

The effect of personalized vitamin and mineral nutrition over skin microcirculation in athletes during the training period

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Published online: January 31, 2023

(Accepted for publication January 15, 2023)

DOI:10.7752/jpes.2023.01007

Abstract:

It is relevant to study the influence of metabolism nutritional correction over systemic and local hemodynamics of the body in professional athletes. *Purpose:* to study the skin blood microcirculation dynamics in professional athletes who received a personalized vitamin and mineral complex. *Materials and methods.* 74 professional cyclic sports athletes took part in the research. They received a personalized vitamin and mineral complex daily during the training period for 30 days. Before the research start, the parameters of oxidative blood metabolism were studied in all athletes to individualize the appointment of metabolic correction agents. To do this, the level of parameters was compared with the untrained people's level characteristic. The state of blood microcirculation in the middle of the forearm was assessed using laser Doppler flowmetry on the LAKK-02 device (NPO Lazma, Moscow), before the start of the vitamin and mineral complex application course and immediately after its completion. *Results.* The research made it possible to establish the positive effect of personalized metabolic correction over the blood microcirculation functioning parameters. They manifested themselves in the form of blood flow velocity activation through small-diameter vessels (according to the level of microcirculation index), which was provided mainly due to endothelial (release of nitrogen monoxide by endotheliocytes), neurogenic and cardiac (contribution of pulse wave) regulation factors. Taking a vitamin and mineral complex contributed to a decrease in the bypass rate to physiological values.

Key Words: athletes, microcirculation, vitamins, mineral complexes

Introduction

The oxidative metabolism of the body as a whole and its individual functional units is supported by a complex set of pro- and antioxidant systems, including enzymatic and non-enzymatic (bioradical and non-radical) components. This combination is provided by numerous regulatory mechanisms, which are represented by both internal and external effectors and affect the enzyme and non-enzyme components of the systems (Martusevich, Karuzin, 2021). The ubiquity of oxidative metabolism determines its participation in the pathogenesis of the absolute majority of diseases, and, on the other hand, provides extensive opportunities for correcting metabolism (Kolar et al., 2021). Disadaptation of oxidative metabolism has been called «oxidative stress», which is considered as a separate syndrome (Panza et al., 2008).

Currently, individual parameters of the body's antioxidant system have been studied in sufficient detail. According to modern ideas about it, it is customary to isolate direct antioxidants (vitamins E, A, C, etc.), enzyme systems of antioxidant protection (superoxide dismutase, glutathione metabolism enzymes, etc.), as well as markers of oxidative damage (8-isoprostane, oxidized lipoproteins, etc.). A comprehensive view of the system as a whole is possible with evaluation of several elements reflecting different aspects of oxidative stress implementation.

The effect of intense and prolonged physical exertion on professional athletes' body can provoke formation and progression of oxidative stress (Pepe et al., 2009). On the other hand, the literature presents contradictory data on this issue. A number of researchers have recorded the presence of the syndrome in question (Martusevich et al., 2022 a), while other works show the protective effect of physical exertion against endogenous and exogenous oxidants (Kolar et al., 2021).

On the other hand, the effect of nutritional correction of metabolism over the athletes' body functional state, in particular, on systemic and local hemodynamics, has not been fully studied (Abraham et al., 2019; Sirufo et al., 2021). At the same time, the fact of a pronounced modification of the microcirculatory bed functioning parameters in trained individuals relative to people who do not engage in sports is indisputable (Montero et al., 2015; Abraham et al., 2019; Hodges et al., 2020; Bocharin et al., 2022a, b), as well as the directional change of the considered indicators in different periods of the training cycle (Iwasaki et al., 2015; Marini et al., 2019; Meng et al., 2019, 2021). At the same time, the nature of the modulating effect of dietary supplements containing various vitamin and mineral components has been disclosed only in isolated studies (Pranskuniene et al., 2020).

Purpose. Studying the skin blood microcirculation dynamics in professional athletes who received a personalized vitamin and mineral complex.

Material & methods

74 professional cyclical sports athletes took part in the research project. They received a personalized vitamin and mineral complex daily for 30 days of the training period. To individualize the appointment of metabolic correction agents in all athletes, their oxidative blood metabolism parameters were studied at the beginning of the course (Martusevich, Karuzin, 2021).

