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The effect of 10-week aerobic training with and without ginger supplementation on aerobic power, BFP, and insulin resistance in obese middle-aged women with type 2 diabetes

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ABSTRACT

Background and aims: Diabetes is a metabolic disorder associated with diseases. The use of supplements, herbal extracts, and exercise training for the treatment of diseases and metabolic disorders has increased among people. Thus, the aim of this study was to investigate the effect of 10-week aerobic training with and without ginger supplementation on aerobic power, BFP, and insulin resistance in obese middle-aged women with type 2 diabetes.

Methods: In this study, 46 obese diabetic women (BMI > 30, blood fasting sugar more than 150-250 mg/dL, 45-60 years old) were selected and randomly assigned into four groups, ginger (n=12), aerobic exercise training + ginger (n=12), aerobic exercise training (n=12) and control (n=10). Participants in supplementary groups received four 250 mg capsules ginger extract 1000 mg daily for 10 weeks. Aerobic training program included 10 weeks of training, 3 sessions per week and each session was 60 minutes at 55% maximum heart rate during the first week and gradually increased with the progress of the training program to 75 percent of maximum heart rate.

Results: After 10 weeks, significant difference was observed in weight, BMI, body composition, VO_2max, Insulin, fasting glucose and insulin resistance ($P<0.05$). In the within group changes was observed significant decrease in insulin levels and insulin resistance was in the aerobic exercise training + ginger group ($P<0.05$).

Conclusion: According to obtained results, it appears that aerobic training plus ginger extract consumption have better effect on insulin levels and insulin resistance in obese middle-aged women with type 2 diabetes.

Keywords: Aerobic training, Ginger, type 2 diabetes.

Original article

INTRODUCTION

Diabetes is a metabolic disorder characterized by decreased release of insulin that leads to increase in plasma glucose levels. Diabetes is also called sugar disease due to the sweet taste of diabetes patients' urine. Costs spent for diabetes was estimated

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378 billion US dollars in Iran in 2009 Over 90-95% of diabetes patients suffer from diabetes mellitus.[1,2]

For several decades, exercise, alongside pharmacotherapy and diet, has been considered the basis of diabetes management, which indicates that physical activity is an effective approach to prevent and treat type 2 diabetes. A 60% decrease in the risk of developing diabetes was reported to be due to exercise in people with impaired glucose tolerance,[3] Studies demonstrated that body mass index (BMI) and triglyceride levels significantly decreased following this protocol.[3,4]

It was well demonstrated that increased body fat percentage (BFP) and insulin resistance are associated, and insulin resistance induced by increased BFP is associated with different diseases such as hypertension, metabolic syndrome, and hepatic steatosis.[5] Bruce et al. studied the effects of aerobic exercise on fat and insulin resistance in men with type 2 diabetes; they reported that VO_2max, triglyceride, and aerobic power increased following eight weeks of 70% to 80%-intensity exercise in these patients.[6]

Trovati et al studied the effects of exercise on aerobic power, blood sugar control, glucose tolerance, and insulin resistance in patients with type 2 diabetes; they found that physical activity caused improvement of diabetes patients' metabolic disorders and aerobic power.[7]

Besides that, supplements and plant extracts are currently being commonly used to treat diseases and metabolic disorders. Ginger (Zingibar officinale Roscoe), from family Zingiberaceae, is widely used as a spice across the world. Studies indicated that ginger modulates fat metabolism through increasing bile acid biosynthesis that removes cholesterol from the body, increases excretion of cholesterol through feces, and prevents the biosynthesis (biological synthesis) of cell cholesterol.[8] Studies helped to offer new attitudes toward ginger effects on the body's metabolism and associated benefits for prevention or treatment of diabetes and relevant mechanisms.[3] For example, Arablou et al. investigated ginger supplementation effect on certain risk factors for cardiovascular diseases in patients with diabetes mellitus. They reported that ginger caused decrease in fasting blood sugar (FBS), certain lipidemia fractions, and C-reactive protein (CRP), and was useful to prevent cardiovascular diseases in the patients.[3] Mozaffari et al. study on 81 patients with type 2 diabetes demonstrated that use of 3 g pulverized ginger a day for eight weeks caused decrease in FBS.[9] Shanmugam et al. reported that ginger caused significant decrease in glycemia in the diabetic mice compared to the diabetic control mice.[4]

Besides that, Atashak et al. reported that long-term use of ginger and resistance exercise could be an effective treatment for insulin resistance in obese men.[10] Edith et al. investigated treadmill workout for one week in ultra-marathon athletes and found that ginger supplementation could not prevent an increase in insulin resistance.[11]

Given the effects of regular physical exercise, the useful effects of ginger in reducing diabetes complications, that most studies have investigated the effects of ginger separately, and few studies have yet been conducted to investigate synergistic effects of ginger supplementation and aerobic exercise on the aerobic power of obese women with type 2 diabetes, our aim was to study the effect of 10-week aerobic exercise alongside ginger supplementation on aerobic power, BFP, and insulin resistance in obese middle-aged women with type 2 diabetes.

