Pharmacophore, 14(3) 2023, Pages: 114-118

Pharmacophore

ISSN-2229-5402

Journal home page: http://www.pharmacophorejournal.com

Pharmacophore
an International Journal
ISSN 2229-5402

COENZYME Q10 IN SPORTS ACTIVITIES: *IN VIVO* ASSESMENT ON LABORATORY RATS

Nurmagomed Vakhidovich Akhmarov[1], Dmitriy Alexandrovich Abramenko[2]*, Artem Sergeevich Pchelkin[2], Anastasia Victorovna Tkacheva[2], Emiliya Ruslanovna Kamalova[3], Ruslan Kazbekovich Esiev[4]

1. ***Department of Therapy, Faculty of Medicine of Astrakhan State Medical University, Astrakhan, Russia.***
2. ***Department of Therapy, Faculty of Medical and Prophylactical, Rostov State Medical University, Rostov-on-Don, Russia.***
3. ***Department of Therapy, Faculty of Pediatrics, Stavropol State Medical University, Stavropol, Russia.***
4. ***Department of Dentistry, Faculty of Dentistry, North Ossetian State Medical Academy, Vladikavkaz, Russian Federation.***

ARTICLE INFO

Received:
21 Apr 2023
Received in revised form:
16 Jun 2023
Accepted:
17 Jun 2023
Available online:
28 Jun 2023

Keywords: Adaptogen, Coenzyme Q10, Royal jelly, Laboratory rats, Forced swimming to failure

ABSTRACT

Adaptogens can be used in sports to improve endurance, resilience to stress, improve recovery, and accelerate muscle growth. They may also improve concentration, speed up reaction times, and reduce fatigue. Currently, a fairly large number of drugs are taken by athletes to normalize the state of the body after stressful loads: ginseng, Rhodiola rosea, Eleutherococcus, and others. In this scientific work, the effect of royal jelly and Coenzyme Q10 on the body is considered using the example of laboratory animals. To do this, two groups of laboratory rats underwent preliminary training - they received a course in royal jelly and Coenzyme Q10. Then, together with the control group of rats, they were subjected to critical loads (forced swimming to failure), and then, according to the main indicators, the state of their organisms was compared with a group of rats that were not subjected to physical loads. Preliminary administration to rats of royal jelly of bees and coenzyme Q10 followed by "forced swimming to failure" led to the formation of an activation reaction of the body's defense systems. The best effect was observed for coenzyme Q10.

To Cite This Article: Akhmarov NV, Abramenko DA, Pchelkin AS, Tkacheva AV, Kamalova ER, Esiev RK. Coenzyme Q10 in Sports Activities: *In Vivo* Assesment on Laboratory Rats. Pharmacophore. 2023;14(3):114-8. https://doi.org/10.51847/UTjLmFRE8H

Introduction

Adaptogens include preparations of natural origin (native or in the form of pure active substances) that have a low-specific effect on the functions of the central nervous system, endocrine regulation, and metabolic processes and increase the adaptation of the body to adverse conditions [1]. The use of adaptogenic drugs in sports has already become standard practice. However, the effectiveness of these funds is controversial. The effectiveness of the use of most classes of biologically active additives based on natural adaptogens in both sports and clinical pharmacology has not yet been established [2, 3].

Adaptogens are plant or animal substances that help the body adapt to various physical and psychological stresses, improving its adaptive abilities and increasing resistance to the impact of adverse factors [4]. They can also improve the functioning of the nervous and immune systems, increase resistance to diseases and improve the overall condition of the body [5, 6].

Adaptogens can be used in sports to increase endurance, stress resistance, improve recovery and accelerate the growth of muscle mass. They can also improve concentration, speed up reactions and reduce fatigue.

