Methods of Increasing Statokinetic Stability in Racers using Normobaric Hypoxia and Neck Muscle Training

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Abstract: In recent years, against the background of a significant improvement in the equipment of pilots, improvement of technical characteristics of cars, a significant increase in the speed of movement of race drivers on the highway has been noted. At the same time, the psychophysiological capabilities of athletes remained virtually unchanged. This discrepancy, in turn, led to the fact that when the dynamic factors of the race and the speed of movement on the track are excessively affected, the athlete's body is affected by forces that impair not only its functional state, but also negatively affect competitive activity. To improve statokinetic stability of the experimental group subjects, a within a month normobaric hypoxia training course in combination with cervical muscle exercises was used. The control group subjects were given “fake” normobaric hypoxia courses and performed no dedicated cervical muscle exercise. The results of the study showed that the experimental group subjects who received normobaric hypoxia in combination with cervical muscle exercise demonstrated a reliably improved continuous cumulation of Coriolis acceleration (CCCA) tolerance time (versus initial measurements). Besides, there was a decrease in the manifestation degree of vestibulosensory, vestibulovegetative, and vestibulosomatic reactions, which generally indicates improvement of CCCA tolerance in this group of subjects. athletes.

1 INTRODUCTION

Currently, the most important conditions for achieving high results in the world of big sports is the presence of a sufficient amount of psycho-physiological reserves, a good functional state and a high level of performance in an athlete.

Especially important is the presence of the optimal state of the above-mentioned psycho-physiological characteristics for athletes-racers, whose competitive activity is associated with high voltage psycho-physiological functions of the body during movement on the track at high speeds. During the competition race car drivers Formula 1 speed of movement on the highway exceeds 300 km per hour. Pilots have great overloads and, against this background, they must make the right decisions for the minimum amount of time during a competitive fight. Such activities place high demands on the psycho-physiological systems of the pilot's body.

Researches of some scientists provides evidence that excessive exposure to dynamic loads negatively influences the bioelectric cerebral cortex activity and conditioned reflexes, memory and attention, emotional responses and orientation in space. Meanwhile, the time on the race track, as well as the number of mistakes, including gross mistakes, affecting the safety of the athlete’s racers movement, increases.

This circumstance dictates the need to search for new effective means and methods for training of race drivers directed at improvement of their functional state and the level of their physical performance (Bakaev et al., 2015, Bolotin & Bakayev, 2016, Dong, 2016, Malcata & Hopkins, 2014, Wrigley, 2015, Bolotin & Bakayev, 2017, Bolotin & Bakayev, 2018, Gorshova, et al., 2017, Ivashchenko, et al., 2017, Bakaev, et al., 2016, Bakaev, et al., 2018). This is related to a high degree of manifestation of sensory, vegetative and somatic components of statokinetic reactions in race drivers.

The physiologic methods currently used for improvement of the functional state and physical performance of athletes, as a rule, directly influence various physiologic systems of race drivers. Such

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methods include, inter alia, the method of normobaric hypoxia training which, apart from improving athletes' tolerance to a lack of oxygen, is used to enhance their bodies' resistive and adaptive capability to adverse effects of a number of other agents (Mao, et al., 2014, Mekjavic, et al., 2016, Gonggalanzi, et al., 2017, Naeije, 2014).

Currently, despite availability of a detailed description of mechanisms of negative impact of hypoxia on organs and tissues, in certain conditions it can also be regarded as a driver of expansion of physiologic ranges of functional systems and facilitate improvement of athletes' psychophysiologic capabilities. The use of normobaric hypoxic training in combination with the training of individual muscle groups can lead to an optimization of the functional state of athletes and an increase in their working capacity (Bolotin, & Bakayev, 2017a, Bolotin, & Bakayev, 2017b, Bolotin, & Bakayev, 2017c).

The aim of this research was to develop a methodology for the use of normobaric hypoxia in combination with special training of the neck muscles, with race drivers, to increase their statokinetic resistance to competitive activity.

