Urgent adaptive effects of a single intake of carbohydrate-electrolyte mixture with plant extracts in maintaining microcirculation parameters of highly qualified athletes

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Abstract

Objective of the study was to evaluate the short-term adaptive effects of a single dose of a carbohydrate-electrolyte mixture with plant antioxidants (CEMA) in maintaining the microcirculation system using the example of highly qualified orienteers under the conditions of a two-stage bicycle ergometric test PWC170.

Methods and structure of the study. Highly skilled orienteers aged 17-22 years old were examined. Two cycles of the study were conducted: a placebo cycle in which athletes consumed 250 ml of bottled water; a cycle of taking 250 ml of CEMA. Laser Doppler flowmetry was used as a method for studying microcirculation.

Results of the study and their discussion. As a result of the conducted studies of a single dose of CEMA, a vasoprotective effect was established. This effect is due to the restoration of the functional activity of the microvascular endothelium and is expressed in an increase in the amplitude values of endothelial rhythms in the cycle of taking CEMA in comparison with the placebo cycle. Also, a single dose of CEMA contributed to a decrease in the effects of sympathetic adrenergic vasomotors on the vascular wall, which can be considered as a concomitant antihypoxic effect and is expressed in a decrease in lactate levels.

Keywords: *carbohydrate-electrolyte mixture with plant antioxidants, single dose, microcirculation; vasoprotective and antihypoxic effects; highly qualified guides.*

Introduction. Considering the seriousness of the problem of doping control of athletes taking vasoprotectors [3], studies of acceptable functional carbohydrate-electrolyte drinks with vasoprotective properties in combination with previously unused in their composition and not prohibited by anti-doping organizations, plant extracts acting as antioxidants, are of high practical importance [2 , 4], namely, the use of Crimean rosemary hydrolate in the formulation of the carbohydrate-electrolyte composition in combination with aqueous extracts of rose hips, nettle leaf and lemon juice.

The expediency of adding antioxidant extracts to the carbohydrate-electrolyte mixture is justified by the need to correct damage to the vascular endothelium during muscular work for 30-120 minutes at an oxygen consumption level of 75-80% of the VO_{2max}, since such work can lead to an increase in the content of lactic acid above the anaerobic threshold and, consequently, to shifts in the acid-base balance to the acid side [5, 8]. Also, under these conditions, an increase in dysfunction of the vascular endothelium can be triggered by the development of a state of dehydration - hypovolemia, activation of the renin-angiotensin-aldosterone system, vasoconstriction, increased blood viscosity, increased heart rate. The authors of [7] convincingly showed that antioxidants stimulate the processes of endothelium-dependent vasodilation under the condition of long-term use, that is, they involve the microvascular endothelium in adaptive responses to oxidative stress factors, including prolonged physical activity, which helps to

reduce the severity of endothelial damage. However, in highly qualified athletes participating in sports with a pronounced component of aerobic endurance manifestation, the effects of a single intake of carbohydrate-electrolyte mixtures with plant antioxidants (CEMA) have not been fully studied. Whereas in many sports, a single intake of functional drinks is practically convenient, and especially in case of urgent, timely and permitted by the competition rules, nutritional support for competitive activity [4].

Objective of the study was to evaluate the short-term adaptive effects of a single dose of a carbohydrate-electrolyte mixture with plant antioxidants (CEMA) in maintaining the microcirculation system using the example of highly qualified orienteers under the conditions of a two-stage bicycle ergometric test PWC_{170}.