Some adaptogens, such as ginseng and Rhodiola rosea, have a stimulating effect that can be used in the pre-competition period to improve physical and psychological indicators [7]. Other adaptogens, such as Eleutherococcus, schizandra, and

Corresponding Author: Dmitriy Alexandrovich Abramenko; Department of Therapy, Faculty of Medical and Prophylactical, Rostov State Medical University, Rostov-on-Don, Russia. E-mail: bucky99@yandex.ru.

ashwagandha, have a calming effect and can be used to reduce stress and recover more effectively after intensive training [8, 9]. Also, some adaptogens can be used to increase muscle mass and improve athletic fitness, for example, epimedium, maca, and Tribulus [10].

The most widely used and available are the royal jelly of bees and coenzyme Q10 [11]. Their properties are currently well-studied on models of various pathologies and are also successfully used in clinical practice. However, the use of these substances in sports medicine is practically not justified.

Coenzyme Q10 is a naturally occurring biologically active compound that is a key component of the electron transport chain in the mitochondria of cells that provide energy supply to the body [12]. Coenzyme comes from quinones – a group of organic compounds that participates in the transport of electrons in the human body and is structurally related to vitamins A and E. The main function is to produce adenosine triphosphate (ATP), an energy carrier for all living things. Coenzyme is found in all tissues and organs of the human body, the highest concentration is achieved in the heart [13].

The main role of the coenzyme is to transfer electrons along the reduction chain of redox reactions in mitochondria, where air and food substances are used to create energy. Thus, coenzyme provides the energy metabolism of the body [14]. In addition, coenzyme Q10 is a powerful antioxidant that protects cells from free radicals and oxidative stress [15]. This is very important because elevated levels of free radicals can cause cell damage, which leads to various diseases.

The symptoms of a lack of coenzyme are diverse and harm health. Primary deficiency is manifested by dysfunction of the central nervous system and concomitant physical symptoms. These include motor disorders – seizures, impaired coordination of movements, muscle weakness, and decreased intelligence. Against the background of primary deficiency, steroid-resistant nephrotic syndrome or heart failure may occur [16].

The beneficial properties of coenzyme Q10 are to support the cardiovascular system – improving the functions of the heart and blood vessels, and reducing cholesterol levels in the blood. Coenzyme increases energy, improving overall well-being and endurance. Protects against oxidative stress, having powerful antioxidant properties that are aimed at preventing cell damage. Participates in the process of creating ATP, the main molecule that provides the energy potential for biochemical reactions in the body [17]. Coenzyme Q10 also increases oxygen levels in cells, which contributes to more efficient energy production. This is especially important for muscles, including the myocardium, which constantly needs energy [18].

Coenzyme is a powerful antioxidant that helps fight free radicals in the body. We are talking about unstable molecules that can damage cells and cause many diseases, such as cancer, heart disease, and obesity.

Coenzyme takes on the role of an antioxidant that removes free radicals from the body and prevents their negative effects [19]. Participates in the restoration of vitamins C and E, which also play an important role in the fight against oxidative stress.

The purpose of this scientific study is to substantiate the possibility of using adaptogens of natural origin (royal jelly of bees and coenzyme Q10) during physical activity on the example of laboratory animals.

Materials and Methods

The study of the effectiveness of adaptogens was conducted on 80 white laboratory rats. Adult males weighing 200-250 grams, without pathologies, were selected for the experiment. All animals were kept in standard vivarium conditions. Working conditions with animals conformed to the rules of the European Convention ET/S 129, 1986, and Directives 86/609 ESC [20].

Laboratory animals were divided into 4 groups: intact group – healthy animals that were in general conditions of maintenance and feeding (n=20); control group – animals that were simulated acute stress based on the model "forced swimming to failure" (n=20); experimental group 1 – animals that were previously produced course administration of royal jelly, at a dose of 100 mg/ kg, before modeling acute stress "forced swimming to failure" (n=20); experimental group 2 – animals that were previously administered a course of coenzyme Q10, at a dose of 15 mg/ kg, before modeling acute stress (n=20).

On the 11th day after the start of the experiment, acute stress was simulated once based on the "forced swimming to failure" model according to Porsolt and Dawson [21]. Blood sampling for the study was performed from the sublingual vein.