2 ORGANIZATION AND METHODS

The research was performed at the Department of Medical and Valeological Specialties in Herzen State Pedagogical University of Russia and the Institute of Physical Culture, Sports and Tourism in Peter the Great St. Petersburg Polytechnic University. Its subjects were race drivers aged 18–20 in whom the continuous cumulation of Coriolis acceleration (hereinafter "CCCA") test tolerance time amounted to less than two minutes.

At the initial stage of the experiment, all the subjects were introduced to the plan and procedure of the forthcoming research, and the methods it used. All subjects provided voluntary written consent to participate in the experiment.

Next, random sampling was used to form two groups of subjects: the experimental group (n-11) and the control group (n-14). Subsequently the experimental group subject were engaged in a within one month course of normobaric hypoxia training (hereinafter "NBHT") in combination with dedicated cervical muscle exercises (hereinafter "DCME"). The control group subjects received "fake" courses of NBHT and performed no DCME.

After a month-long experiment, all subjects were re-examined in their original volume. Then the survey in the original volume was repeated after one, two and three months after the end of the experiment.

In the course of the experiment, the CCCA test tolerance time was determined using the procedure and evaluation according to the traditional R. Barany chair method.

The severity of sensory, vegetative, and somatic components of statokinetic reactions was also assessed. It was determined with the help of the scoring system developed by us: 0 - no sensations; 1 - mild; 2 - strong sensations.

In the experimental group (EG) for the NBHT we used the *Bionova-Nova-204, AF* system (Russia). The NBHT was performed in a course of 14 sessions. Duration of each session was 30 minutes. During the first session, the subjects were administered hypoxic gas mix with 17.0% oxygen content. During the following four sessions, oxygen content was reduced to 1.0–2.0%. Starting from the fifth session to the end of the NBHT course, oxygen content in the hypoxic gas mix was maintained at the level of 12.0–14.0%.

The DCME method included two exercises in the supine position. In Exercise No.1, the subject was supine on the gymnastic bench, with the head poised (earphone helmet loaded with 500 g weight prevented engagement of muscles adducting the head to the chest). In Exercise No.2, a rubber band, secured around the head with the loose end protracting from the back of the head, was fixed 0.8 meters higher than the bench level, preventing engagement of muscles extending the head. In both exercises the subject evenly tilted the head upward and downward, making one movement in two seconds, with the tilt angle of 30.0°, duration of each exercise 5 minutes, and break between exercises also 5 minutes.

Immediately after CCCA, the *ST-02* stabilograph was used for the subjects to perform a static stabilometric test in the integrated functional computer stabilography (hereinafter "SST IFCS"), consisting of two tests: test No.1 was performed with the eyes open and gaze of the subject fixed on the remote (5 m) object; test No.2 was performed with the eyes closed. The duration of tests amounted to 20 seconds, with the break of 1 minute between them. The following parameters were captured: the average rate of increase of the statokinesiogram length and area, oscillation amplitude (hereinafter "OA"), coefficient of asymmetry (hereinafter "CA") of the projection of the common center of gravity (hereinafter "PCCG") in the frontal and sagittal planes and directions.

Statistical processing of the obtained data was performed using Microsoft Excel software kit according with accepted standards. For each sample of parameters, numerical distribution characteristics were calculated. The statistical significance of difference between the compared samples was evaluated using the parametric Student's t-test.

3 RESULTS AND DISCUSSION

The results obtained in the course of the experiment justify a conclusion that the monthly combined use of NBHT and DCME reliably improved CCCA tolerance in the subjects of the experimental group. This was accompanied by a reduced degree of manifestation of sensory, vegetative and somatic components of statokinetic reactions (Table 1).

As seen from Table 1, in the open eyes test there was a reliable decrease in the parameters descriptive of the rate of increase in the length (by 11.3%) and area (by 12.4%) of the statokinesiogram, OA PCCG in the frontal (by 14.1%) and sagittal (by 12.7%) planes, CA in the frontal (by 13.6%) and sagittal (by 11.9%) directions. At the same time, in the closed eyes test there was no statistically significant difference between the parameter values before and after course use of NBHT and DCME.