To do this, the level of parameters was compared with the level characteristic of untrained people. With the predominance of parameters characterizing the intensity of free radical processes, athletes were prescribed a complex with lower concentrations of antioxidants – «vitantioximin»®, and with a conjugate shift of pro- and antioxidant blood systems – a complex containing increased concentrations of compounds with antioxidant activity – «vitametabolomin 5»® («Akafarm» LLC, RF).

The complexes used are additional sources of vitamins C, E, A, D, group B, macro- and microelements (calcium, potassium, magnesium, silicon, chromium, iron, copper, zinc, selenium, iodine, manganese, molybdenum), sources of carotenoids (beta-carotene - 1.5 mg, lutein – 4.5 mg) and L-carnitine contain biotin, folic acid, natural carotenoids, α - and γ -tocopherol, niacin, pantothenic and α -lipoic acids, a combination of macro- and microelements and other compounds as the main components.

Obtaining blood samples from athletes was carried out before the start of the course and immediately after its completion. The content of 8-isoprostane in blood serum was determined by the enzyme immunoassay using the kit «8-isoprostane ELISA» («USBiological», USA). Quantitative determination of oxidized low-density lipoproteins (oLDL) was carried out by the method of «competitive» enzyme immunoassay (ELISA) - enzyme immunoassay method based on the use of enzyme-linked immunosorbent (EIA; enzyme immunoassay) in a microplate format, which was carried out on an automatic enzyme immunoassay analyzer «Evolis» («Bio-Rad», Germany-USA) using reagents from «Biomedica Gruppe» LLC (Austria).

The activity of superoxide dismutase (SOD) was determined by the change in the amount of the epinephrine oxidation product - adrenochrome, which is formed in the absence of additional sources of superoxide generation (Martusevich et al., 2021, 2022b).

The microcirculation state was assessed at a single point, located at the midpoint of the forearm, before the start of the course of the vitamin and mineral complex application and immediately after the end of this course. The study was carried out by laser Doppler flowmetry on the apparatus «LAKK-02» (NPO "Lazma», Moscow). The recording of the LDF gram was continued for 3 minutes. The LDF-gram analysis made it possible to calculate the microcirculation index (MI), which characterizes the average intensity of blood flow through small-diameter vessels for the specified period. MI is the arithmetic mean of the microcirculation index, measured in perfusion units. The calculation was performed by the integrated software of the complex.

The amplitudes of internal (endothelial, neurogenic and myogenic) and external (respiratory and cardiac) regulatory factors were determined based on the amplitude-frequency analysis of fluctuations in the microcirculation intensity (according to the corresponding frequency ranges).

According to their ratio, the bypass indicator was calculated by software, indicating the degree of participation of the shunting pathways in ensuring microcirculation. This approach fully corresponded to the methodology laid down by the developers of this technology (Dunaev et al., 2014; Goltsov et al., 2017).

The research was approved by the Local Ethics Committee of the A.I. Burnazyan Federal Medical Biophysical Center of the Federal Medical and Biological Agency of Russia and did not contradict the medical and biological principles of the Helsinki Declaration of 2008. All athletes, participants of the project gave written informed consent to the examination.

The obtained research materials were processed by methods of variational statistics in the licensed software package Statistica 6.0. The normality of the parameter values distribution was evaluated using the Shapiro-Wilk criterion. The average values of the indicators and their standard deviation were calculated. The statistical significance of the differences was assessed using the Kraskel-Wallis H-criterion.

Results

It was found that the course intake of a personalized vitamin and mineral complex contributes to a significant shift in the parameters of laser Doppler flowmetry of the skin relative to the initial state, Figures 1-4. The modulating effect of biologically active components of the complex was evaluated by an integral criterion - the microcirculation indicator, Figure 1.