The assessment of the adaptive capabilities of the organism was carried out based on hematological parameters. The number of erythrocytes, hemoglobin, and platelets was determined using the hematological analyzer "Abacus Junior" (Diatron MI Zrt., Hungary). Calculation of the leukocyte formula, calculation of indices, and determination of electrophoretic mobility of erythrocytes were carried out by standard methods [22].

Results and Discussion

After a single "forced swimming to failure" in the blood of the control group of animals, a statistically significant increase in the number of neutrophils by 48% and monocytes by 16%, a decrease in the number of lymphocytes by 32% in intact animals was observed **(Figure 1)**.

Based on the results obtained, leukocyte indices were calculated **(Figure 2)**. It was found that in the control group of animals, the indices of Krebs, intoxication, neutrophil, and monocyte ratios increased by 88%, 79%, and 10%, respectively, against the background of a decrease in the indices of nuclear, leukocyte, lymphocyte and monocyte ratios by 14%, 47%, and 48%, relative to the "intact animals" group.

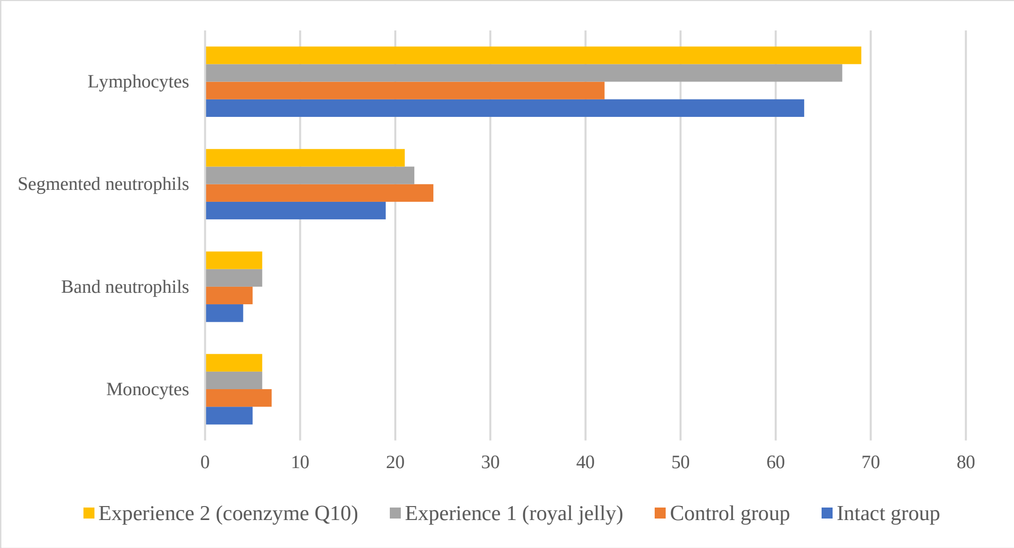

Figure 1. The effect of pre-administration of adaptogen substances on the leukocyte formula of rat blood under acute stress

