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Regular Exercise-training Affects Serum Lipid and Carnitine Profiles in Some College Students

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Abstract

This study investigated the effect of regular exercise on serum lipid profiles and carnitine levels in college students. Daily nutrient intake, anthropometry, serum lipid, and carnitine profiles in serum and urine were evaluated prior to beginning the study and after 35 days of treadmill running for 30 minutes per day. The results obtained were summarized as follows: 1) Concentrations of total lipid and triglyceride in serum were decreased by regular exercise in female subjects but unaffected in males. 2) Serum LDL-cholesterol was significantly decreased, but total cholesterol and HDL-cholesterol in serum were not affected in both male and female subjects. 3) Nonesterified carnitine, acid-insoluble acylcarnitine, and total carnitine levels in serum were not affected, but acid-soluble acylcarnitine level was increased by regular exercise in both subjects. 4) Urinary excretion of the acid-soluble acylcarnitine of female students was increased by regular exercise-training. These results suggest that regular exercise-training has different effects on serum lipid profiles depending on gender, and modulates several lipid profiles which was due to the acceleration of fat oxidation via carnitine metabolism in this condition.

Key words: regular exercise, college students, lipids, carnitines

INTRODUCTION

Exercise requires energy expenditure. Most muscles utilizes stored glycogen first for the production of energy and generates energy from fat. With exercise, there are fundamental changes in skeletal muscle energy metabolism that are dependent on exercise intensity and duration. It has been reported that regular exercise stimulates the muscle cells to have bigger mitochondria, the cellular structures conduct aerobic energy production, and that stored fat is used to generate energy for the working muscular movement(1). When constant-load exercise is performed at low intensity, there is an increase in both the plasma concentration and uptake of free fatty acids by exercising muscle(2). As free fatty acids become the major substrate for energy metabolism, there is a fall in the plasma concentrations of insulin and glucose(3). In contrast, with high-intensity exercise at a constant work load, carbohydrates serve as the primary substrate for exercising muscle, with an increase in the oxidation of amino acids also contributing to muscle energy metabolism(4).

Carnitine(β-hydroxy-γ-trimethylamino butyrate) is a quaternary amine which plays an important role in the lipid catabolism and energy production(5). It is a cofactor for a "shuttle" mechanism whereby long-chain fatty acids are made into acylcarnitine derivatives and transported across the inner mitochondrial membrane(which is impermeable to long-chain fatty acids per se and to their coenzyme A esters) for energy liberation via β-oxidation.

Exercise-training increases the capacity of the oxidative enzymes to metabolize free fatty acids. The increased transport of fatty acids into the mitochondria would be required. Therefore, changes in the carnitine level may represent an important biochemical adaptation to chronic training or acute activity(6). Many attempts have been made to find out the relationship between body fuel and carnitine metabolism. Most of the previous studies have been done with subjects who had westernized diets(7) and special conditions like athletes(8) and disease state(9).

The purpose of this study was to evaluate serum lipid and carnitine profiles prior to beginning the study and after 35 days of regular exercise-training in some male and female college students. Specifically the purposes of

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the present investigation were: 1) to determine if there were any differences in daily nutrient intake and anthropometry before and after exercise-training; and 2) to evaluate the effect of regular exercise-training(35 days) on lipid in serum and carnitine levels in serum and urine.

SUBJECTS AND METHODS

Subjects

Normal healthy college students(N=22, 11 males, 11 females) from the Yosu National University voluntarily provided informed consent to participate in the experiment.

Exercise-training

This study was practiced from October 7 to November 10 in 1996. The experimental subjects were run on a Vitamaster 8712WM treadmill(Vitamaster, Tokyo, Japan), for 30 minutes per day(10^0 incline, 3.0 km/h). During the experimental period, all subjects were encouraged to maintain their normal life and to avoid drinking alcohols and acute exercise.

