Original article
DOI: 10.14529/hsm230207

SELENIUM AS A FACTOR FOR MAINTAINING PHYSICAL PERFORMANCE IN ELITE ATHLETES

V.V. Kornyakova[1]*, bbk_2007@inbox.ru, https://orcid.org/0000-0002-4820-039X*
V.A. Badtieva[2,3]*, maratik2@yandex.ru, https://orcid.org/0000-0003-4291-679X*
I.P. Stepanova[1]*, stepanova_ip@mail.ru, https://orcid.org/0000-0001-7506-949X*
I.G. Shteynborm[1]*, omgma-obschim@mail.ru, https://orcid.org/0000-0002-5703-2236*
[1] *Omsk State Medical University, Omsk, Russia*
[2] *Moscow Centre for Research and Practice in Medical Rehabilitation, Restorative and Sports Medicine of Moscow Healthcare Department, Moscow, Russia*
[3] *I.M. Sechenov First Moscow State Medical University (Sechenov University), Moscow, Russia*

Abstract. **Aim.** The aim of this study was to identify the effect of selenium on physical performance in elite athletes during control and preparatory training mesocycles. **Materials and methods.** This research involved 44 highly skilled male track and field athletes aged 19.9 ± 0.21 years; 20 athletes were included in the control group. Athletes in the experimental group (12 athletes) took the selenium-containing supplement at a 50 μg selenium dose per day for 21 days of intensive training loads; the same number of athletes made up the no-treatment group. The control group was examined once, while the experimental and no-treatment groups were examined twice: at the beginning of the study and after 21 days of intensive training. Heart rate was recorded, blood pressure was measured, and the heart rate variability parameters and overall physical performance were determined by the PWC_{170} test. **Results.** The results of the PWC_{170} test increased 1.22 times ($P < 0.05$), the Mo index by 1.1 times ($P < 0.05$) and the ΔRR by 1.44 ($P = 0.03$) times. A 1.72-fold decrease in the stress index ($P = 0.01$) was recorded. **Conclusion.** Taking a selenium-containing supplement supported physical performance and heart rate regulation in elite athletes during control and preparatory training mesocycles.

Keywords: selenium, physical performance, athletes

For citation: Kornyakova V.V., Badtieva V.A., Stepanova I.P., Shteynborm I.G. Selenium as a factor for maintaining physical performance in elite athletes. *Human. Sport. Medicine*. 2023;23(2):55–60. DOI: 10.14529/hsm230207

Научная статья
УДК 612-087 + 612.392
DOI: 10.14529/hsm230207

ИСПОЛЬЗОВАНИЕ СЕЛЕНА ДЛЯ ПОДДЕРЖАНИЯ РАБОТОСПОСОБНОСТИ У ЭЛИТНЫХ СПОРТСМЕНОВ

В.В. Корнякова[1]*, bbk_2007@inbox.ru, https://orcid.org/0000-0002-4820-039X*
В.А. Бадтиева[2,3]*, maratik2@yandex.ru, https://orcid.org/0000-0003-4291-679X*
И.П. Степанова[1]*, stepanova_ip@mail.ru, https://orcid.org/0000-0001-7506-949X*
И.Г. Штейнборм[1]*, omgma-obschim@mail.ru, https://orcid.org/0000-0002-5703-2236*
[1] *Омский государственный медицинский университет, Омск, Россия*
[2] *Московский научно-практический центр медицинской реабилитации, восстановительной и спортивной медицины Департамента здравоохранения Москвы, Москва, Россия*
[3] *Первый Московский государственный медицинский университет имени И.М. Сеченова, Москва, Россия*

Аннотация. **Цель.** Целью данного исследования было изучение влияния селена на физическую работоспособность элитных спортсменов в течение контрольных и подготовительных тренировочных мезоциклов. **Материалы и методы.** В исследовании приняли участие 44 профессиональных легкоатлета в возрасте 19,9 ± 0,21 года. В контрольную группу вошли 20 человек. Спортсмены

