

# Effect of Spirulina Food Supplement on Blood Morphological and Biochemical Composition in Sportsmen

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**Objective:** Highly active food supplements find an ever-growing application in sportsmen's nutrition. Of highest biological value are natural concentrates of optimally combined substances produced by nature. One of the food supplements of this kind is dietary Spirulina produced by the Tianshi firm (China). It is a most rationally balanced food supplement of a high biological value; it satisfies the needs of the whole body and improves its immune system.

The aim of the current work was to assess the effect of the multicomponent natural food supplement Spirulina on the physical development, blood morphological and biochemical picture of sportsmen.

**Materials and methods:** Investigations carried out on endurance-training sportsmen showed that a 14-d administration of Spirulina exerted a positive effect on blood morphological composition indices and biochemical changes. Erythrocyte increment was more significant for the sportsmen whose initial indices were low. Throughout the experiment, blood haemoglobin level increased on average by 1.42 g/l, white blood hematocrit showed a decreasing tendency. Spirulina administration was accompanied by a leucocyte count upregulation tendency and positive changes in leucocyte formula. Leucograms showed a marked leveling of the agranulocytes-granulocytes ratio.

**Results and discussion:** Analysis of the biochemical indices showed that during the whole experimental period the mean values of the indices were within the recommended limits. Under the effect of Spirulina intake, blood creatinine-kinase levels tended to increase and creatinine levels showed a decreasing tendency (on average from 93.99 to 90.45 mmol/l); also, triglyceride and bilirubin levels tended to decrease, while those of urea and uric acid increased. Most of the positive changes in blood morphological and biochemical indices were still present two weeks after the Spirulina intake was interrupted.

**Key words:** sportsmen, blood picture, food supplements, Spirulina

## INTRODUCTION

Great physical loads and their intensity impose strict requirements on sportsmen's nutrition. It must be well balanced, highly efficient and meet the bodily demands. Therefore more and more popular in sports practice become highly efficient products, best of them being natural, optimally balanced concentrates of biologically active substances (1, 2). They act as adaptogens by improving bodily response to unfavorable external stimuli (both physical and emotional), raising physical capacity, stimulating the im-

une system and the functioning of the endocrine glands. However, there is a shortage of information on which products should be used as biologically active food supplements and which functional systems of the body are influenced by their effect in sportsmen. Earlier we have published a series of papers on the use of various food supplements in sportsmen's nutrition (3-5).

Over the recent years, many new dietary supplements have appeared on the market and are used by sportsmen. Products of the Chinese firm Tianshi are gaining popularity in their nutrition. Its products, such as Spirulina, Cordiceps, are being produced following the millenium-long traditions of Chinese medicine. They may be used in higher doses

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than homeopathic and lower than pharmacological preparations (6).

Spirulina is a very popular dietary supplement. It is an alga containing a valuable combination of substances, including those practically absent in common food. Spirulina contains about 14% of the protein complex phycocyanin. Research shows it to stimulate the immune system, build both red and white blood cells and assist detoxification (7). Spirulina is a best balanced highly efficient dietary supplement, which satisfies the demands of all systems of the organism and, what is most important, improves the condition of its immune system and is a source of easily available iron (8–10). The literature data show that Spirulina enhances the haemopoietic system and increases resistance to hypoxia (11, 12). R. Henrikson who has been studying *Spirulina platensis* for 20 years, in his publications calls it superfood, an especially efficient concentrate of a perfect composition. The World Health Organization prognosticates that in the 21st century *Spirulina* will become one of the most important curative and prophylactic components of nutrition and recommends it also in children's nutrition (13). However, despite of a rather high popularity of this product, there is a lack of more or less comprehensive studies to analyze the effect of Tianshi dietary supplements on the sportsmen's adaptation to physical loads.

The aim of the present work was to assess the effect of the multicomponent natural food supplement Spirulina on the sportsmen's physical development and blood composition.

## METHODS

The study cohort comprised 12 students of physical culture speciality of Vilnius Pedagogical University, aged 20–22 years, who combined studies with endurance training. After the first investigation, when the physical development, blood morphological and biochemical composition were determined, the study subjects were using tablets of Spirulina, a dietary product of the Tianshi firm, based on dry powder of the alga *Spirulina platensis*, fermented *Cordyceps sinensis* mycelium and beta-carotene. One tablet contained 250 mg of Spirulina. Three tablets were consumed three times a day between the meals with ample water for 14 days by each participant of the study. Their nutritive regime was determined by the methods of questioning and questionnaires. Examinations were performed before Spirulina supplementation, immediately following the supplementation, and two weeks after the supplementation had been interrupted.