Anthoropometry and collection of blood and urine

Body weight, height, mid-upper-arm-circumferenc (MUAC), skinfold triceps, skinfold subscapalar, and blood pressure were measured(10). Body mass index(BMI) was calculated. Immediately after physical assessment, 12 hours fasting blood samples were drawn from each subject in vaccum tubes. Urine from each subject was collected every 24 hour into a tared plastic container. Thymol was used as a preservative for urine. Serum and urine samples were kept frozen at -20°C until samples were analyzed.

Survey of dietary intake

The diet survey was conducted by 24-hour recall method for three consecutive days excluding weekends (11,12). All dietary intakes were assessed by the same reseacher who conducted the initial survey. Direct interview for each subject was carried out by using measuring instruments and book for eye measurement(13). Intakes of energy, carbohydrate, protein, fat, and other nutrients were calculated using nutrient contents of Korean foods(14). For each subject, an average value of three days for a particular nutrient was used as the mean daily intake for the nutrient and compared with Korean RDA.

Serum lipid parameters and urinary creatinine

Serum total cholesterol was analyzed with a commercial kit(Youngdong Pharmaceutical Co., Korea). HDL-cholesterol was analyzed with the same method, following the precipitaion of LDL and VLDL with dextran sulfate-Mg^{++}(Kyotto Pharmaceutical Co., Japan). LDL-cholesterol was calculated by substrating the combined VLDL and HDL which were assayed as mentioned above after precipitation of LDL-cholesterol using an assayed Quantolip commercial kit(Imuno AG, Wein, Austria). Triglyceride in plasma was assayed using a commercial kit(Youngdong pharmaceutical Co., Korea). Total lipid was analyzed with a commercial kit based on sulfo-phospho-vanillin method (Kokusai pharmaceutical Co., Japan). Urinary creatinine was determined by the alkaline-picrate method(15).

Analysis of carnitine

Nonesterified carnitines(NEC), acid-soluble acylcarnitines (ASAC), and acid-insoluble acylcarnitines(AIAC) in serum and urine were determined by the radio-enzymatic procedure of Cederblad and Lindstedt(16) as modified by Sachan and Rhew(17). In this method AIAC are precipitated with perchloric acid and centrifugation leaving the ASAC and NEC in the supernatant. An aliquot of the supernatant is assayed to determine the NEC and another aliquot hydroyzed with 0.5 mol/L KOH to assay all acid-soluble carnitines(ASAC+NEC). ASAC is calculated as the difference between the NEC and the total acid soluble carnitines. The pellets containing the AIAC are drained, washed, and hydrolyzed in 0.5 mol/L KOH for 60 min in a hot water bath at 60°C. In each case carnitine is assayed by using carnitine acetyl transferase (Sigma Chemical Co., St. Louis, MO, USA) to esterified the carnitine to a [^{14}C]acetate from [1-^{14}C]acetyl CoA (Amersham, USA). Radioactivity of samples was determined in a Beckman LS3801 liquid scintillation counter (Beckman Instruments, Palo Alto, CA).

Statistical analysis

All values are expressed as group means±SD. Significance of differences were determined by analysis of Student's t-test(paired t-test) using GraphPad Version 2.0(GrapPad San Diego, CA, USA). A $p<0.05$ or less was considered as having a significant difference.

RESULTS AND DISCUSSION

Anthropometry and nutrient intake

Anthropometric parameters of subjects are shown in Table 1. The mean daily intakes of energy, total fat, carbohydrates, and protein is shown in Table 2. During the 35 days of the experiment, there were no significant changes in their anthropometric measurements and their daily nutritional intakes by regular exercise-training on both male and female students. The mean daily energy intake of the male subjects was similar to the Korean RDA. However, female energy intake was 88% of Korean RDA. The proportions of energy in percentage contributed by carbohydrate : protein : and lipid were 59.3 : 20.6 : 20.1 for male and 63.25 : 13.46 : 23.29 for females, respectively. The energy ratios indicated that the protein and lipid intakes were higher in males and the lipid intake was much higher in females than in the Korean Nutritional Survey of 1993(18).

