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Ginger extract and aerobic training reduces lipid profile in high-fat fed diet rats

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Abstract. – OBJECTIVE: Obesity, hyperglycemia and dyslipidemia, are major risk factors. However, natural therapies, dietary components, and physical activity may effect on these concerns. The aim of this study was to examine the effect of aerobic exercise and consumption of liquid ginger extract on lipid profile of Male rats with a high-fat fed diet.

MATERIALS AND METHODS: 32 rats were randomly divided into 4 groups: 1) aerobic exercise, 2) Ginger extract, 3) combined aerobic exercise and Ginger extract, and 4) the control. Subjects of the first three groups received ginger extract via gavage feeding of 250 mg/kg. The exercise program was 3 sessions per week on 3 different days over 4 weeks. Total cholesterol (TC), Triglyceride (TG), HDL and LDL were measured 24-h before the first session and 24-h after the final training session.

RESULTS: The concentration of TG in the control group was significantly higher than other groups. In addition, the mean concentration of TG in the aerobic exercise group was significantly lower than Ginger extract group but there was no significant difference as compared to combined aerobic exercise and ginger extract group. The combination of aerobic exercise and ginger consumption significantly reduced the TG level compared to ginger group. TC and LDL concentrations were significantly decreased in all groups compare to control. The combination of aerobic exercise and ginger extract feeding caused a significant increase in HDL levels.

CONCLUSIONS: The finding of this study suggests that the combination of aerobic exercise and liquid ginger extract consumption might be an effective method of reducing lipid profiles, which will reduce the risk of cardiovascular diseases caused by high-fat diets.

Key Words:
Aerobic exercise, Ginger, Profile lipid, High-fat diet.

Introduction

Dyslipidemia is defined as a metabolic disorder, which is characterized by increased levels of serum lipoproteins. It is one of the major causes for coronary heart disease (CHD) and has been identified as the leading cause of death worldwide[1]. Apart from genetic reasons, dyslipidemia is usually associated with reduced physical activity. Recent studies have shown that physical activity, particularly aerobic exercise, can increase HDL cholesterol (HDL-C) and reduce the ratio of total cholesterol (TC) to HDL-C[2]. This issue represents an improvement in the lipid profile by the effect of aerobic exercise and can reduce the risk of cardiovascular disease[3]. Alternative medicine and natural therapies have gained popularity in recent years and many scientists have shown interest in traditional herbal medicine. This is due to their alleged effectiveness, minimal side effects in clinical trials and relatively low costs[4].

Zingiber officinale or better known as Ginger belongs to the Zingiberaceae family. So far, numerous studies have been conducted and investigated on ginger and its therapeutic effects in the treatment of several diseases. Numerous medicinal properties of ginger, including anti-inflammatory, antioxidant, antiplatelet, blood sugar and fat loss, prevention of cardiovascular disease, anticancer activity, nausea and vomiting have been investigated[5-7]. Also, ginger has been proposed as a hypolipidemic agent in rabbits fed with high cholesterol diet[8], and it is shown that by increasing the activity of liver enzyme, cholesterol 7 alpha-hydroxylase, the biosynthesis of bile acid is

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increased in rats which results in cholesterol removal from the body[9-11]. Also, ginger reduces the level of cholesterol and triglycerides in fructose-induced hyperlipidemia rats[10]. Moreover, ginger has significant effects on fat loss in patients with hyperlipidemia[12].

A great number of researches imply that regular moderate exercising can prevent the development and advancement of atherosclerosis. This in turn improves levels of dyslipidemia and reduces symptoms of cardio vascular diseases. Regular exercising results in maintenance of body weight, control of blood pressure, insulin resistance and dyslipidemia management[13]. Physical activity has multiple benefits, which are related to the intensity and duration of the exercise. It has been shown that moderate physical activity has improved life expectancy by 1.5 years in men and women[14]. Regular physical exercise has shown to improve all parameters of dyslipidemia including TGs, HDL and LDL. Leon and Sancher[15] reported that physical activity increases HDL by 4.6% and decreases TGs and LDL by 3.7 and 5% respectively. There is abundance in literature of the benefits of exercising coupled with nutrients in reducing levels in lipid profiles. For instance it has been shown that tocotrienol rich fractions of palm oil were able to reduce total cholesterol and LDL by 22 and 55% respectively in female chickens[16]. Rats fed with tocotrienol rich fractions showed a significant decline of 30% in total cholesterol and 67% in LDL[17].