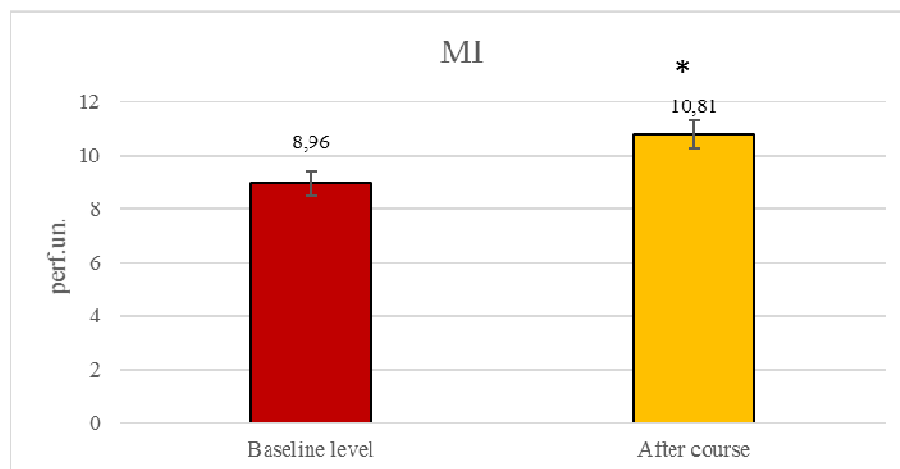


Fig. 1. Dynamics of microcirculatory index in athletes before and after administration of vitamin and mineral complex

It was revealed that the course of individualized metabolic correction has a beneficial effect on this parameter. There was an increase in the blood microcirculation index value by 20.6% compared to the baseline level (before the vitamin and mineral complex prescription).

In order to clarify the mechanism of the revealed microcirculation shifts, we conducted an amplitude-frequency analysis of time fluctuations in the intensity of blood flow through small-diameter vessels.

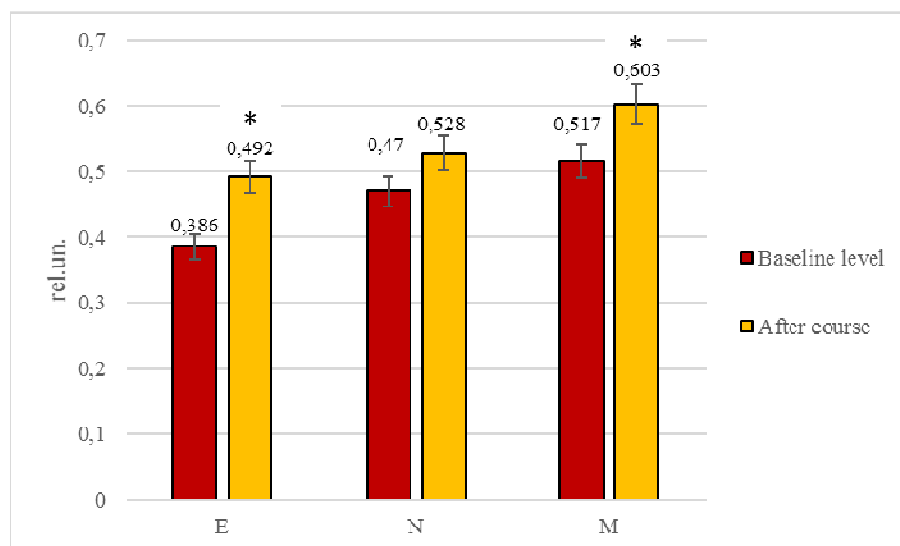


Fig. 2. Intravascular regulatory components of microcirculation in athletes before and after administration of vitamin and mineral complex

It was found that under the personalized metabolic correction influence, the involvement of endothelial and myogenic regulation components increases. There was an increase in the values of indicators by 27.5 and 16.6% relative to the initial level of indicators, respectively; $p < 0.05$ for both regulatory components. At the same time, the neurogenic component remains at the initial values of the indicator, without reaching the level of statistical significance, Figure 2.

Heterogeneity of the response to individual metabolic correction was also observed for extravascular regulatory components of microcirculation, Figure 3.