Lipid and lipoproteins

Generally, it has been considered that analysis of blood lipid fractions is the first method to diagnoses coronary heart disease and atherosclerosis. A previous study(19) has shown that maintaining the ratio of LDL- cholesterol/ HDL-cholesterol rather than total cholesterol at lower level in blood is the most effective way to prevent atherosclerosis and coronary heart diseases. Therefore, the LDL-cholesterol content is the main concern for lipoprotein metabolism because it has shown positive correlation to those diseases(20). In our study, regular exercise reduced plasma LDL-cholesterol concentration in both male and female students(Fig. 1). Parrel and Baboriak(21) has reported that exercise-training did not alter blood total cholesterol, a finding similar to ours, and they concluded that it was due to low cholesterol levels present before exercise- training. Exercise-training(aerobic dance for 2 ~3 months) has been reported to increase HDL-cholesterol (22). However, the results of the present study did not support that conclusion. Moreover, another study(23) concurs with our findings after observing that 10 weeks

Table 1. Anthropometric parameters of subjects

Parameters	Male (n=11)		Female (n=11)	
	BE	AE	BE	AE
Age(year)	25.18±2.4[1)]	25.18± 2.4	21.54± 1.03	21.54± 1.03
Height(cm)	172.08±4.9	172.15± 5.15	159.68± 6.4	159.68± 6.4
Weight(kg)	68.63±5.72	68.86± 6.12	50.55± 8.52	49.11± 7.53
BMI(kg/m^2)	22.95±2.75	22.23± 2.22	19.77± 2.75	19.01± 2.10
W/H	0.8 ±0.05	0.79± 0.08	0.76± 2.75	0.74± 0.03
Triceps(mm)	14.4 ±4.32	13.44± 4.21	15.85± 2.49	15.42± 2.05
Subscapualar(mm)	13.8 ±4.2	12.6 ± 3.3	14.65± 3.3	12.37± 1.93
SBP(mmHg)	134.4 ±8.7	128.6 ± 7.7	117.5 ± 6.3	117 ± 8.9
DBP(mmHg)	89.5 ±8.0	90.11±12	77.9 ± 5.7	74.7 ± 4.4
Pulsation rate	72.18±8.5	67.4 ± 9.76	83.9 ±16.25	78.8 ±11.16
MUAC(cm)	28.45±2.69	27.94± 3.10	24.2 ± 2.52	23.14± 1.9

[1)]Mean±SD

Paired t-test was used for the comparision between before and after exercise-training in both male and female groups
BE: Before exercise-training, AE: After exercise-training, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MUAC: Mid-upper-arm-circumference

Table 2. Daily nutrient intake of the subjects

Parameters	Male(n=11)		Female(n=11)	
	BE	AE	BE	AE
Energy(kcal)	2978 ±943[1)]	2429 ±530	1766 ±454	1763 ±379
Protein(g)	155.1 ± 62	127.08± 68	81.3 ± 47.8	63.96± 20.12
Lipid(g)	102.53± 43	72.93± 38	55.02± 21	48.86± 18.66
Carbohydrate(g)	368 ±119	488 ±156	232 ± 87	326 ±203

[1)]Mean±SD

Paired t-test was used for the comparision between before and after exercise-training in both male and female groups
BE: Before exercise-training, AE: After exercise-training

