PROCEEDINGS OF THE YEREVAN STATE UNIVERSITY

Chemistry and Biology 2019, **53**(2), p. 113–118

Biology

APPLICATION OF CLOVE ESSENTIAL OIL FOR CORRECTION OF SHIFTS IN HEMODYNAMIC PARAMETERS IN STUDENTS INDUCED BY CYCLE ERGOMETER EXERCISE

E. S. GEVORKYAN [*], L. E. GHUKASYAN [**]

Chair of Human and Animal Physiology YSU, Armenia

Shifts in some cardiac hemodynamic parameters were studied in students during a 15-minute cycle ergometer load attended with cold inhalation of clove essential oil. It is shown that the use of essential oil of cloves contributes to the alignment of shifts in the level of functional indicators of students, by increasing the adaptive capacity of the organism. Essential oil of cloves causes a decrease of "physiological cost" of physical activity performed by students by strengthening the economization processes of functional systems activity. Curing an increase in the sympathetic effects on the body, induced by physical activity, the oil of cloves contributes to the rapid restoration of the functional state of the body in the nearest post-load period. As a control, indicators of the functional state and cardiac hemodynamics of students who, during bicycle ergometer load, were not subjected to the corrective influence of the essential oil of cloves, were used.

***Keywords*:** functional status, physical activity, aromatherapy, clove essential oil.

Introduction. At the present stage of the reform of higher education, there is a constant increase in the number of stress factors that have a negative impact on the body of students. Among them, special attention should be paid to a sedentary lifestyle and the formation of a "stress of limited time," due to the increasing complexity of curricula, the introduction of new disciplines, and the use of innovative computer technologies in the educational process. Adaptation of students to a complex of factors specific to educational institutions, being a complex socio-physiological process, requires considerable tension of the compensatory-adaptive systems of the body [1]. The growth of emotional and psychological stress in everyday life and in the process of learning, reduction of physical activity leads to the development of psycho-vegetative dysfunctions at behavioral and physiological levels, which can afterwards cause maladaptation and transform into diseases of various etiologies [2–4]. In this regard, in modern biomedical research, special attention is paid to the study of integral constitutional-typological characteristics of prognostic importance, such as the type of functional organization of the autonomic nervous system (initial autonomic tone), which can be diagnosed with a high degree of accuracy, based on the study of heart rate variability and cardiac

[*] E-mail: emma.gevorkyan@ysu.am [**] E-mail: gh.lilit@ysu.am

hemodynamic indices [5]. Types of vegetative regulation reflect relatively stable constitutional features of the organism and can be used to assess the functional capabilities of the organism, the "psychophysiological cost" of various activities [6] and search for optimal non-pharmacological methods for correcting the functional state and identifying the mechanisms of their influence.

Correcting technologies have an extensive arsenal of traditional and modern methods, among which water, air, music, physio, aroma, reflex therapies, and others have recently received wide recognition [7]. According to modern concepts, in the case of prolonged exposure to sensory flows, optimization of functions occurs more quickly when the combined use of several corrective factors is made, and the strength of each of these factors can be reduced. So, with the right combination of aromatherapy methods, one can influence the physical, psycho-physiological and bio-energetic state of a person [7, 8].

It is impossible to argue about the adaptive abilities of an organism of students to an academic load by the level of functional indicators at rest. The reliability of these indicators can be judged only by changes under the influence of various functional and physical loads. The most studied method of analysis and correction of the functional state is physical activity [9].

Another method of non-pharmacological correction of functions, combining high efficiency and the minimum number of risk factors, is also aromatherapy [10, 11]. Currently, there are known more than 200 names of essential oils, which have a pronounced corrective and therapeutic effect and do not have side effects. Our choice of clove essential oil was due to little study of its corrective effect. Its composition includes acetyl eugenol, caryophyllene and a mixture of bicyclical sesquiterpenes. The aroma of clove oil has tonic and bactericidal effect, weakens stress-induced tension, helps get rid of mental and physical fatigue, actively influences the neuro-psychological processes occurring in the body, contributes to the increase in the amount of active memory [10].

Methodology of Research. A common clinical method for assessing the adaptive-compensatory capabilities of the cardiovascular system of an organism is a bicycle ergometer load. In this regard, we studied the dynamics of indicators of the functional state of the cardiovascular system in 20 absolutely healthy female students (the average age of the subjects was 19.5 ± 1.5 years) of YSU. All studies were conducted with the consent of the students and their parents.