METHODS

The study population of this quasi-experimental study consisted of all

obese women (BMI > 30) with type 2 diabetes in Shahrekord city. The samples were 46 obese women with type 2 diabetes aged 45-60 years who were purposively selected and randomly assigned to four groups: ginger (n=12), aerobic exercise training + ginger aerobic(n=12), exercise training (n=12) and control (n=10). The participants had no history of myocardial infarction, uncontrolled arrhythmia, and diabetes complications such as diabetic foot ulcer and nephropathy as well as no regular physical activity, were not smokers, did not use any special diet or therapy, and were sufficiently prepared to begin physical exercise. This information was investigated using medical history questionnaire and the Physical Activity Readiness Questionnaire (PAR-Q). The participants were assessed for body composition and physical preparation 24 h before biochemical tests. Weight was measured by a digital scale (Saros Co., USA) to the nearest 0.1 kg and height measured by a height scale (Saros Co., USA) to the nearest 0.1 cm. Waist–hip ratio (WHR) represents the ratio of waist circumference to hip circumference. To calculate body fat percent (BFP), subcutaneous fat thickness of three sites, abdomen, suprailiac, and triceps, were measured using subcutaneous fat thickness caliber. The formula below was used to measure BFP.

Body Density= 1.089733 - 0.0009245(x) + $0.0000025(x)^2$ - 0.0000979(age)

BFP = (495/ Body Density) - 450

The study protocol was approved by the Research and Technology Deputy of the Shahrekord University of Medical Sciences (approval no: 94/220).

To measure cardiorespiratory fitness, Rockport 1.0 mile walk test was used. To conduct this test, one is required to walk as briskly as possible for one mile (to reach heart rate over 120 beats/min). In all groups, to conduct pretest, the blood samples were collected and then centrifuged. Then, the blood plasma was taken, and blood sample collection was duplicated 10 weeks later.

The subjects were instructed to take four 250 mg ginger extract capsules a day alongside routine diet. Ginger capsules (Zintoma) were purchased from Goldaru Pharmaceutical Co. with health certificate IRC 1228022777 issued by the Food & Drug Administration of Iran Ministry of Health and Medical Education.[10] In addition, for the control group, capsules containing roasted wheat flour with similar appearance to the ginger supplementation capsules.[12]

The aerobic exercise training protocol consisted of three 60-min sessions every week for 10 weeks that started with 55% maximum heart rate in the first week and gradually reached 75% maximum heart rate. Each session consisted of warm-up (10 min), stand-up aerobic workouts (40 min), and recovering the baseline state at sitting position (10 min).[13] The intensity of the exercise was determined by calculating maximum heart rate using polar heart rate sensor using the formula 220-age. The percentage of target heart rate in each session was calculated by the Karvonen formula.

Target heart rate= (training% × heart rate reserve) + resting heart rate

After 10-12 h of overnight fasting, the participants attended the place of blood collection at 8 am. The primary blood samples (10 ml) of anterior brachial vein were taken by a blood drawing laboratory expert. After centrifugation, the serum samples were isolated. Serum insulin level was measured by ELISA and glucose concentration measured by a glucometer kit. Insulin resistance (HOMA-IR) was calculated by the formula below.[14]

$$\text{HOMA IR} = \frac{\text{Insulin assay (microunits/ml)} \times \text{Fasting Plasma Glucose (mmol/ml)}}{22.5}$$

After primary data gathering, the exercise protocol was started and continued for 10 weeks. After completion of the exercise protocol, the measurements of anthropometric and laboratory variables were duplicated by the researcher and laboratory expert.

Data analysis was conducted by descriptive and inferential statistics in SPSS 16. For descriptive statistics, mean and standard deviation were used. To investigate the study hypotheses, first, normal distribution of the data was investigated by kolmogorov-smirnov tests. Between groups differences were investigated by one-way Anova and tukey's test. The level of significance was considered 0.5.

RESULTS

Table 1 shows changes in weight, BMI, BFP, waist circumference, hip circumference, WHR, and maximal oxygen uptake (VO_2max) before and after eight weeks of exercise interventions.

Table 1: The comparison of changes in the measured variables before and after eight weeks of exercise interventions

