

Research Article

Research on the Effect of Anti-fatigue Refreshing Drink Supplement on Blood Glucose in Exercise

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Abstract: The effect of anti-fatigue refreshing drinks on blood glucose in the body exercise is understood to provide the basis for screening efficient anti-fatigue refreshing drinks. The double blind method and self-contrasted method are used to test the quantitative load exercises of 24 healthy and male college students majoring in the long-distance race and within 5 min after the exercise, individual supplement of high and low-concentration anti-fatigue refreshing drinks is conducted and an hour later, the physical fitness test for 12-min long-distance race is carried out. After the subjects supplement refreshing drinks D₁, D₂, D₃ and D₄, blood glucose response is the most obvious between 0.5 and 1.0 h and there is significant difference between high-concentration drinks and low-concentration drinks; after the same supplement, no significant difference exists for subjective sensation of physical ability; after the supplement of high-concentration refreshing drinks, the heart rate recovers quickly and there is no significant difference between two drinks; after the subjects supplement refreshing drinks D₁, D₂, D₃ and D₄, the physical fitness test for runners is conducted for 12 min, with results showing that there is no significant difference between refreshing drinks D₁, D₂, D₃ and D₄. After the quantitative load operation for individual, refreshing drinks D₁, D₂, D₃ and D₄ facilitate the blood glucose response and heart rate recovery after exercise and the recovery effect of high-concentration drinks is stronger than that of low-concentration drinks, but there is no significant difference between both refreshing drinks.

Keywords: Anti-fatigue, blood glucose in human body, individualization, refreshing drinks

INTRODUCTION

Currently, although Chinese athletes largely use sports nutrition, these nourishments have not been tested for constitution and content by any professional authority and have not been assessed for safety and efficiency (Hongju and Fuxing, 2011). In “Manual of China’s National Team on Centralized Procurement of Sports Nourishments (Version 2009)” prepared by China Sports Science Society, two kinds of nourishments, i.e., CPT Power Restorative and Metagenics All-round Restorative, are selected to eliminate physical fatigue of athletes and recover blood glucose in human body (Jianhua *et al.*, 2011). By individual supplement test, this paper aims to study the influencing mechanism of anti-fatigue refreshing drink supplement on blood glucose in human body and provide the basis for athletes to select efficient sports nutrition and meanwhile to help Chinese athletes to scientifically and reasonably select sports nutrition, standardize the nutrition market and assess currently long-acting nourishments for athletes (Van Loon, 2007).

MATERIALS AND METHODS

After signing the “Informed Consent Form”, 24 male students majoring in long-distance race from a

Table 1: Basic information of subjects

Age (years)	Height (cm)	Weight (kg)	VO ₂ max (mL/min/kg)
22.0±1.5	176.2±5.3	68.0±9.2	51.6±7.3

sports university volunteer to participate in this test, with overall conditions as Table 1.

Research method:

Test procedures and test arrangement: The subjects are tested for maximum oxygen uptake at the lab of Sports Nutrition Research Center under the Institute of Sports Medicine of the State General Administration of Sports, with test environment: 25°C, 1004 mbar. The subjects are loaded progressively on the bike, with start loads at 80 and 20W for 2 min (Xiao, 2005). After signing the “Informed Consent Form”, these 24 subjects become volunteers of this test and participate in 4 field exercise tests respectively, with test interval of 7 days and test procedures as shown in Fig. 1.

Four field tests are conducted at the ground track field of Peking University. On the test day, these subjects are recorded for morning pulses and their morning urines are placed and they eat breakfast on time (rest for one hour after the meal) and prepare for site test. They keep quiet for 10 min at the test site, with placement of heart rate monitors. The subjects run for an hour at the heart rate corresponding to 60% of maximum

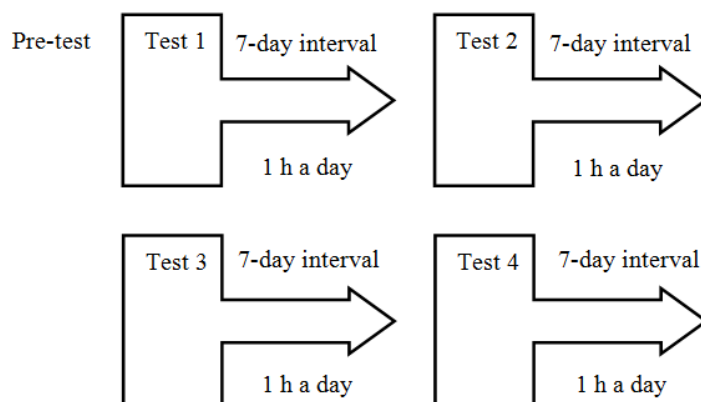


Fig. 1: Schematic diagram for test procedures

Table 2: Drink supplement composition for the subjects

Test	D ₁	D ₂	D ₃	D ₄
Test 1	1, 3, 7	2, 8, 5	4, 9, 11	6, 10, 12
Test 2	6, 12, 7	1, 2, 11	3, 9, 10	4, 5, 8
Test 3	4, 6, 10	5, 11, 12	1, 2, 9	3, 7, 8
Test 4	3, 5, 9	4, 8, 10	6, 7, 12	1, 2, 11