The criterion for evaluating the functional capabilities of the students' cardiovascular system was the reactivity of the studied parameters to a 15-minute load on a Proteus Pec 3320 exercise bike, accompanied by aromatic correction with clove essential oil (manufactured by "Natural Oils" LLC, Solnechnogorsk, TC 9158-004-08628011-00). Preliminary testing of approved oil revealed a positive perception of the aroma of cloves by all subjects. Numerous clinical data indicate that in healthy trained people, after a 15-minute load on an exercise bike, indices of cardiovascular system recover at 7–10 *min* of a post-load recovery period [12]. In order to avoid the negative effect of fatigue due to the academic load on the adaptive reactions of the students, all studies were conducted in the morning. Aroma correction was carried out by cold inhalation, since one of the most affordable and popular ways to use aromatherapy is the aromatization of air. All measurements were taken thrice: before exercise (physiological norm); immediately

after a 15-minute load on a stationary bike, attended with inhalation of clove oil; 15 *min* after exercise. As a control, we took previously obtained indicators of the cardiovascular system of female students subjected to physical exertion of the same intensity without the concomitant influence of sensory flows from aromatic oils [13]. The functional state of the students was assessed by the main hemodynamic parameters and heart rate indicators: heart rate (HR), systolic and diastolic blood pressures (SBP and DBP), stroke volume (SV) of the heart and the cardiac output (CO), as well as the following calculated indices: pulse pressure (PP), mean arterial pressure (MAP) and mean dynamic pressure (MDP), type of circulatory autoregulation (TCA). The adaptation degree of the parameters of the cardiovascular system to physical activity was also assessed by the dynamics of the adaptive potential of the circulatory system (AP), the level of the functional status of the body (FS), and the Kvass endurance coefficient (CE).

The value of AP up to 2.1 indicates a good functional capabilities of the body and a state of satisfactory adaptation; from 2.11 to 3.2 – a state of functional stress; above 3.2 – a disruption of the adaptation process. TCA characterizes the phenotypic characteristics of the organism. Fluctuations in magnitude of TCA in the range of 90–110 indicate the predominance of the cardiovascular type of circulatory autoregulation; above 110 – vascular type; less than 90 – cardiac type.

Statistical processing of experimental results, involving the assessment of the average value and reliability of situational shifts of the studied parameters, was carried out by the method of analysis of variance, taking into account the Student's *t*-criterion.

Results and Discussion. Analysis of the studied parameters of the subjects of the control group found that at rest most of them were characterized by a dynamic equilibrium of the activities of the sympathetic and parasympathetic contours of the autonomic nervous system, but the cardiac hemodynamic indicators were at a somewhat low level compared with the age norm. According to our previous studies, after a 15 *min* load on a stationary bike, an increase in heart rate and blood pressure indicators was observed, amounting to 87.2% for heart rate ($p<0.001$), 18.57% for SBP ($p<0.001$), 8.17% for DBP ($p<0.001$), 38.66% for PP ($p<0.001$), 13.77% for MDP ($p<0.01$), 7.88% for SV of blood ($p<0.01$) and 65.93% for CO ($p<0.001$) [19]. The observed shifts are most likely caused by a shift in the vegetative balance towards the dominance of the activity of the sympathetic circuit of regulation of functions aimed at restoring the body's oxygen balance disturbed due to the activation of redox processes in the body and, in particular, skeletal muscle during exercise. A significant increase in the values of PP, MDP, HR and SBP may indicate the tension of the functional systems of the body, directed at ensuring the optimal level of blood circulation. One of the reasons for the increase in all blood pressure indicators can also be disharmony between the changed amount of cardiac output and peripheral vascular resistance.

An increase in the chronotropic activity of the heart during a bicycle ergometer load led to a pronounced increase in CO (65.93%, $p<0.001$), whereas the level of SV of blood increased only slightly, by 7.88%, $p<0.01$. The latter allows us to judge the small range of adaptive responses of the cardiovascular system of subjects to physical activity. A pronounced chronotropic reaction with a slight inotropic reaction indicates a lack of myocardial strength and suggests that students overcome the load on a bicycle ergometer with a high "physiological cost". The

functional tension of the myocardium is also indicated by a shift in AP of the circulatory system to the zone of functional stress (AP=2.93±0.11, $p<0.001$), a decrease in the FS index by 69.5%, $p<0.001$, and some increase in CE. This is also confirmed by a decrease in the TCA index by 29.83%, ($p<0.001$), which indicates a shift in the mechanism of blood flow regulation towards the dominance of the cardiac type of circulatory autoregulation. By the 15th minute of the post-load period, at the trend level, we observed a shift in most of the studied indicators towards recovery, but remaining at a somewhat elevated level compared to the norm. The low lability of the indicators of cardiac hemodynamics in the process of restoring the initial level in the post-load period may be a consequence of the lack of fitness of the subjects and their prolonged stay in the state of hypodynamia.

