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Original Article

Sympathoadrenal monitoring of the influence of artificial hypoxia on sprinters' training

YAROSLAV SVYSHCH[1], MARIA SYBIL[2], OLHA PAVLOS[3], TETIANA DUKH[4], ANTONINA DUNETS-LESKO[5], VALERII MELNYK[6], ROSTYSLAV PERVACHUK[7]
[1,3,4,5,]Department of Athletics, Lviv State University of Physical Culture, UKRAINE
[2]Department of Biochemistry and Hygiene, Lviv State University of Physical Culture, UKRAINE
[6] Department of Sports and recreation games, Lviv State University of Physical Culture, UKRAINE
[7] Department of Athletics sports, Lviv State University of Physical Culture, UKRAINE

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Abstract. In modern sports one of the main tasks of a coach is to expand the adaptive capabilities of sprinter's body and to increase the efficiency of its energy supply. Mostly, this is achieved by improving traditional methods of training through introduction of nontraditional ones into the training process. The article presents the author's program of development of speed-strength qualities, which combines traditional training with the hypoxic one. The hypoxic training included exercises at Frolov breathing simulator 2 hours before bedtime during general stage of training. The following research methods were used: theoretical analysis and summary of the data of scientific and methodical literature; analysis and summary of empirical data of scientific research; studying and summary of leading sports practice experience; pedagogical observation; pedagogical experiment; functional methods; biochemical methods; methods of mathematical statistics. During the experimental part of research for the control of the effect of experimental factor, veloergometric test «Vita max» was used. The article presents the dynamics of the sympatho-adrenal system in terms of excretion of catecholamines - adrenaline and noradrenaline in response to the test load "Vita max" on the background of hypoxic training of sprinters throughout the annual macrocycle. Having analyzed the biochemical parameters of the sympathe-adrenal system of sprinters during the pedagogical experiment, it is possible to state the positive influence of author's program of development of speed-strength qualities with the inclusion of breathing by Frolov method on the state of homeostasis function of catecholamines (adrenaline and noradrenaline) in qualified sprinters. Consequently, as a result of pedagogical experiment with the use of artificial hypoxia by Frolov method in the process of sprinters training, a significant increase of adaptive capabilities of athletes was established, which gives the right to recommend this program for improvement of their training.
Keywords: homeostatic regulation, sympathoadrenal system, adrenaline, noradrenaline, artificial hypoxia, sprinters.

Introduction.

Modern scientific research, aimed at expanding adaptive capabilities of sprinter's organism, and efficiency of its energy supply, are usually based on improving traditional methods of athletes training and only sometimes are combined with nontraditional ones [2, 6, 8]. At the same time, a number of researchers have stated that the use of motor hypoxia in combination with a variety of artificial hypoxia increases both anaerobic and aerobic capacity of the body, i.e. increases the effect of physical training [4, 5, 7]. These data originate from the known effects of improving physical performance such as adaptive effect during training sessions in the territory of medium height mountains where hypoxia is a natural [2, 6]. But due to the current economic conditions in Ukraine such training camps for athletes are limited financially. Therefore, the development of techniques that would enhance adaptive capacity of sprinters viewing hypoxic state is of great importance. This justifies the need to find innovative methods of hypoxic training. In particular, noteworthy are the data of experts in the field of medicine viewing the efficacy of respiratory gymnastics by Frolov use [4]. As it is known, in setting up the adaptive reactions of an athlete sympathoadrenal system is involved [1, 10]. Thus, it is important to study the effects of artificial hypoxia by Frolov method by examining changes in the homeostatic regulation of sympathoadrenal system during annual macrocycle of sprinters training.

Material and methods.

The following methods were used during the research: theoretical analysis, summary of scientific and methodological literature and empirical research data; study and summary of the top sports practice experience;

Corresponding Author OLHA PAVLOS., E-mail: olha_slisenko@ukr.net

pedagogical observation; pedagogical experiment (PE); functional methods; biochemical methods; methods of mathematical statistics. The study was conducted at the Department of Biochemistry and Hygiene and at the Department of Athletics in Lviv State University of Physical Culture. The research involved 24 qualified sprinters: 12 of them are masters of sports, 8 − candidates for master of sports, and 4 − athletes with the 1st grade. The athletes were divided into the main or experimental group (G1) and the comparison or control group (G2) and they were similar in their qualification level.