In view of that, this study was designed to investigate the effects of ginger consumption and aerobic exercising on lipid profiles of rats fed with a high-fat diet. The lipid profile was measured via observing changes in triglyceride (TG), total cholesterol (TC), low-density lipoprotein (LDL) and high-density lipoprotein (HDL).

Materials and Methods

Experimental animals and ethical aspects

In this work, 50 days old male Sprague-Dawley rats (n=32) were used. The rats were purchased from Stem cells and transgenic Technology Research Center, Shiraz University of Medical Sciences (Shiraz, Iran). The rats were kept in standard polycarbonate cages with stainless steel mesh ceiling under controlled conditions of humidity (65±5%) and temperature (25±2°C) with alternating 12-h cycles of light (08:00-20:00) and darkness (20:00-8:00). The rats were allowed to adapt to the laboratory housing conditions for a week prior to the experiment. Also 20 days before the experiments, the rats were subjected to running exercises on a treadmill for an hour at 10 m/min at zero inclination to get familiarized. All procedures involving animal experiments were approved and carried out in in strict accordance with the United States Institute of Animal Research guidelines for the care and use of laboratory animals[18], and was approved by the Animal Care and Use Committee (ACUC) University Malaya Institutional with ethics number: FIS/22/11/2011/FD(R). Rats were randomly assigned into 4 groups of 8: 1) aerobic exercise, 2) ginger extract, 3) combined aerobic exercise and ginger extract, 4) control. Rats weighed 240±30 g at the beginning of the study and were weighed again at the end of the first and fourth week. A high fat diet was created by addition of (10 g/kg of food) of liquid fat to the standard food. In addition, 2 ml of egg yolk was also administered by oral gavage daily.

Ginger Extract Preparation

The ginger roots were purchased from a local market and identified by a botanist. The roots were then cleaned, dried and powdered with a grinder. The powder (100 g) was then added with 400 ml of distilled water and the mixture was incubated at room temperature for 24-h after which the solution obtained was filtered (Whatman® no. 42). An additional 400 ml of distilled water was added to the residues and then incubated at room temperature for 12 hrs. The solution was filtered and pooled with the previous solution obtained. The resulting water extract was then subjected to evaporation with a rotary evaporator preset to 90-rpm and 50°C. This reduced the volume to one third and the final extract was placed in a 50°C oven for a few days to further concentrate the extract to powder level. The resulting powder was weighed and dissolved in distilled water to a concentration of 250 mg/ml. The extract was kept at 4°C and was used later in the animal studies.

The Training Program

Aerobic exercise was used to train the rats within four weeks. The rats were trained to run on a treadmill three times a week for 25, 35 and 45 minutes on each day. The speed of the treadmill was set to 18, 20, 22, and 24 m/min on week one, two, three and four.

Blood Analysis

Blood samples were collected in two stages: 24-h prior to the first training session and 24-h after the last session in week 4. The plasma was separated by centrifugation and measured for triglyceride (TG), cholesterol (TC), total LDL and HDL.

Lipid Profile Analysis

Total serum cholesterol was measured using an enzymatic colorimetric method (CHOD-PAP) for single-point measurement through a photometric method using Pars AZ moon kits (Tehran, Iran).

HDL-cholesterol and triglyceride concentrations in the serum were evaluated by enzymatic colorimetric method at sensitivity of 1mg/dL and CV less than 4.5% and 5 mg/dL and CV less than 4% using Ziest Chemie kits (Tehran, Iran). Also, LDL-cholesterol serum concentrations were calculated using the Friedewald formula (LDL = Total - C-HDL - (TG/5)).

Statistical Analysis

The SPSS 18.0 program was used for statistical analysis of this study (SPSS, Inc., Chicago, IL, USA). Two-way analysis of variance was used in in different groups and times of the experiment. In addition, Pearson correlation coefficient was used to determine the correlation between triglycerides, total cholesterol, LDL, HDL, and body weight.