Physical development was determined with the aid of standard methods by measuring the study

subjects' height, body mass, muscle and fat mass and index, lung vital volume (14, 15).

Blood samples were taken from the vein. The general blood picture was analyzed with the aid of a Micros-60 hematological analyzer (France). We used it to measure red blood corpuscles (RBC), haemoglobin (HB), haematocrit (HCT), mean red corpuscle volume (MCV), erythrocyte sedimentation rate (ESR), red corpuscle distribution area (RDA), white blood corpuscles (WBC) count, lymphocyte (LYM), monocyte (MON), granulocyte (GRA) count and percentage. A Reflatron-IV express-analyzer was employed to measure blood biochemical indices, such as creatinekinase (CK), creatinine (Crea), cholesterol (Chol), triglycerides (Tg), bilirubin (Bil), urea (Urea) and uric acid (Ua) (16).

The obtained data were processed by methods of mathematical statistics. Parametrical statistics hypotheses were verified according to Student's criterion. The arithmetical mean  $\bar{x}$ , error  $S_{\bar{x}}$ , standard deviation were calculated. To evaluate differences among the mean indices of different stages of the study, Student's *t* criterion was applied to related sets. The Kolmogorov–Smirnov test was used to evaluate the correspondence of the distribution of indices to the standard level.

## RESULTS AND DISCUSSION

The dynamics of physical development indices reflects the sum total of the structural and of some functional properties of the human body and greatly depend not only on inheritance, but also on the physical activity, the quality and habits of nutrition of an individual. In the test subjects, the indices of physical development (height, body mass) changed but little over the experimental period (Table 1). Body mass over this period decreased on average from  $76.0 \pm 2.4$  to  $75.0 \pm 2.2$  kg. Lung capacity showed an insignificant increase (from the average of 5.5 l to  $5.6 \pm 0.22$  l, but the increase was statistically not reliable). The most important information on the physical development of the sportsmen is derived from the muscle and fat mass ratio. With a decreasing body mass, over the study period also fat mass decreased from  $9.0 \pm 0.8$  kg at the beginning of the experiment to  $8.89 \pm 0.70$  kg at its end, and after 2 weeks it decreased to  $8.55 \pm 0.70$  kg.

The role of blood morphological composition in the sportsmen's body is very significant. The blood supports the vitality of the bodily systems and organs by performing various functions, supplying organs with oxygen and nutritive substances, eliminating the products of metabolism, protecting the body against infections, regulating the hormone level, etc.

**Table 1. Dynamics of the sportsmen's physical development indices over the experimental period**

Indices	Height cm	Body mass kg	Lung vital volume l	Fat kg	Muscles kg	Muscle and fat mass index
Before the use						
$\bar{X}$	182.25	75.99	5.53	9.03	40.58	4.89
$S\bar{x}$	2.29	2.37	0.19	0.77	1.26	0.49
<i>S</i>	7.93	8.19	0.65	2.68	4.37	1.68
After a 2-week use						
$\bar{X}$	182.25	75.57	5.53	8.89	40.60	4.95
$S\bar{x}$	2.29	2.17	0.21	0.74	1.15	0.51
<i>S</i>	7.93	7.52	0.73	2.57	3.97	1.77
2 weeks after the use						
$\bar{X}$	182.25	75.03	5.61	8.55	40.90	5.21
$S\bar{x}$	2.29	2.24	0.22	0.70	1.17	0.56
<i>S</i>	7.93	7.75	0.75	2.41	4.06	1.93
t						
I-II	0	0.132	-0.030	0.124	-0.015	-0.081
I-III	0	0.297	-0.291	0.456	-0.189	-0.441
II-III	0	0.174	-0.249	0.336	-0.183	-0.355

At the beginning of the study, blood structural indices of the involved sportsmen were within the normal levels. After two weeks of Spirulina administration these indices showed a positive effect of this dietary product on the haemopoietic system (Table 2). Erythrocyte count in the sportsmen's blood over the study period showed no significant changes; nevertheless, immediately following Spirulina administration it showed an increasing tendency (on average  $0.07 \times 10^{12}/l$ ). Analysis of RBC counts in the first and second stages of the experiment revealed a more significant increase of this index in the sportsmen whose initial RBC levels had been low. The average erythrocyte volume following 14

(by 1.42 g/l) in the second stage.

Another important index of blood composition, haematocrit, throughout the study period kept decreasing, but showed no statistically reliable changes. A higher erythrocyte count and a higher haemoglobin level at a lower mean volume and a higher mean haemoglobin content in them and a decreased haematocrit percentage are the desirable phenomena for the sportsmen whose activities require especially high endurance.