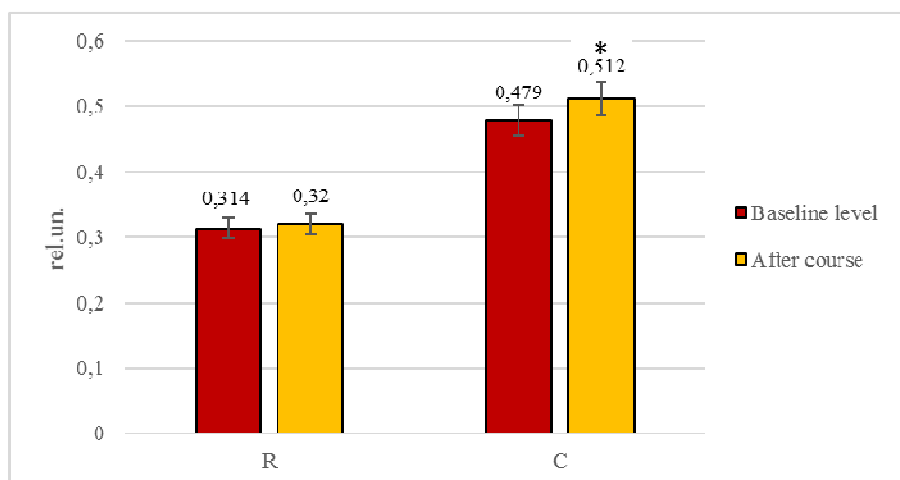


Fig. 3. Extravascular regulatory components of microcirculation in athletes before and after administration of vitamin and mineral complex

Analysis of these indicators allowed establishing the fact that upon completion of a full course of vitamin and mineral complexes, the respiratory component remains at the initial level. On the contrary, the amplitude of the cardiac component reflecting the contribution of the pulse wave to the blood flow intensity formation increases moderately, but statistically significantly (by 7.9% compared to the baseline level; $p < 0.05$).

Finally, the last of the evaluated was the bypass index, which characterizes the blood discharge degree through arterio-venous anastomosis bypassing the capillary bed, Figure 4.

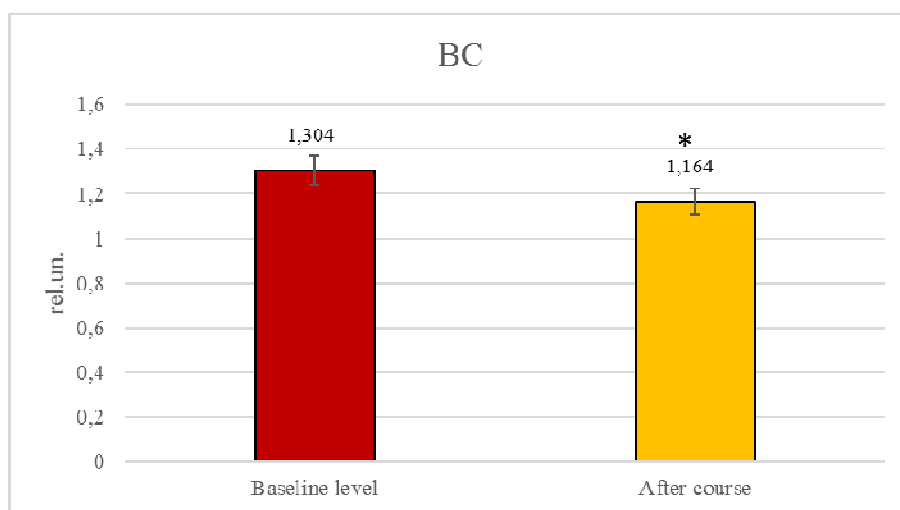


Fig. 4. Bypass coefficient in athletes before and after administration of vitamin and mineral complex

It was revealed that before the start of taking vitamin and mineral complexes, the level of the indicator was at a higher level relative to practically healthy untrained individuals. This indicates signs of the formation of the so-called «steal phenomenon».

Upon the full course of vitamin and mineral complexes completion, the bypass rate decreased to physiological values (by 12.0% relative to the initial state; $p < 0.05$), which indicates the adaptability of functional rearrangements to ensure a rapid increase in blood flow.

Dicussion

The process of restoring professional athletes' body after intense physical loadings plays an important role in the training process (Lopatina & Prihodko, 2020; Gryaznykh et al., 2021; Butakova et al., 2019). One of the restorative means includes vitamin and mineral complexes that can have a significant effect on blood

metabolism and microcirculation (Kolar et al., 2021; Sirufo et al., 2021; Martusevich et al., 2021, 2022a). Therefore, the study of these issues for sports practice is important.

