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Acute Garlic Supplementation Ameliorates Exercise-Induced Lipid Peroxidation in Sedentary Individuals

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Abstract

Background: *The aim of study was to determine the acute effect of garlic supplementation on total antioxidant capacity and some markers of exercise-induced oxidative stress in sedentary individuals.*
Methods: *In a randomized and double-blinded study, 10 sedentary males (age 22.9 ± 1.9 years, weight 70.5 ± 8.7 kg, BMI 22.9 ± 2 kg/m2, and fat 14.2 ± 4.6 %) performed two sessions of aerobic exercise after either placebo (1000 lg starch) or garlic consumption (1000 mg allicin). Aerobic exercise consisted of 30 minutes running at the intensity of %75-80 of maximal heart rate. Three blood samples were taken before supplementation, 4 hours after supplementation and immediately after exercise and were analyzed for total antioxidant capacity (TAC), Malondialdehyde (MDA), and creatine kinase (CK) levels. Repeated measures of ANOVA and Bonferroni post hoc test were applied to analyze the data. The significance level was set at 0.05.*
Results: *Results showed that garlic supplementation had no significant effect on resting levels of variables (Pvalue > 0.05). Aerobic exercise significantly decreased TAC and increased serum levels of MDA and CK levels (Pvalue < 0.05) but the rise of MDA level following exercise was significantly diminished at garlic condition (P < 0.05).*

Conclusions: *Based on the findings of the present study, acute garlic supplementation had no effect on exercise-induced cell damage but may ameliorate exercise-induced lipid peroxidation.*

Keywords: Garlic, Antioxidant capacity, Exercise, Oxidative stress, Lipid peroxidation, CK.
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Introduction

Intense exercise is associated with the production of free radicals, which can lead to oxidative stress.[1] Free radical can damage various cellular components such as lipids, proteins, and nucleic acids. The damage of free radicals to various cellular components is called oxidative stress.[1] In physiological state, there is a balance between the production of free radicals in the body and the antioxidant defense system, but under various conditions such as different lifestyles, nutrition, and environmental factors as well as exercise, endogenous antioxidants is not able to completely prevent oxidative damage and the balance between the production and disposal of free radicals is disturbed.[1,2] Previous studies have reported that vigorous and prolonged exercise activity increases levels of malondialdehyde (oxidative stress index) and decreases total antioxidant capacity.[3] For instance, Aguilo et al., (2005) reported that exhaustive exercise increases markers of oxidative stress such as hydrogen peroxide and induces activities of endogenous antioxidant enzymes.[4] Munoz et al., (2010) also suggested that acute exercise increases the generation of ROS and elevates MDA levels which are dependent to exercise intensity.[5] Thus, antioxidant capacity seems to be reduced temporarily in response to exercise.

