Effects of Astaxanthin on Recovery from Whole Fatigue with Three Stepwise Exercises

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Journal Title: Hiro to Kyuyo no Kagaku

ISSN: 0913-0241

VOL.18;**NO.**1;**PAGE.**35-46(2003)

Abstract;This study was designed to evaluate the effects of astaxanthin (A) ingestion upon recovery from whole fatigue, that were generated by progressive loads of three stepwise exercise-30%HRmax, 50%HRmax, and 70%HRmax. Nineteen healthy volunteers were randomized into two groups: Group A (10 subjects) received oral astaxanthin capsule (5mg) daily for two weeks, while Group C (9 subjects) ingested oral placebo (C) capsule (5mg) with the double blind method. After a month from this ingestion, another capsules were taken again with cross-over system for the same subjects respectively. Comparative detections were practiced to estimate with effectiveness of A ingestion upon changing ratios between two groups. Significant difference between A and C groups were obtained to inhibit the increase of respiratory-circulatory function from expired gases analysis. Additionally sympathetic nervous activities (LF/HF ratio) during exercise and parasympathetic nervous activities (HF/TF 100) during recovery were observed to significant increase. Otherwise, blood serum concentration of LDL cholesterols showed significant decrease, while concentration of creatine phosphokinase had increased to higher level than that of C ingestion, significantly. Then, findings of the present study indicated that with astaxanthin ingestion for human, respiratory-circulation ability and activities of sympathetic nervous system were augmented to make efficient metabolism during exercise load. Those anti-fatigue and anti-oxidative function might be promoted for human to make recovery ability from the whole fatigue generated by exercise stress.

II. Study Design

Subjects took astaxanthin 5mg capsules (A capsules) or placebo-control 5mg capsules (C capsules) randomly daily for two weeks. As shown in Figure 1, subjects were induced with fatigue individually by three stepwise intensities of 30%, 50%, and 70% of maximum heart rate (HRmax) computed with Karvornen Formula before ingestion and 2 weeks after ingestion. Observed them for total of 20 minutes with the components of: 2 minutes rest; 1 minute warm-up; 3 minute each intensities of three stepwise running exercise, total of 9 minute; 3 minute cool-down; and 5 minute recovery time. During observation, electrocardiography and blood pressure were measured, and the safety of subjects were considered. These exercise stress test were done before and after each ingestion, and a total of 4 times.

22 subjects were arranged for the ingestion test; however, 3 subjects were withdrawn due to the result of medical examination before the test, and 19 healthy subjects were chosen ultimately. Nineteen healthy volunteers were randomized into two groups: Group A (10 subjects) and Group C (9 subjects). Their background include, average age: 35.7±4.4 years, average body weight: 69.0±9.2kg, average body height: 170.6±3.8cm, rest heart rate:

74.8±14.5bpm, total cholesterol: 198±36mg/dl, lactic acid: 6.3±1.3mg/dl, CPK: 172.1±123.4IU, GOT: 24.9±9.3IU, TG: 155.6±161.1mg, and LDL: 305.6±46.4IU. The study started with double-blind system (First stage). Exercise stress load was done before and after 2 weeks of ingestion period. One month of rest period was provided after this ingestion. After a month from this ingestion, another capsule was taken again with cross-over system for two weeks for the same subjects respectively (Second stage).
Testing and Measuring items include the following five:
Expired Gases Analysis

Measured Ventilatory exchange volume (VE), Oxygen uptake per body weight (VO_2/kg), and Carbon dioxide output (VCO_2). Constantly collected and analyzed expired gases with breath-by-breath using Expired gases analysis system (RD17MX). Sampled the data of a minute of rest, exercise (last half of three stepwise intensities) and recovery time, and computed the average value.

Heart Rate Variability

Coefficient of variance of R-R intervals in electrocardiography was recorded by CM5 Precordial Leads method and heart rate variability spectrum was drawn by MemCalc method. 0.05Hz – 0.4Hz of power spectrum was set as total frequency band power density (TF), and 0.05Hz-0.4Hz was set as high frequency band power density (HF). LF/HF ratio (AU) was used as sympathetic nervous system activity. Also, coefficient of variance of R-R intervals (CV_{RR}) was found and used to evaluate the balance of autonomic nervous system.

Blood Pressure and Heart Rate (HR)

Systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate were periodically measured during rest and recovery time by STBP-780B of Oscillometric methods on brachial artery.

Blood Test

Tested 11 items before and after the exercise stress load, including: Total cholesterol (T-CHO), LDL-cholesterol and HDL-cholesterol, Tryglyceride (TG), Lactic acid (LA), Glucose (G), Malondialdehyde (MDA), Uric acid (UA), Creatine-phosphokinase (CPK), Pyruvic acid (PRY), Adrenalin, Noradrenalin, Dopamine of Catecholamine (CA). Sampled blood from median cubital vein 10 minutes before and after exercise, and analyzed by Scientific Resources for the Law (SRL, Inc.).

The values from before and after ingestion for these items were compared and examined. Tukey's method was used to find average value of each data and testing significant change ratio immediately after ingestion for testing. Significance level was set as less than 0.05.

III. Result

Expired Gases Analysis

Ingested astaxanthin (A capsules) and placebo (C capsules) for two weeks, and done 4 exercise stress tests before and after ingestion period. Ventilatory exchange volume (VE), Oxygen uptake per body weight ($\mathrm{VO_2}$/kg), and Carbon dioxide output ($\mathrm{VCO_2}$) during exercise and the change of the value before and after the ingestion are stated in Table 1 and Figure 2. VE showed a tendency of restraint of increase during exercise by A capsule ingestion than C capsule ingestion. Significant increase ($p<0.05$) was found during recovery time after exercise (Rec.1 and Rec.2). Similarly, $\mathrm{VO_2}$/kg and $\mathrm{VCO_2}$ showed the significant increase ($p<0.05$, $p<0.01$) during recovery time. Therefore, both values changed from 8% to 15% after A capsules ingestion than C capsules ingestion.

Heart Rate Variability

Coefficient of variance of R-R intervals $\mathrm{CV_{RR}}$(%) in electrocardiography, LF/HF ratio (AU) in heart rate variability spectrum, and the change of HF/TF*100(%) were collected as periodical data before and after A capsules and C capsules ingestion. These results were shown in Table 2 and Figure 3. All heart rate variability spectrum value showed the significant change during rest, exercise, and recovery time ($p<0.01$, $p<0.05$). Astaxanthin ingestion caused CV_{RR} and LF/HF to increase during the first half of exercise (Ex2 and Ex3) and recovery time (Rec2). Decreased during recovery time (Rec1), but increased during the last half of exercise (Ex3) and recovery time (Rec2).

Blood Pressure and Heart Rate

Change of blood pressure and heart rate after astaxanthin and control ingestion were shown in Table 3. After ingesting A capsules, SBP and DBP decreased significantly during recovery time based on the variability rate CR ($p<0.05$, $P<0.01$). HR had a tendency to increase during recovery time (Rec2) ($p<0.05$).

Blood Test Value

Changes of 11 items of blood serum concentration before and after A capsules and C capsules ingestion, and before and after exercise stress load, were shown in Table 4 and Figure 4. Compared with C capsules ingestion, A capsules ingestion caused LDL-cholesterol to decrease significantly. On the other hand, Creatine-phosphokinase (CPK) and Glucose (G) increased significantly ($p<0.0001$, $p<0.05$). Increase of CPK after exercise was especially remarkable. Comparison of post values between control and astaxanthin groups or changing ratio of before and after ingestion did not show significant change in other 8 items of blood serum concentration ($p>0.05$).