Progress in Nutrition 2021; Vol. 23, N. 3: e2021298 DOI 10.23751/pn.v23i3.10867

Original article

Fatigue Relief for Tennis: Nutritious High-Protein Drink

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Abstract. *Objective:* This study aims to analyze the fatigue relief effect of nutritious high-protein drinks for tennis players after training. *Methods:* Twenty tennis players were randomly divided into two groups: group A and group B. One group took a nutritious high-protein drink, and the other group took pure water. They received two months of tennis training, and the related indexes were measured. *Results:* After the experiment, the movement speed of the two groups of athletes increased, the fat-free weight increased, and $p < 0.05$ in the comparison of group A and B; compared to before experiment, the red blood cell (RBC) and hemoglobin (Hb) of group A increased, the blood urea nitrogen (BUN) and creatine kinase (CK) of group B significantly increased, and the blood lactic acid (BLA) value of group A was significantly lower than that of group B after the experiment ($p < 0.05$). *Conclusion:* The intake of nutritious high-protein beverages can maintain the stability of indexes such as RBC, inhibit the production of BLA, and reduce the increase of BUN and CK, which is conducive to the relief of fatigue.

Key words: Tennis, exercise fatigue, fatigue relief, nutritious high-protein drink

Introduction

Because of the increasing attention and love for sports activities, various sports events have been widely concerned by people. Tennis, as a popular ball game, needs a lot of training. After training, athletes often have the symptom of fatigue, which will lead to the decline of physical and psychological performance (1). How to quickly relieve fatigue has been widely concerned by researchers. Studies have shown that the supplement of nutritious food is effective in eliminating fatigue (2). Through the exhaustive swimming test of mice, Wei (3) found that puerarin was significantly effective in reducing exercise fatigue and that it could enhance the exercise performance of mice by reducing the increase of hemoglobin, platelet, etc., and blood viscosity. Mumford et al. (4) randomly assigned a supplement or a placebo containing caffeine to 12 golfers. The analysis found that the athletes supplemented with caffeine had better performance and milder fatigue. Miao (5) fed 40 mice with different concentrations of maca polypeptide. After two weeks, the physiological indexes of the mice were measured. It was found that maca polypeptide had an anti-fatigue effect, and the higher the concentration was, the better its performance was. Domínguez et al. (6) studied beetroot juice and found that single or continuous uptake of beetroot juice could promote the resynthesis of phosphocreatine and improve muscle strength output and fatigue index. In this study, twenty tennis players were divided into two groups. They were given a nutritious high-protein drink and pure water, respectively. After two months of tennis training, the blood routine and other indicators of the two groups were compared to confirm the positive effect of nutritional high-protein drinks on fatigue relief. The present study provides some theoretical bases for the further application of nutritious high-protein drinks in sports training.

Nutritious and High-Protein Beverage

Sports drinks refer to the drinks that can supplement substances such as water and energy for the body and are quickly absorbed by the human body. They can effectively maintain body fluid balance and

quickly restore physical fitness. The main raw materials of sports drinks include water, minerals, protein, etc. In recent years, sports drinks have become more and more popular (7). Whey protein has characteristics of high protein, low fat, and good absorption (8). The content of amino acids in sports drinks is very high, and it has effects of lowering blood fat and blood sugar (9). In the process of exercise, athletes have a greater demand for protein. If protein is insufficient, negative nitrogen balance may appear, which is not conducive to the recovery of physical fitness. Whey protein can be used as a supplement of protein during exercise. In this study, the effect of the high-protein beverage containing whey protein on fatigue recovery was studied, and its nutritional components are shown in Table 1.

Research Methods

Research Subjects

Taking 20 men players from the tennis team of the Department of P.E. of Xi'an University of Architecture & Technology as an example, all athletes understood the purpose and process of the experiment and signed informed consent. Before the experiment, they did not take strenuous exercise and did not eat food containing coffee and tea. They were healthy and in good mental condition. The dominant hand of them was the right hand. They were randomly divided into group A and group B. Group A took the nutritious high-protein beverage, while group B took the pure water. The comparison of the general information is shown in Table 1.

Table 1. Nutrient composition of the high-protein beverage

Component	Every 100 ml	NRV/%
Energy	78 KJ	1%
Protein	4.6 g	8%
Fat	0 g	0%
Carbohydrate	0 g	0%
Sodium	6 mg	0%
Vitamin B6	0.08 mg	6%
Vitamin B12	0.10 μg	4%
Nicotinamide	0.60 mg	4%

Methods

During the experiment, the two groups of athletes completed the same training task. Under the coach's arrangement, tennis training was conducted once every morning and afternoon, each time for 2.5 h. Group A took 400 mL of the nutritious high-protein drink half an hour before training, half an hour after training, and one hour before going to bed, while group B took 400 ml of pure water at the same time points. The experiment lasted for two months. In the experimental period, the athletes ate in the canteen without additional nutrition supplements. Before and after the experiment, the weight of athletes was measured, and venous blood was collected.

