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Effects of Red Ginseng Intake on Muscle Injury Due to Eccentric Exercise

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Abstract

This study examined the effects of Korean red ginseng (RG) on muscle injury induced by eccentric exercise. Eighteen college male students were randomly assigned to either the RG group or the placebo group (P). The RG group ingested RG extract at 20 g/day (mixed with 200 mL of water) for 7 days prior to performing a downhill treadmill exercise and for 3 days after performing the downhill treadmill exercise, while the P group ingested 200 mL of water containing *Agastachis Herba* for 7 days prior to and 3 days following a downhill treadmill exercise. All subjects performed 2 bouts of a downhill treadmill exercise (6 km, -14 degree slope, 12 km/hr speed) with a 5 minute resting interval between bouts. Blood samples were drawn immediately before and after exercise, and at 1 hr, 24 hr, 48 hr, and 72 hr. Two-way repeated ANOVA documented that creatine kinase (CK) levels in the RG group were significantly reduced at 48 hr after exercise, as compared with P group, and remained constant until 72 hr after exercise. Lactate levels in the RG group were also significantly lower at 24 hr and 72 hr after exercise as compared to the P group. We conclude that supplementation of RGreduces CK levels and may prevent muscle injury induced by eccentric exercise.

Key words: ginseng, anti-inflammatory, antioxidants, woundhealing

INTRODUCTION

Panax ginseng C. A. MEYER, also known as Korean red ginseng (RG), has been traditionally used as a medicinal herb for over 2000 years in Asian countries. RG contains various ginsenosides, 20(S)-protopanaxadiol and 20(S)-protopanaxatriol, and has been widely used as an ergogenic aid. Although only one human study has found an association between RG intake and exercise performance (1), several rat studies have demonstrated a positive association between RG intake and exercise performance (2-5).

Some investigators have also reported that RG intake may prevent muscle injury following eccentric exercise in human and murine models (6-9). Eccentric exercise, actions where skeletal muscle lengthens as it produces force (e.g. lowering weights or running downhill), has a well documented association with muscle injury (10). Elevated plasma creatine kinase (CK) level is a marker of skeletal muscle injury due to eccentric exercise, and the CK levels usually peak at 2 to 4 days after exercise (8). However, there has been little research on the relation between RG intake and CK values in human models when CK levels are known to peak. To address muscle injury prevention strategies, it is important to investigate whether RG intake can protect against exercise-induced muscle injury by reducing levels of CK. We therefore examined the effects of RG intake on plasma CK levels after eccentric exercise from healthy male college students.

SUBJECTS AND METHODS

Subjects

Eighteen healthy male college students, aged 19 to 22 years, were recruited to participate in the present study. Subjects' health and drug-use profiles were assessed using the standardized questionnaire. All subjects were drug free and signed informed consent for the clinical examination and were asked to fast for 12 hours before the clinical examination. The University Institutional Review Boards approved the protocol.

Experimental protocol

All subjects were randomly assigned to either the RG or placebo (P) group. The RG group was instructed to ingest RG extract at 20 g/day (mixed with 200 mL of water and instructed to ingest 3 separate times/day) for 7 days prior to performing a downhill treadmill exercise test and for 3 days after the treadmill test, while the

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placebo group was instructed to ingest 200 mL of water containing *Agastachis Herba*. All subjects performed 2 bouts of a downhill treadmill exercise tests (6 km, -14 degree slope, 12 km/hr speed) with a 5 minute resting interval between bouts. The subjects were asked to maintain their normal eating habits, restrict vigorous activity, and abstain from drug and alcohol consumption.

Blood collection and analysis

Approximately 5 mL of venous blood was drawn daily between 6～7 a.m. following a 12 hr overnight fast for the 10-day experimental period. Each blood sample was placed into 250 μL of cold EDTA and 93 μL aprotinin. Two hundred microliters of the whole blood was immediately added to 400 μL perchloric acid (8% v/v) and centrifuged at 1000×*g* for 15 minutes and stored at -70°C until further analysis. The lactic acid content was analyzed using Hohorst's method (11). The remaining blood was centrifuged at 1000×*g* for 10 minutes. The plasma was removed, separated into aliquots and stored at -70°C for subsequent analysis. The plasma CK levels were determined with a spectrophotometer technique (Elitech, Sees, France).