Methods and structure of the study. The study involved 12 highly qualified orienteers (masters of sports) aged 17-22, who gave voluntary informed consent. The study of microcirculation processes was carried out on a laser analyzer "LAZMA-MC" by the method of laser Doppler flowmetry. The amplitude values of endothelial (Ae, perf. u.), myogenic (Am, perf. u.), neurogenic (An, perf. u.), respiratory (Ar, perf. u.) and pulse (Ap, perf. u.) rhythms were recorded. The registration area is the ventral surface of the index finger, which makes it possible to evaluate various regulatory factors that control microcirculation due to the high representation of sympathetic vasomotors. The short-term adaptive effects of a single intake of carbohydrate-electrolyte mixtures with plant antioxidants were studied under the conditions of a two-stage bicycle ergometric test PWC_{170} and included two study cycles: 1) a placebo cycle in which athletes consumed 250 ml of bottled water imitating the aroma of CEMA; 2) a cycle of taking 250 ml of carbohydrate-electrolyte mixtures with plant antioxidants. Water and CEMA were taken 15 minutes before bicycle ergometric exercise testing, in which heart rate (HR, beats/min) and work power ($kg \cdot m \cdot min^{-1}$) were recorded at HR150 (W_1) and HR170 (W_2). The partial pressure of oxygen in the exhaled air (R_EO_2, mmHg) was determined by the gasometric method using a PGA-KM radio-measuring gas analyzer, the minute volume of respiration (V_E, $l \cdot min^{-1}$) was determined by a spirometer (SPIROBANK G, Italy), the indicators were recorded at the last minute W_1 and W_2 in the PWC_{170} test. Oxygen consumption (VO_2, $ml \cdot min^{-1}$) was calculated by the formula $VO_2 = V_E \times {}_{\Delta}P_EO_2 \times 1000/100$, where D is the difference between P_EO_2 at W_1 and W_2. Maximum oxygen consumption (VO_{2max}, $ml \cdot min^{-1}$) was determined indirectly using Astrand nomograms. Peripheral blood lactate content (La, mmol/l) was determined using a lactate analyzer, LACTATE PLUS lactate analyzer, Lactate Plus Test Strips for lactate, capillary blood sampling (from a finger) was performed using Safety disposable lancets. The intake cycle of carbohydrate-electrolyte mixtures with plant antioxidants was carried out two weeks after the placebo cycle. The composition of a standard carbohydrate-electrolyte drink is enriched with a natural mineral complex (Black Sea sea salt - 0.4 g), rosemary hydrolate - 65 ml, water extract of rose hips (1:10) - 100 ml, water extract of nettle leaves (1:10) - 100 ml, lemon juice - 5 ml. The studied drink complies with TR TS 022/2011, standardized according to GOST R 56543-2015.

Results of the study and their discussion. When recording microcirculation parameters in athletes in the initial state in the cycles of placebo and carbohydrate-electrolyte mixtures with plant antioxidants, the pattern of hemodynamic rhythms was dominated by transient endothelial-neurogenic rhythms, which indicated adequate releasing of nitric oxide by the microvascular endothelium, as well as the absence of significant pressure from the sympathetic adrenergic vasomotors. The pronounced peak in the range of pulse rhythms determined by us indicates a moderate decrease in the tone of arterioles, and the established low values of the amplitudes of myogenic rhythms indicate the dominance of shunt blood flow in the registration area, which is a physiological norm.

In turn, the performance of physical work by athletes on a bicycle ergometer at the second stage of the PWC_{170} test was accompanied by an increase in the level of VO_2 consumption to an average of 75% of VO_{2max}, which led to an increase in the level of La above the anaerobic threshold. Under such loading conditions in the placebo cycle, the Am indicator increased to 13.24±2.17, perf. units ($p<0.05$), and the Ap indicator - up to 15.03±1.75 perf. units ($p<0.05$) in comparison with the initial state, which indicates a decrease in peripheral resistance in the region of precapillaries and arterioles. The increase in Am and Ap became natural due to the increase in La production due to the involvement of the anaerobic mechanism of energy supply during muscle work at the level of 75% of VO_{2max}, which is consistent with the metabolic regulation of tissue blood flow, where the accumulation of La above the anaerobic threshold causes relaxation of precapillaries, followed by activation capillary blood

flow. Whereas the increase in the Ap value registered by us under the conditions of test physical activity probably reflects an increase in cardiac output.

In addition, in the placebo cycle, the performance of physical work by athletes in the PWC_{170} test at the W_2 stage was accompanied by a decrease in the Ae index to 9.87±0.88 perf. units, relative to the initial values equal to 14.47±1.61 ($p< 0.05$), which indicates a moderate decrease in endothelial activity under these conditions of physical activity. The results obtained confirm the literature data on endothelial dysfunction in athletes during physical work at the level of 75% of VO_{2max}. [1], which may be due to the accumulation of low-density lipoprotein molecules with the formation of oxidatively modified lipoproteins, as well as an increase in the level of homocysteine and D-dimer, as was shown in the study [6]. The values of An, which dominated in the initial state, also decreased after the test load ($p<0.05$) to the level of 9.96 perf. units, in comparison with the level of initial values - 14.15 perf. units, which indicates an increase in the activity of sympathetic adrenergic vasomotors innervating arterioles and anastomoses and is a normal physiological response to the proposed load.

Thus, the fulfillment by athletes of the conditions of the test load in the placebo cycle stimulates the myogenic component of the regulation of vascular tone, contributing to the relaxation of precapillary myocytes with subsequent blood filling of the capillaries against the background of shunt spasm and reduces the activity of the endothelial component of regulation.

