Article

Functional and hormone changes in ice hockey players using Cytoflavin

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Abstract: The purpose of the study was to assess the effect of 35-day Cytoflavin consumption on hormonal status, blood lactate level and functional parameters in elite ice hockey players. Material and methods: the study included 60 male professional hockey players (aged 19 to 36 years) divided into two groups of 30 subjects. Group I underwent a course of metabolic therapy with the use of succinic acid (Cytoflavin) for 35 days. Group II whose pharmacological support included only "basic" sports nutrition did not include succinic acid preparations or other metabolic agents. All patients underwent blood pressure and heart rate measurements, laboratory tests, pulse oximetry, ergospirometry. Trends in lactate levels in the blood and hormonal status in athletes were assessed. Moreover, such parameters as testing time, maximum heart rate, maximum oxygen consumption (VO2max), aerobic and anaerobic threshold pulse, time to reach the aerobic and anaerobic threshold were analyzed. Results: athletes who received a course of metabolic therapy on the 35th day of the preparatory period showed a significant increase in the indicators of maximum oxygen consumption (VO2max), the time of the test and the time of the anaerobic threshold ($p<0.05$), which, against the background of a statistically significant decrease in lactate levels ($p=0.014$) indicates an improvement in aerobic performance and the possibility of faster recovery of athletes after physical exertion compared with athletes who did not receive metabolic therapy with succinic acid. Conclusion: The results obtained allow us to recommend the use of step therapy with succinic acid as a metabolic therapy for professional hockey players in the preparatory period.

Keywords: ice hockey players; Cytoflavin; hormonal status; lactate level; functional parameters; aerobic fitness; overtraining.

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1. Introduction

Ice hockey is a physiologically complex sport that requires aerobic and anaerobic energy metabolism. The aerobic level of hockey players increases as they grow up, physically and physiologically mature [1], [2]. At the same time, performance in sports requiring the development of aerobic endurance largely depends on the capabilities of the system for the delivery and removal of energy metabolism products, as well as the oxidative potential of working muscles and the availability of energy substrates [3], [4].

The sport of the highest achievements with its physical and psycho-emotional loads requires a new level of adaptation from the human body, the achievement of which without additional intervention becomes extremely difficult [5]. Overtraining is the accumulation of training and/or non-training stress, leading to a long-term decrease in performance in the presence or absence of corresponding physiological and psychological signs and symptoms of poor adaptation, due to which recovery of performance can take several weeks or months [6]. A highly qualified athlete constantly balances between the optimal level of training and overtraining. Overtraining can be experienced in the course of the athlete's sports career; up to 20% of highly qualified athletes in the general selection, made without taking into account specialization, and up to 70% of elite athletes in sports associated with the predominant development of endurance [7].

The most important problem to this day remains the provision of the body with energy substances and the complete removal of metabolites. In the context of such problems, there is a physiologically justified need for the use of non-marketing ergogenic means of correcting metabolic disorders, which are designed to activate and shorten the time of the body's adaptive reactions to progressively increasing workouts [8].

The main pharmacological means necessary for highly qualified hockey players in the annual training cycle, taking into account the functional state of the limiting systems, are biologically active additives of complex restorative action, neurotropic agents, adaptogens, means of protection and restoration of the ligamentous-articular apparatus [9]. Recently, succinic acid preparations have been increasingly used in sports, which increase adaptation to stress and have a stimulating effect on the processes of cellular respiration and energy formation [4], [10]. Therefore, the aim of our study was to assess the effect of 35-day Cytoflavin consumption on hormonal status, blood lactate level and functional parameters in elite ice hockey players.

2. Materials and Methods

The study was approved by the Ethics Committees of the Federal Scientific Center of Physical Culture and Sports (protocol number 14 dated 25 November 2019). All subjects included in this study provided written informed consent. The study involved 60 professional male hockey players aged 19 to 36 years, whose average age was 24.1±3.8 years. All athletes, depending on the application of the pharmacological support scheme, were divided into two groups of 30 people, comparable in age, anthropometric, clinical and instrumental indicators. Of these, 25 athletes are Masters of sports of international class (MSIC), 26 athletes are masters of sports (MS) and 9 athletes are candidates for Masters of sports (CMS).