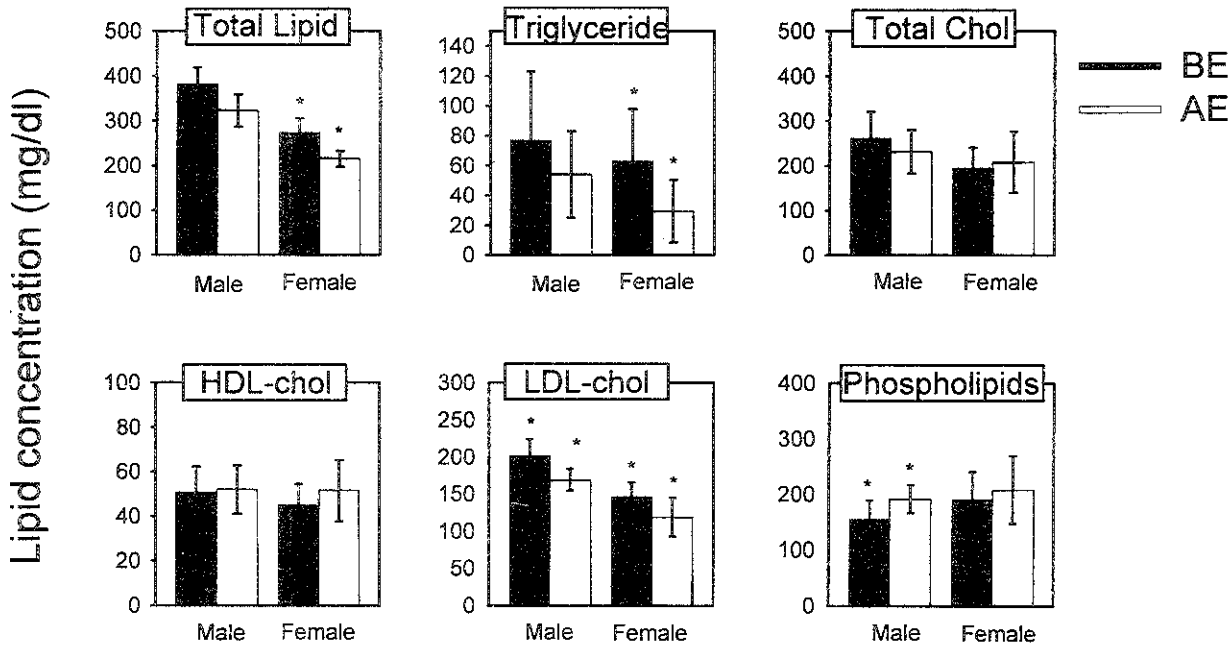

Fig. 1. The effects of exercise on serum lipid and lipoprotein concentrations.
The error bars show the standard deviations of the means for the male(n=11) and female(n=11) college students. Bars that have asterisk are significantly different($p<0.05$) between before and after exercise-training by Paired t-test. BE: Before exercise-training, AE: After exercise-training, Chol: Cholesterol.