экспериментальной группы (12 спортсменов) принимали добавку с содержанием селена в дозе 50 мкг в сутки в течение 21 дня интенсивных тренировочных нагрузок, такое же количество спортсменов вошло в группу участников, не получавших добавку. Спортсменов контрольной группы обследовали однократно, а спортсменов экспериментальной группы и группы без добавки – дважды: в начале исследования и через 21 день интенсивных тренировок. В ходе исследования регистрировали частоту сердечных сокращений, измеряли артериальное давление, определяли параметры вариабельности сердечного ритма и оценивали общую физическую работоспособность с помощью теста PWC170. **Результаты.** Показатели теста PWC170 выросли в 1,22 раза ($P < 0,05$), индекс Mo – в 1,1 раза ($P < 0,05$), а ΔRR – в 1,44 ($P = 0,03$) раза. Зарегистрировали снижение индекса стресса в 1,72 раза ($P = 0,01$). **Заключение.** Прием селенсодержащей добавки способствовал поддержанию физической работоспособности и регуляции сердечного ритма у спортсменов высокой квалификации в течение контрольных и подготовительных тренировочных мезоциклов.

Ключевые слова: селен, физическая работоспособность, спортсмены

Для цитирования: Selenium as a factor for maintaining physical performance in elite athletes / V.V. Kornyakova, V.A. Badtieva, I.P. Stepanova, I.G. Shteynborm // Человек. Спорт. Медицина. 2023. Т. 23, № 2. С. 55–60. DOI: 10.14529/hsm230207

Introduction. Increasing the intensity of physical exercises in high-performance sports often results in straining the adaptation processes or failing in adaptation, as well as the emergence of overtraining in athletes [2, 4]. Overtraining results in a decrease in an athlete's physical performance and the effectiveness and quality of their professional activity.

Due to the need for professional athletes to avoid prohibited substances, the search for effective nondoping means to increase the functional readiness of athletes is becoming increasingly urgent [10, 12]. The reduction of muscle damage in professional athletes requires expanding the range of oral supplements that are not considered doping [8, 14]. To date, research findings on the benefits of selenium supplementation for professional athletes are insufficient [5, 17, 19, 20].

The aim of this research was to identify the benefits of selenium on the athletes' physical performance and their parameters of cardiac autonomic regulation.

Materials and methods. This study was performed during the stages of the control and preparatory mesocycles, distinguished by the maximum training intensity. All athletes were randomly assigned to one of the experimental groups: taking no supplements (no-treatment, n = 12) or taking a selenium-containing supplement (50 μg dose of selenium) per day during 21 days of training (n = 12).

For the control group, 20 highly skilled athletes of the same gender and age as in the experimental groups were selected by random sampling. The age of the athletes in the experimental groups was 19.9 ± 0.22 years, and that of the athletes in the control group was 19.5 ± 0.21 years. The results of the control group's thorough medical examination for sports admission were used as reference indicators.

All athletes involved in the study had to fill out a questionnaire [13]. The questions included information about their health status, training load performed, physical and psychological states, working capacity during training, tolerance of sports loads, adherence to the diet and daily regimen, as well as the use of food supplements and any medications.

All examined participants were on a diet following the recommendations of V.A. Tutelyan and coauthors [18].

As a source of selenium, the biologically active supplement "Selenium-active" (manufactured by a plant with ecological equipment and eco-nutrition Diode, Moscow, Russia, registration number No. 77.99.23.3.U.6028.11.04 dd. 18.11.2004 TU 9197-019-17664661-2004; series 010108, 010109) was used. This supplement contains organic selenium, such as selenoxanthene.