The point of the pedagogical experiment was to include in the training process of sprinters respiratory gymnastics by Frolov method [3, 9]. To control the influence of the experimental factor veloergometric test «Vita max» was used. During the experiment biochemical monitoring of SAS (sympatho-adrenal system) dynamics was conducted by studying the changes in catecholamines excretion (A and NA) in response to a test load «Vita max».

Author's program viewing speed-strength qualities development, combined traditional sports training with hypoxic one. It included exercises done at Frolov breathing simulator 2 hours before sleep during general stage of training in mode 3 × 3 '/ 3' - 5 '/ 5'. The air, which was inhaled through Frolov breathing simulator, contained 12-14% of oxygen and 5-6% of carbon dioxide, which ensured hypoxic and hypercapnic effects simultaneously.

Results.

At Figure 1 and Figure 2 changes of adrenaline (A) and noradrenaline (NA) excretion of sprinters presented at the beginning of the experiment are homogeneous, confirming right distribution of athletes into groups G1 and G2. That is why there are no statistically significant differences between group indicators of catecholamines at a state of relative rest (morning portion of urine), before and after loading.

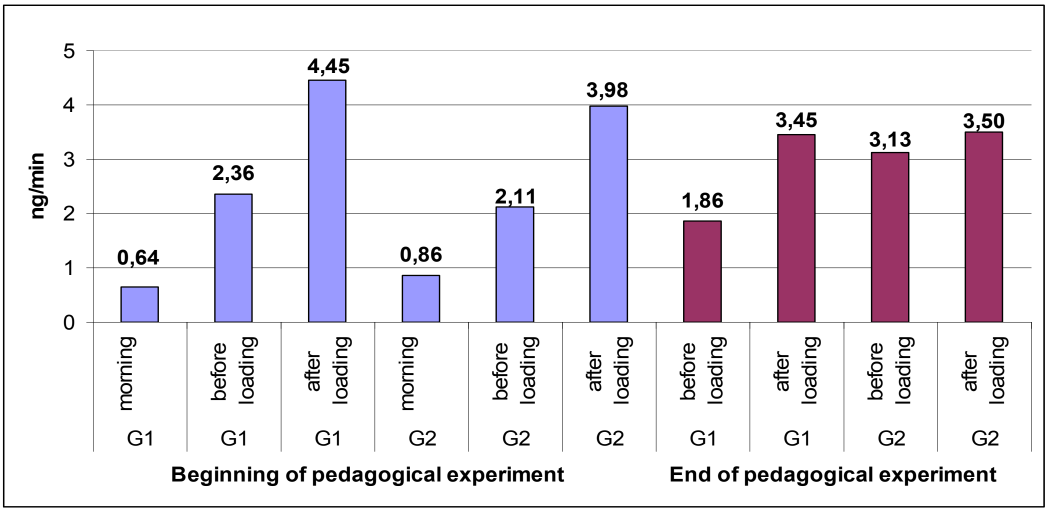

Fig.1. Changes in adrenaline excretion of sprinters during pedagogical experiment

At the end of the experiment as a result of artificial hypoxic and hypercapnic factors influence on the members of group G1 (Figure 1) we received statistically significant difference between the group "pre-start" indicators. Namely, the author's training program optimized pre-start situation in group G1. For example, excretion of adrenaline at the end of the experiment "in the pre-start " state was equal to 1.86 ng/min (nanograms per minute) against 2.36 ng/min at the beginning of the experiment, by smoothing effects of stress, which was a positive change. Representatives of group G2, whose rate of excretion at the beginning of the experiment was equal to 2.11 ng/min, at the end showed 3.13 ng/min.