White blood corpuscles (WBC) perform various protective functions, participate in cellular and humoral immunity. In the leucograms of the sportsmen - participants of our study, after 2 weeks of Spirulina administration the leucocyte class percentage was within the recommended normative levels. In the third stage (2 weeks following the interruption of Spirulina intake), an increasing tendency of leukocyte count and positive shifts in the leukocyte formula were observed. In the leucogram, the per cent ratio of agranulocytes (lymphocytes and monocytes) and granulocytes (neutrophils, basophils, eosinophils) was smoothed (Table 3).

Throughout the whole period of study the mean values of blood biochemical indices were within the recommended limits (Table 4). The mean creatinekinase indices were nearly the sa-

**Table 2. Dynamics of the sportsmen's general blood picture over the experimental period**

Indices	RBC $10^{12}/l$	HGB g/l	HCT %	MCV $\mu^3$	RDA %	ESR mm/a
Before the use						
$\bar{X}$	4.94	146.33	44.00	88.00	11.42	5.17
$S\bar{x}$	0.13	3.09	0.96	0.78	0.15	2.11
<i>S</i>	0.46	10.71	3.34	2.70	0.50	7.32
After a 2-week use						
$\bar{X}$	5.00	147.17	43.91	88.00	11.22	3.58
$S\bar{x}$	0.10	1.99	0.66	0.69	0.11	0.58
<i>S</i>	0.35	6.90	2.28	2.37	0.40	2.02
2 weeks after the use						
$\bar{X}$	4.98	147.75	42.83	86.08	11.68	4.58
$S\bar{x}$	0.07	1.53	0.43	0.68	0.13	1.08
<i>S</i>	0.24	5.29	1.50	2.35	0.46	3.73
t						
I-II	-0.37	-0.23	0.08	0.00	1.08	0.72
I-III	-0.27	-0.41	1.11	1.86	-1.36	0.25
II-III	0.17	-0.23	1.37	1.99	-2.67	-0.82

Table 3. Dynamics of the sportsmen's leukocyte count and formula over the experimental period

Indices	WBC 10 9/l	#LYM 10 9/l	LYM %	#MON 10 9/l	MON %	#GRA 10 9/l	GRA %
Before the use							
$\bar{X}$	5.33	1.70	34.08	0.25	6.04	3.38	59.88
$S\bar{X}$	0.31	0.08	2.15	0.03	0.70	0.32	2.52
$S$	1.07	0.26	7.46	0.10	2.43	1.10	8.71
After a 2-week use							
$\bar{X}$	5.18	1.54	33.28	0.18	4.68	3.45	62.04
$S\bar{X}$	0.48	0.08	2.73	0.02	0.34	0.45	2.84
$S$	1.67	0.27	9.47	0.07	1.17	1.56	9.85
2 weeks after the use							
$\bar{X}$	5.49	1.62	30.48	0.28	5.92	3.59	63.61
$S\bar{X}$	0.21	0.09	1.56	0.02	0.40	0.18	1.67
$S$	0.73	0.31	5.41	0.08	1.37	0.64	5.79
t							
I-II	0.28	1.46	0.23	1.88	1.76	-0.12	-0.57
I-III	-0.42	0.71	1.35	-0.89	0.15	-0.57	-1.23
II-III	-0.60	-0.64	0.89	-3.15	-2.39	-0.29	-0.47

Table 4. Dynamics of the sportsmen's blood biochemical indices over the experimental period

Indices	Ck u/l	Crea mmol/l	Chol mmol/l	Tg mmol/l	Bil mmol/l	Urea mmol/l	Ua mmol/l
Before the use							
$\bar{X}$	92.35	93.99	3.81	2.52	18.14	5.60	307.00
$S\bar{X}$	15.13	2.84	0.23	1.46	2.03	0.46	9.83
$S$	52.42	9.83	0.81	5.05	7.04	1.60	34.05
After a 2-week use							
$\bar{X}$	97.13	90.45	3.72	0.94	16.40	6.20	321.00
$S\bar{X}$	18.25	4.05	0.22	0.08	2.83	0.33	19.61
$S$	63.22	14.03	0.75	0.27	9.81	1.15	67.92
2 weeks after the use							
$\bar{X}$	96.83	94.47	3.75	1.14	18.13	6.75	340.42
$S\bar{X}$	16.36	2.71	0.21	0.14	1.87	0.35	17.24
$S$	56.68	9.40	0.72	0.48	6.49	1.23	59.72
t							
I-II	-0.20	0.72	0.27	1.13	0.50	-1.05	-0.64
I-III	-0.20	-0.12	0.18	1.72	0.00	-1.97	-1.68
II-III	0.01	-0.82	-0.09	-1.27	-0.51	-1.13	-0.74

me, however, the difference between their maximal and minimal parameters was very high. Two persons stood out for their creatinekinase levels, which were above norm. It is worth noting that these sportsmen before study had been taking several dietary supplements. In 7 persons of 12, for whom blood creatinekinase in the first trial reached the average level (from 24.4 to 194 u/l), immediately following Spirulina intake it increased from 39.8 to 244 u/l. Blood creatinine level throughout the study period decreased on average from  $93.99 \pm 2.84$  to  $90.45 \pm 4.05$  mmol/l, and this difference can be regarded as a positive phenomenon.