Table 1

Cardiac hemodynamic parameters in students undergoing physical exertion

Indicator	Norm	By the 15th *min* after physical exertion	Immediately after physical exertion
HR (*bpm*)	63.29±2.74	97.14±3.13	118.50±5.38
SBP (*mm* Hg)	110.40±2.04	110.40±2.38	130.91±4.96
DBP (*mm* Hg)	72.64±2.01	73.14±2.08	78.57±2.37
PP (*mm* Hg)	37.71±2.63	37.21±2.65	52.29±3.92
MDP (*mm* Hg)	88.86±1.88	89.12±1.78	101.10±3.16
SV (*mL*)	59.25±2.13	58.71±2.20	63.92±2.23
CO (*L*)	4.96±0.28	5.72±0.31	8.23±0.47
FS (*a.u.*)	0.59±0.02	0.46±0.03	0.18±0.04
AP (*a.u.*)	2.10±0.04	2.34±0.11	2.93±0.11
TCA (*a.u.*)	88.86±4.59	76.44±3.57	62.32±2.76
CE (*a.u.*)	23.32±1.68	28.13±2.41	26.76±2.75

In order to study the aromatherapy effect of the essential oil of cloves on the functional stress of the cardiovascular system of students exposed to bicycle ergometer load, and on the process of restoring the functional state of the subjects, the dynamics of the same vegetative parameters were studied in the experimental group. Application of the essential oil of cloves revealed the presence of differences in the effects obtained in the experimental group compared to the control (Tab. 2).

Immediately after the 15-minute exercise with a concomitant aroma correction, the subjects of the experimental group experienced an increase in heart rate by 22 *bpm* (26.2%, $p<0.001$), the level of SBP increased by 15.2%, $p<0.001$, while DBP slightly decreased. In contrast to the control group, subjects of the experimental group, after a cycle ergometer load, showed also an increase in SV and CO indices by 16.2 and 45.2%, $p<0.001$, respectively. The pronounced increase in CO in this case was due to an increase in both chronotropic and inotropic functions of the cardiac muscle, and is a more perfect form of adaptation to physical exertion. The shifts of SBP and DBP also caused an increase in the value of PP by 49.7%, $p<0.001$, which indicates an adequate hyperfunction of the heart, aimed at ensuring the energy balance of the body. The AP of the circulatory system at the same time passed into the zone of weakly expressed functional strain (AP=2.38±0.63, $p<0.001$), which in turn provided a slight decrease in FS compared with the control group

(44.3%, $p<0.001$, vs. 69.5%, $p<0.001$, in the control group), and a decrease in tension of cardiac muscle (CE by 13.4%) of the subjects of the experimental group, due to the aroma-therapeutic effect of the essential oil of cloves. The observed changes indicate that both cardiac and cardiovascular mechanisms are involved in the process of regulation of blood circulation, which is confirmed by a shift in the TCA index in the majority of subjects towards a more pronounced dominance of cardiac and cardiovascular types of circulatory autoregulation. The changes we have observed also point to the relaxing effect of aromatherapy on the central nervous system, most pronounced in terms of systemic hemodynamics, possessing a hypersensitivity to the effects of clove fragrance.

Table 2

Cardiac hemodynamic parameters in students undergoing physical exertion attended with inhalation of clove essential oil

Indicator	Norm	By the 15th *min* after physical exertion	Immediately after physical exertion
HR (*bpm*)	83.62±3.15	105.5±3.21	91.86±2.75
SBP (*mm* Hg)	101.7±2.93	117.1±3.97	101.2±2.98
DBP (*mm* Hg)	68.1±1.77	66.9.±2.25	65.38±2.00
PP (*mm* Hg)	33.57±1.95	50.24±2.85	35.81±2.03
MDP (*mm* Hg)	82.53±2.14	88.51±2.77	80.35±2.26
SV (*mL*)	59.67±1.31	69.31±1.62	67.58±1.54
CO (*L*)	5.00±0.24	7.26±0.28	5.98±0.17
FS (*a.u.*)	0.61±0.03	0.34±0.02	0.54±0.02
AP (*a.u.*)	1.93±0.06	2.38±0.63	1.97±0.05
TCA (*a.u.*)	84.41±4.12	65.05±3.41	68.92±3.17
CE (*a.u.*)	26.32±1.61	22.81±1.80	25.97±2.04