oxygen uptake (60% VO₂max) and are tested for blood glucose and lactic acid after exercise, with venous blood drawing and heart rate recording. Within 5 min after exercise, the subjects are nourished by two kinds of sports drinks with different concentrations according to the nutrition table as shown in Table 2. They are tested for blood glucose and lactic acid 30 min after exercise (Chen *et al.*, 2013). Their venous bloods are drawn one hour after exercise; meanwhile, they are tested for blood glucose and lactic before and after the physical fitness test for 12 min, respectively and their urines are collected for test (Burke *et al.*, 2004).

Exercise training and sports drink supplement: The interval for each test is 7 days in order to reduce the impact of each sports drink supplement. The subjects take exercise once a day, the exercise content is long-distance run for 1 h and the exercise intensity is controlled at the heart rate corresponding to 60% of maximum oxygen uptake (60% VO₂max). During the exercise process, the subjects are nourished with fresh water only and cannot be nourished with any type of refreshing drink. On the test day, the double blind method and self-contrasted method are used to make the subjects take quantitative load exercises and randomly drink high and low-concentration refreshing drinks “CPT Power Restorative” and “Metagenics All-round Restorative”. In each test, six subjects in a group take one kind of sports drink simultaneously (Table 2).

Diet control and refreshing drink preparation during the test: Two days before test, the subjects are given a copy of “Diet Record Table” in order to record their daily meal content and food intake. On the test day, high intensity exercise should be avoided and the subjects cannot take food after supper and can only drink fresh

water. The subjects cannot add food by themselves and can only eat foods in “Diet Record Table” on the test day. At the time of breakfast, lunch and supper of one day before test and at breakfast on the test day, the computer software “Chinese Athlete and Public Dietary Nutrition Analysis and Management System” is used to prepare the recipe for the subjects and provide meals strictly according to the recipe, ensuring that the subjects eat the same food under the same conditions. Total daily energy of each subject is 2700 kcal, 682 kcal at breakfast, 1055 kcal at lunch and 1032 kcal at supper, including 60% carbohydrate, 26% fat and 14% protein. According to “Nourishments for Eliminating Physical Fatigue and Promoting Recovery” in “Manual of China’s National Team on Centralized Procurement of Sports Nourishments (Revised in 2009)” prepared by China Sports Science Society, two kinds of refreshing drinks are selected, including CPT Power Restorative (developed and manufactured by Beijing Competitor Wuchuang Technology Co., Ltd.) with main ingredients being glutamine, taurine, creatine, glucose and vitamin C and Metagenics All-round Restorative (developed and manufactured by Metagenics) with main ingredients being whey protein hydrolysate, oligosaccharide, vitamin, electrolyte and mineral substance. These two refreshing drinks are prepared at the standard ratio of carbohydrate supplementation to body weight into a high-concentration drink (carbohydrate supplementation: 1.5 g/kg* body weight) and a low-concentration drink (carbohydrate supplementation: 0.5 g/kg* body weight).

Test index and method: Table 3 shows the Rating of Perceived Exertion.

Blood glucose concentration measurement: A test paper method, i.e., glucometer and test paper (developed

Table 3: Rating of perceived exertion

Number of cycles	Subjective sensation
6	No feeling
7-8	Extremely relaxed
9-10	Very relaxed
11-12	Relaxed
13-14	A bit tired
15-16	Tired
17-18	Very tired
19-20	Extremely tired

and manufactured by Life Scan Co., Lt. in the U.S), is used for blood glucose measurement.

Blood glucose response IAUC: A curve of blood glucose response is drawn by time as X-coordinate and blood glucose level as Y-coordinate, with test formula as follows:

$$IAUC = \sum_n^{x=1} AX$$

Suppose the time t0, t1 ... tn represent 0, 15 ... 120 min, respectively, blood glucose concentrations are expressed as G0, G1 ... Gn IAUC.

Blood lactic acid concentration measurement: Portable type blood lactic acid tester (M1025 Type) and special test strip (Lactate Pro) are used to test blood lactic acid.

Physical fitness test: The subjects take exercise of long-distance run for 12 min at the ground track field of Peking University and their running distances are recorded.

Rating of perceived exertion: The subjects keep quiet for 10 min at the test site, wear psychological instrument and know well the rating of perceived exertion and inquire about heart rate for each cycle and rating of perceived exertion.

