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Evolutionary age peculiarities of adaptation of highly qualified athletes

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Abstract
In a series of studies on the adaptation processes of the main body systems of highly skilled male and female athletes in the range of 16-46 years old using immunological biochemical, hematological, eographical, spirometric, gasometric, anthropometric and ergometric methods and load testing established the physiological patterns of formation of involutive-age-related changes in the functional state of athletes of the second adult age. In the age range of 37-46 years old relative to the range of 16-36 years old: changes in the morphometric parameters of the physical status are determined, causing a decrease in the integrated bioenergy indicators; the intensive formation of metabolic factors of fatigue was established at a low-intensity threshold mode of work – aerobic-anaerobic; high intensity of non-specific adaptation processes is shown; revealed features of urgent responses of the main adaptation systems (hormone-metabolic, autonomic nervous, cardiovascular, respiratory) at the level of threshold operation modes. Highly qualified female athletes of 37-45 years old have an anovulatory character of the menstrual cycle, during which chronobiological mechanisms of adaptation processes are studied and systematized, consisting in the features of regulatory nervous effects on heart rate, hemodynamic and ventilatory functions. The revealed changes in adaptation processes in athletes of the second adult age can be used as the basis of the analytical base for predicting the functionality of elite and professional athletes of late periods of ontogenesis.

Keywords: *involutive age adaptation vector, highly skilled athletes, men, female, adaptive capacity, threshold loads.*

1. Introduction

Intensive commercialization of sports, when it is an alternative source of income, contributes to the appearance on the sports arena of highly skilled

male and female athletes of the fourth and even fifth decade. As it is known, at this age, physiological processes associated with an involutive decline in the adaptation functions in both men and women are active (Christensen, Bentley, Cabrera et. al., 2012, Statsenko, Fedotova, 2011; Voronkov, Tizul, 2011). Therefore, the problem of involutive-age-related changes in the functions of the main systems is particularly relevant for athletes of those sports in which the professional component of success is significantly expressed. Hockey, football, tennis, cycling, biathlon, swimming, athletics are sports in which the average age of male and female winners of the Olympic Games often exceeds the limit of 35 years old (Yakimovich, 2014)**Errore. L'origine riferimento non è stata trovata.**. These circumstances also actualize the issues of predicting the adaptive capabilities of "age" athletes and also require a comparison of functional reserves with relatively young athletes (Aleksanyants, Pogodina., Yuferev, Epishkin, 2018; Uiba, 2012). Studying the above problem will help identify physiological factors underlying stabilization and support a high level of a functional status of individuals ageing in conditions of prolonged and intensive physical training (Akhmetov, Pogodina, Manolaki, Aleksanyants 2018; Talibov, Dalsky, Naumenko, 2013).

The aim of the work was to study the physiological characteristics of the main systems of the highly skilled male and female athletes in the involutive-age vector of adaptation.

2. Research methods

Highly qualified female (n=50) and male (n=359) athletes were examined in the youth (16-18), first (22-26 years) and second (37-46 years) mature age ranges. representatives of sports aimed at the development of aerobic endurance (swimmers, cyclists, long-distance runners – group "endurance") and speed-strength endurance (weightlifters – group "strength"). 8 series of studies were conducted (4 for men and female) to study the main adaptation mechanisms – hormonal, metabolic, non-specific, autonomic, nervous, hemodynamic and respiratory. Modern technologies are used to assess adaptive reactions and functional status: anthropometric and functional measurements to study the characteristics of the physical status of athletes; linked immunosorbent assay to assess hormonal functions; biochemical and hematological methods for the study of lacto- and leukograms; rheographic method and heart rate variability (HRV) technology for assessing vegetative and hemodynamic responses; spirometry method and analysis of the gas composition of exhaled air for the evaluation of ventilatory reactions. The studies were carried out in standard conditions of the ergometric test of step-increasing load, performed at least 5 minutes in the following modes of work (W): aerobic (W1 - 50 W, HR - 130-140 beats/min), aerobic-anaerobic (W2 - 100-120 W, HR - 150-160 beats/min), anaerobic-aerobic (W3 - 150-220 W,

HR - 170-185 beats/min). As a specific load test for swimmers was used the test “distance swimming”, in which swimming regimes were modelled by means of distances of varying intensity and duration. Specific load testing for weightlifters has carried out through the power exercise "jerk weights" for 10 minutes. The modes of operation were simulated by changing the weight of the weights. In highly skilled female athletes, indicators were determined in different periods of the ovarian-menstrual (OMC) and anovulatory (AMC) menstrual cycle (Chapman, Zamudio., Woodmansee et al.,1997). Statistical processing was carried out using parametric and non-parametric methods of Student's t-test, Wilcoxon's t-test.