The research involved athletes with titles of "Master of sport", "Candidate for the Master of Sport", or 1st rank athletes. All athletes provided their informed consent to participate in the research. This research was conducted in accordance with the principles of the Helsinki Declaration and was approved by the Research Ethics Committee of the Moscow Research and Practical Center for Medical Rehabilitation, Restorative and Sports Medicine, Moscow Healthcare Department, Russia (Protocol No. 1 dd. September 19, 2019).

The physiological measurements of athletes

in the experimental groups were obtained on the first day of the study and were repeated after 21 days; in the control group, the measurements were obtained only once. Their heart rate and blood pressure findings were determined using standard techniques.

The overall physical performance was evaluated by the PWC_{170} test following the V.L. Karpman et al. protocol [9]. The PWC_{170} test was performed with the Seca Cardiotest 100 (UK) ergometer. The athletes consecutively performed two loads of increasing power with a pedaling frequency of 60–70 rpm. The duration of each of the loads was five minutes, with a 3-minute rest interval between loads. Before loading, at the end of the first and second stages, heart rate measurements were performed. The power of the first stage was set based on the subject's body weight, and that of the second stage was based on the pulse and power achieved at the end of the first stage. The absolute value of the PWC_{170} test was calculated using the V.L. Karpman formula: $PWC_{170} = W1 + (W2 – W1) \times (170 – f1)/(f2 – f1)$, where PWC_{170} is the absolute value of PWC_{170}, expressed in kg/min; W1 is the power of stage I; W2 is the power of stage II; f1 is the heart rate at the end of stage I; and f2 is the heart rate at the end of stage II. The relative value of the PWC_{170} test was expressed in kgm/min/kg.

The heart rate variability data were studied according to R. M. Baevsky et al. [3]. The stress index was calculated based on the statistical characteristics of the heart rate. For this, an electrocardiogram was recorded for each athlete during 100 cardiac cycles in the supine position. Before recording the electrocardiogram, the athlete rested in the supine position for 10 minutes. Then, the indicators were calculated: mode (Mo) was the most frequently recorded value of the cardiac intervals; mode amplitude (Amo) corresponded to the number of cardiac intervals with mode values, expressed in % with respect to the volume of the entire sample; ΔRR was the variation range, the difference between the smallest and largest values of the cardiac intervals. Based on these indicators, the stress index was determined by the formula $Amo/2 \times \Delta RR \times Mo$. The stress index characterized the activity of the central mechanisms of heart rate regulation and the degree of centralization of HR control.

The statistical analysis of the obtained data was performed with nonparametric methods using the SPSS 13.0 package for Windows. The nonparametric Mann–Whitney and Wilcoxon U tests were used. The level of signifycance was considered sufficient for a P value less than 0.05.

Results. The improvement of athletes' functional state was evaluated by questionnaire findings and physiological measurements after the course of the selenium-containing supplement. In particular, athletes noted decreased fatigue during training, improved well-being, and enhanced physical performance. In addition, the athletes tolerated their training loads more easily.

The results of the bicycle ergometer test confirmed that the overall physical performance of the athletes was enhanced by 1.22 times after the 21-day course of selenium supplement ($P < 0.05$; Fig. 1).

The analysis of heart rate variability data indicated a decrease in the influence of the sympathetic system on HRV regulation in athletes who took the supplement. In particular, the mode and variation range values increased by 1.1 ($P < 0.05$) and 1.44 ($P = 0.03$) times, respectively.

A decrease in the stress index by 1.72 times ($P = 0.01$) was also noted as evidence of heart rate regulation recovery (Table 1). In the placebo group, no statistically significant differences were found when comparing baseline HRV and physical performance values with those obtained at the second examination (after 21 days).

The heart rate and blood pressure findings at rest in both the experimental and no-treatment groups did not deviate from the reference values throughout the study. Statistically significant differences between the abovementioned indicators were not found among the groups of athletes.