According to our data, it was found that conducting a course of individualized metabolic correction using vitamin and mineral complexes increases blood microcirculation by 20.6% compared to the baseline level (before a vitamin and mineral complex prescription). This fact indirectly confirms the information that the isolated introduction individual metabolites with antioxidant properties (for example, ascorbic acid) into athletes' diet provides both significant shifts in laboratory (Kolar et al., 2021), functional (Choo et al., 2017) and sports results (Pranskuniene et al., 2020). At the same time, the main focus of these research works is clearly shifted towards studying the athletes' body metabolic processes, while the assessment of the microcirculatory response to vitamin stimulation is presented in a single work and concerns exclusively grapefruit extract (Pranskuniene et al., 2020).

We have established an increase in the participation of endothelial and myogenic components of metabolism regulation. It is known that the endothelial component contribution directly correlates with the release of nitrogen monoxide by the vascular wall (Dunaev et al., 2014; Goltsov et al., 2017; Martusevich et al., 2021). On this basis, and taking into account the most significant increase in the amplitude of this component in our research, it can be assumed that NO-dependent metabolic cascades play a significant role in the vitamin-mineral complex under consideration action mechanisms.

According to our data, it was revealed that before the start of taking vitamin and mineral complexes, the level of the bypass index was at a higher level relative to practically healthy untrained individuals, which is consistent with the results of other researchers (Dunaev et al., 2014; Goltsov et al., 2017). This fact indicates signs of the «steal phenomenon» formation. This phenomenon may have adaptive significance, providing an increase in the reserve capacity of blood flow through microvessels under conditions of intense physical loads (primarily during the competitive period). In addition, it can be the basis of vascular disorders pathogenesis in the corresponding part of the human body. After completion of the full course of exposure, the indicator in question decreased to physiological values (by 12.0% relative to the initial state; $p < 0.05$), which indicates the functional rearrangements adaptability to ensure a rapid increase in blood flow due to inhibition of bypass pathways and precapillary sphincters activation (Sommer et al., 2013; Dunaev et al., 2014; Goltsov et al., 2017).

Conclusions

The conducted research project made it possible to establish the positive effect of personalized metabolic correction of the vitamin-mineral complex on the parameters of the blood vessels microcirculatory bed functioning. Positive changes were manifested in the form of blood flow velocity activation through small-diameter vessels (according to the microcirculation index level), which was provided mainly due to endothelial (release of nitrogen monoxide by endotheliocytes), neurogenic and cardiac (contribution of pulse wave) regulation factors. In addition, taking a vitamin and mineral complex contributed to a decrease in the bypass rate to physiological values. The obtained research results allow them to be used in the planning of biomedical means for athletes' recovery.

Funding

This research work was supported by the Academic leadership program Priority 2030 proposed by Federal State Autonomous Educational Institution of Higher Education I.M. Sechenov First Moscow State Medical University of the Ministry of Health of the Russian Federation (Sechenov University).

Conflicts of interest. The authors declare no conflict of interest.

References

- Abraham, P., Guilleron, C., Bigou, Y., & Henni, S. (2019). Microcirculation study to determine the anaerobic threshold during exercise. *Clinical biomechanics (Bristol, Avon)*, 70, 80. <https://doi.org/10.1016/j.clinbiomech.2019.07.027>
- Bocharin, I., Guryanov, M., Martusevich, A., Apoyan, S., Kolokoltsev, M., Melnichuk, A., Vorozheikin, A., & Romanova, E. (2022). Young men's body hemodynamics variability in different states of motor activity. *Journal of Physical Education and Sport*, 22(3), 562-569. <https://doi.org/10.7752/jpes.2022.03070>
- Bocharin, I., Guryanov, M., Mukhina, I., Kolokoltsev, M., Vrachinskaya, T., Romanova, E., Aganov, S., Martusevich, A. (2022) Comparative analysis of methods for determining some hemodynamic parameters for students. *Journal of Physical Education and Sport*, 22(11), 2663-2668. <https://doi.org/10.7752/jpes.2022.11338>
- Butakova, M., Gryaznikh, A., & Kiseleva, M. (2019). Vegetative support of functional reserves in the post-stress recovery period. *Proceedings of the 4th International Conference on Innovations in Sports, Tourism and Instructional Science. Advances in Health Sciences Research*, Vol. 17, 31-33. <https://doi.org/10.2991/icistis-19.2019.9>

