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BRIEF NOTE

Effect of astaxanthin and exercise on antioxidant capacity of human body, blood lactic acid and blood uric acid metabolism

Effet de l'astaxanthine et de l'exercice sur la capacité antioxydante, la lactatémie, et le métabolisme de l'acide urique

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Summary
Objective. — We investigated the effects of astaxanthin supplementation and acute high intensity exercise on serum antioxidant capacity of human body, blood lactic acid and serum uric acid metabolism.
Methods. — Sixteen subjects were trained 28 days and were randomly divided into two groups: group A (experimental) and B (control). Four weeks later, all subjects underwent exercise on power bike.
Results. — Immediately after exercise, the anti-oxidative capacity decreased in 2 groups, the lactic acid values of blood significantly increased, but compared with the group B the antioxidant capacity of the A group was significantly higher and blood lactate value lower.
Conclusion. — (1) Exercise can temporarily reduce the body's antioxidant capacity, increase blood lactic acid content, and slightly decrease blood uric acid content. (2) Astaxanthin intake can eliminate free radicals produced in the body, significantly reducing the increase in blood lactic acid and reducing blood uric acid value after acute high-intensity exercise.

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MOTS CLÉS
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Uricémie

Résumé
Objectif. — Nous avons étudié les effets de la supplémentation en astaxanthine et de l'exercice aigu de haute intensité sur la capacité antioxydante sérique de l'organisme, de la lactatémie et de l'uricémie.
Méthodes. — Seize sujets ont été entraînés pendant 28 jours et ont été répartis de façon randomisée en deux groupes: groupe A (expérimental) et B (témoin). Quatre semaines plus tard, tous les sujets ont réalisé un exercice sur ergocycle.
Résultats. — Immédiatement après l'exercice, la capacité anti-oxydante a diminué dans 2 groupes, la lactatémie a considérablement augmenté, mais par rapport au groupe B, la capacité antioxydante du groupe A était significativement plus élevée et la lactatémie était plus basse.
Conclusion. — (1) L'exercice de haute intensité peut réduire temporairement la capacité antioxydante de l'organisme, augmenter la lactatémie et légèrement l'uricémie. (2) La consommation d'astaxanthine peut éliminer les radicaux libres produits dans le corps, réduisant de façon significative l'augmentation de lactatémie et d'uricémie après exercice aigu de haute intensité.

1. Introduction

The free radicals are active which can easily react with lipids, proteins, DNA and so on thus to make their own structure stable and this is called ''oxidation''. Body's own redox reaction is in a state of equilibrium under the normal conditions, but pesticides, strong ultraviolet radiation, haze and other internal conditions will make it produce excessive free radicals resulting in atherosclerosis, diabetes, cataract, aging and cancer and other disease [1].

As early as in 1982, Devies [2] et al. proposed that the acute high intensity exercise will cause a large number of free radicals, which cause the attention to free radicals in sports medicine. It can damage body's coenzyme, neurotransmitter, mitochondria, and muscle cell membrane if a large amount of free radicals produced by the movement uncleared immediately, therefore resulting in cell necrosis and damage of tissue and organs even increases the vulnerability to athletes. Hence, how to effectively inhibit the oxidation and prevent the oxidative damage caused by free radicals is an important subject for research of sports medicine.

Astaxanthin is a kind of natural carotenoid cyan that generally exists in marine algae, fish, shrimps and crabs, shellfish and other organisms. Recent studies have shown that natural astaxanthin has a strong antioxidant activity, its ability to scavenge oxygen free radicals is approximately 500 times that of vitamin E, 60 times of Q10, 7 times of lycopene, which has attracted wide attention of scholars, and then they has done a large amount of research for astaxanthin in the prevention and treatment of disease. Studies show that astaxanthin has the efficacy of treating chronic inflammation, cardiovascular disease, diabetes, metabolic syndrome, neurodegenerative diseases and anticancer. Research results are not sufficient in the field of sports, and animals are frequently used for their experiments. While there is no evidence regarding the influence of pre-supplement astaxanthin 4 weeks on human antioxidant capacity, blood lactic acid, uric acid metabolism in response to human acute high intensity per and post exercise. Therefore, this study was performed to investigate this issue.

2. Materials and methods

2.1. Grouping of experimental objects

Sixteen male students grade 2016 from Physical Education Institution (age: 19.13 ± 2.52, height: 179 ± 4.21 cm and weight 68.23 ± 7.81 kg). They were randomly divided into two groups ($n = 8$ per group): experimental group A (Supplementary medium dose astaxanthin: 12 mg/d) and control group B (Placebo). Sixteen subjects were asked the medical history and undergo a routine physical examination to confirm their health and no major disease or suffer upper respiratory tract infections, cardiovascular, otherwise they were not intake supplements as free radical scavenger (V_E, V_C, lycopene) and traditional Chinese medicine recently. This clinical trial followed the Declaration of Helsinki, and informed consent was obtained from the subjects before the experiment.