Statistical analyses

Independent t-tests were used to compare mean differences for anthropometrics, CK and lactate levels between the RG and P groups. Two-way (Group×Time) repeated measures analysis of variance (ANOVA) was used to test mean differences for groups and for times factor, and groups×times interaction factor. The sphericity assumption was justified by using Huynh-Feldt Epsilon (ε) test. If the sphericity assumption was violated, the F critical value was corrected and re-evaluated by multiplying with degrees of freedom. We also used Bonferroni post-hoc test to detect mean differences across groups and times, separately. All statistical procedures were performed by Statistical Analysis Systems software (SAS Institute) with a significance level at 0.05.

RESULTS

Baseline characteristics of the RG and P groups are presented in Table 1. There was no statistical difference in CK (p=0.42) and lactate (p=0.92) values between the RG and P groups at baseline. As shown in Fig. 1, the CK activity levels in both RG and P groups were elevated until 24 hr after the treadmill test, but the CK levels in the RG group were significantly reduced at 48 hr after exercise (p=0.01) and remained constant until 72 hr after exercise compared with the P group. The RG group had significantly lower mean CK values at 48 h after exercise when compared with the P group (552.8 vs 303 U/L, p=0.03). The RG group also had significantly lower CK values at 72 hr after exercise as compared with the P group (506.8 vs 305.1 U/L, p=0.04). Fig. 2 shows that the lactate levels in both RG and P groups were significantly elevated after the treadmill test, and the RG group had lower plasma lactate levels at 24 hr and 72 hr after exercise as compared with the P group (p<0.05).

Table 1. Baseline characteristics of study participants

Variables	RG group (n=9)	P group (n=9)	p-value
Age (yr)	20.2±0.5	19.9±0.6	
Height (cm)	178.1±1.4	175.3±1.6	
Weight (kg)	67.7±1.8	67.2±2.0	
Creatine kinase (U/L)	117.9±37.8	123.7±42.1	0.42
Lactate (mmol/L)	2.4±0.5	2.3±0.7	0.92

Mean±SE.

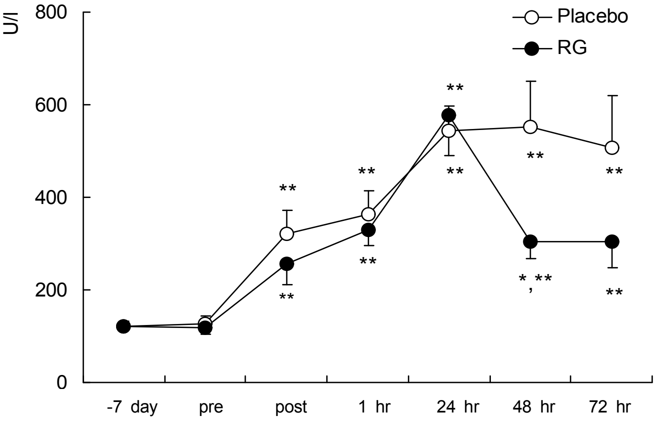

Fig. 1. Plasma CK levels for 10-day experimental period in a RG group (n=9) and a placebo group (n=9). Each point represents the mean±SE. *p<0.05 vs placebo group; **p<0.05 vs -7 day.

