mobility. The findings of this study indicated a statistically significant correlation between the final scores achieved on apparatus such as the pommel horse, parallel bars, rings and horizontal bar, and the baseline indicators of muscle strength and flexibility.

However, it is imperative to acknowledge the methodological limitations inherent in the aforementioned studies. Specifically, the sample size in the study by León-Prados et al. was restricted to 11 highly skilled gymnasts, while the physical fitness tests employed in both studies exhibited a certain degree of narrowness in scope. Furthermore, the specific algorithm and criteria used in the procedure for identifying sporting aptitude (talent identification) were not provided with a comprehensive theoretical and methodological justification or a systematic explanation in these publications.

Conclusion: It is evident that the temporal and intensity of fatigue experienced by gymnasts during training exert a substantial influence on the qualitative and biomechanical parameters of the motor tasks they are undertaking. In summary, the level of aerobic capacity functions as a limiting factor, thereby determining the tolerance of training and competition loads of a given intensity.

It can be argued that ensuring high efficiency in the training process, as well as the high-quality development and stabilisation of gymnasts' technical skills, can only be achieved with a high level of specific endurance. In this context, the key physiological determinant of specific endurance is the athletes' aerobic capacity.

In this regard, the aim of the present study was to determine the influence of training loads aimed at developing endurance on the intensity of physical effort

during the execution of complete gymnastic combinations. Furthermore, the study examined the dynamics of qualitative indicators relating to the execution of complex elements and competition routines throughout the entire training microcycle.

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