- Choo, H. C., Nosaka, K., Peiffer, J. J., Ihsan, M., Yeo, C. C., & Abbiss, C. R. (2017). Reliability of laser Doppler, near-infrared spectroscopy and Doppler ultrasound for peripheral blood flow measurements during and after exercise in the heat. *Journal of sports sciences*, 35(17), 1715–1723. <https://doi.org/10.1080/02640414.2016.1235790>
- Dunaev, A. V., Sidorov, V. V., Krupatkin, A. I., Rafailov, I. E., Palmer, S. G., Stewart, N. A., Sokolovski, S. G., & Rafailov, E. U. (2014). Investigating tissue respiration and skin microhaemocirculation under adaptive changes and the synchronization of blood flow and oxygen saturation rhythms. *Physiological measurement*, 35(4), 607–621. <https://doi.org/10.1088/0967-3334/35/4/607>
- Goltsov, A., Anisimova, A. V., Zakharkina, M., Krupatkin, A. I., Sidorov, V. V., Sokolovski, S. G., & Rafailov, E. (2017). Bifurcation in blood oscillatory rhythms for patients with ischemic stroke: a small scale clinical trial using laser doppler flowmetry and computational modeling of vasomotion. *Frontiers in physiology*, 8, 160. <https://doi.org/10.3389/fphys.2017.00160>
- Gryaznykh, A., Butakova, M., Grebenyuk, L., Kiseleva, M., Nasyrov, T., Kolokoltsev, M., Vorozheikin, A., Romanova, E., Bayankin, O., Kowalski, W., & Tyupa, P. (2021). Effect of carbohydrate intake on endogenous hormones: anabolic and catabolic orientation content of highly qualified sportsmen–combat athletes. *Journal of Physical Education and Sport (JPES)*, 21 (3). Art 181, pp. 1421 – 1428. <https://doi.org/10.7752/jpes.2021.03181>
- Hodges, G. J., Klentrou, P., Cheung, S. S., & Falk, B. (2020). Comparison of laser speckle contrast imaging and laser-Doppler fluxmetry in boys and men. *Microvascular research*, 128, 103927. <https://doi.org/10.1016/j.mvr.2019.103927>
- Iwasaki, W., Nogami, H., Takeuchi, S., Furue, M., Higurashi, E., & Sawada, R. (2015). Detection of Site-Specific Blood Flow Variation in Humans during Running by a Wearable Laser Doppler Flowmeter. *Sensors (Basel, Switzerland)*, 15(10), 25507–25519. <https://doi.org/10.3390/s151025507>
- Kolar, L., Stupin, M., Stupin, A., Šušnjara, P., Mihaljević, Z., Matić, A., Jukić, I., Kolobarić, N., & Drenjančević, I. (2021). Does the endothelium of competitive athletes benefit from consumption of n-3 polyunsaturated fatty acid-enriched hen eggs? *Preventive nutrition and food science*, 26(4), 388–399. <https://doi.org/10.3746/pnf.2021.26.4.388>
- Lopatina O. A. & Prihodko J. S. (2020). The relevance of sports nutrition during training in the gym. *Health, physical culture and sports*, 19(3), 106–114. URL: <http://hpcas.ru/article/view/8135>. [https://doi.org/10.14258/zosh\(2020\)3.10](https://doi.org/10.14258/zosh(2020)3.10)
- Marini, E., Mariani, P. G., Ministrini, S., Pippi, R., Aiello, C., Reginato, E., Siepi, D., Innocente, S., Lombardini, R., Paltriccia, R., Kararoudi, M. N., Lupattelli, G., De Feo, P., & Pasqualini, L. (2019). Combined aerobic and resistance training improves microcirculation in metabolic syndrome. *The Journal of sports medicine and physical fitness*, 59(9), 1571–1576. <https://doi.org/10.23736/S0022-4707.18.09077-1>
- Martusevich, A. K., & Karuzin, K. A. (2021). Metabolic estimation of efficiency of vitamin and mineral complexes in qualified athletes. *Voprosy pitaniia*, 90(1), 94–101. <https://doi.org/10.33029/0042-8833-2021-90-1-94-101>
- Martusevich, A., Bocharin, I., Karuzin, K., Guryanov, M., Uspenskaya, O., Kolokoltsev, M., Vyazovichenko, Yu., & Romanova, E. (2022) Comprehensive assessment of structural and metabolic peculiarities of blood plasma in highly qualified athletes. *Journal of Physical Education and Sport*, 22(1), 160–166. <https://doi.org/10.7752/jpes.2022.01020>
- Martusevich, A.K., Bocharin, I.V., Guryanov, M.S., & Kashirina, A.O. (2022). Adaptive potential of the cardiovascular system of medical students on the basis of load testing. *Teoria i Praktika Fizicheskoy Kultury*, 9, 63–65.
- Meng, Z., Gao, B., Gao, H., Ge, P., Li, T., & Wang, Y. (2019). Four weeks of hypoxia training improves cutaneous microcirculation in trained rowers. *Physiological research*, 68(5), 757–766. <https://doi.org/10.33549/physiolres.934175>
- Meng, Z., Gao, H., Li, T., Ge, P., Xu, Y., & Gao, B. (2021). Effects of eight weeks altitude training on the aerobic capacity and microcirculation function in trained rowers. *High altitude medicine & biology*, 22(1), 24–31. <https://doi.org/10.1089/ham.2020.0059>
- Montero, D., Walther, G., Diaz-Cañestro, C., Pyke, K. E., & Padilla, J. (2015). Microvascular dilator function in athletes: a systematic review and meta-analysis. *Medicine and science in sports and exercise*, 47(7), 1485–1494. <https://doi.org/10.1249/MSS.0000000000000567>
- Morrissey, C., Montero, D., Raverdy, C., Masson, D., Amiot, M. J., & Vinet, A. (2018). Effects of Exercise Intensity on Microvascular Function in Obese Adolescents. *International journal of sports medicine*, 39(6), 450–455. <https://doi.org/10.1055/a-0577-4280>
- Panza, V. S., Wazlawik, E., Ricardo Schütz, G., Comin, L., Hecht, K. C., & da Silva, E. L. (2008). Consumption of green tea favorably affects oxidative stress markers in weight-trained men. *Nutrition (Burbank, Los Angeles County, Calif.)*, 24(5), 433–442. <https://doi.org/10.1016/j.nut.2008.01.009>