2.2. Laboratory instruments and reagents

Sweden made Monark874E quantitative load power cycle was using to complete acute exercise. The antioxidant capacity and blood uric acid and the content of blood lactic acid was measured by the Italy CR3000RC type oxygen free radical biochemistry analyzer, centrifuge, adjustable pipette, anti-oxidation Kit (FORD), blood lactic acid Kit (LACTIC ACID), blood uric acid Kit (URIC ACID) (kits were produced from Italy Callegari company). The astaxanthin used in this study supplied by Hubei Asta Biotech Inc ASTA

astaxanthin soft capsule 500 mg/tablets (each containing astaxanthin is larger than 4 mg, Hubei food Key words: 2012 Article No. 0014).

2.3. Experimental design and motion scheme

The experiment was set 29 days. The experimental group supplement astaxanthin in doses of 12 mg at 21:00 7d a week for 4 weeks. The control group taking the Placebo as similar appearance as astaxanthin for 4 weeks too. Twenty-eight days after the drug supplement, in the next morning at 8 AM, all the participants performed fasting blood sampling was carried out and tested in the laboratory for first time. Later, participants taking acute exercise immediately on pedal power bicycle with all strength 30 seconds × 3/3 min interval (loading a weight of 0.075 kg/kg) [3]. At the end of the exercise, all subjects performed second blood taking. Each blood collection was using capillary microtubules on the fingertip, and the antioxidant capacity, blood lactate and serum uric acid blood samples were tested instantly.

2.4. Test indexes and methods

2.4.1. Test of antioxidant capacity (FORD)

Testing fundamentals: The FORD test is the chromogenic reaction (4-diethyl-aminoaniline sulfate included) that an oxidizing agent (Ferric chloride) in acid environment (pH = 5.2) forms the corresponding cation radical (Chromogenic substrate^{+}). The stability and color of this type of amino acid can be measured at 505 nm. Adding antioxidant compounds (AOH) to the sample reduces the amount of cationic free radical amino acids and also make the color loss proportional. The absorbance value of concentration was measured through the law of Lambert-Beer.

$$(1)\text{Chromogenicsubstrate}^{+}(\text{colorless}) + \text{Fe3}^{+} + \text{H}^{+} \rightarrow \text{Chromogenicsubstrate}^{+}(\text{red})$$

$$(2)\text{Chromogenicsubstrate}^{+}(\text{red}) + \text{AOH} \rightarrow \text{Chromogenicsubstrate}^{+}(\text{colorless}) + \text{AO}$$

2.4.2. Blood lactic acid test (Lactic Acid)

Testing fundamentals: The lactic acid is oxidized to pyruvate and hydrogen peroxide under the action of lactic acid oxidase (LOD) (action 1). A red compound was composed in the presence of peroxidase and catalyzed by hydrogen peroxide, 4- aminoatipyrine (4-AP) and phenolic derivatives (action 2). Reading the compound intensity of such color at 505 nm and directly proportional to the concentration of lactic acid in the sample.

$$(1)\ \text{Lactic acid} \xrightarrow{\text{Lactic acid oxidase}} \text{Pyruvate} + \text{H}_2\text{O}_2$$

$$(2)\ \text{H}_2\text{O}_2 + \text{4-aminoatipyrine (4-AP)} + \text{Phenolic derivative} \xrightarrow{\text{Peroxidase}} \text{Compound (red)} + \text{H}_2\text{O}_2$$

2.4.3. Uric acid test (Uric Acid)

Testing fundamentals: Uric acid can produce uric acid allantoin and hydrogen peroxide in the role of uric acid oxidase (action 1). Hydrogen peroxide, 4-amino antipyrine and phenol derivatives form a red compound and water under the action of peroxidase (action 2). Reading at 505 nm of the compound intensity of such color is directly proportional to the concentration of uric acid in the sample.

$$(1)\ \text{Uric acid} \xrightarrow{\text{Acid oxidase}} \text{Uric acid allantoin} + \text{H}_2\text{O}_2$$

$$(2)\ \text{H}_2\text{O}_2 + \text{4-aminoatipyrine (4-AP)} + \text{Phenolic derivative} \xrightarrow{\text{Peroxidase}} \text{Compound (red)} + \text{H}_2\text{O}_2$$

2.5. Experimental results processing

SPSS for Windows v18.0 was used for statistical analyses. Comparative the two groups using independent sample *T*-test, and per-post each group were compared with paired samples *T*-test, $P < 0.05$ for the difference was significant, and $P < 0.01$ was considered significant. A value of $P < 0.05$ was accepted as statistically significant, and $P < 0.01$ was striking significant.

3. Results

3.1. Effects of acute high-intensity exercise on body anti-oxidation ability value, blood lactate, uric acid

Body anti-oxidation ability value were decreased in both two groups ($P < 0.05$), but the average of the experimental group significantly higher than the control group after acute high-intensity exercise ($P < 0.05$). Blood lactate values were significant increased in two groups of subjects, with difference significantly ($P < 0.01$), but the experimental group was significantly lower than the control group, with difference significantly ($P < 0.05$). Body's blood uric acid levels of two groups were slightly reduced and no significant difference. The average is still tended to be lower than in the control and with difference significantly ($P < 0.05$) (Table 1).