Statistics: The above-mentioned data are expressed as "M±S.D." and the software "SPSS 16.0" is used for statistics. GLM Repeated Measures is used to test blood glucose responses. When overall difference is obvious, Post Hoc Tests is used to test the differences at different time of each test, with significance level being

"α = 0.05". Blood glucose IAUC is tested with ANOVA method, with significance level being "α = 0.05".

TEST RESULTS

Change of blood glucose concentration after supplement of different refreshing drinks: As shown in Table 4, blood glucose responses of the subjects are most significant between 30 and 60 min after supplementing refreshing drinks D₁, D₂, D₃ and D₄ and there is significant difference between both high-concentration refreshing drink and low-concentration drink (p = 0.034 in comparing high-concentration CPT Power Restorative A with low-concentration CPT Power Restorative; p = 0.015 in comparing high-concentration Metagenics All-round Restorative with low-concentration Metagenics All-round Restorative) and 60 min after the supplement, there is significant difference between high-concentration CPT Power Restorative A and low-concentration CPT Power Restorative (p = 0.008).

IAUC values of blood glucose responses after supplement of different refreshing drinks: As shown in Table 5, blood glucose response IAUC of high-concentration CPT Power Restorative increases by 54.6% over low-concentration CPT Power Restorative, by 26.7% over high-concentration Metagenics All-round Restorative and by 96.4% over low-concentration Metagenics All-round Restorative. The blood glucose response IAUC of high-concentration Metagenics All-round Restorative is obviously under that of high-concentration CPT Power Restorative, increasing by 21.7% over low-concentration CPT Power Restorative and by 56.5% over low-concentration Metagenics All-round Restorative. The effects of high-concentration CPT Power Restorative and high-concentration Metagenics All-round Restorative on blood glucose responses of the subjects are not significantly different, the effect of high-concentration CPT Power Restorative on blood glucose response is significant compared with low-concentration CPT Power Restorative as well as low-concentration Metagenics All-round Restorative and meanwhile the effect of high-concentration Metagenics All-round Restorative is significant compared with low-concentration Metagenics All-round Restorative.

Table 4: Comparison of blood glucose concentrations after supplement of different refreshing drinks (unit: mmol/L)

Time	D ₁	D ₂	D ₃	D ₄
Before test	5.79±0.81	5.72±0.61	6.19±0.71	5.89±0.83
0 min after test	5.30±0.81	5.22±0.81	5.39±0.71	5.39±0.73
30 min after test	7.79±0.81 ¹	7.72±0.81 ¹	7.69±0.99 ¹	6.89±0.82 ¹
60 min after test	6.79±1.81 ²	5.32±1.31 ²	6.16±0.81 ²	5.69±0.23 ²
After physical fitness test	6.79±1.81 ¹	6.72±1.61 ¹³	7.19±1.71 ¹³	6.19±1.23

¹: Immediate comparison after test; ²: Comparison made 30 min after test; ³: Comparison between before test and after test, p<0.05

Table 5: Blood glucose response IAUC after supplement of different refreshing drinks (unit: mmol/L*min)

Time	D ₁	D ₂	D ₃	D ₄
Blood glucose IAUC	102.11±45.81 ^{1,2}	66.12±42.61	81.19±41.71 ²	52.89±32.23

¹: Comparison with low-concentration CPT power restorative; ²: Comparison with low-concentration metagenics all-round restorative, p<0.05

Table 6: Rating of Perceived Exertion (RPE) of the subjects after supplement of different refreshing drinks (unit: mmol/L*min)

Time	D ₁	D ₂	D ₃	D ₄
Before supplement of sports drink	16.32±1.30	16.15±0.38	17.24±1.49	16.18±0.75
60 min after supplement of sports drink	15.42±0.75	15.76±0.21	16.62±1.99	15.18±0.35
Immediately after 12-min long-distance run	17.64±1.65	17.89±0.68	18.24±1.59	17.12±1.45

Table 7: Changes in heart rates of the subjects after supplement of different refreshing drinks (unit: times/min)

Time	D ₁	D ₂	D ₃	D ₄
Before supplement of sports drink	16.32±1.30	16.15±0.38	17.24±1.49	16.18±0.75
One hour after exercise	71.22±2.75	72.26±1.31	69.62±2.69	75.18±3.05
0 min after 12-min long-distance run	163.64±12.65	166.69±14.68	159.24±15.59	161.72±10.45
3 min after 12-min long-distance run	172.32±12.30	178.15±16.38	174.24±18.49	176.48±13.75
5 min after 12-min long-distance run	89.42±17.75	96.76±14.21	97.62±13.99	102.28±12.35
8 min after 12-min long-distance run	73.14±4.65	74.89±5.68	72.24±3.59	74.12±7.45
Morning pulse on the next day	51.32±4.30	56.15±6.38	52.24±5.49	53.18±7.75

Table 8: Physical fitness test results of the subjects after supplement of different refreshing drinks