Measurement Index

1. Body composition: the fat-free weight of athletes.
2. Blood routine examination: red blood cell (RBC) count, hemoglobin (HB) concentration, and hematocrit (HCT) of athletes.
3. Blood biochemical examination: blood lactic acid (BLA) concentration, blood urea nitrogen (BUN), and creatine kinase (CK) of athletes.

The body composition of the athletes was measured by the experiment personnel. The blood samples were sent to Shaanxi Provincial People's Hospital to detect blood routine and biochemical indexes.

4. Movement speed: before and after the experiment, a tennis match was held to record the maximum and average movement speed of the athletes.

Table 2. General information of athletes

	Group A (n = 10)	Group B (n = 10)
Age/year	22.35±1.27	23.04±1.19
Height/m	175.64±5.33	174.29±4.87
Weight/kg	63.58±5.26	64.77±4.92
Training years/year	4.31±0.89	4.25±0.76

Statistical Analysis

The data were statistically analyzed in SPSS17.0. Data were expressed by $(\bar{x} \pm SD)$. An independent sample t-test was carried out. P < 0.05 meant that the two groups of data had a statistic difference.

Results

Changes of Movement Speed

The movement speed changes of the two groups of athletes before and after the experiment are shown in Figure 1.

Before the experiment, the average speed of the two groups was 3.73 ± 0.78 m/s and 3.74 ± 0.69 m/s respectively, and the maximum speed was 4.21 ± 0.51 m/s and 4.19 ± 0.59 m/s, respectively. After the experiment, the movement speed of athletes increased; the average speed of group A and group B were 4.27 ± 0.64 m/s and 3.98 ± 0.71 m/s, respectively, and the maximum speed was 4.92 ± 0.33 m/s and 4.51 ± 0.46 m/s, respectively. The results showed that the movement speed of group A significantly improved after the experiment compared with that before the experiment and compared with group B. The results revealed that the fatigue of the athletes was effectively alleviated after the intake of the nutritious high-protein beverage, thus obtaining better training performance.

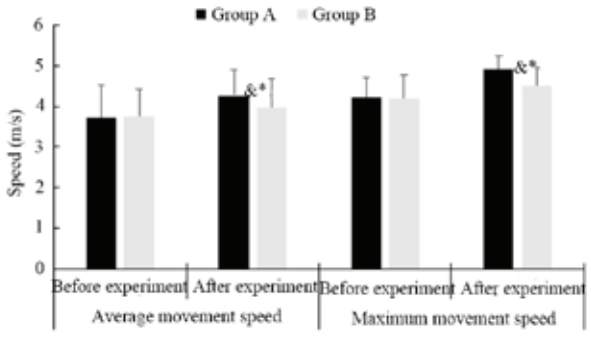

Figure 1. Changes of movement speed

Changes in Body Composition

The changes in body composition of the two groups of athletes before and after the experiment are shown in Figure 2.

As shown in Figure 2, before the experiment, the fat-free weight of groups A and B was 52.37 ± 0.56 kg and 51.68 ± 0.73 kg, respectively, and there was no significant difference; after the experiment, the fat-free weight of athletes in group A increased to 55.84 ± 1.12 kg, and P < 0.05 compared to before the experiment, i.e., the difference was significant; after the experiment, the fat-free weight of athletes in group B increased to 53.16 ± 0.97 kg, which was not significantly different with that before the experiment, but the fat-free weight of group A was significantly higher (p < 0.05), which indicated that the muscle of the athletes in group A fully grew.

Changes in Blood Routine Indexes

The changes in blood routine indexes of the two groups of athletes before and after the experiment are shown in Table 3.