Group I consisted of 30 people who, against the background of "basic" sports nutrition, underwent a course of metabolic therapy with the use of succinic acid (Cytoflavin) according to the following scheme: 2 tablets 2 times a day with an interval between doses of 8-10 hours 30 minutes before meals, without chewing, washed down with sweet tea, for 35 days. The course of taking the drug was 35 days.

Group II consisted of 30 people whose pharmacological support included only "basic" sports nutrition and did not include succinic acid preparations or other metabolic agents.

All patients underwent blood pressure and heart rate measurements, laboratory tests, pulse oximetry, ergospirometry.

Laboratory tests included a biochemical blood test to determine the level of lactic acid (lactate), as well as an assessment of hormonal status to determine the level of testosterone, cortisol and thyroid-stimulating hormone (TSH). The calculation of the "anabolism index" (AI) was carried out according to the formula: AI (in %) = Testosterone / Cortisolx100.

Pulse oximetry was performed using the PulseOx 7500 apparatus (SPO Medical, Israel), the parameters of oxygenated hemoglobin (peripheral oxygen saturation) SpO2 and heart rate were evaluated. Ergospyrography-treadmill testing with gas analysis was carried out using: the Quark PFT modular system (Italy), the Treadmill MTM-1500 med treadmill from SCHILLER (Germany), the NihonKohden electrocardiograph (Japan) of the CARDIOFAXGEM series. Such parameters as testing time, maximum heart rate, maximum oxygen consumption (VO2max), aerobic and anaerobic threshold pulse, time to reach the aerobic and anaerobic threshold were analyzed.

All parameters were evaluated before the study (baseline values), on the 14th and 35th day of the study (training).

The research materials were subjected to statistical processing using parametric and nonparametric analysis methods in accordance with the results of checking the compared aggregates for the normality of the distribution. Statistical analysis was carried out using the IBM SPSS Statistics program.23. Arithmetic averages (M) and mean square deviations (SD) were calculated. The differences in the indicators were considered statistically significant at a significance level of $p<0.05$. Comparison of the indicators measured in the nominal scale was carried out using the Pearson criterion $\chi 2$.

3. Results

The study of hormonal status parameters in dynamics showed the absence of statistically significant changes in cortisol parameters in both groups throughout the study period ($p>0.05$), however, it is necessary to note the multidirectional dynamics of cortisol levels in the groups (Table 1, Fig. 1, 2).

Table 1. Trends in hormonal status parameters of athletes by groups

Parameter	Time point	Group I	Group II
Cortisol (mcg/l)	Pre-study	254,32±34,34	237,8±29,13
	Day 14	258,44±28,76	243,04±28,46
	Day 35	245,56±34,71	245,72±25,08
Testosterone (nmol/L)	Pre-study	17,84±4,76	17,06±4,61
	Day 14	18,62±4,83″	16,64±4,26′

	Day 35	18,52±4,81″	16,68±4,01
AI (%)	Pre-study	7,01±2,17	7,27±2,14
	Day 14	6,58±2,13	6,94±1,95
	Day 35	7,81±2,79	7,62±2,18

′p < 0.01, ″p < 0.001 – statistical significance of differences compared to the baseline.