Results

The findings show a significant decrease in the levels of TG in the exercise and exercise-ginger groups (Table I). There was a 2 fold and 2.5 fold decreases in TG, respectively which were significantly lower as compared to the ginger group. Total cholesterol was also significantly decreased in the exercise, exercise-ginger and ginger groups but the exercise-ginger group had the highest decrease of about 1.5 fold. The results showed a significant decrease in low density lipoproteins (LDL) in all groups of exercise, exercise-ginger and ginger. Among the three groups, the LDL of the exercise-ginger group was halved which showed a higher decrease in LDL. The high density lipoprotein (HDL) was significantly increased for the exercise and the exercise-ginger groups. This increase was observed higher in the exercise-ginger group. In addition, significant direct correlations between

Table I. Changes in lipid profile after four weeks intervention. Data is expressed as mean ± standard deviation.

	Exercise		Ginger		Exercise-Ginger		Control	
	Baseline	Follow up	Baseline	Follow up	Baseline	Follow up	Baseline	Follow-up
Triglyceride (TG)	150 ± 8.31	71 ± 6.92*†	162.50 ± 10.41	131.50 ± 11.46	158.38 ± 13.66	63 ± 5.48*†	160.12 ± 13.35	175 ± 14.10
Total cholesterol (TC)	84.62 ± 7.42	59.25 ± 2.55*	83 ± 7.47	67 ± 5.66*	87.37 ± 11.59	58.76 ± 1.76*	90.37 ± 11.50	96.25 ± 10.50
Low-density lipoprotein (LDL)	35 ± 1.77	19.75 ± 1.91*	33.37 ± 1.92	23.12 ± 1.96*	36.50 ± 4.75	18 ± 1.41*	39.75 ± 6.67	44.62 ± 7.11
High-density lipoprotein (HDL)	19.75 ± 6.02	25.62 ± 2.92*	16.87 ± 5.54	17.50 ± 3.58	19.25 ± 7.50	28.87 ± 1.88*	18.62 ± 3.96	16.58 ± 2.48

*Denote significant differences from Control group. †Denote significant differences from ginger group.

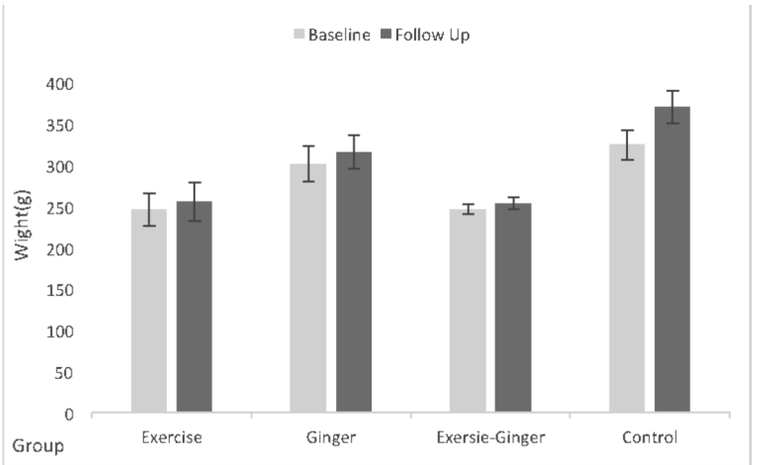

Figure 1. Changes in body weight (g) before and after the experiment.

changes on weight and TG (r=0.694, *p*=0.000), LDL (r=0.627, *p*=0.000) and HDL (r=0.438, *p*=0.014) was observed. While, this was not statistically significant in correlation with TC (r=0.004, *p*=0.498).

Discussion

The finding of this study suggests that aerobic exercise for 4 weeks significantly reduced the blood concentration of triglycerides (TG), total cholesterol (TC), and low-density lipoprotein cholesterol (LDL) in male Sprague-Dawley rats. These findings are supported by other research that has shown the TG, LDL-C and TC levels are reduced by exercising in obese men[19]. However, the reason for this reduction is not entirely clear and may be due to the changes occurring in the metabolism of triglycerides and lipoproteins during aerobic exercise[20]. Another work demonstrated that plasma lipoprotein lipase (LPL) and hepatic lipase (HL) which use more TG were increased with aerobic exercise[21].

Nevertheless, the findings are inconsistent with the research of Motoyama et al[22] which showed that, TG and LDL cholesterol did not significantly change with aerobic training and detraining in adult male and female. Animal model was used in this study to better control the independent variables and other factors such as food, sleep and wakefulness, environmental conditions (temperature and humidity), and training intensity and volume. A recent paper[15] showed that despite a 17% in the VO_{2max} of the participants, the HDL did not increase significantly. In addition, aerobic exercise showed no difference in HDL levels of sedentary overweight women before and after menopause[23].