As shown in Table 3, before the experiment, there was no significant difference in the indexes between the two groups of athletes; after the experiment, the RBC of athletes in group A significantly improved, reaching 5.12 ± 0.1710^{12}/L, and P < 0.05 compared to that before the experiment; after the experiment, the RBC of group B also increased, but the difference was not

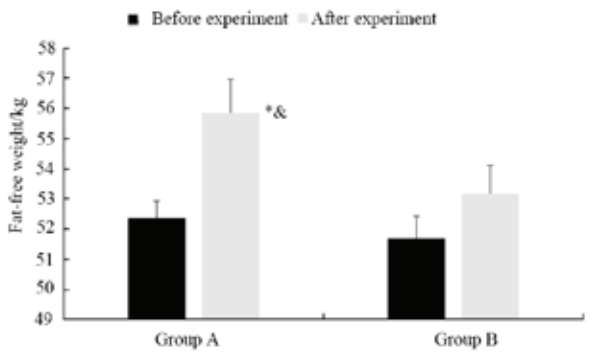

Figure 2. Changes in body composition
Note: *: p < 0.05 compared to group B; &: p < 0.05 compared to before experiment.

Table 3. Changes in blood routine indexes

	Group A		Group B	
	Before the experiment	After the experiment	Before the experiment	After the experiment
RBC (10^{12}/L)	4.72±0.27	5.12±0.17&	4.81±0.29	4.69±0.33
HB (g/L)	137.64±5.12	140.29±5.18*&	138.34±4.69	130.78±4.58
HCT (%)	34.28±1.07	38.27±0.93	35.76±1.29	38.77±0.84

Note: * means $p < 0.05$ compared to group B; & means $p < 0.05$ compared to before experiment.

significant, and the difference between group A and group B was significant; after the experiment, the HB of athletes in group A also increased significantly, the HB of athletes in group B decreased to 130.78 ± 4.58 g/L, and $P < 0.05$ in the comparison between group A and group B, i.e., the difference was significant; after the experiment, the HCT of the two groups of athletes increased, but compared with that before the experiment and between groups, $P < 0.05$, i.e., the difference was not significant. It was found from Table 1 that the intake of the nutritious high-protein beverage had a positive effect on maintaining RBC function and inhibiting the decrease of Hb.

Changes in Biochemical Blood Indexes

The change in the BLA value of the two groups of athletes before and after the experiment is shown in Figure 3.

Before the experiment, the BLA values of group A and group B were 3.33 ± 0.22 mmol/L and 3.51 ± 0.27 mmol/L respectively, $P > 0.05$; after the experiment, the BLA values of the two groups increased significantly, and $P < 0.05$ compared with those before the experiment; the BLA value of group A increased to 8.12 ± 0.31 mmol/L, and that of group B increased to 10.73 ± 0.33 mmol/L, i.e., the BLA value of group A was significantly smaller, and the difference was significant. It was found from Figure 3 that the intake of the nutritious high-protein beverage could inhibit the production of BLA in blood.

The change of the BUN value of the two groups of athletes before and after the experiment is shown in Figure 4.

Before the experiment, the BUN values of the two groups were 4.21 ± 0.72 mmol/L and 4.18 ± 0.33mmol/L, respectively ($P < 0.05$), i.e., there was no significant difference between the two groups. After the experiment, the BUN value of group A was 4.22 ± 0.56 mmol/L, while that of group B was 4.53 ± 0.81 mmol/L ($P < 0.05$). It was found that the intake of the nutritious high-protein beverage could inhibit the increase of BUN.

Before and after the experiment, the change of the CK value of the two groups of athletes is shown in Figure 5.

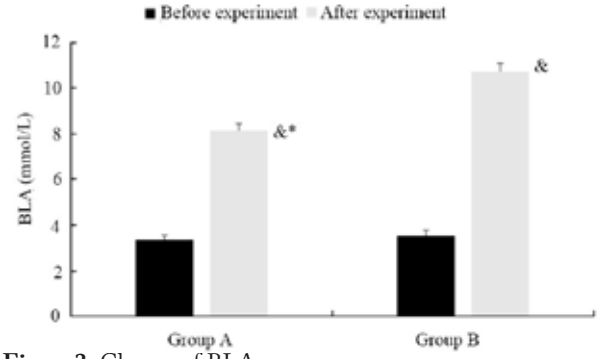

Figure 3. Change of BLA
Note: $p < 0.05$ compared to before group B; &: $p < 0.05$ compared to before experiment.

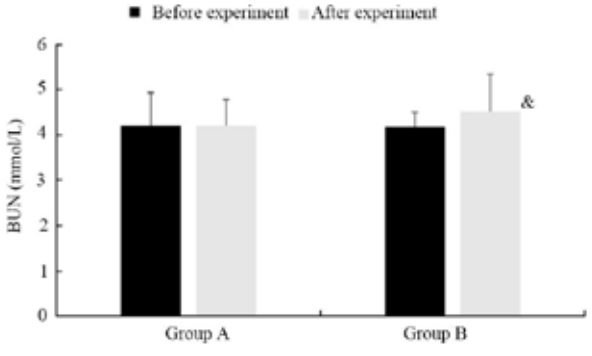

Figure 4. Change of BUN
Note: &: $p < 0.05$ compared to before experiment.