As it is known, reduction of adrenaline excretion, which is also known hormone of anxiety, in the pre-start condition is a positive sign of adaptation to training, which took place in the experimental group in contrast to the control group. It should be noted that athletes of G1 as a result of the experimental factor during testing on exercise bike (sample «Vita max») at the end of the experiment coped with load 225,00 W against 119.671 W at the beginning of the experiment. If to compare the results –athletes of G2 at the end of the experiment coped with load 212,50 W against 191.67 W at the beginning. Besides, G1 athletes showed a reduced reaction of SAS to adrenaline (excretion of adrenaline after loading at the end of the experiment was 3, 45 ng/min against 4.45 ng /min – at the beginning of the experiment). This fact indicates the mode of energy saving gained by athletes as a result of experimental factor influence. The representatives of the control group showed only a tendency to adrenaline excretion reduction (with 3.98 ng/min – at the beginning of the experiment to 3.50 ng/min – at the end of the experiment), because the difference was not statistically confirmed. In addition, the result of test "Vita max ", was not as good as that of the G1 representatives and was at the end of the experiment 212.50 W against 191.67 W at the beginning of the experiment ($p> 0,05$).

Under influence of experimental factor in G1 pre-start indicator of noradrenaline was optimized (from 5.55 ng/min at the beginning of pedagogical experiment to 4.85 ng/min at the end of it, while normal rate of NA excretion is = 4.0 ng/min). While representatives of G2 showed less rates of noradrenaline (NA = 5.65 ng/min – at the beginning of PE, NA 5 = 55 ng/min – at the end of PE). However, we observed lower "noradrenaline feedback" in response to higher veloergometric load in G1 representatives, indicated a statistically significant reduction in the excretion of noradrenaline after load from 6.77 ng/min to 6.35 ng/min, which is not observed in G2 representatives.

Discussion.

In practice of biochemical control in professional sport of SAS [1, 10] the ratio of noradrenaline to adrenaline is used. According to physiological norm, noradrenaline is excreted twice as much as adrenaline. This is the ratio (NA / A = 2) which describes the state of readiness to start. If we preserve this ratio while adequate to physical load increase in absolute values of adrenaline and noradrenaline during exercises aimed at muscular effort, we will get economical energy supply of speed-strength endurance.

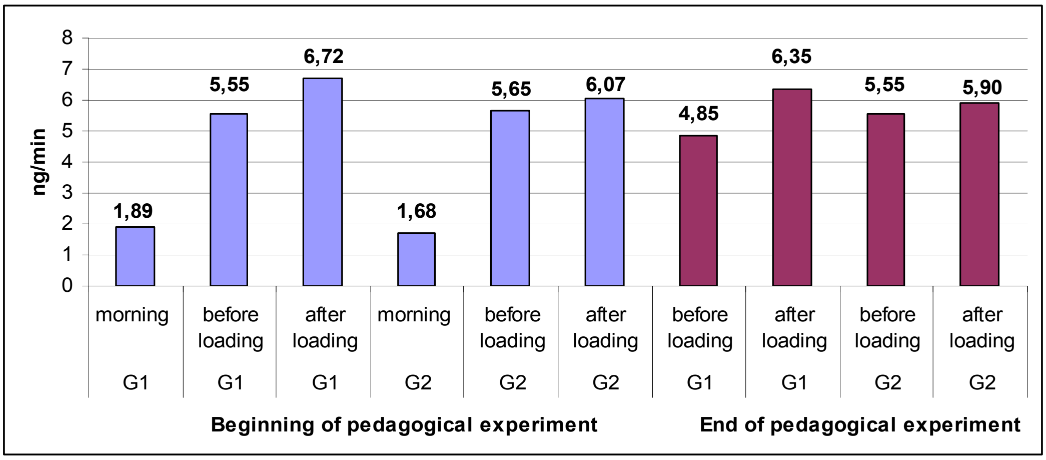

Fig.2. Changes in noradrenaline excretion of sprinters during pedagogical experiment

Therefore, noteworthy is information (Figure 3) that members of G1 who performed breathing exercises at Frolov simulator, the ratio of NA to A due to pedagogical experiment was 2.61 ng/min (before) and 2 52 ng/min (after). Such ratio is not observed in athletes of G2. Some dominance of noradrenaline part of SAS in G1, both at the start and after the muscular load, is also positive because it is in favour of the growth of speed-strength endurance.