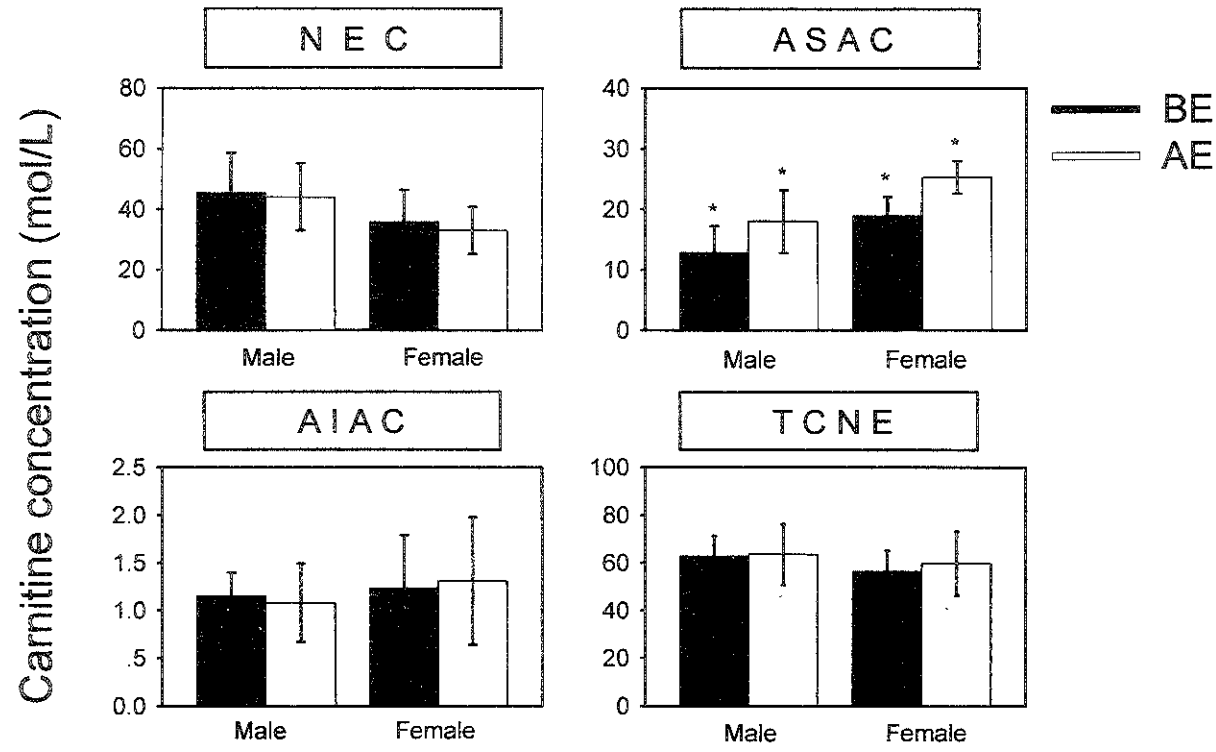

Fig. 2. The effects of exercise on serum carnitine concentrations.
The error bars show the standard deviations of the means for the male(n=11) and female(n=11) college students. Bars that have asterisk are significantly different($p<0.05$) between before and after exercise-training by Paired t-test. BE: Before exercise-training; AE: After exercise-training, NEC: Nonesterified acylcarnitine; ASAC: Acid-soluble acylcarnitine; AIAC: Acid-insoluble acylcarnitine; TCNE: Total carnitine.

of exercise-training did not increase HDL-cholesterol levels. Plasma triglyceride is a potential source of energy for muscular movement and recovering intramuscular triglyceride during long periods between exercise bouts is important(24). In our study, serum triglyceride and total lipid levels in regularly exercising females showed lower levels than those of females who did not exercise regularly (before exercise-training), but these trends were not apparent in male students. These differences in exercise-training effects might be due to various factors, including state of physical training, diet, and physical condition(25). However, it is clear from our study that regular exercise-training has a beneficial effect on blood lipids.

Blood and urinary carnitine levels

Regular exercise is known to increase the aerobic capacity of muscle cells by increasing the number and size of the mitochondria(1) giving them a greater capacity for utilizing stored fat(26). During prolonged endurance exercise, fatty acid metabolism increases as carbohydrate stores are depleted, thereby delaying exhaustion resulting from depletion of energy substrate(27,28). It has been reported that endogenous carnitine synthesis may not be sufficient to meet the demands for the fatty acid oxidation in persons engaging in regular endurance exercise over extended periods of time(29). Others, however, have reported that endogenous carnitine biosynthesis is adequate for maintaining adquate carnitine pools(30). It has been generally accepted that endogenous carnitine biosynthesis is enough to meet carnitine pools for normal persons with regular activity, but exogenous carnitine supplements would be helpful for people who are either unhealthy(i.e. those with cancer) or who over exert themselves(i.e. athletes). The present study evaluated the effects of regular excercise-training on blood(Fig. 2) and urinary(Fig. 3) carnitine fractions of both male and female students. Carnitine homeostasis appears to be regulated to a large extent by changes in the renal threshold for carnitine. For example, carnitine excretion was studied in strict vegetarians, lacto-ovo-vegetarians, and non-vegetarians, representing diets containing very low, low, and normal amounts of carnitine, respectively(31). There were no differences in NEC, AIAC, and TCNE of blood and urine among groups in this study, and exercise-training did not affect carnitine excretion of male students in our experimental study. However, female students who exercised regularly had