Heart rate variability parameters are informative markers of an athlete's current functional state and can be used to judge the body's regulatory system strain and adaptation to training loads, to recognize timely adaptation failure, and to detect the onset of overtraining [1, 11, 16]. This is determined by the fact that the cardiovascular system is regulated by the autonomic nervous system through the influence of its sympathetic and parasympathetic subsystems. By observing changes in the heart rate structure, the effectiveness of recovery in athletes can be judged [6, 7].

The heart rate structure alterations recorded in our research in track and field athletes taking selenium reflect improvements in their functional

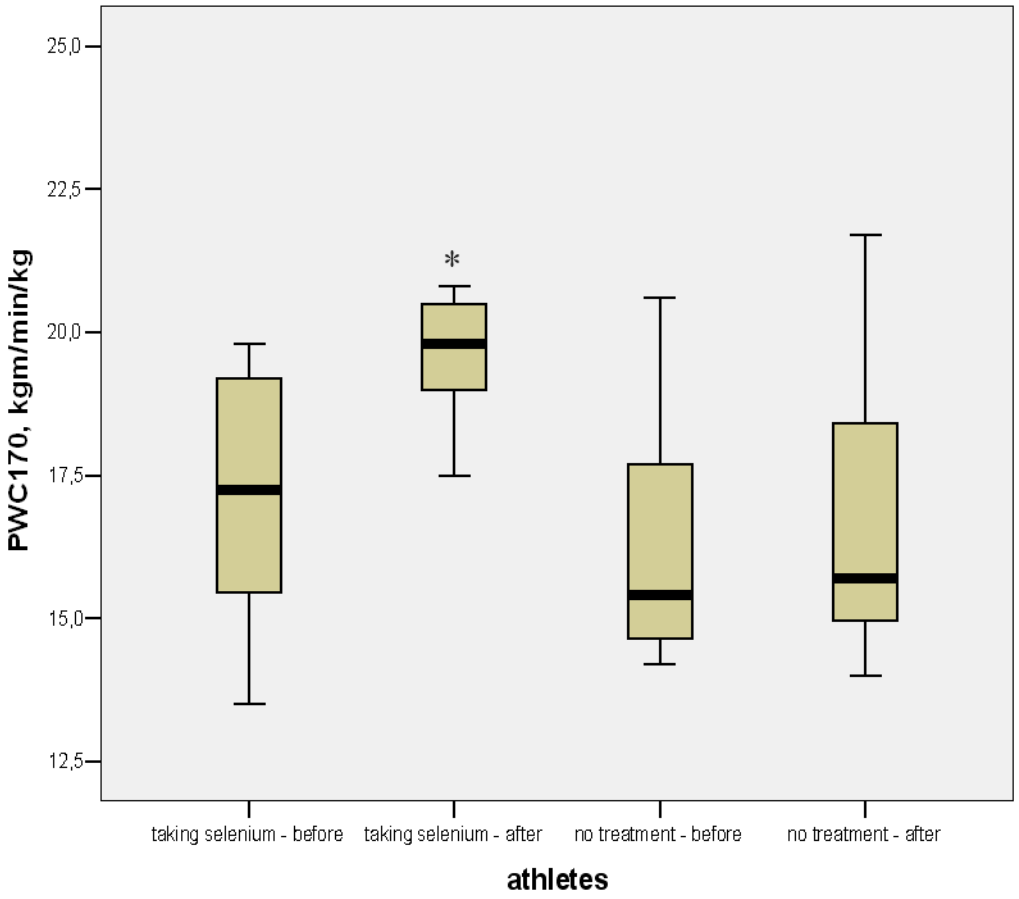

Fig. 1. Results of the PWC_{170} test
The data are presented as the median and interquartile range, minimum and maximum
*** – P < 0.05 compared to the results obtained before the course of treatment**