3. Analysis Results

The studies of hormonal adaptation functions revealed a tendency to increase glucocorticoid reactions in the body of male athletes in the range of the second mature age, in which the load threshold, on which an increase in cortisol production was noted, decreased. In the “strength” group, in the conditions of specific work, an excessive increase in the content of cortisol was determined in the initial state. When studying the hormonal background of female athletes, there was a failure in the level of hormones of the reproductive axis in the age range of 37-45 years old, that indicated the involutive-age changes and manifested itself in a low degree of preservation of ovarian-menstrual function, the restructuring of the menstrual cycle to anovulatory character. The specificity of hormonal reactions of female athletes aged 37-45 years old was associated with a weakening and decrease in the range of the glucocorticoid reaction.

The results of studies of the metabolic mechanism of adaptation showed that the greatest increase in the production of lactic acid at a specific load performed in the anaerobic-aerobic mode was noted in male and female athletes in the ranges of youthful and especially first mature age. In the range of the second mature age, an increase in the production of lactic acid was noted at a relatively low threshold of load – in an aerobic-anaerobic mode. The study of the nonspecific mechanism of adaptation through the analysis of leukocyte formula allowed to establish in male athletes the age range of the second mature age the formation of nonspecific reactions at a relatively high activation level (increased activation) which is associated with a large influence of humoral factors on the activity of non-specific mechanisms. Non-specific reactions of calm activation are predominantly determined in the body of female athletes. In turn, the formation of reactions was noted at a stable activation level in the dynamics of the AMC in athletes 37-45 years old, whereas the decrease in the activity of non-specific reactions to the level of training was recorded in athletes 16-26 years old with a OMC (and in particular

in the period from 8-16 day). This fact indicates a period of the OMC with a reduced response of the body to external stress exposure.

Studies of the functions of the cardiovascular system of highly skilled athletes and in particular of the vegetative regulation of heart rhythm revealed the greatest effectiveness of the vegetative and hemodynamic reactions of male athletes of the age range of 17-26 years old. At 40-46 years old the significant reduction in parasympathetic influences was detected in weightlifters under the anaerobic-aerobic mode of work, which led to an increase in the voltage index of regulatory systems over 230 conv. units ($p < 0,01$), high chronotropic effects (increase in HR over 147%, $p < 0,05$), a significant increase in stroke blood volume (SBV) to 36%, ($p < 0,05$) with a decrease in the external work of the myocardium (LVH) on average to 21%, ($p < 0,01$), increase in systolic blood pressure to $178,8 \pm 3,70$ mm. Hg Art. ($p < 0,01$). Athletes of 40-46 years old who are training aerobic endurance, the parasympathetic tone was not significantly reduced under the load, as a result of which the weakening of the response of the cardiovascular system to the load was registered.

In the age groups of highly qualified female athletes, there were chronobiological features of autonomic nervous mechanisms and their effects on heart rate and hemodynamic functions (Eckberg,1997). In anaerobic-aerobic mode of work was established an increase in parasympathetic tone (power of HF waves), decrease in suprasegmental activity (power of VLF waves) in cardiac rhythm control (fig. 1), increase SBV, LVH in female athletes of 16-26 years old with a OMC in the period from 8-16 day, and female athletes of 37-45 years old with the AMC in the period from 20-22 day. The identified features indicate differences in the time periods of the OMC and the AMC with a high level of functionality of the cardiovascular system.

Age-related features of the reactivity of the respiratory system are determined at the level of threshold loads when evaluating the ventilatory reactions of highly skilled athletes. For men, relatively high reactivity and conjugacy of respiratory and gas exchange functions, that provide effective breathing patterns at all levels of exercise testing are shown in the age range of 17-26 years old. In the range of 40-46 years old the high efficiency of breathing pattern is maintained in conditions of relatively low intensity – aerobic and aerobic-anaerobic. A decrease in the efficiency of breathing patterns was revealed with greater severity in the weightlifters during the anaerobic-aerobic mode of work.

Thus, conditions for the decrease in ventilation efficiency were formed for the weightlifters in the anaerobic-aerobic mode of work – increasing the ventilatory equivalent of carbon dioxide ($VECO_2$) to $47,32 \pm 1,92$ l/min, ($p < 0,01$), excess carbon dioxide and an increase in the values of the respiratory coefficient (VCO_2/VO_2) to $1,02 \pm 0,02$ conv. units, ($p < 0,05$), reduction of the oxygen cost of the respiratory cycle (VO_2/f), causing a decrease in oxygen

delivery to the lungs to 52,30 ± 2,12 ml/min/cycle, (p <0,001).When assessing changes in the structure of the respiratory response of athletes 37-45 years old, a decrease in the reaction threshold is noted, which increases the reactivity of the respiratory system to threshold loads during periods of the AMC with relatively low elimination of carbon dioxide from the body.