For this, athletes usually consume antioxidants in the form of natural foods or supplements in an effort to attenuate exercise-induced oxidative stress.[6] Several types of researches have been conducted investigating the effects of exogenous antioxidants on exercise-induced oxidative stress. Thus, researchers have included several antioxidants to attenuate oxidative damage induced by exercise.[1] Supplements such as vitamin C, E, beta-carotene have known to act as an antioxidant and boost antioxidant capacity.[4] Vitamin C, for example, represents a potential antioxidant defense in plasma and vitamin E is a major lipid-soluble antioxidant.[4] Bryer et al., (2006) reported that a high dose of vitamin C supplementation can decrease muscle soreness, delay CK elevation and improve antioxidant defense in healthy men.[7] With this regard, dietary herbals have received attention due to their health benefits. Garlic is an herbal food that is popular for its health benefits including antioxidant, antibacterial, and antimicrobial potential.[8,9] It has been reported that garlic consumption along with exercise training can have an additive impact on the lipid-lowering effect of exercise training in sedentary subjects.[10] Aged garlic extract has been reported to improve glucose metabolism and ameliorate exercise-induced fatigue.[11] Garlic also exerts antioxidant properties which can improve antioxidant defense and protect against oxidative stress.[6,11,12] Gorinstein et al., (2006) suggested that both raw and boiled garlic was effective in reducing oxidant stress and improving antioxidant capacity.[13] The health benefits of garlic have been attributed to sulfur compounds, most notably Alicine.[14] Antioxidant effects of garlic include increased activity of superoxide dismutase (one of the antioxidant enzymes), decreased serum lipid peroxide and scavenging hydroxyl radicals which have been reported by in vitro and in vivo studies.[9] Recently, the effect of short and long-term garlic supplementation on oxidative stress induced by exercise has been investigated. For instance, Su et al., (2008) showed that administration of 800 mg of allicin supplement for 14 days significantly reduced cellular damage and inflammation in response to exercise and improve antioxidant capacity.[15] Jafari et al., (2011) also reported that short-term supplementation with garlic extract can improve resting antioxidant status and attenuate exercise-induced oxidative damage and inflammation.[16] Morihara et al., (2006) investigated the effects of 4-week aged garlic extract administration on oxidative stress induced by exercise and reported that this treatment can improve antioxidant enzyme activities and protect against oxidative damage.[11] Previous studies have examined the short-term and long-term effects of garlic supplementation on exercise-induced oxidative stress.[15-17] However, little is known about the antioxidant effects of acute garlic supplementation during exercise. In the present study, we aimed to investigate the acute effect of garlic supplementation on MDA, CK and TAC response to exhaustive exercise.

Materials and Methods

Ten inactive male subjects volunteered to participate in a randomized double-blind cross-over study. Subjects were informed about the procedure of the study and then gave their written consent. All procedures were conducted according to the principals of the Declaration of Helsinki for human research. Inclusion criteria were a healthy state, the age range of 20-30 years, inactive life-style according to physical activity assessment, and exclusion criteria included tobacco use and medicine and supplement intake. All subjects were non-smoker and they went through a medical examination to ensure to be healthy. They were not taking any medication or supplements. The subjects were screened to assess physical activity levels using a modified international physical activity questionnaire and were ensured to be physically inactive.[18] The participants attended the laboratory on 3 different occasions. The first was a familiarization session during which they completed the questionnaires and anthropometric measurements were completed. On second and third attendance to the lab, a blood sample was taken after a thirty-minute rest in supine position before supplementation. Then the subjects consumed supplement (1000 mg allicin, Nature made, USA) or placebo (starch) with plain water. Afterward, the second blood sample was taken 4 hours after the supplementation and immediately before the exercise test. Subjects then underwent an exercise test on a treadmill for 30 minutes with an intensity of 75-80% of maximal heart rate. The third blood sample was collected immediately upon completing the exercise test. Subjects were supplemented in a cross-over double-blind design and there was a week washout period between each treatment (supplement or placebo).

All basic measurements including weight, height, body mass index, height, body fat percent and waist-to-hip ratio (WHR) were performed at the first session. Body mass index (BMI) was calculated as body weight (kg) divided by height (m^2). The skin folds were measured using skinfold caliper (SlimGuioe, US) on the right side of the body at chest, abdominal, and suprailiac sites. Skinfold measurements were performed in triplicate and average values were used to estimate fat percent using Jackson-Pollack formula.[19]

Three blood samples were taken at the main sessions and plasma samples were separated by centrifugation at 3000 rpm for 10 min. The plasma samples were then frozen and stored at -40 °C for later assessments of MDA, CK, and TAC. MDA was assessed using a quantitative assay on the basis of the colorimetric method (Cayman, US). CK level was also assessed using a quantitative calorimetric assay (Pars-Azmoon, Iran). TAC was assessed using quantitative assay (TPR, Iran).

Data were first checked for distribution using the Kolmogorov-Smirnov test. Statistical analyses then were performed using the repeated measures of ANOVA to determine any treatment * time interactions. Bonferroni post-hoc test was used to determine the place of differences when interactions reached significance level. Statistical analyses were performed by SPSS software version 18. The significance level was set at 0.05.