	Blood lactic acid concentration (unit: mmol/L)		Test result of 12-min long-distance run (m)
	Before exercise	1 h after exercise	
D ₁	3.32±1.30	4.15±1.38	2779.32±276.30
D ₂	4.12±0.75	5.26±2.31	2995.22±210.75
D ₃	3.14±0.65	4.69±1.68	2814.64±306.65
D ₄	3.64±0.65	4.69±1.68	2912.64±267.65
	Blood lactic acid concentration (unit: mmol/L)		Test result of 12-min long-distance run (m)
	Before 12-min long-distance run	After 12-min long-distance run	
D ₁	4.24±2.49	12.18±3.75	2779.32±276.30
D ₂	3.62±1.69	14.18±3.05	2995.22±210.75
D ₃	5.24±3.59	12.72±5.45	2814.64±306.65
D ₄	4.24±1.59	13.72±3.45	2912.64±267.65

Effect on athletic ability after supplement of different sports refreshing drinks:

Rating of perceived exertion after supplement of different sports refreshing drinks: As shown in Table 6, there is no significant difference between Ratings of Perceived Exertion (RPE) for 4 refreshing drinks and this shows that no significant effect on rating of perceived exertion is made during the test after the supplement of sports refreshing drinks with different concentrations.

Effect on heart rate after supplement of different sports refreshing drinks:

As shown in Table 7, after the supplement of sports drinks D₁, D₂, D₃ and D₄, the heart rates of the subjects are compared 3, 5 and 6 min, respectively after physical fitness test (relative to the quiet state before exercise). After supplement of refreshing drinks, there is no significant difference between heart rates at different time points. After supplement of refreshing drinks, there is no significant difference for morning pulses on the next day (relative to basic comparison table).

Effect on physical fitness test after supplement of different sports refreshing drinks:

As shown in Table 8, there is no significant difference between sports drinks D₁, D₂, D₃ and D₄ 6 min after the supplement of sports refreshing drinks D₁, D₂, D₃ and D₄, respectively.

ANALYSIS AND DISCUSSION

Refreshing drinks are functional drinks with high nutrition and high bioactivity which satisfy the demand for self-metabolism and physiological function and help athletes to quickly recover energy (Jianhua *et al.*, 2011). Refreshing drinks are nutritious foods reasonably used to replenish energy, promote human health, improve athletic ability and solve the exercise problem. Currently, refreshing drinks are divided into two categories: “sports nutrition supplements” and “sports body function modifiers” and the latter falls into “energy metabolism modifier”, “muscle function state modifier”, “physical power restorative”, “weight control modifier” and “immunologic function modifier”.

Physical power recovery in exercise mainly depends on blood glucose and the reduction of concentration and muscle glycogen storage capacity of blood glucose could result in fatigue of athletes (Van Loon, 2007). Practices have proved that during the athletic competition, to supplement exogenous carbohydrate at different time can increase the glucose uptake by muscles and the internal muscle glycogen storage capacity and delay fatigue. It is found in this study that after the supplement of sports refreshing drinks D₁, D₂, D₃ and D₄, the heart rates of the subjects

recover by 50% within 5 min after test and basically recover within 8 min. After the supplement of high-concentration refreshing drinks, the heart rates recover more quickly than low-concentration refreshing drinks and there is significant difference ($p < 0.05$). During the supplement of refreshing drinks, there is no significant difference between heart rates at different time points. One hour after the supplement of refreshing drinks D₁, D₂, D₃ and D₄, a physical fitness test of 12-min long-distance run is conducted and it is found that there is no significant difference between Rating of Perceived Exertion (RPE) immediately after test and RPE before such supplement and there is also no significant difference between the results for physical fitness test of 12-min long-distance run. This fully demonstrates that two refreshing drinks facilitate physical power recovery and the effectiveness of high-concentration refreshing drink is more significant than that of low-concentration refreshing drinks. During the test process, after the supplement of high and low-concentration sports refreshing drinks, there is no significant difference between Rating of Perceived Exertion (RPE) and physical fitness test results. For the ingredients of drinks supplemented for the subjects during the test, the all-round restorative (main ingredient: whey protein hydrolysate) and the power restorative (main ingredient: glutamine, taurine and creatine) have significant anti-fatigue effect, but the test results in this study have not been enough to distinguish between them by their advantages and disadvantages. There are accordingly differences between them for anti-fatigue and physical power recovery mechanism, with specific recovery mechanism to be researched.

CONCLUSION

This study has come to the following conclusions: after the quantitative load exercise test for college students majoring in long-distance run, individual supplements of CPT Power Restorative and Metagenics All-round Restorative can improve blood glucose response and heart rate recovery speed. Although the effect of high-concentration refreshing drinks is superior to that of low-concentration refreshing drinks, there is no significant difference between them.

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