Table 1

Heart rate variability measurements

Parameter	Reference value (n = 20)	Track and field athletes			
		selenium (n = 12)		no treatment (n = 12)	
		before (I)	after (II)	before (III)	after (IV)
Mo, c	0,95 (0,90; 1,05)	0,79 (0,76; 0,82)***	0,83 (0,79; 0,91)** ^	0,75 (0,70; 0,79)***	0,74 (0,65; 0,78)*** ▲▲
Амо, %	28,5 (24,1; 32,9)	42,1 (36,7; 57,5)***	31,6 (27,7; 45,1)	46,2 (40,7; 52,9)***	44,7 (42,5; 50,6)*** ▲
ΔRR, c	0,48 (0,37; 0,51)	0,25 (0,23; 0,30)***	0,36 (0,26; 0,41)** ^	0,26 (0,22; 0,28)***	0,24 (0,22; 0,27)*** ▲
SI, units	30,9 (24,9; 45,7)	105,5 (74,2; 142,4) ***	61,2 (55,7; 112,2) *** ^	115,6 (98,5; 131,0) ***	115,4 (96,9; 150,4)*** ▲▲

Note. The data is expressed as a median and interquartile range (25 and 75 percentiles); **– p < 0.01; *** – p < 0.001 – compared to the reference value; ^ – p < 0.05 – compared to the values before taking selenium (I); ▲ p < 0.05; ▲▲ – p < 0.01 – compared to the values after taking selenium (II).

state, the reduction of the sympathetic nervous system's influence on regulatory processes, and improvements in adaptive capabilities. Consequently, an increase in general physical performance is observed in these athletes. This must be due to the fact that athletes need an increased intake of selenium during exercise [15].

Conclusion. Selenium intake contributes to the recovery of the balance between the sympathetic and parasympathetic systems in HRV regulation in athletes. The results of this study allow us to propose a selenium-containing supplement as a means of improving the physical performance of athletes under intense physical exertion.

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Information about the authors

Vera V. Kornyakova, Doctor of Biological Sciences, Associate Professor, Professor of the Department of Health and Safety, Disaster Medicine, Omsk State Medical University, Omsk, Russia.

Viktoriya A. Badtieva, Doctor of Medical Sciences, Professor, Head of Branch No. 1 of the Moscow Centre for Research and Practice in Medical Rehabilitation, Restorative and Sports Medicine of Moscow Healthcare Department, Moscow, Russia; Professor of the Department of Restorative Medicine, Rehabilitation and Balneology, I.M. Sechenov First Moscow State Medical University, Moscow, Russia.

Irina P. Stepanova, Doctor of Biological Sciences, Professor, Professor of the Department of Chemistry, Omsk State Medical University, Omsk, Russia.

Ivan G. Shteynborm, Senior Lecturer, Department of Forensic Medicine and Law, Omsk State Medical University, Omsk, Russia.

Информация об авторах

Корнякова Вера Валерьевна, доктор биологических наук, доцент, профессор кафедры безопасности жизнедеятельности, медицины катастроф, Омский государственный медицинский университет, Омск, Россия.

Бадтиева Виктория Асланбековна, доктор медицинских наук, профессор, заведующий филиалом № 1, Московский научно-практический центр медицинской реабилитации, восстановительной и спортивной медицины Департамента здравоохранения г. Москвы; профессор кафедры восстановительной медицины, реабилитации и курортологии, Первый Московский государственный медицинский университет имени И.М. Сеченова, Москва, Россия.

Степанова Ирина Петровна, доктор биологических наук, профессор, заведующая кафедрой химии, Омский государственный медицинский университет, Омск, Россия.

Штейнборм Иван Геннадьевич, старший преподаватель кафедры судебной медицины, правоведения, Омский государственный медицинский университет, Омск, Россия.

Contribution of the authors: the authors contributed equally to this article.
The authors declare no conflicts of interests.

Вклад авторов: все авторы сделали эквивалентный вклад в подготовку публикации.
Авторы заявляют об отсутствии конфликта интересов.

The article was submitted 18.02.2023
Статья поступила в редакцию 18.02.2023