Results

The characteristics of the participants are presented in table 1. The Mean ± SD values of the variables are also illustrated in table 2. Data analysis indicated that irrespective of garlic/ placebo consumption, exercise significantly reduced TAC levels. Garlic consumption attenuated TAC reduction following exercise but the changes did not reach significance level ($F = 0.647$, Pvalue = 0.535). CK levels also increased following exercise test at both conditions and garlic consumption prior to exercise did not significantly alter CK response to exercise test ($F = 0.133$, Pvalue = 0.876). Moreover, MDA indicated a similar trend to that of CK following exercise, but garlic administration significantly alleviated MDA response to exercise ($F = 22.596$, Pvalue = 0.0001) (figure 1).

Table 1. Characteristics of the subjects

Variables	Mean ± SD
Age (yrs)	22.90 ± 1.90
Weight (kg)	70.54 ± 8.75
Height (cm)	174.00 ± 5.74
BMI (kg/m^2)	22.90 ± 2.00
Fat (%)	14.23 ± 4.60

Table 2. Mean ± SD of variables including TAC, MDA and CK

	TAC (mM/L)			MDA (µM)			CK (U/L)		
	Pre-ingestion	Pre-exercise	Post-exercise	Pre-ingestion	Pre-exercise	Post-exercise	Pre-ingestion	Pre-exercise	Post-exercise
Garlic	0.98 ± 0.19	1.0 ± 0.19	0.92 ± 0.19	2.03 ± 0.07	2.05 ± 0.11	3.84 ± 0.12*#	228.6 ± 60.06	229.10 ± 63.08	276.66 ± 91.0*
Placebo	0.94 ± 0.17	0.94 ± 0.14	0.84 ± 0.14	1.98 ± 0.18	1.94 ± 0.14	4.22 ± 0.12*	242.1 ± 71.3	245.9 ± 59.1	285.4 ± 99.3*

* Significantly (Pvalue < 0.05) different with pre-exercise
# Significantly (Pvalue < 0.05) different with the placebo

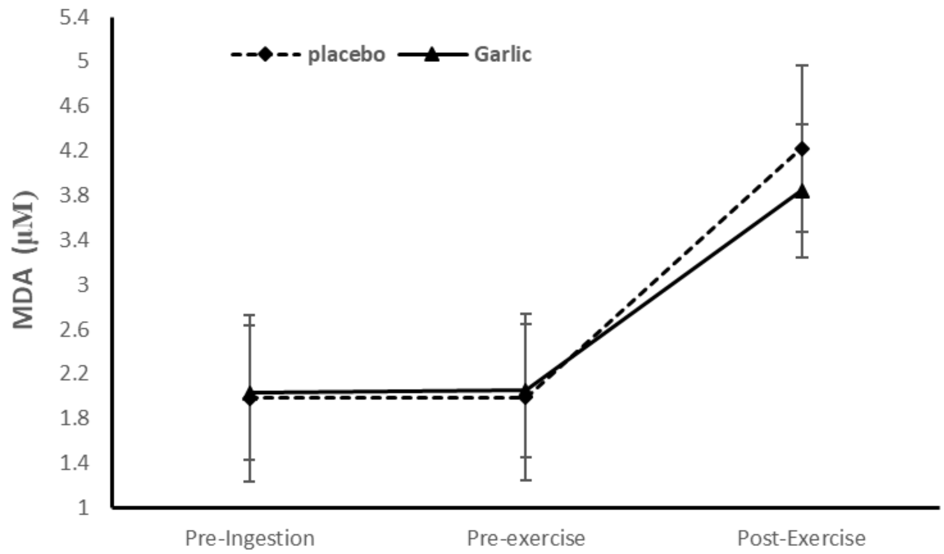

Figure 1. Alterations in plasma MDA from baseline to post-exercise following consumption of Garlic and placebo

Discussion

The purpose of the study was to determine the acute effect of garlic supplementation on total antioxidant capacity (TAC), creatine kinase (CK), serum malondialdehyde (MDA) response to exercise in inactive individuals. The results showed that exercise reduced total antioxidant capacity and increased serum CK and MDA levels, and acute supplementation of garlic had no significant effect on TAC and CK but had the potential to ameliorate MDA response to exercise.