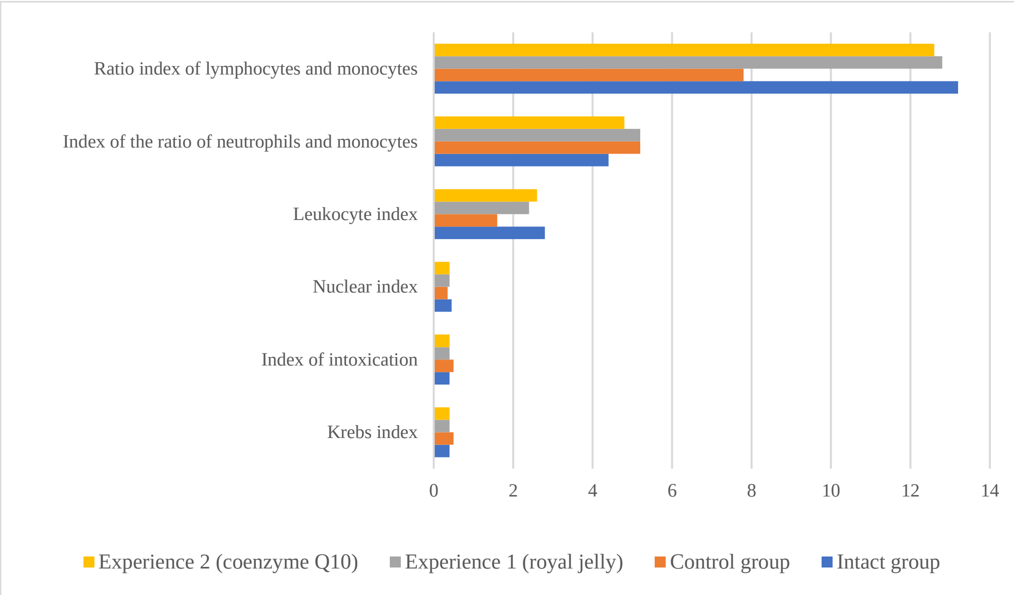

Figure 2. The effect of pre-administration of adaptogen substances to rats under acute stress on leukocyte indices

It was also shown that "forced swimming to failure" led to a decrease in the number of red blood cells in the blood by 22% and, as a result, a decrease in the concentration of hemoglobin by 18% **(Table 1)**.
We noted a decrease in the electrophoretic mobility of red blood cells by 33%. The number of platelets, on the contrary, increased by 28% relative to the indicators in the "intact animals" group.

Table 1. Some morphological and functional parameters of the blood of rats after a single "forced swimming to failure" against the background of a course of preliminary administration of royal jelly and Coenzyme Q10

Indicator	Group of laboratory animals			
	Intact	**Control**	**Experience 1 (royal jelly)**	**Experience 2 (Coenzyme Q10)**
Erythrocytes, 10^{12}/l	8,17±0,6	6,42±0,44	9,14±0,9	8,88±0,3
Hemoglobin, g/l	144,5±5,4	118,9±6,2	157±11,6	152,6±3,5
Electrophoretic mobility of erythrocytes, μm·cm/(V·s)	2,27±0,11	1,51±0,54	2,16±0,36	2,28±0,2
Platelets, 10^9/l	353,3±31,4	453,4±21,4	421,2±28,30	432,2±12,9

Based on the results obtained, it can be concluded that in the control group of animals during "forced swimming to failure", the development of an acute stress reaction was observed, which was characterized by a high degree of activation of