Blood cholesterol and triglyceride levels for all study participants were below the lower recommended level. Urea and uric acid levels in their blood over the study period showed no statistically significant changes, however, immediately following Spirulina intake and two weeks later exhibited a pronounced increasing tendency, implying the intensifying effect of this drug on protein metabolism in the body.

The questionnaire interrogatory research proved that the sportsmen's nutrition ratio was rational, sportsmen did not use any other food supplements or medical preparations during the study period. The usage of Spirulina had no negative impact on the sportsmen's body. After five days of Spirulina usage, the sportsmen felt more bouncing, their sleeping quality improved, fatigue after physical load performance was less, recreational processes became quicker, and their endurance when performing strength exercises improved.

## CONCLUSIONS

1. During the two weeks of Spirulina intake, the physical development of the sportsmen showed no statistically significant changes.

2. Immediately following the 14-d period of Spirulina administration, in the sportsmen's blood the erythrocyte count and haemoglobin concentration had a tendency to an increase accompanied by a decrease of the mean erythrocyte volume and unchanged blood haematocrit. The leucocyte count also showed an increasing tendency, and the per cent ratio of agranulocytes and granulocytes was levelling.

3. Spirulina administration caused no violation of the recommended standard levels of blood biochemical indices. The levels of cholesterol, triglycerides, bilirubin in the blood showed a decreasing and of urea and uric acid an increasing tendency.

4. Most of the positively changed morphological and biochemical indices of the sportsmen's blood composition retained similar levels for another two weeks following the withdrawal of Spirulina from their diet.

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**MAISTO PAPILDO „SPIRULINA“ POVEIKIS SPORTININKØ KRAUJO MORFOLOGINEI IR BIOCHEMINEI SUDĖĖIAI**

**S a n t r a u k a**

Sportininkø mityboje vis plačiau vartojami padidintos biologinės vertės maisto papildai, iš kuriø tinkamiausi yra natūraliø, gamtos sukurtø, optimaliai suderintø, biologiškai aktyviø medþiagø koncentratø. Vienas tokiø maisto papildø – Kinijos firmos „Tianshi“ produktas „Spirulina“. Tai – labiausiai subalansuotas, visavertis maisto papildas, tenkinantis viso organizmo poreikius, gerinantis jo imuninę sistemà.

Mūsų darbo tikslas – ištirti daugiakomponenėio natūralaus maisto papildø „Spirulina“ vartojimo poveikà sportininkø fiziniam išsivystymui, kraujo morfologinei ir biocheminei sudėėiai.

Ištyrus ištvermà lavinanėius sportininkus paaiškėjo, kad 14 dienø trukmės maisto papildø „Spirulina“ vartojimas teigiamai paveikė kraujo morfologinà ir biocheminà sudėtà. Nustatyta, kad sportininkø kraujyje labiau padidėjo eritrocitø skaiėius, ypaė kai pradiniai rodikliai buvo maþi. Hemoglobino koncentracija kraujyje eksperimento metu padidėjo vidutiniškai 1,42 g/l, o kraujo hematokrito maþėjo. Vartojant maisto papildà „Spirulina“ pastebimas leukocitø skaiėiaus didėjimas bei teigiami poslinkiai leukocitø formulėje. Leukogramoje matyti, kad procentinis santykis tarp agranulocitø ir granulocitø išsilygino.

Sportininkø biocheminiø kraujo tyrimø duomenø analizė parodė, kad per visà eksperimentà vidutiniai rodikliai atitiko rekomenduojamas normas. Nustatyta, kad „Spirulina“ padidino kreatiniazės koncentracijà tiriamøjø kraujyje, o kreatinino sumaþino (vidutiniškai nuo 93,99 iki 90,45 mmol/l). Taip pat maþėjo trigliceridø ir bilirubino koncentracija, o ðlapalo ir ðlapimo rûgšties – didėjo. Daugelio sportininkø teigiami kraujo morfologiniø ir biocheminiø rodikliø poslinkiai pavartojus maisto papildà „Spirulina“ išsilaukė ir po 2 savaiėiø.

**Raktaþodþiai:** sportininkai, kraujo vaizdas, maisto papildai „Spirulina“

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