Our findings support the literature that a single bout of exercise can lead to oxidative stress and may result in elevated lipid peroxidation. Increased oxygen uptake and metabolism can result in free radical generation.[20] Overproduction of free radicals during exercise can also be caused by exercise-induced hyperemia.[21] Due to the increased production of free radicals in response to exercise, the antioxidant capacity may transiently decrease.[1] Thus, the extent of oxidative damage during exercise depends not only on the amount of free radical generation but also on the antioxidant status.[1] Following this, antioxidant supplementation is a commonly used measure by athletes to ameliorate damages related to oxidative stress.[22] For this reason, numerous studies have been conducted on the effect of certain supplements such as vitamin C, vitamin E, beta-carotene and coenzyme 10 on antioxidant capacity during exercise and various results have been reported.[23-25] Studies have shown that pre-exercise dietary supplements with antioxidant properties such as vitamins E and C can diminish exercise-induced oxidative damage.[26] Recently, the use of herbal supplements has been received attraction by researches and athletes as antioxidant agents.[26] Garlic has also been suggested to exert antioxidant effects by in-vitro studies.[9]

We observed that following garlic supplementation resting levels of TAC increased from 0.98 ± 0.19 to 1.0 ± 0.19 but this change did not reach significance level. This is in contrast to some studies that have indicated garlic administration elevates antioxidant capacity. Su et al., (2008) reported that short-term supplementation with garlic can augment antioxidant capacity and diminish TAC reduction following exercise.[15] Evidence shows that sulfur compounds of garlic exert antioxidant properties.[27] We speculated that acute garlic consumption of 1000 mg is not sufficient to improve antioxidant capacity and longer durations are needed. Moreover, we observed that acute supplementation of garlic had no significant effect on CK, the indicator of cell damage. This is in contrast with Su et al., (2008) who suggested that 14-day supplementation with Allicin ameliorated CK response to downhill running.[15] Sangeetha et al., (2006) also indicated that S-allyl cysteine sulfoxide, the active ingredient in garlic, over 5 weeks reduced CK levels and other markers in rats.[28] Our study is comparable with that of Su et al., (2008) and Sangeetha et al., (2006) in some aspects. First, unlike this study that investigated the acute effect of garlic on CK response to exercise, both studies examined the short-term effect of garlic administration. Thus, these studies are different from ours regarding supplementation protocol. We assume that to observe the protective effect of garlic on indices of cell damage in exercise, supplementation with longer durations may be required. Moreover, downhill running is accompanied by eccentric contraction which has been established to induce more cell damage compared with usual physical activity.

However, results indicated that a single dose of garlic administration 4 hours prior to exercise significantly lowered MDA response. The increase in MDA after exercise was 30% lower following supplementation with garlic compared to the placebo. It is in line with Jafari et al., (2011) who reported that garlic consumption attenuated MDA response to exercise in non-athletes men.[16] During the states of overproduction of free radicals, like during exercise, lipids are prone to be oxidized. MDA is a marker of oxidation of whole fatty acid oxidation. Garlic contains active sulfur compounds including allicin that may interact with the exogenous antioxidant system to protect macromolecules from oxidation. They can also independently combat oxidative stress and related damages to macromolecules. Thus, acute consumption of garlic has the potential to prevent or diminish lipid peroxidation.

In the present study, we found that exercise increased blood levels of CK and MDA as markers of cell damage and lipid peroxidation. Acute garlic consumption of 1000 mg prior to exercise had no remarkable effect on resting and post exercise antioxidant capacity and CK levels. However, it was the potential to attenuate MDA increase in response to exercise tests.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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