phagocytosis processes, due to a shift in cellular immunity towards the microphage link. This was confirmed by an increase in the number of segmented neutrophils and a decrease in the nuclear and leukocyte indices.
In addition, against the background of a decrease in the number of erythrocytes and hemoglobin, there was also a morphological restructuring of the cell membrane, which affected its mobility in the electric field. This may be due to the peroxidation of lipids and proteins of the erythrocyte membrane that occurs during acute hypoxia.
At the next stage of the experiment, we conducted a preliminary course introduction of products of natural origin: royal jelly of bees and coenzyme Q10. It was found that in the "royal jelly" group there was a decrease in the number of segmented neutrophils by 8% and an increase in the pool of lymphocytes by 54% relative to the "control" group. It is worth noting that the number of lymphocytes becomes comparable to the group of "intact animals" **(Figure 1)**.
The calculation of leukocyte indices showed a decrease in the Kerbs index by 67%, the intoxication index by 64%, the index of the ratio of neutrophils and monocytes by 10%, and an increase in the nuclear index, the leukocyte index, the index of the ratio of lymphocytes and monocytes by 22%, 208%, 184%, respectively, relative to the control group **(Figure 2)**.
In the blood of the royal jelly group, after the experiment, an increase in the number of red blood cells was found by 2 times, the concentration of hemoglobin by 1.6 times, and the electrophoretic mobility of red blood cells by 2 times relative to the control group. The number of platelets, on the contrary, decreased to the level in intact animals **(Table 1)**.
Similar data were obtained in the coenzyme Q10 group, however, it should be noted that even minor fluctuations in the population composition of leukocytes led to significant changes in the immune response of the body, which affected the indicators of leukocyte indices. As can be seen from **Figure 2**, they have become comparable to those in the "intact animals" group.
A similar pattern is observed in the morpho-functional characteristics of the erythrocyte and platelet pools **(Table 1)**.
Thus, both royal jelly and coenzyme Q10 with a preliminary course of administration have a positive effect on the body of experimental animals. Based on the data obtained, it can be assumed that the studied substances caused an activation reaction in rats, which allowed them not to experience acute stress during "forced swimming to failure".
It is known that the activation reaction is anabolic, i.e. it is formed against the background of increased energy expenditure. The substances studied by us are the best suited for the formation of this reaction due to their biological characteristics. So royal jelly, being, in fact, a mixture of albumins and globulins, can easily be integrated into protein metabolism, affect hematopoiesis and, indirectly, provide the body with oxygen, which is important for the mitochondria of the cell to perform the energy function. Coenzyme Q10 is a participant in the respiratory chain of ATP synthesis in mitochondria. Therefore, it is directly embedded in the metabolism, supporting the activation reaction.
We believe that the results obtained may be a prerequisite for the use of adaptogens (royal jelly and coenzyme-10) by athletes as supplements to sports nutrition in the training process.

Conclusion

A single application of the "forced swimming to failure" method caused the development of acute stress in experimental animals, which was characterized by moderate neutrophilosis and lymphopenia, activation of the microphage link of immunity, physiological anemia accompanied by a decrease in the functional ability of erythrocytes, thrombocytosis.
Preliminary administration of both royal jelly of bees and coenzyme Q10 to rats, followed by "forced swimming to failure", led to the formation of an activation reaction of the body's defense systems. The best effect was observed for coenzyme Q10.

Acknowledgments: None

Conflict of interest: None

Financial support: None

Ethics statement: The protocol for experiments with laboratory animals complied with the requirements of the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes.

References

1. Todorova V, Ivanov K, Delattre C, Nalbantova V, Karcheva-Bahchevanska D, Ivanova S. Plant adaptogens-history and future perspectives. Nutrients. 2021;13(8):2861. doi:10.3390/nu13082861
2. Rathore S, Khuntia BK, Wadhawan M, Sharma V, Sharma G. Herbal adaptogens: An integrative approach for enhancing performance and resilience in athletes. Phytother Res. 2022;36(10):3678-80. doi:10.1002/ptr.7529
3. Sánchez IA, Cuchimba JA, Pineda MC, Argüello YP, Kočí J, Kreider RB, et al. Adaptogens on depression-related outcomes: A systematic integrative review and rationale of synergism with physical activity. Int J Environ Res Public Health. 2023;20(7):5298. doi:10.3390/ijerph20075298