In comparison with the initial measurements, the CCCA test tolerance time was improved by 93.7%. Moreover, there was a 42.8% reduction in parameters descriptive of heat sensation, 43.7% reduction in head heaviness sensation, 57.2% reduction in vertigo sensations, and 53.7% reduction in stomach discomfort. Besides, there was a reduction in hypersalivation by 54.3%, hyperhidrosis by 53.7%, manifestation degree of protective movements by 47.9%, and time of post-rotation nystagmus by 17.8%.

The observed positive dynamics in the above-listed parameters indicates that the experimental group test subjects could tolerate CCCA loads on the R. Barany chair longer and easier.

The obtained dynamics is concordant with the nature of change in parameters obtained during SST IFCS which the subjects underwent after the CCCA test (Table 2).

One of the tasks we intended to solve by the experiment was to determine the duration of the achieved effect from the monthly combined use of NBHT and DCME. To this end, after the course performance of NBHT and DCME, the subjects were retested in one, two and three months.

The analysis of the obtained data shows that the highest value of CCCA tolerance time in the experimental group subjects was reached immediately after course application of NBHT and DCME; later its values started to gradually decrease and were back to the initial level by the end of the third month (Figure 1).

Simultaneously there was a reduction of basal metabolism and more economical use of oxygen by tissues. These changes helped expand reserve capabilities of the body's functional systems and increase physical performance of athletes (Hackett, & Rennie, 2016, Luks, et al., 2017).

Table 1: Tested Functional Parameters for Subjects "Before" and "After" monthly Use of NBHT in Combination with DCME (X±δ).

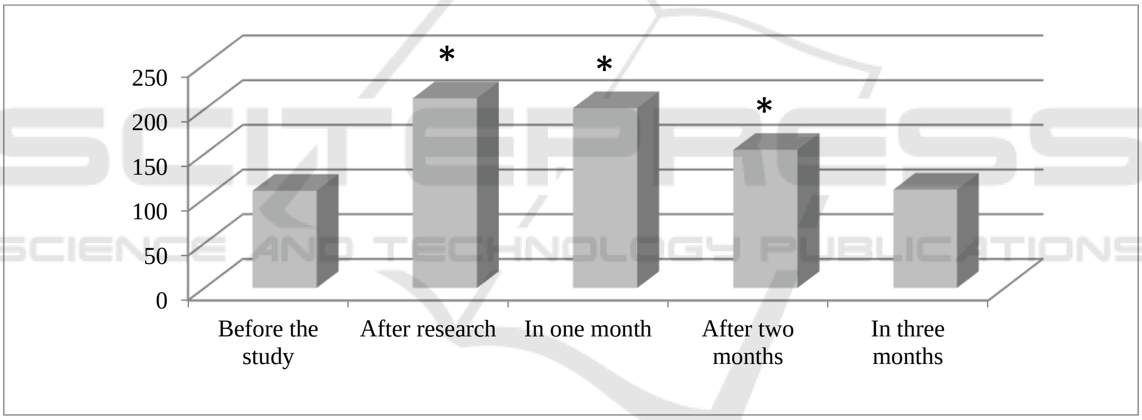
Test parameters	**Experimental group**		**Control group**	
	Before	**After**	**Before**	**After**
CCCA tolerance time (seconds)	109.7±5.7	213.4±9.7*	98.5±6.6	98.9±7.5
Heat sensation (points)	0.5±0.05	0.3±0.04*	0.4±0.06	0.4±0.05
Head heaviness sensation (points)	0.5±0.06	0.3±0.07*	0.5±0.06	0.5±0.07
Vertigo sensation (points)	0.4±0.06	0.2±0.05*	0.4±0.05	0.4±0.06
Stomach discomfort (points)	0.4±0.05	0.2±0.06*	0.4±0.07	0.4±0.08
Hypersalivation degree (points)	0.6±0.05	0.3±0.06*	0.5±0.07	0.5±0.08
Hyperhidrosis degree (points)	0.4±0.04	0.2±0.05	0.4±0.06	0.4±0.07
Protective movements (points)	0.7±0.08	0.4±0.06*	0.6±0.07	0.6±0.08
Nystagmus duration (seconds)	21.0±3.3	17.3±3.5*	20.1±3.5	20.0±3.7
Number of subjects	11	11	14	14

Note: - reliability of differences: * - p<0.05 versus initial parameter values.