By the 15th minute of the post-loading period, there was a tendency to restore all the studied cardiac hemodynamics parameters and the calculated characteristics of the functional status of the subjects of the experimental group at the levels of the physiological norm. The changes observed immediately after physical exertion and aromatherapy are indicative of the optimization of functional status and the expansion of the functional capabilities of the body of students. In all likelihood, the effect of clove odor, exerting a tonic effect on the students' body, helps to overcome physical loads with less exertion of sympathetic mechanisms, weakens sympathetic effects, as evidenced by hemodynamic changes we have observed.

Conclusion. Thus, on the basis of the data obtained, it can be concluded that the bicycle ergometer loads at intensities we used, leads to a pronounced activation of the sympathetic regulation contour, thereby causing a decrease in the functional capacity of students' cardiovascular system. Analysis of the cardiac hemodynamic data we obtain in the experimental group showed that the use of clove essential oil at bicycle ergometer loads has a harmonizing effect on the functional status of students. By lowering the level of tension of the heart muscle, the essential oil of cloves contributes to an increase in the adaptive capacity of the organism and provides reduction in the "physiological cost" of physical activity performed by students. Despite the presence of few data on the effect of clove oil on various

functions of the body, there is no doubt that the specific mechanism of action of various olfactory stimuli involves sensory specific areas of the central nervous system, as well as limbic, associative, and nonspecific brain structures.

Received 12.04.2019
Reviewed 06.05.2019
Accepted 22.05.2019

REFERENCES

1. Krivolapchuk I.A., Chernova M.B. Functional State of Pupil Under Intense Information Load in the Initial Period of Adaptation to the Educational Environment. *Human Ecology*, no. 9 (2018), 18–26.
2. Tarasova O.L., Kazin E.M. et al. Age and Typological Features of the Psycho-Vegetative Status of Schoolchildren. *Valeology*, no. 4 (2015), 33–40.
3. Shalamova E.Yu., Safonova V.R. et al. Factor Analysis of the Parameters of Daily Hemodynamics in Students of the NMU. *Human Ecology*, no. 3 (2018), 39–44.
4. Efimova N.V., Mylnikova I.V. On the Influence of Environmental Factors and Lifestyle on the Formation of the Syndrome of Vegetative Dysfunction in Schoolchildren. *Hygiene and Sanitation*, **98** : 1 (2019), 76–81.
5. Averyanova N.V., Maksimov A.L., Kharin A.V. Interrelations of Somatometric Characteristics, Hemodynamic Parameters and Capillary Blood Flow in Young Men of the Magadan Region. *Human Ecology*, no. 3 (2018), 45–50.
6. Shkolnik T.K., Lushekina E.A., Strelets V.B. Individual Peculiarities of Psychological Manifestations of Stress Reaction in Adolescents under Chronic Familial Stress. *J. Higher Nervous Activity after. I.P. Pavlov*, **62** : 4 (2012), 416–421.
7. Shutova S.V. Non-Pharmacological Optimization of Brain Functions in Students when Adapting to the Conditions of Learning in High School. Tambov (2012), 169 p. (in Russian).
8. Popov V.M., Sentyabrev N.N., Mandrikov V.B. Dynamics of Body Functional State and Anaerobic Performance Characteristics of sprinters after Exposure to Essential Oils. *Scientific Notes of NSU after P.F. Lesgaft*, **75** : 5 (2011), 96–100.
9. Dernova B.F., Prosheva V.I. Comprehensive Assessment of the Cardiovascular System of Athletes-Skiers in the Winter during Preparation for the Competition. *Human Ecology*, no. 8 (2018), 46–51.
10. Nikolaev V.V. *Aromatherapy*. M., Medicine (2000), 330 p. (in Russian).
11. Sentyabrev N.N., Karaulov V.V., Kaydalin V.S., Kamchatnikov A.G. Essential Oils in Sports Practice. Volgograd (2009), 138 p. (in Russian).
12. Mikhailov V.M. Heart Rate Variability: Experience of Practical Application of the Method, Ivanovo (2002), 290 p. (in Russian).
13. Gevorkyan E.S., Minasyan S.M., Abrahamyan E.T. The Study of the Degree of Tolerance of the Cardiovascular System of Students to Bicycle Ergometer Load. *Valeology*, no. 3 (2013), 61–68.