This optimization regarding the ratio of NA to A can be explained by a favorable effect of hypoxic training respiration on sympatho-adrenal system, which is responsible for providing dynamic homeostatic regulation. At this fact once more are pointed constant data of G2 members, who had not included in the process of training breathing exercises at Frolov simulator, thus we did not observe optimization of adaptive changes in the dynamics of SAS in G2 representatives (Figure 3).

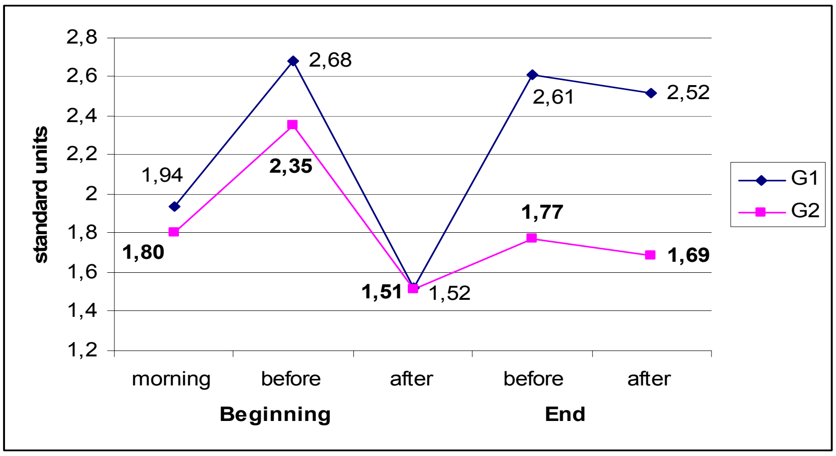

Figure 3. Changes in the ratio of NA to A excretion of sprinters during pedagogical experiment

It can be once again emphasized that in terms of excretion of both A and NA in G1 athletes in response to load, sympatho-adrenal system coped with the task to ensure homeostasis. It also appropriately responded to the increase in the limit test load i.e. stress reaction was not observed. This point is very important in understanding the fact of absence of pathological changes in the body. This fact scientifically justifies proposal to use Frolov breathing simulator in practice of skilled sprinters training.

Among all parameters that were measured during the pedagogical experiment most significantly improved physical performance (Table 1) (at 17.39% at the $p < 0{,}001$). Physical performance is considered integrative indicator of human capabilities and is included in the concept of health. Increasing of physical perfomance indicates that regular performing of training loads and exercises at Frolov breathing simulator leads to forming of physiological reserves.

Athletes that were trained according to traditional methods without using artificial hypoxia in the training process, also improved statistically ($p < 0{,}01$) the volume of work done till the end of their abilities. However, the pace of growth in physical performance were not as significant (10.87%). Eventually – after the end of pedagogical experiment - in terms of physical performance differences were observed between the indicators of two experimental groups (6.52% at $p > 0{,}05$).

Table 1.Changes in physical perfomance (W) of qualified sprinters during pedagogical experiment

Groups	Indicators	Testing results		Changes of indicators (%)	Probability of indicators differences between testing
		Beginning of PE	End of PE		
G1	X	191,67	225,00	17,39	***p<0,001***
	± m	27,78	29,17		
	σ	35,89	33,71		
	V, %	18,72	14,98		
G2	X	191,67	212,50	10,87	***p<0,01***
	± m	27,78	25,00		
	σ	60,73	59,16		
	V, %	31,69	32,00		
P (G1-G2)		*>0,05*	*<0,05*	–	–

Conclusions.

Analysis of biochemical parameters of SAS during pedagogical experiment allows us to state that there is positive impact of author's training program based on breathing method by Frolov on the state of catecholamines homeostatic function (adrenaline and noradrenaline) in qualified sprinters, gives right to recommend it for improvement of their training.

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