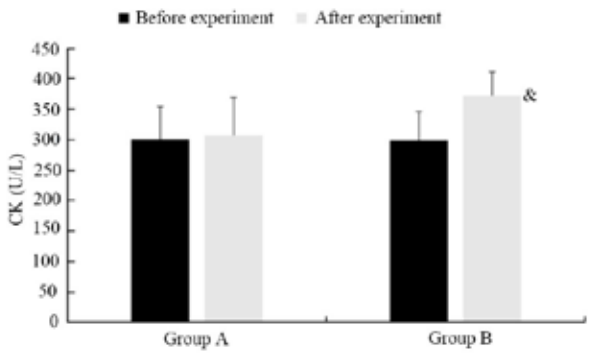

Figure 5. Change of CK
&: Compared with that before the experiment, P < 0.05

Before the experiment, the CK values of the two groups were 299.78 ± 53.69 U/L and 298.36 ± 48.33 U/L, respectively. After the experiment, the CK value of group A was 307.29 ± 61.33 U/L, which was slightly higher than that before the experiment ($p < 0.05$), while the CK value of group B was 371.64 ± 40.22 U/L, significantly higher than that before the experiment, but $P > 0.05$ in the comparison between group A and B. It was seen from Figure 5 that the nutritious high-protein beverage could reduce the increase of CK level in blood.

Discussion

Tennis originated in France at first and then became popular all over the world. In China, tennis has also been developing rapidly. There are many high-level tennis competitions held in China. With the development of tennis, the requirements for players' skills and levels have become higher and higher, which can not be separated from long-term and comprehensive training. In training, athletes' physical fitness is quickly consumed; therefore, it is very important to relieve fatigue as quickly as possible.

It was found from the experimental results that the movement speed of group A significantly improved, and the fat-free weight increased significantly after the experiment. Muscle strength is related to muscle volume, and muscle strength can also be improved by promoting muscle growth. Whey protein can promote muscle growth (10). According to the experimental results, it was found that athletes' muscle mass and physical fitness increased after the intake of the nutritious high-protein beverage.

In the process of exercise, the blood will transport oxygen to the relevant organs and make use of it. As the exercise goes on, the RBC of the human body will decrease, the HB level will decrease, and the oxygen-carrying capacity will be weak, which is more likely to induce fatigue. It was found from the experimental results that the RBC and HB values of group B decreased after the experiment, while those of group A increased. It showed that the intake of the nutritious high-protein beverage could ensure the stability of these indexes and avoid significant reductions, thus promoting the alleviation of fatigue.

The body's high-intensity exercise will lead to muscle hypoxia, consume a large amount of glycogen, and produce pyruvate (11). The higher the concentration of pyruvate is, the higher the content of BLA is. The accumulation of BLA will make muscles ache and make the human body feel fatigued. It was found from the experimental results that the BLA value of athletes increased significantly after the experiment, but the increase of group A was smaller, and $p < 0.05$, which demonstrated that the nutritious high-protein beverage was effective in reducing the production of BLA and was conducive to the alleviation of fatigue.

BUN is the final product of protein metabolism. Dehydration caused by a lot of exercises may cause an increase in BUN. After the experiment, the BUN values of the two groups of athletes increased; the BUN value of group B after the experiment was significantly larger than that before the experiment, while the change of group A was not obvious. It showed that the intake of the nutritious high-protein beverage could inhibit the increase of BUN and promote the alleviation of fatigue.

CK, an energy converting enzyme (12), mainly distributes in skeletal muscle (13), which is related to glycolysis, muscle contraction, etc., and its elevation will cause muscle soreness. It was found from the results that the CK value of group B increased significantly after the experiment, $p < 0.05$ compared to before the experiment, but the change in the CK value in group A was not obvious, which showed that the nutritious high-protein beverage could reduce the

production of CK and inhibit the activity of CK and had a positive effect on the alleviation of fatigue.

Conclusion

This paper mainly analyzed the effectiveness of the nutritious high-protein beverage in relieving fatigue. Taking 20 tennis players as an example, the experiment was carried out, and the blood routine and biochemical blood indexes were compared and analyzed. It was found that the intake of the nutritious high-protein beverage could improve the movement speed of athletes, increase the fat-free weight, ensure the stability of HB, RBC, etc., inhibit the accumulation of BLA, and reduce the increase of BUN and CK, thus promoting the relief of fatigue. The nutritious high-protein beverage can be promoted and applied in practice.

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