Effects of Korean red ginseng intake during endurance training on resting energy metabolism in male mice

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(Received: 2013/02/12, Revised: 2012/02/20, Published online: 2012/02/22)

ABSTRACT

This study was designed to investigate the effect of red ginseng (RG) intake during 2 weeks of training on the resting energy metabolism in mice. RG (20 mg/kg body weight) were orally administered to 7-week old male ICR mice during 2 weeks of endurance training. The resting metabolic rate for 24h was measured before and after the 2 week experimental periods. The total amount of food intake was significantly higher in the RG group than in the control group ($p < 0.05$), whereas mean body weight was not different. Oxygen uptake during 24 hours both before and after the experimental session was not different between the two groups. Carbohydrate oxidation and fat oxidation in resting were significantly decreased and increased by endurance training, respectively, but no difference was observed between the two groups. Accordingly, we suggest that red ginseng intake of 20mg/kg body weight during 2 weeks of endurance training may not affect resting energy metabolism (RER) over one day in male mice.

Keywords: ginseng, endurance training, RMR, carbohydrate oxidation, fat oxidation

INTRODUCTION

Panax ginseng is well known as a Korean herbal medicine and used primarily to enhance many beneficial effects in regards to recovering from fatigue, psychologic function, exercise performance, and resistance to many diseases [1], [2]. Panax ginseng have a many possess 10 biologically-active steroid glycosides which is ginsenosides [3]. Moreover, ginsenosides become generally known as a major active component of Korean red ginseng (RG) [4]. Recently, Shim *et al.* (2009) have proposed that red ginseng may reduce body weight and fat content in high-fat diet rats in a manner similar to those of the normal diet fed rats by the administration of red ginseng. In addition, ginseng crude saponins are known to contain a variety of bioactive saponins. Administration of protopanaxadiol and protopanaxatriol type saponons in the high-fat diet group reduced the serum total cholesterol and

leptin levels [5].

Many positive effects of ginsenosides administration associated with exercise training have been reported on carbohydrate or fat metabolism. Acute ginseng extract administration for 30 to 60 minutes of swimming effectively suppressed the depletion of muscle glycogen and facilitated fat utilization [3]. Shin *et al.* (2006) reported that the effect of administering ginseng extract for 3 days regarding time to exhaustion was increased by about 530% in mice treated with ginseng extract compared with the control group and the mice treated with ginseng extract also demonstrated enhanced fat utilization after 1% body weight load for 3h of endurance swimming [6]. In those studies, the effect of ginseng or its components intake on energy metabolism were examined at multiple points during and/or after exercise and only serum FFA was not able to evaluate the organization of lipid oxidation. However, there are few studies examining the effect of ginseng during

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endurance training on fat utilization over the course of a whole day. Thus, the aim of the present study was to investigate the effect of red ginseng intake during 2 weeks of endurance training on resting energy metabolism in mice. We measured the resting energy metabolism (RER) using an animal calorimeter over one day before and after the 2 week experimental period.

MATERIALS AND METHODS

Animals & Treatment

7-week old male ICR-mice ($n = 48$) were used. The mice were purchased from Orient Bio Inc., (Seongnam, Korea). All mice were housed in standard plastic cages under controlled conditions of humidity (50%), and temperature ($23 \pm 1^\circ\text{C}$) with alternating 12h cycles of light (light on 08:00 to 20:00) and dark (dark on 20:00 to 08:00). Mice were adapted to the laboratory housing for 1 week. Forty-eight male mice were separated into 2 groups, control (CON, $n = 24$) and Red ginseng extract administered (RG, $n = 24$). They were given free access to water and a non-purified commercial diet (5L79, Orient Bio Inc., Seongnam, Korea), containing (g/kg diet): crude protein, 180; crude fat, 52; crude fiber, 52; minerals, 57; and carbohydrate, 368. The protein, fat, and carbohydrate ratio (%) based on calories was 21:14:65, and gross and metabolizable calorie contents of the diet were 4.04 and 3.21 Kcal/g, respectively. Red ginseng extract was administered to the RG group daily at the dose 20mg/kg body weight for 2 weeks (Table. 1). Similarly, the mice in the control group received the same amount of distilled water. All mice were measured to the body weight, food intake (Innotem IB-6100 balance, Korea). All experimental procedures were carried out

at the Animal Experiment Research Center of Konkuk University. This study was conducted in accordance with the ethical guidelines of the Konkuk University Institutional Animal Care and Use Committee.

Training methods & Measurement of resting metabolic rates

After 3 days of the adaption period for the treadmill, all mice were forced to run on a treadmill for 50 min once a day five times a week for 2 weeks. The exercise intensity (running speed) would be set at the speed of 20m/min and be raised by maintaining the slope at eight. On the last week of training, the intensity of exercise was carried out at 25 /m min for 50 minutes.

Resting metabolic rate was measured on the week before and two weeks after exercise as previously described [7]. Two hours before the experiment, mice were put in a metabolic chamber to reduce stress. They were given free access to water and food. Flow velocity within the chamber was set to 1.2 L/min and measured for 24 hours (model RL-600, Alco System, Chiba, Japan).

Statistical analyses

The SPSS 19.0 program was used in statistical analysis in the study (SPSS, Inc., Chicago, IL, USA). The effect of time and group were analyzed by two-way repeated measures analysis of variance (ANOVA). Since significant interaction was not detected, a *post hoc* Tukey test was employed for multiple comparisons among the exercise groups and the diet groups. Differences were considered significant at $P < 0.05$.