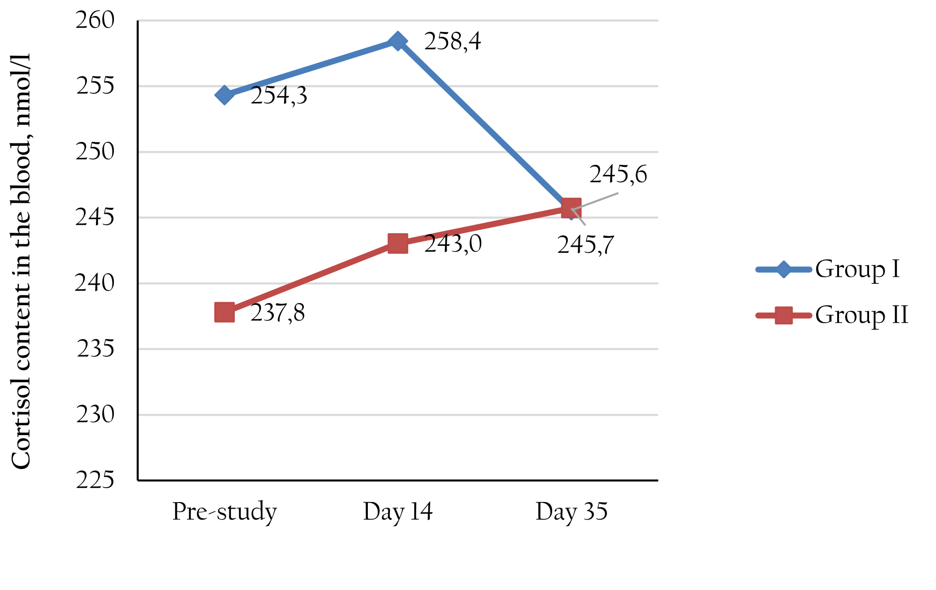

Figure 1. Trends in cortisol levels in the blood of athletes by groups

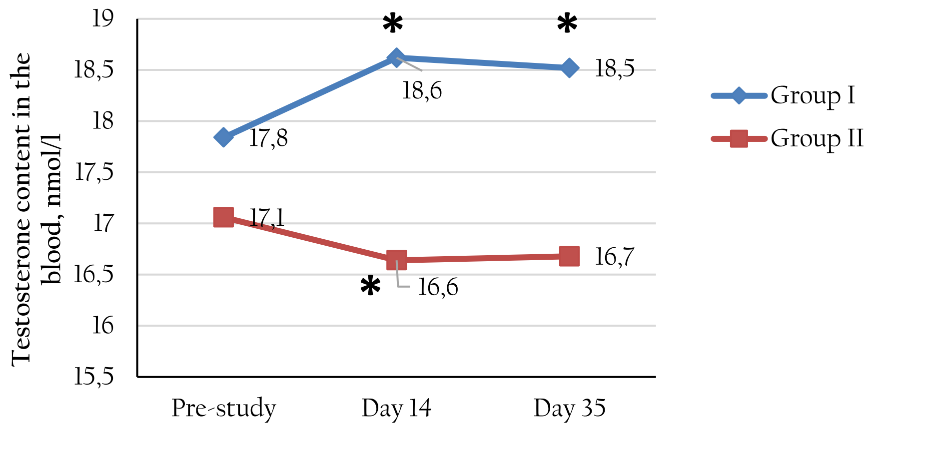

Figure 2. Trends in testosterone levels in the blood of athletes by groups (* p<0.05 – statistical significance of differences within each group compared to the baseline)

Thus, in the group I, there was a decrease in cortisol levels by an average of 3.7% from 254.32±34.34 to 245.56±34.71 mcg/l (p>0.05), while in the group II there was an increase in cortisol levels by an average of 3.3% from 237.8±29.13 to 245.72±25.08 mcg/l (p>0.05). Analyzing the dynamics of testosterone levels, it should be noted its statistically significant increase in group I throughout the study from 17.84±4.76 to 18.52±4.81 nmol/L (p<0.001), while in group II there was a statistically significant decrease in this parameter from 17.06±4.61 to 16.64±4.26 nmol/L (p=0.016) on the 14th day, and stabilization by the 35th day of the study at the level of 16.68 ±4.01 nmol/L.

A study of the trends of the anabolism index, which characterizes the degree of overtraining of athletes, showed its increase in the group I by an average of 14.2%, in the comparison group – by 4.8%.

The examination of the trends in lactate content in the blood of athletes of the main group on the 35th day of the study showed a statistically significant decrease in it both before training (p=0.14) and after training (p=0.14) compared with baseline indicators. The data obtained indicate that the use of Cytoflavin helps to prevent the accumulation of excess lactic acid in the muscles, which is considered as the main cause of fatigue (Table 2, Fig. 3).