4. Discussion

Research on astaxanthin structure and function, mechanism of action, safety, the extracted and other aspects mainly focus on medicine and chemistry, relatively few studies of astaxanthin on body movement function influence, especially on it's effect of human body movement function. This study aims to research the effect of astaxanthin and exercise on antioxidant capacity of human body, blood lactic acid and blood uric acid metabolism and other indicators.

After acute high intensity exercise, the antioxidant capacity decreased in two groups ($P < 0.05$), which is related to intense free radicals. A large number of experiments show that acute high-intensity exercise or exhaustive exercise will

Table 1 Change of antioxidant capacity of human body, blood lactic acid and blood uric acid before and after acute and high-intensity exercise.

		Antioxidant capacity (mM)	Blood lactic acid (mM)	Blood uric acid (mM)
Control group ($n=8$)	Previous	0.78 ± 0.22	1.85 ± 0.81	231.06 ± 23.76
	After	0.60 ± 0.19[b]	5.71 ± 0.72[c]	222.16 ± 45.14
Experimental group ($n=8$)	Previous	1.02 ± 0.18	1.13 ± 0.44	197.80 ± 36.23
	After	0.83 ± 0.22[a,c]	4.97 ± 0.60[a,c]	193.05 ± 28.51[a]

Note: Each value represents mean $\pm$ SD.
[a] $P < 0.05$ vs. control group.
[b] $P < 0.05$ vs. before exercise.
[c] $P < 0.01$ vs. before exercise.

lead to abundant free radicals in the body, which lead to oxygen consumption in the body increased during exercise, ischemia and hypoxia, increased antioxidant enzyme consumption [4]. When the body's own antioxidant system is not against free radicals, the performance of the body's antioxidant capacity would decrease, and in this study the antioxidant capacity of experimental group was significantly higher than the control group that indicate the addition of astaxanthin plays a role in scavenging free radicals.

Lactic acid is one of the longest and most widely used index in sports science research to monitor the blood lactic acid value during exercise. It has become a widely accepted and effective method for assessing exercise intensity and training effect. Lactic acid is a by-product of anaerobic exercise, short period of amount accumulation in the body will make the body PH decline, hinder the synthesis of ATP, reduce the regulation of the nervous system, resulting in nerve excitability and muscle work ability decreased, resulting in sports fatigue [5]. In the present study, the blood lactic acid values increased significantly in two groups ($P < 0.01$) after acute high-intensity exercise immediately, but the experimental group was significantly lower than the control group ($P < 0.05$). Many factors affect the metabolism of lactic acid, from the results of this experiment, it was shown that supplementation of astaxanthin had a significant effect on inhibitory lactic acid produced by the exercise-induced body lactation, thus delaying exercise-inducing fatigue.

Uric acid is the end production of purine metabolism, much produces or bad excretion of uric acid leads to the formation of high urate crystal deposition in the joints caused by gout. At present, more people suffer from gout. Studies have shown that high blood uric acid is not only a risk factor for gout, but also lead to hypertension, atherosclerosis, diabetes and other risk factors of type II [6]. But studies also have shown that uric acid can improve the body's antioxidant capacity of motion and reduce oxidative stress, as the antioxidants have an equivalent effect with ascorbic acid (vitamin C). Human has a longer life expectancy compared to lower animals that because the relatively low rate of mutations in human cells. It tends a positive correlation between cell mutation and peroxide to stimulate. Uric acid that in the human body's has antioxidant capacity to prevent cell mutation, so some people think that uric acid may inhibit the production of cancer cells. Low blood uric acid levels may be a cause of cancer [7]. In this study, blood uric acid levels were slightly lower in both groups after acute high-intensity exercise and no significant difference. It suggests that uric acid not increased because the blood plasma uric acid participates in the removal of free radicals. Studies have shown that, after strenuous exercise, allantoin in plasma was increased 200%, while uric acid levels increased only 20%, This indicate that uric acid as an antioxidant is oxidized to allantoin, that is allantoin can be used as a suitable marker of acute oxidative stress [8]. This study did not detect allantoin levels in the blood, which can only be speculated that uric acid not increases because removed free radicals. It may also be a better indication if we detect the allantoin levels.

At present, different studies show the impact of the presence of uric acid on human body, which are the interests of part scholars. More precise studies on the levels of uric acid, and other mechanisms, which is the next step in our research need continue to explore.

5. Conclusion

Acute high-intensity exercise can temporarily reduce the body's antioxidant capacity, increase blood lactic acid content, and slightly decrease blood uric acid content.

Astaxanthin intake can improve the reduction and restoration of antioxidant capacity of human body meanwhile speed the generation and elimination of blood lactic acid and blood uric acid after acute and high-intensity exercise.

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Authors' contribution

Lijun WU Prof.: First author, substantial contributions to conception and design, drafting and revising the manuscript and confirmation of final version to be published.

Zhuo SUN (Master): Revising the manuscript and confirmation of final version to be published and Submitted manuscript.

An'ping Chen Prof: Revising the manuscript and confirmation of final version to be published.

Xinming GUO A/Prof.: Conceived and designed the experiments.

Jie WANG (Master): Performed sample collection.

Disclosure of interest

The authors declare that they have no competing interest.

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