RESULTS

Body weight and food intake

Changes in body weight and food intake during the 2week experiment period were shown in Fig. 1(A) Body weight increased significantly throughout the experiment period ($p < 0.001$) whereas the final body weight was not different between two groups. On the other hand, the RG group consumed significantly higher amounts of food (0.2 g/day) compared to the CON group ($p < 0.05$; Fig. 1(B)).

Resting metabolic rate

As shown in Fig. 2, both before and after the experimental

Table. 1. Ginsenosides contents of Red-Ginseng Extract (mg/g)

Ingredient	Content
Rg1	0.71
Re	0.93
Rf	1.21
Rh1	0.78
Rg2(s)	1.92
Rg2®	1.29
Rb1	4.62
Rc	2.41
Rb2	1.83
Rd	0.89
Rg3(s)	2.14
Rg3®	0.91
Total	19.66

Fig. 1. The changes of body weight in CON and RG groups for 2 weeks (A). The changes of food intake in CON and RG groups for 2 weeks (B). * $p < 0.05$, *** $p < 0.001$, N.S.; no significance.

Fig. 2. Changes of oxygen uptake (RMR) of pre (A) and post (B) in CON and RG groups for 24 hour measurements. *** $p < 0.001$, N.S.; no significance.

Fig. 3. The carbohydrate oxidation of pre and post in each group for 24 hours (A). The fat oxidation of pre and post in each group for 24 hours (B). N.S.; no significance.

session, oxygen uptake (%) during 24 hours was not different between groups. Especially, although changes in oxygen uptake during 24 hours were relatively high during the dark

phase since all of the rodents in the two groups are more active during the night, no significance was shown between the two groups.

Resting carbohydrate oxidation and fat oxidation

Resting carbohydrate oxidation during 24 h after the experimental session was significantly lower compared with that before the experimental session (exercise effect), but it was not different before or after the experimental session (no group effect) (Fig. 3(A)). Resting fat oxidation during 24 h after the experimental session was significantly higher compared with that before the experimental session (exercise effect), but it was not different before or after the experimental session (no group effect) (Fig. 3(B)).

DISCUSSION

This study examined the effect of red ginseng (RG) intake during 2 weeks of training on resting energy metabolism in mice. The major findings of the present study were as follows; firstly, the total amount of food intake was significantly higher in the RG group than in the control group ($p < 0.05$), whereas mean body weight was not different. Secondly, oxygen uptake during 24 hours for both before and after the experimental session was not different between the two groups. Thirdly, carbohydrate oxidation in resting was significantly decreased but fat oxidation increased by endurance training. However, no difference was observed between the two groups.

Several studies have suggested that RG ingestion reduced body weight, food intake and fat content [5,8,9]. RG treatment in rats increased insulin sensitivity and inhibited hypothalamic neuropeptide Y (NPY) [10] which has been implicated in mediating many leptin-induced effects of food intake [9]. However, in this study, final body weight was not different between CON and RG groups although the total amount of food intake for 2wks was significantly higher in the RG group than in the CON group. As a possible reason for the discrepancy in regard to the food intake result compared with those studies [5,8,9], it might be, in part, involved with the hypothalamic neuropeptide Y (NPY) hormone which is also sensitively affected by exercise stimulus. Voluntary running training for rats increased hypothalamic NPYergic activity [11], in contrast to the effect of RG treatment. However, it cannot be excluded that daily physical activity might have been higher in the RG group than in the CON group.

Although the possible effect of RG ingestion on decrease in food efficiency ratio (FER; CON: 0.05 ± 0.02 , RG: 0.04 ± 0.02) for a short period in this study no change was observed in carbohydrate oxidation and fat oxidation during 24 hours between both groups after the experimental session. Thus, we cautiously presumed that the effect of RG ingestion

on the decrease in food efficiency may not be due to the alteration in resting energy metabolism but the increase of fat utilization during exercise training. Previous research reported that acute ginseng extract administration can have effects on the flux of intermediary carbohydrate and fat metabolism during exercise. Rats treated with ginseng extract at 30 minutes of swimming had higher glucose and lower FFA levels in plasma compared with control rats [3]. Avakian *et al.* [13] reported that ginseng extract had no apparent effect on the resting level of white muscle glycogen. However, after a 90 min swim bout, the ginseng treated rats showed 39% higher levels than controls, and after 3 hours of swimming those rats treated with ginseng showed 115% higher levels than controls. These results indicate that ginseng extract can influence pathways of substrate metabolism during prolonged exercise and increases the fat utilization of endogenous muscle glycogen. Another report indicated that combined ginsenoside intake with unloaded swimming aerobic exercise could better lower serum lipid (total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDLc)), regulated in lipid metabolism in hyperglycemic mice [14]. In this study, pre- and post-endurance training changed in the carbohydrates and fat metabolism [15], but resting carbohydrate and fat metabolism showed no difference between groups.

In conclusion, we suggest that red ginseng administration of 20 mg/kg body weight during 2 weeks of endurance training may not affect resting energy metabolism over one day in male mice. However, RG ingestion demonstrated a possible effect on the decrease in FER. In future investigations, it is necessary to measure energy metabolism and body energy stores during exercise.

ACKNOWLEDGEMENT

This study was supported by a grant (NRF-2011-32A-G00050) from the National Research Foundation funded by the Korean Government.

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