Table 2. Trends in lactate levels in the blood of athletes by groups

Time point	Training stage	Group I	Group II
Before the study	Before training	2,02±0,32	1,9±0,29
	After training	4,58±0,49	4,47±0,4
Day 35	Before training	1,86±0,24	1,94±0,23
	After training	4,48±0,43	4,64±0,51
Significance level, p	Before training	0,014	0,566
	After training	0,014	0,222

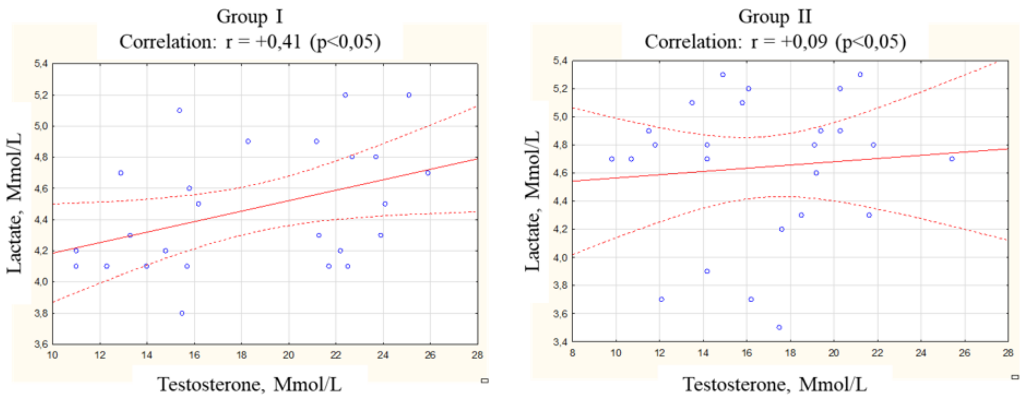

Figure 3. The correlation between lactate and testosterone levels on the 35th day of observation

The study of functional diagnostic parameters during metabolic correction revealed the absence of statistically significant differences in blood pressure from baseline and between groups (p>0.05) (Table 3, Fig. 4).

Table 3. Trends in blood pressure and pulse oximetry indicators in athletes by groups

Parameter	Time point	Group I	Group II
Systolic blood pressure, mmHg	Before the study	123,96±4,8	121,52±5,87
	Day 35	122,8±3,25	121,2±4,4
Diastolic blood pressure, mmHg	Before the study	76,6±5,02	76,04±3,81
	Day 35	76,0±4,08	77,4±3,57
Heart rate	Before the study	62,6±4,97	61,08±5,11
	Day 35	62,4±3,59	62,0±4,22′
SpO_2, %	Before the study	98,32±0,9	98,28±0,89
	Day 35	98,92±0,64″	98,40±0,71*

*p < 0.05 – significance of differences compared to group I, 'p < 0.05, "p < 0.001 – statistical significance of differences compared to the baseline.

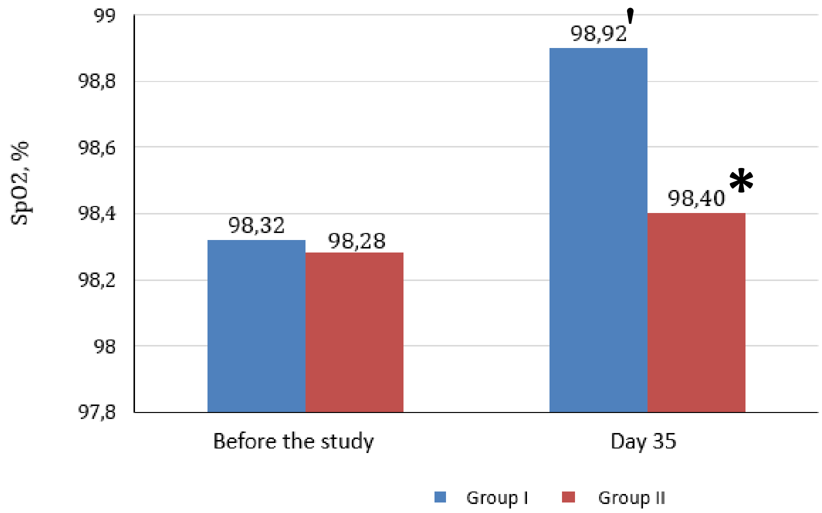

Figure 4. Trends in blood oxygen saturation (SpO2) (*$p < 0.05$ – significance of differences compared to group I, 'p=0.001 – statistical significance of differences compared to the baseline)

Analysis of pulse oximetry results revealed statistically significant dynamics of blood oxygen saturation in the main group from 98.32±0.9 to 98.92±0.64 (p=0.001), as well as significant differences in SpO2 on the 35th day of the study between the groups. (p=0,009). In the group II, changes in the SpO2 index were not statistically significant throughout the study (p=0.503).

