SHORT REPORT

Mechanism of layered double hydroxide sports nutrition supplement promoting sports training

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Layered double hydroxide as an inorganic compound has become an important carrier of drugs and nutritional supplements due to its good safety, stability, biocompatibility, and biodegradability. It can effectively improve the stability, bioavailability, and patient compliance of nutrients. This study investigated the effect of layered double hydroxide sports nutrition supplement to promote sports training. A total of 24 female athletes from the Sports College of Anyang Vocational and Technical College were involved in this study and were randomly divided into experimental group and control group with 12 people in each group. There was no statistical difference between the experimental and the control groups in terms of age, weight, height, and training years. The control group did not take any medication, while the experimental group was first given a placebo followed by the administration of green tea active extract. Through the comparative analysis of the relevant indicators under the two intake conditions, the results showed that the maximum oxygen consumption after taking the green tea active extract was significantly higher than that of the placebo in the experimental group ($P < 0.05$). Further observation showed that the concentrations of serum superoxide dismutase, glutathione peroxidase, and serum catalase after taking the green tea active extract were significantly higher than those when taking the placebo in the experimental group ($P < 0.05$). However, there was no linear correlation between the increase in maximum oxygen consumption and the increase in superoxide dismutase (SOD) activity in the antioxidant enzyme system in the experimental group before and after taking the green tea active extract ($P > 0.05$). The active extract of green tea could improve both the antioxidant capacity and the aerobic capacity, indicating that the active extract of green tea could significantly improve the aerobic capacity by improving the antioxidant capacity.

Keywords: female athletes; green tea active extract; aerobic capacity; oxygen uptake; serum superoxide dismutase; glutathione peroxidase; serum catalase.

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Introduction

In recent years, with the in-depth development of sports science, people have gained a more comprehensive understanding of the relationship between athletes' physical function and sports performance [1, 2]. Among them, aerobic exercise has become an important part of athletes' daily training due to its ability to effectively improve cardiopulmonary function and body metabolism. However, during high-intensity aerobic exercise, athletes often produce a large amount of free radicals and inflammatory factors in their bodies. These substances not only affect athletes' physical recovery but also pose potential threats to their health. Therefore, finding methods that can effectively remove free radicals and reduce exercise fatigue is crucial for

improving athletes' aerobic exercise ability and overall sports performance.

Green tea active extracts have attracted widespread attention in the sports science community due to their unique antioxidant and anti-inflammatory properties [3, 4]. The main component of green tea active extracts is tea polyphenols, which can effectively remove free radicals and reduce oxidative stress during exercise [5], thereby contributing to athletes' physical recovery and improvement in sports performance. In recent years, research on the impact of green tea active extracts on athletes' aerobic capacity has gradually increased [6]. These studies not only reveal the potential application of green tea active extracts in the sports field but also provide new ideas for athletes' daily training and nutritional supplementation [7]. Layered double hydroxide sports nutrition supplements and green tea active extracts are two substances that have attracted much attention in the modern health field [8]. The relationship between them lies in that they both can serve as nutritional ingredients, providing the body with various essential minerals, trace elements, and antioxidants to help maintain health. In addition, the special structure of layered double hydroxide sports nutrition supplements enables them to be better absorbed and utilized by the body, thus enhancing their nutritional value. Layered double hydroxide sports nutrition supplements can be used to improve athletic performance, accelerate recovery, and enhance muscle strength, while green tea active extracts can be used for antioxidation, anti-inflammatory, boosting metabolism, and promoting fat burning. Both nutritional supplements can be applied in the fields of health food, sports nutrition, and functional food, providing people with healthy lifestyles and ways to improve their health [9, 10].

This study took female athletes as the research subjects and observed their changes in antioxidant enzymes and oxygen uptake by comparing with their own baseline, placebo, and control group. The study aimed to investigate the effects of green tea active extracts, mainly composed of tea polyphenols, on athletes' antioxidant capacity and aerobic capacity, providing a reference for selecting nutritional supplements to improve aerobic exercise performance.

Materials and methods

Research subjects and grouping

A total of 24 female sprint athletes from the Physical Education School of Anyang Vocational Technical College in Anyang City, Henan Province, China was involved in this study, who satisfied the inclusion criteria as 14 to 18 years old Chinese Han ethnicity, in good health and normal electrocardiogram (ECG), not during menstruation, agree to participate in this study. The participants were randomly divided into experimental and control groups with 12 people in each group. All procedures of this study were approved by the Ethical Review Committee of Anyang Vocational and Technical College (Anyang, Henan, China) (Approval No. SCNU-SPT-2022-119).

Group treatments

A double-blind study of green tea active extract/placebo was conducted. The green tea active extract tablet (100 mg) was provided by Chengdu Chenlv Biological Technology Co., Ltd. (Chengdu, Sichuan, China) and had been confirmed by animal experiments and doping tests that it was not a stimulant. The tablet was dissolved under the tongue, which allowed the drug to quickly enter the bloodstream and improve treatment efficiency. The same dose of plant starch capsule (Shuida Pharmaceutical Group (Jilin) Co., Ltd., Changchun, Jilin, China) was used in this study as placebo, which was made of pure natural plant starch without any additives and had no side effects on the human body.

Detection of blood indicators baseline levels

Table 1. Comparison of various indexes between the experimental group and the control group when taking placebo in both groups.