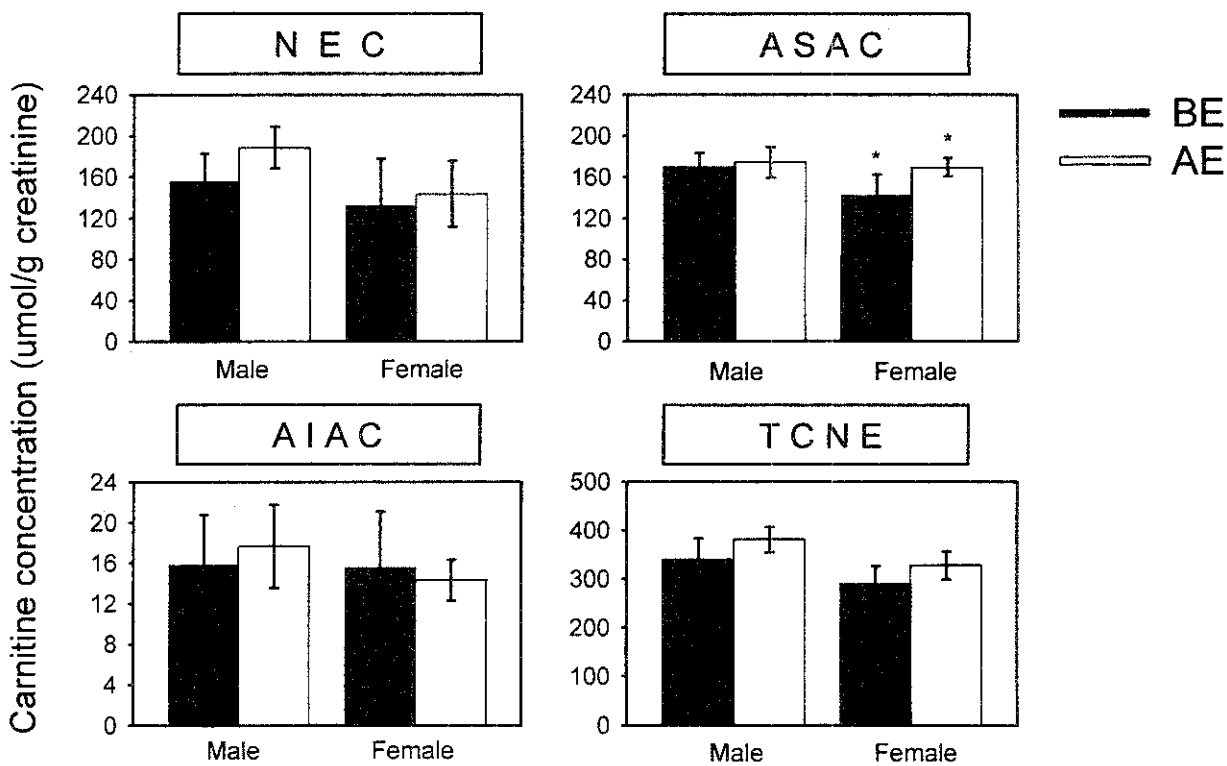

Fig. 3. The effects of exercise on 24 hr urinary carnitine concentrations(umol/g creatinine).
The error bars show the standard deviations of the means for the male(n=11) and female(n=11) college students. Bars that have asterisk are significantly different($p<0.05$) between before and after exercise-training by Paired t-test. BE: Before exercise-training; AE: After exercise-training, NEC: Nonesterified acylcarnitine; ASAC: Acid-soluble acylcarnitine; AIAC: Acid-insoluble acylcarnitine; TCNE: Total carnitine.

higher ASAC levels in both blood and urine after exercising. There was also a trend toward higher ASAC levels in blood, but not in urine, for male subjects. That may be because of various factors, including intensity and duration of exercise, dietary intake, and gender differences of carnitine metabolism. We did not control the exogenous carnitine intake which might be one of factors. It has been reported that plasma levels of these ASAC are sharply elevated under physiological conditions of accelerated fatty acid oxidation(32,33). We observed significant changes in blood lipids in students who exercised regularly, as well as significantly increased in blood ASAC levels.

Therefore, it is suggested that regular exercise-training has some effects on several blood lipid profiles, and carnitine may be involved in those mechanism.

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