The assessment of heart rate indicators revealed a statistically significant increase in heart rate compared to baseline values (p=0.045) in the group II on the 35th day of the study.

Evaluation of ergospirometry parameters revealed a statistically significant increase in all studied parameters in both groups (p<0.01). However, on the 35th day of the study, statistically significant differences were noted between the groups in terms of maximum oxygen consumption, test time and anaerobic threshold time. In the main group, these parameters were statistically significantly higher than similar parameters in the comparison group (p<0.05) (Table 4, Fig. 5).

Table 4. Trends in ergospirography parameters in athletes depending on the intake of Cytoflavin

Parameter	Time point	Group I	Group II
Maximum heart rate, beats/min	Before the study	178,88±10,85	176,96±6,78
	Day 35	188,00±11,31	180,32±21,16
Significance level, p		<0,001	<0,001
Test time, min	Before the study	12,53±1,40	11,98±0,9
	Day 35	14,15±1,30	13,27±1,04*
Significance level, p		<0,001	<0,001
VO2 Max (ml/kg/min)	Before the study	46,99±3,17	47,21±2,84
	Day 35	52,25±4,20	49,06±2,76*
Significance level, p		<0,001	<0,001
Heart rate of the anaerobic threshold, beats/min	Before the study	170,3±10,93	167,84±7,52
	Day 35	174,6±10,92	172,84±8,95
Significance level, p		<0,001	<0,001
Anaerobic threshold time, min	Before the study	10,36±1,31	10,24±1,04
	Day 35	11,97±1,28	11,32±0,93*

Significance level, p		‹0,001	‹0,001
Heart rate of the aerobic threshold, beats/min	Before the study	106,12±11,80	100,84±8,45
	Day 35	115,76±10,08	112,48±6,65
Significance level, p		‹0,001	‹0,001
Aerobic threshold time, min	Before the study	2,97± 0,9	2,71±0,63
	Day 35	3,60±0,85	3,35±0,70
Significance level, p		‹0,001	‹0,001