- Pepe, H., Balci, S. S., Revan, S., Akalin, P. P., & Kurtoğlu, F. (2009). Comparison of oxidative stress and antioxidant capacity before and after running exercises in both sexes. *Gender medicine*, 6(4), 587–595. <https://doi.org/10.1016/j.genm.2009.10.001>
- Pranskuniene, Z., Belousoviene, E., Baranauskiene, N., Eimantas, N., Vaitkaitiene, E., Bernatoniene, J., Brazaitis, M., & Pranskunas, A. (2020). Modulation of endothelial glycocalyx and microcirculation in healthy young men during high-intensity sprint interval cycling-exercise by supplementation with pomegranate extract. A randomized controlled trial. *International journal of environmental research and public health*, 17(12), 4405. <https://doi.org/10.3390/ijerph17124405>
- Sirufu, M. M., Catalogna, A., Raggiunti, M., De Pietro, F., Galeoto, G., Bassino, E. M., Ginaldi, L., & De Martinis, M. (2021). Capillaroscopic Evidence of Microvascular Damage in Volleyball Players. *International journal of environmental research and public health*, 18(20), 10601. <https://doi.org/10.3390/ijerph182010601>
- Sommer, B., Berschin, G., & Sommer, H. M. (2013). Microcirculation under an elastic bandage during rest and exercise - preliminary experience with the laser-doppler spectrophotometry system O2C. *Journal of sports science & medicine*, 12(3), 414-421.