In this report, no significant difference was seen in the body weight of the subjects before and after the training program. In a study conducted by Marques et al[24] a significant increase in body weight been observed in the subjects after the assessment which included aerobic exercising. Thus, there were no relationships between body composition, aerobic endurance and lipid profiles. Duration and intensity of the physical exercise could also be responsible in levels of HDL. In one study[20], moderate endurance exercise, regardless of the duration of the training, caused no significance change in the subject's lipid profiles. However, it was shown[25] that high intensity aerobic activity resulted in improvements in HDL levels. It is suggested that an intensity threshold may exist for aerobic exercising which will cause effective changes in HDL levels[26]. In this study, this threshold may not have been reached during the training program hence lesser effectiveness in HDL levels was observed.

The data obtained from this research suggests that ginger extract caused a reduction in TG, TC and LDL with slight increment in HDL levels. These results were consistent with Fuhrman et al[27] and Abd-Elraheem et al[8]. In addition, methanol extracts of ginger have been shown effective in lowering cholesterol levels in rabbits[26]. Ginger has also been proven to reduce lipid profiles significantly in atherosclerosis subjects[28]. It was also shown that feeding fructose-induced hy-

perlipidemic rats with ginger extract reduced their serum cholesterol and TG levels[10]. Ethanol extracts of ginger have shown to reduce total cholesterol and TG in blood serum[29]. This could be due to the presence of (E)-8 beta, 17-epoxyl-labed-12-ene-15, 16-dial, which is a compound isolated from ginger, that inhibits the biosynthesis of cholesterol in liver of hypercholesterolemic mice[27]. Ginger increases the activity of liver enzyme cholesterol 7-alpha-hydroxylase, which is the limiting enzyme in the biosynthesis of bile acids, which results in removal of cholesterol from the body[26]. Reduction of cellular cholesterol biosynthesis is associated with increasing activity of LDL receptors that leads to increase in removal of plasma LDL which, results in reduction of plasma cholesterol concentrations[8].

The effective concentration of ginger extracts in reducing lipid profiles has been already investigated. For instance, one study showed that consumption of 1 g of ginger had no significant effect on lipid profile and insulin sensitivity in obese men but increasing the amount to 3 g showed hypolipidemic properties[10]. Some researcher[26] suggests that consumption of ginger (10% per body weight per day) would have no immediate effect in the serum cholesterol. In one report[30], it was even shown that consuming ginger for 3 months had no impact on lipid profile and insulin resistance in patients with coronary artery disease.

In this study combining aerobic exercise with ginger extract consumption for 4 weeks proved to be the most effective method in decreasing levels of TG, TC and LDL significantly, while HDL was increased by 1.5 fold. It has been shown that ginger supplementation with resistance training, significantly reduced total cholesterol in obese men[31]. Other factors that may influence the uptake of ginger extracts by the subjects include nutrition, stress levels, and genetics, which result in total cholesterol changes[3,19].

The weights of the rats in this work were slightly increased at the end of the study, which could be due to the increase in HDL levels. Several authors suggest a significant relation between changes in body weight and lipid-lipoprotein responses to aerobic exercise[32]. Obesity, especially visceral obesity, is correlated with increased concentrations of free fatty acids (FFA) and inversely related to glucose and lipoprotein metabolism. This includes the development of insulin resistance, an increase in production of TG-rich very low-density lipoproteins (VLDL), and reduction in HDL particles. Therefore, it seems that the effect of aerobic exercise on HDL-C levels depends on the initial body weight and the distribution of localized fat deposits, duration and intensity of aerobic exercise, and the presence or absence of weight loss[19]. Also type of exercise being aerobic or resistant may alter lipid profile in different ways[3,20].

Conclusions

Our findings suggest that aerobic exercise coupled with ginger extract consumption synergistically affect lipid profile in high fat diet fed rats. We suggest several improvements in obtaining the desired results. A purified fraction of the ginger extract could be used for future studies and also effect of resistant exercise on lipid profiles could also be studied further.

Declaration of Funding Interests

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Conflict of Interest

The Authors declare that they have no conflict of interests.

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