*p ‹ 0.05 – significance of differences compared to group I

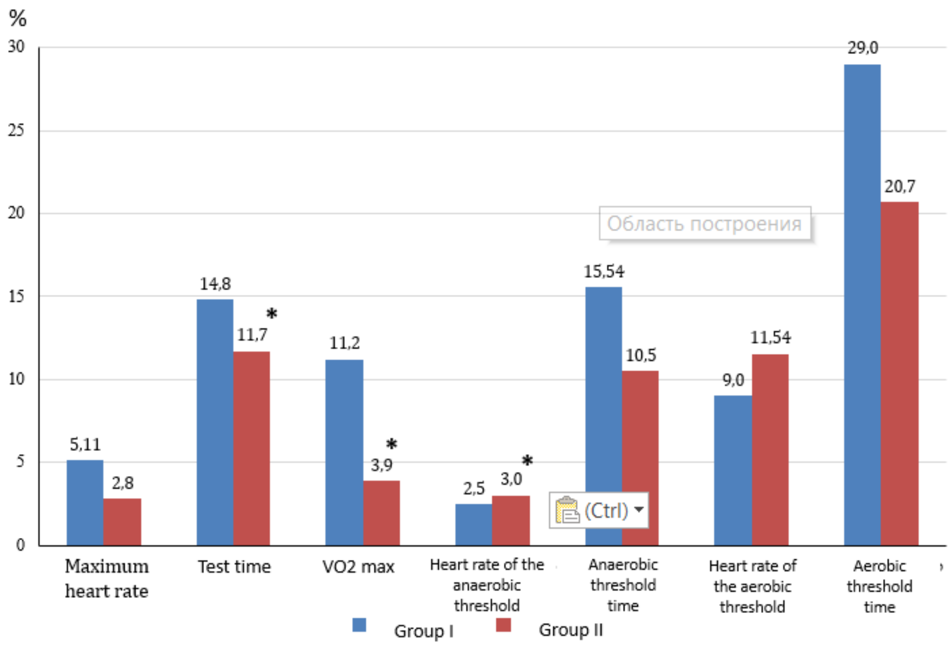

Figure. 5. Increase in ergospirography parameters on the 35th day of the study (*p ‹ 0.05 – significance of differences compared to group I)

The average increase in the index of maximum oxygen consumption in the group I was 11.2%, while in the group II the increase in the parameter was only 3.9% (p=0.003); the parameter of the test time increased in the group I by 12.9%, in the group II – by 10.8% (p‹0.05) (median increase this parameter was 14.8%, in the group II – by 11.6%); the increase in the average time to reach the anaerobic threshold in the group I was 15.5%, in the group II – 10.5% (p=0.045).

4. Discussion

Earlier it was shown that cytoflavin promotes physical fitness of athletes by improving energy supply, psycho-emotional state and competitive form. It is recommended to use cytoflavin for the preparation of athletes in the pre-competition period [11]. It is known that the use of step therapy with succinic acid as a metabolic therapy allows to stabilize hemoglobin indicators, significantly reduce the degree of damage to the cells of the muscular system and heart muscle, increase the anabolism index by 14.2% due to a statistically significant increase in testosterone levels and a decrease in cortisol levels.

Analyzing the obtained parameters, it should be noted that a decrease in testosterone levels as an indicator of the intensity of anabolism processes and an increase in cortisol levels as a parameter of the intensity of catabolism processes in the body in group II may indicate that an athlete is in a state of chronic stress, fatigue, in other words, overtraining. At the same time, the revealed dynamics of testosterone and cortisol parameters in the main group may indicate an improvement in the recovery processes in the body after exertion and a better formation of exercise tolerance when bringing metabolic therapy with the use of Cytoflavin.

The revealed change in the level of blood oxygen saturation during metabolic correction with the use of Cytoflavin may be associated with both an improvement in microcirculation and changes in the erythrocytes themselves or in their ability to bind oxygen.

The results obtained during ergospirography in the main group indicate an improvement in aerobic performance, which is not only the basis for demonstrating high achievements in various sports, but also a means of the best and fastest recovery of athletes after physical exertion.

In turn, an increase in the time to reach the anaerobic threshold against the background of a decrease in lactate indicators suggests a more successful elimination of oxygen debt, which is the key to the processes of recovery and fitness of the athlete.

5. Conclusion

The use of step-by-step therapy with succinic acid as metabolic therapy in hockey players in the preparatory period makes it possible to increase blood oxygen saturation, increase the anabolism index, which indicates the formation of exercise tolerance, improvement of recovery processes after exertion and the absence of signs of overtraining.

At the same time, a significant increase in the index of maximum oxygen consumption, an increase in the time of the test and the time to reach the anaerobic threshold, as well as an increase in the time to reach the anaerobic threshold against the background of a decrease in lactate parameters during metabolic correction with the use of succinic acid preparation allows to improve the parameters of aerobic performance and increase the level of exercise tolerance compared to with athletes who have not had metabolic therapy.

The results obtained allow us to recommend the use of step therapy with succinic acid as a metabolic therapy for professional hockey players in the preparatory period.

Application of artificial intelligence:

The article is written without the use of artificial intelligence technologies.

Author Contributions: Conceptualization, V.Z.; methodology, V.K..; software, V.K; validation, V.Z.; formal analysis, V.Z.; investigation, K.K.; resources, K.K.; data curation, K.K..; writing—original draft preparation, V.K.; writing—review and editing, K.K.; visualization, V.Z..; supervision, V.Z.; project administration, V.K.. All authors have read and agreed to the published version of the manuscript."

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Ethics Committee of the Federal state budgetary institution Federal Scientific Center of Physical Culture and Sports (protocol number 14 dated 25 November 2019).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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

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