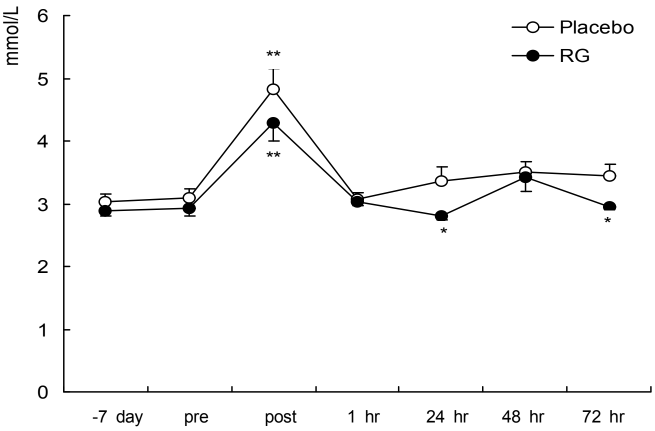

Fig. 2. Plasma lactate concentrations for 10-day experimental period in a RG group (n=9) and a placebo group (n=9). Each point represents the mean±SE. *p<0.05 vs Placebo group; **p<0.05 vs -7 day.

DISCUSSION

Our major finding was that plasma CK levels measured at 48 hr after eccentric exercise were significantly lower in the RG group compared to the P group. We also found that plasma lactate levels measured at 24 hr and 72 hr after exercise were significantly lower in the RG group compared to the P group.

Our finding of lower CK levels among those consuming RG is consistent with the results from other studies (6,7), which showed that ginseng intake reduced CK levels after strenuous exercise in both murine and human models. Elevated plasma CK level usually peaks at 2 to 4 days after eccentric exercise (8). Although Hsu et al. (7) reported a difference in CK levels within 2 hr post exercise, no human study has investigated measures of CK values during the time when blood levels of CK levels are at their peak. Our study is the first to measure CK levels in human models between 48 and 72 hr after exercise when CK levels are known to peak. Another measure of muscle damage, plasma lactate, was also significantly lower in the RG group at 24 hr and 72 hr after exercise as compared with the placebo group. We also observed similar sharp reductions of plasma lactate levels at 1 hr post exercise, similar to that shown by Hsu et al. (7), although Hsu et al. (7) observed higher absolute peak lactate levels immediately following exercise. It is plausible that RG consumption may attenuate muscle damage after eccentric exercise partially due to either anti-inflammatory or antioxidant actions, or both. We could not exactly explain what mechanism in RG supplementation could be responsible for the attenuation of muscle injury in this study. However, it can be suggested that the antioxidant effect of Korea red ginseng may partly explain the lower CK levels in RG group. Mechanical stress caused by eccentric exercise disturbs the ultrastructural integrity of skeletal muscle fibers (12), resulting in an acute inflammatory response where neutrophils and macrophages infiltrate skeletal muscle cells, generating reactive oxygen species (ROS), including free radicals. It has been shown that ginseng intake lowers inflammatory markers (6) and protects against inflammation after eccentric exercise (13), as such, ginseng may prevent muscle damage by reducing inflammation. Furthermore, the increase of ROS in exercise has been implicated in muscle fatigue and oxidative stress. ROS are also believed to contribute to the inflammatory response by attracting neutrophils and increasing vascular permeability (14). Under physiological conditions, the body has enough antioxidant reserves to counteract ROS production. However, it is possible that muscle damage and fatigue results when these antioxidant reserves are exhausted. Literature suggests that dietary antioxidants may prevent muscle damage by scavenging ROS produced during exercise (15,16). It is possible that ginseng and dietary antioxidants might have similar function; Korean red ginseng contains the major antioxidant enzyme, Rb2 (17), which scavenges hydroxyl radicals and protects unsaturated fatty acids from oxidation (13).

Limitations of this study are that we did not include a subjective measure of muscle injury (e.g. muscle soreness) and used plasma CK levels as the primary measure of muscle injury without objective measures of functional impairment. Although CK levels were greater in the placebo group, it is not known if the placebo group experienced more subjective muscle soreness and greater objective functional impairment than the RG group. The strength of this study is that, to our knowledge, this is the first human study to examine the effects of Korean red ginseng on muscle damage due to eccentric exercise at times of peak muscle injury. Our study is well designed by using downhill running protocol. Further studies are needed to examine whether long-term Korean red ginseng intake relates to other chronic diseases across different ethnic groups.

In conclusion, we found that Korean red ginseng intake is associated with reduction of plasma CK levels. Our findings suggest that Korean red ginseng intake may play a role in preventing muscle injury due to eccentric exercise.

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