Under similar conditions of the test load in the cycle of taking a CEMA, an increase in the values of the Ae index to the level of 16.00 perf. units ($p<0.05$), in comparison with the initial values of this indicator - 14.05 perf. units, as well as in comparison with the data of this indicator, registered in the placebo cycle - 9.89 perf. units ($p<0.05$), which may indicate an increase in the efficiency of the regulatory element of urgent adaptation. Also, a single intake of carbohydrate-electrolyte mixtures with plant antioxidants during a test load contributed to an increase in An values to 16.41±0.96 perf. units $p<0.05$, relative to the data of this indicator registered in the placebo cycle - 9.96 perf. units, which indicates a decrease in vasomotor pressure from the sympathetic vasomotors and is confirmed by a significant decrease in the lactate value ($p<0.01$) to values not exceeding the level of anaerobic threshold.

At the same time, we did not determine a significant change in the values of the Am indicator in the placebo cycle and in the cycle of taking CEMA, since physical work at the level of 75% of VO_{2max} is a stress factor that causes pronounced metabolic shifts and enhances the metabolic control of vascular regulation, regardless of adaptation cofactors.

Conclusions. A vasoprotective effect was found in highly qualified orienteers as a result of a single intake of carbohydrate-electrolyte mixtures with plant antioxidants when performing muscular work under the conditions of a two-stage bicycle ergometric test PWC_{170}. This effect is due to the restoration of the functional activity of the microvascular endothelium, which is expressed in an increase in the amplitude values of endothelial rhythms in the CEMA cycle compared to the placebo cycle. Also, a single dose of CEMA contributed to a decrease in the effects of sympathetic adrenergic vasomotors on the vascular wall, as evidenced by an increase in the amplitude values of neurogenic rhythms in comparison with the data of this indicator recorded in the placebo cycle. In turn, the established drop in adrenergic vasomotor influences can be considered as a concomitant antihypoxic effect of a single dose of CEMA and is expressed in a decrease in lactate levels.

References

1. Biryukova E.A., Husainov D.R., Mishin N.P., Pogodina S.V., Chuyan E.N. Fiziologicheskie osobennosti processov kompensacii metabolicheskih sdvigov v organizme kvalificirovannyh orientirovshchikov pri vozdejstvii sorevnovatelnoy nagruzki [Physiological features of the processes of compensation of metabolic shifts in the body of qualified orienteers under the influence of a competitive load]. Teoriya i praktika fizicheskoy kultury. 2021. No. 5. pp. 26-28.
2. Gunina L., Konyushok S. Antioksidantnoe vliyanie rastitelnyh adaptogenov na membrany eritrocitov tyazheloatletov [Antioxidant effect of plant adaptogens on erythrocyte membranes in weightlifters]. Nauka v olimpiiskom sporte. 2008. No. 1. pp. 111-114.
3. Gunina L. Mediko-biologicheskie aspekty mekhanizmov vliyaniya antioksidantov na fizicheskuyu rabotosposobnost sportsmenov [Medico-biological aspects of the mechanisms of the influence of antioxidants on the physical performance of athletes]. Nauka v olimpiiskom sporte. 2016. No. 1. pp. 25-32.
4. Dmitriev A.V., Gunina L.M. Sportivnaya nutrici-

ologiya [Sports nutrition]. Moscow: Sport publ., 2020. 640 p.
5. Kim V.N., Krivulina G.A., Prosekin G.B. Vliyanie obezvozhivaniya na razvitie disfunkcii endoteliya u yunyh sportsmenov: sravnitelnyy analiz effektivnosti novogo medovogo izotonicheskogo napitka i obshcheprinyatyh sredstv vosstanovleniya vodno-elektrolitnogo balansa [The effect of dehydration on the development of endothelial dysfunction in young athletes: a comparative analysis of the effectiveness of a new honey isotonic drink and conventional means of restoring water and electrolyte balance]. Acta Biomedica Scientifica. 2020. Vol. 5 (5). pp. 86-98.
6. Lopatina Z.V., Vasilenko V.S. Markery endotelialnoy disfunkcii u sportsmenov pri trenirovochnyh nagruzkah [Markers of endothelial dysfunction in athletes during training loads]. Sovremennye problemy nauki i obrazovaniya. 2019. No. 1. pp. 414-416.
7. Kang P., Kang-Hyun R., Jeong-Min L. Endothelium and smooth muscle-dependent vasodilator effects of Citrus aurantium L. var. amara: Focus on Ca (2+) modulation. Biomed Pharmacother. 2016. No. 82. pp. 467-471.
8. Green D.J., Hopman M.T., Padilla J. Vascular Adaptation to Exercise in Humans: Role of Hemodynamic Stimuli. Physiol. Rev. 2017. No. 97 (2). pp. 495-528.