Table 2: SST IFCS Parameters for Subjects “Before” and “After” monthly use of NBHT in combination with DCME (X±δ).

Test Parameters	Experimental group		Control Group	
	Before	After	Before	After
Open eyes test				
Length increase rate (mm/s)	41.2±1.8	37.4±1.7*	38.5±2.3	39.0±2.0
Area increase rate (mm²/s)	68.4±3.4	61.3±3.3*	62.4±4.1	61.3±4.8
OA PCCG, frontal plane (mm)	6.8±0.4	5.9±0.3*	6.3±0.6	6.4±0.5
OA PCCG, sagittal plane (mm)	7.1±0.3	6.3±0.4*	6.4±0.7	6.6±0.8
CA, frontal direction (%)	7.4±0.4	6.4±0.5*	6.6±0.6	6.8±0.7
CA, sagittal direction (%)	7.6±0.3	6.7±0.4*	7.3±0.6	7.2±0.7
Closed eyes test				
Length increase rate (mm/s)	46.2±4.5	44.3±4.6	44.4±5.1	43.6±4.9
Area increase rate (mm²/s)	64.3±5.5	62.0±4.8	69.8±5.4	60.1±5.0
OA PCCG, frontal plane (mm)	8.0±0.8	8.0±0.9	7.7±0.8	7.5±0.8
OA PCCG, sagittal plane (mm)	7.5±0.7	7.4±0.8	8.2±0.7	8.1±0.8
CA, frontal direction (%)	7.4±0.9	7.3±0.8	7.8±0.8	7.9±0.7
CA, sagittal direction (%)	7.2±0.8	7.1±0.9	8.1±0.9	8.0±0.8

Note: Reliability of differences: * p<0.05 versus initial parameter values.



Note: Reliability of differences: * - p<0,05 versus initial parameter values.

Figure 1: The CCCA test tolerance time in the experimental group subjects “Before”, “After”, and in 1, 2, and 3 months following the course use of NBHT in combination with DCME (in seconds).

On the cellular level, the body responded by enhancing the capacity of the energy supply system due to the increase of mitochondria count and activation of the respiratory chain ferments.

Therefore, improvement of non-specific resistance of the body emerging as a result of adaptation to normobaric hypoxia induces a whole array of physiologic changes in race driver. These changes play an important role in correction of the athletes’ functional state and optimization of capabilities of organs and systems in athletes (Pieralisi, 2017, Mao, 2014).

Finally, this mechanism plays a role of a critical link in the chain of adaptation changes and ultimately facilitates improvement of tolerance to statokinetic exposures and reduction of the manifestation degree of sensory, vegetative and somatic reactions (Gonggalanzi, et al., 2017, Hopkins, et al., 2009, Luks, et al., 2017).

In their turn, physical exercises in the form of regular and adequately selected types of loads assist enhancement of the vascular tone, improve the cardiovascular and external respiratory function. They optimize gas exchange and redox processes, thereby improving bioelectric activity and reinforcing excitatory processes in the structures of the central nervous system, facilitating overall enhancement of the stamina and physical performance of the body race drivers.

It has been established that the increase of statokinetic stability under the influence of DCME is caused by the change in the sensitivity threshold of the vestibular, visual, interoceptive, tactile and proprioceptive analyzers (Wrigley, 2015).

In turn, this improves tolerance to statokinetic loads through faster and more adequate build-up of a single statokinetic stability system in athletes.

4 CONCLUSIONS

1) The use of NBHT in combination with DCME during the month of training significantly increases the tolerance time of the CCCA test, while reducing the severity of the sensory, vegetative and somatic components of the statokinetic reactions of the race drivers.
2) The highest value of the time of portability of CCCA is noted immediately after the monthly use of NBHT in combination with DCME. The achieved effect lasts for two months, then gradually decreases to baseline. This indicates the need for such training with racers at the final stage of the preparatory period for competitive activities.

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