4. Esmaealzadeh N, Iranpanah A, Sarris J, Rahimi R. A literature review of the studies concerning selected plant-derived adaptogens and their general function in the body with a focus on animal studies. Phytomedicine. 2022;105:154354. doi:10.1016/j.phymed.2022.154354
5. Gerontakos SE, Casteleijn D, Shikov AN, Wardle J. A critical review to identify the domains used to measure the effect and outcome of adaptogenic herbal medicines. Yale J Biol Med. 2020;93(2):327-46.
6. Gholizadeh B, Nabavi SS, Baghaei S, Zadeh FJ, Moradi-joo E, Amraie R, et al. Evaluation of risk factors for cardiovascular diseases in pregnant women referred to Golestan hospital in Ahvaz. Entomol Appl Sci Lett. 2021;8(3):40-5.
7. Bang VMJ, Aranão ALC, Nogueira BZ, Araújo AC, Bueno PCDS, Barbalho SM, et al. Effects of rhodiola rosea and panax ginseng on the metabolic parameters of rats submitted to swimming. J Med Food. 2019;22(10):1087-90. doi:10.1089/jmf.2019.0062
8. Todorova V, Ivanov K, Ivanova S. Comparison between the biological active compounds in plants with adaptogenic properties (Rhaponticum carthamoides, Lepidium meyenii, Eleutherococcus senticosus, and Panax ginseng). Plants (Basel). 2021;11(1):64. doi:10.3390/plants11010064
9. CG SK, Alshammari QT, Reddy RS, Kandakurti PK, Amaravadi SK. Stress among teachers in virtual classrooms working in the higher education sector during the COVID-19 outbreak. Int J Pharm Res Allied Sci. 2022;11(3):55-9.
10. Panossian A, Efferth T. Network pharmacology of adaptogens in the assessment of their pleiotropic therapeutic activity. Pharmaceuticals (Basel). 2022;15(9):1051. doi:10.3390/ph15091051
11. Raizner AE. Coenzyme Q10. Methodist Debakey Cardiovasc J. 2019;15(3):185-91. doi:10.14797/mdcj-15-3-185
12. Hargreaves I, Heaton RA, Mantle D. Disorders of human coenzyme Q10 metabolism: An overview. Int J Mol Sci. 2020;21(18):6695. doi:10.3390/ijms21186695
13. Al Saadi T, Assaf Y, Farwati M, Turkmani K, Al-Mouakeh A, Shebli B, et al. Coenzyme Q10 for heart failure. Cochrane Database Syst Rev. 2021;2(2):CD008684. doi:10.1002/14651858.CD008684.pub3
14. Pravst I, Rodríguez Aguilera JC, Cortes Rodriguez AB, Jazbar J, Locatelli I, Hristov H, et al. Comparative bioavailability of different coenzyme Q10 formulations in healthy elderly individuals. Nutrients. 2020;12(3):784. doi:10.3390/nu12030784
15. Testai L, Martelli A, Flori L, Cicero AFG, Colletti A. Coenzyme Q10: Clinical applications beyond cardiovascular diseases. Nutrients. 2021;13(5):1697. doi:10.3390/nu13051697
16. Mantle D, Lopez-Lluch G, Hargreaves IP. Coenzyme Q10 metabolism: A review of unresolved issues. Int J Mol Sci. 2023;24(3):2585. doi:10.3390/ijms24032585
17. Mantle D, Turton N, Hargreaves IP. Depletion and supplementation of coenzyme Q10 in secondary deficiency disorders. Front Biosci (Landmark Ed). 2022;27(12):322. doi:10.31083/j.fbl2712322
18. Covey C. Coenzyme Q10 for heart failure. Am Fam Physician. 2021;104(5):458-9.
19. Pastor-Maldonado CJ, Suárez-Rivero JM, Povea-Cabello S, Álvarez-Córdoba M, Villalón-García I, Munuera-Cabeza M, et al. Coenzyme Q10: Novel formulations and medical trends. Int J Mol Sci. 2020;21(22):8432. doi:10.3390/ijms21228432
20. Lyashenko EN, Uzbekova LD, Polovinkina VV, Dorofeeva AK, Ibragimov S-US-u, Tatamov AA, et al. Study of the embryonic toxicity of TiO2 and ZrO2 nanoparticles. Micromachines. 2023;14(2):363. doi:10.3390/mi14020363
21. Ueno H, Takahashi Y, Murakami S, Wani K, Matsumoto Y, Okamoto M, et al. Effect of simultaneous testing of two mice in the tail suspension test and forced swim test. Sci Rep. 2022;12(1):9224. doi:10.1038/s41598-022-12986-9
22. Demchenkov EL, Nagdalian AA, Budkevich RO, Oboturova NP, Okolelova AI. Usage of atomic force microscopy for detection of the damaging effect of CdCl2 on red blood cells membrane. Ecotoxicol Environ Saf. 2021;208:111683. doi:10.1016/j.ecoenv.2020.111683