In this way, as a result of studies of adaptation processes in highly skilled athletes of male and female age range of 37-46 years old and classification and comparative analysis of types of adaptive reactions of the main systems with relatively young athletes were determined the age-related changes in the adaptive functions of the body of highly skilled athletes of the second adult age at the level of threshold modes of work. It's known that in conditions of intense physical exertion, the optimization of functional capabilities of highly qualified athletes is mainly carried out due to the integral increase in the activity of the leading adaptive mechanisms and the increased response of the main body systems. At the same time, in the process of long-term adaptation and with age are noted the effects of habituation to influencing factors, and opposite, the lag of the adaptation level from the proposed magnitude of the impact, which is expressed in the weakening or redundancy of the adaptation reaction, and as a consequence – in voltage compensatory functions. From this point of view, the ageing of male athletes was primarily expressed in a lowering the load threshold, which was dominated by increased adaptation reactions of the main systems (hormonal, metabolic, non-specific), and in case of force specificity of the loading factor, excessive reactions and, especially, reactions of regulatory systems were predominant. Along with intensification, a selective weakening of adaptive reactions was noted – mainly ventilatory. The ageing female athletes were associated with the loss of ovarian-menstrual function, the formation of the AMC in the age range of 37-45 years old. Noted shifts in reproductive homeostasis in this age group of female athletes caused changes in adaptive-regulatory processes that affect the effectiveness of vegetative functions during the AMC.

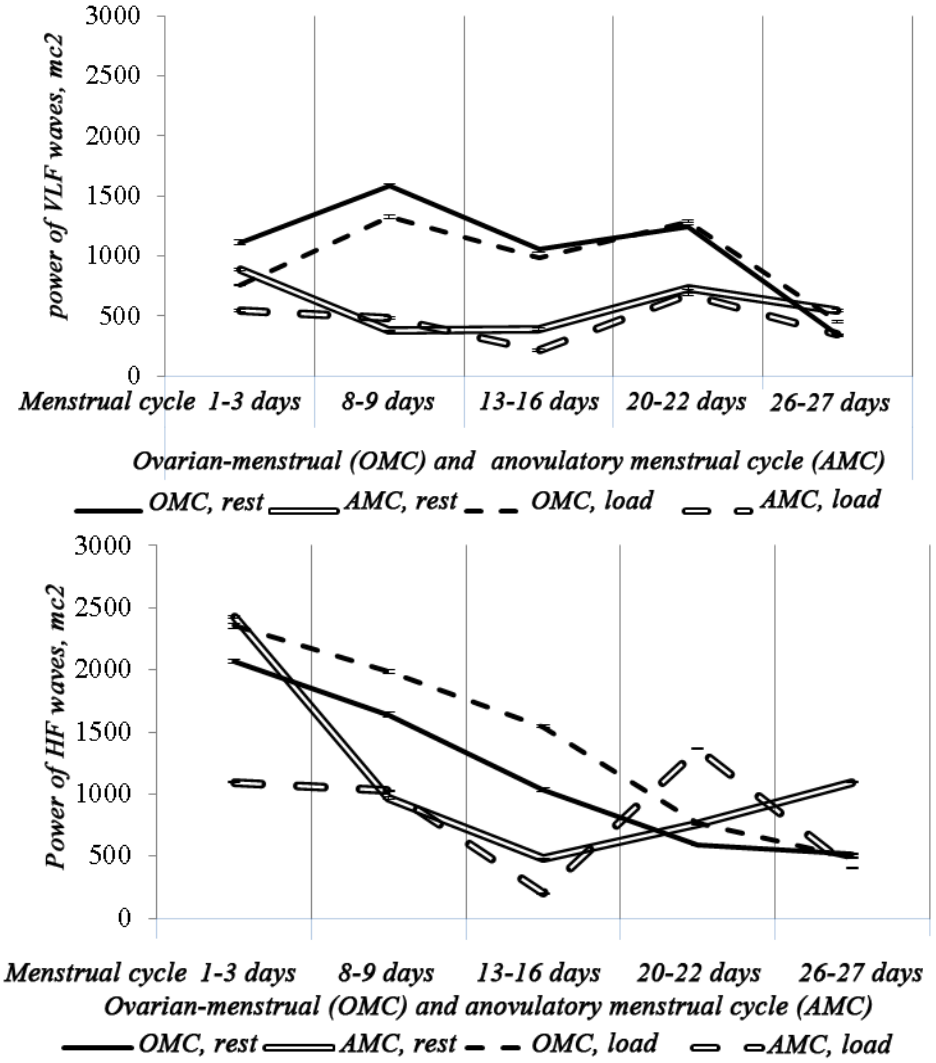

Fig. 1. Chronobiological features of the characteristics of heart rate variability in the age groups of highly skilled female athletes

Conclusion.

1. The adaptation efficiency of highly skilled male and female athletes in the age range of 37–46 years old can be reduced due to adverse bioenergetic shifts, imperfect mechanisms of the hormonal and nervous regulation of vegetative functions, which is caused by involutive-age changes in the response to high-intensity load.

2. For athletes of the second period of mature age, the loads in the anaerobic-aerobic mode of work are a factor in the adaptation stress of functions, which must be considered in the preparation of training programs.

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