Index	Experimental group (n = 12)	Control group (n = 12)	*P* value
Exercise time (s)	452.8 ± 18.6	453.4 ± 21.4	0.773
Average power (P) (Watts)	234.4 ± 31.3	240.5 ± 31.5	0.786
Jet frequency (F) (pulp/min)	28.5 ± 1.1	29.0 ± 1.0	0.32
Blood lactic acid (LA) (mmol/L)	11.7 ± 1.2	13.35 ± 1.72	0.346
CK (U/L)	283.6 ± 45.5	281.8 ± 44.6	0.691
BU (mmol/L)	6.3 ± 0.4	6.36 ± 0.65	0.861
SOD (NU/L)	72.5 ± 4.2	72.8 ± 4.6	0.58
GSH-PX (kU/l)	51.45 ± 5.5	51.4 ± 5.4	0.826
CAT (kU/L)	35.3 ± 5.4	34.5 ± 4.7	0.7
Maximum oxygen uptake (mL/min)	3,581.6 ± 67.1	3572.1 ± 104.2	0.686

The week before and during the study period, no long and heavy exercise was arranged except for the experimental required activities. The experiment was arranged on Monday morning after rest the day before. Four (4) placebo tablets were taken under the tongue one hour before the sample collection followed by jogging for 10 minutes in both groups. After wearing the breathing mask of Jianqiao FGY-200 Lung Function Tester (Jianqiao, Shanghai, China), the adaptive exercise on the dynamometer (Anta, Quanzhou, Fujian, China) was performed for about 1 minute followed by simple exercises up to 1 hour. The blood indicators including lactic acid (LA), serum urea (BU), serum creatine kinase (CK), serum superoxide dismutase (SOD), serum glutathione peroxidase (G-PX), and serum catalase (CAT) were measured for both groups four minutes post-exercise to determine the baseline levels of all indicators in both groups. The blood samples were tested by Kingmed Diagnostics Laboratory (Shanghai, China)

Different treatment tests

After the baseline levels were established, the control group was treated with a placebo only, while the experimental group was treated with the green tea active extract. The relevant indicators including the maximum oxygen uptake, exercise performance, average power, and plasma frequency were measured subsequently.

Statistical analysis

SPSS (IBM, Armonk, New York, USA) was employed in this study for data mean value, group t-test comparison, and correlation analysis. *P* value less than 0.05 was defined as significant differences between groups.

Results

Comparison of the baselines between the groups

The results showed that the placebo treatments of experimental and control groups showed no statistically significant difference in the baseline level of each index in both groups (Table 1).

Comparison of test results before and after taking green tea active extract

The results showed that no significant difference was found in blood indicators and the maximum oxygen uptake of the control group that taking placebo twice during the experiment. However, the comparative results of experimental group that taking the green tea active extract during the experiment demonstrated that the maximum oxygen uptake was higher than that of treatment ($P < 0.05$), while the concentrations of serum superoxide dismutase, glutathione peroxidase, and serum catalase were also significantly increased comparing to that of placebo treatment ($P < 0.05$) (Table 2). In addition, the

Table 2. Comparison of various indexes of the experimental group.

Index	Green tea active extract (n = 12)	Placebo (n = 12)	*P* value
Exercise time (s)	450.4±19.15	452.2±18.5	0.189
Average power (P) (Watts)	243.2±33.35	244.2±31.3	0.488
Jet frequency (F) (pulp/min)	29.65±0.92	30.6±1.2	0.327
Blood lactic acid (LA) (mmol/L)	12.8±1.55	13.92±1.31	0.147
CK (U/L)	287.5±41.4	284.6±45.2	0.352
BU (mmol/L)	6.66±0.89	6.54±0.81	0.753
SOD (NU/L)	76.2±4.85	72.89±4.72	0.027
GSH-PX (kU/l)	56.39±5.14	52.62±5.45	0.038
CAT (kU/L)	40.5±5.32	36.6±5.3	0.013
Maximum oxygen uptake (mL/min)	3513.4±64.47	3591.7±67.8	0.011

exercise time was lower than that of the placebo treatment, and the average power was higher than that of the placebo treatment. However, no significant differences were observed.

Correlation between oxygen uptake and time consumption, average power, and antioxidant enzyme activity

The maximum oxygen uptake was negatively correlated with time consumption ($\gamma = -0.754$) ($P < 0.05$) and positively correlated with SOD activity ($\gamma = 0.713$) ($P < 0.05$). There were no linear correlations with GSH (Glutathione, r-glutamyl cysteingl + glycine) and CAT activities. Compared with taking placebo in the experimental group, the increase of the maximum oxygen uptake after taking the green tea active extract showed no linear correlation with the increase of SOD activity in the antioxidant enzyme system of the body.

Discussion

The outcomes of human exercise experiments are inherently susceptible to numerous variables, particularly the activity of enzymes, which tend to exhibit substantial variations. The design of exercise experiments always endeavors to mitigate the influence of non-experimental factors, yet their impact remains inevitable. When athletes served as the subject of this research, the experiment encountered an even greater number of influencing factors, which included that athlete engaged in training tasks, and such training was prone to causing injuries, significantly affecting the measurement of indicators. There were numerous interfering factors when experiments were conducted at varying times and with different athletes. To ensure the credibility of the experimental outcomes, rigorous efforts should be devoted to the design of experiments, which might include that every effort should be made to eliminate interfering factors, and the existence of interfering factors should be detected if interfering factors were present.

Green tea active extract mainly contains tea polyphenols, caffeine, catechins, flavonoids, and other bioactive components. These components have good antioxidant, anti-inflammatory, anti-cancer, anti-hypertensive, anti-hyperlipidemic and weight loss activities. Green tea active extract taken by female athletes after exhaustive exercise significantly enhanced serum antioxidant enzymes like superoxide dismutase, glutathione peroxidase, and catalase, improving antioxidant capacity. It also boosted maximum oxygen uptake, indicating an enhancement in aerobic capacity. The superoxide dismutase activity positively correlated with maximum

oxygen uptake, suggesting a simultaneous enhancement in antioxidant and aerobic functions by green tea extract.

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