Variables	Groups	Mean ± SD		P within group	P between groups
		Pretest	Posttest		
Weight (kg)	G	80.12 ± 6.78	77.58±6.44	0.000**	0.000**
	G + AT	83.83 ± 13.01	80.25±13.10	0.000**	
	AT	84.75 ± 8.10	82.83±8.14	0.000**	
	Control	86.30 ± 11.33	85.40±11.47	0.223	
BMI (kg/m^2)	G	32.60±1.84	31.69±1.81	0.000**	0.000**
	G + AT	33.96±4.32	32.49±4.60	0.000**	
	AT	31.50±2.04	30.64±2.05	0.000**	
	Control	34.61±4.86	34.44±4.91	0.200	
Body Fat percent	G	27.34±2.82	23.58±2.77	0.000**	0.000**
	G + AT	32.28±3.26	27.94 ± 2.73	0.000**	
	AT	31.32±4.63	27.99 ± 2.36	0.016**	
	Control	33.18±3.51	31.51±2.96	0.065	
WC (cm)	G	91.08±29.45	87.33±28.60	0.013*	0.333
	G + AT	99.08±7.48	93.50±9.08	0.002**	
	AT	96.41±11.22	92.33±9.89	0.004**	
	control	100.50±8.43	100.60±8.47	0.34	
HC (cm)	G	104.75±35.91	100.66±34.30	0.000**	0.365
	G + AT	113±13.81	107.91±13.04	0.000**	
	AT	113±14.65	107.91±14.67	0.026**	
	Control	116.10±9.51	116.10±9.51	0.111	
WHR	G	0.80±0.26	0.79±0.26	0.536	0.602
	G + AT	0.87±0.07	0.86±0.07	0.101	
	AT	0.85±0.09	0.85±0.07	0.880	
	Control	0.86±0.48	0.87±0.048	0.340	
VO_2max (ml/kg/min)	G	15.13±1.48	16.88±1.61	0.000**	0.000**
	G + AT	14.46±1.42	16.28±1.67	0.000**	
	AT	14.83±1.59	15.84±1.53	0.000**	
	Control	13.54±1.39	13.33±1.41	0.138	

*G: Ginger group; G+AT: Ginger + aerobic exercise training group; AT: Aerobic exercise training group; Control group: Subjects who not participated in exercise training. *: Significant difference between two groups (P<0.05); **: Significant difference between two groups (P<0.01).*

One-way ANOVA indicated a significant difference in weight (P=0.000), BMI (P=0.000), BFP (P=0.000), and maximal oxygen uptake (P=0.000) among the groups. In addition, within group changes in weight, BMI, BFP, waist circumference, hip circumference, and maximal oxygen uptake were significant.

Table 2: The comparison of changes in the measured variables in within and between groups

Variables	Groups	Mean ± SD		P within group	P between groups
		Pretest	Posttest		
Insulin resistance	G	3.24±3.08	3.13±4.92	0.948	0.001**
	G + AT	2.80±1.90	1.87±1.25	0.009**	
	AT	3.76±3.30	2.01±0.86	0.108	
	Control	5.23±4.45	5.35±4.42	0.449	
Insulin (μu/ml)	G	8.07±6.56	6.42±7.75	0.586	0.007**
	G + AT	7.92±4.48	5.00±2.09	0.007**	
	AT	9.89±7.52	5.82±2.71	0.148	
	Control	11.35±9.61	11.62±2.71	0.367	
FBS (mg/dl)	G	231.00±69.33	136.30±54.94	0.001**	0.001**
	G + AT	175.50±62.65	671.90±49.36	0.000**	
	AT	192.70±74.68	147.30±47.45	0.003**	
	Control	200.0±98.50	200.50±98.38	0.082	

One-way ANOVA demonstrated significant differences in insulin resistance (P=0.001), insulin (P=0.007), and FBS (P=0.001) among the groups. In addition, within Group change in FBS was significant in the experimental groups (P=0.001, 0.000 and 0.003), but in insulin resistance and insulin were significant only in G+AT (P=0.009 and 0.007) (Table 2).

DISCUSSION

The current study demonstrated that weight, BMI, BFP, and FBS decreased significantly in all three experimental groups compared to the control group, but no significant difference in WHR was seen among the experimental groups after 10 weeks of aerobic exercise. Moreover, maximal oxygen uptake increased significantly in all three experimental groups compared to the control group. After 10-week treatment with ginger, insulin and insulin resistance did not decrease significantly, but when the treatment was combined with 10-week exercise, these two variables decreased significantly.

Atashak et al., Black et al., and Tripathi et al. consistently, reported that glycemia and insulin resistance decreased after ginger supplementation.[5,15,16] In our study, supplementation with ginger, which is an anti-inflammatory agent, caused decrease in the above cytokines compared to their levels before the exercise. Overall, ginger supplementation causes antioxidant effects anti-inflammatory effects by inhibiting cyclo-oxygenase and lipoxygenase pathways that prevent the metabolism of arachidonic acid, inhibit platelet adhesion, and suppress the production of free radicals.[17-20]

Mozaffari et al. study on 81 patients with type 2 diabetes demonstrated that use of 3g

pulverized ginger a day for eight weeks caused decrease in FBS.[9] Shanmugam et al. reported that ginger caused significant decrease in glycemia in the diabetic mice compared to the diabetic control mice.[4] Arablou et al. reported that ginger caused significant decrease in FBS which is consistent with the current study.[3] Mahluji et al. reported that use of ginger (2 g/day) for two months had no effect on FBS but could decrease serum insulin levels and insulin resistance, which is inconsistent with our findings.[21] This inconsistency can be due to difference in response among diabetes patients that, in turn, may be attributable to difference in the duration of suffering from diabetes, the case group's wrights, the severity of insulin resistance, and certain indices measured at the baseline. To date, a number of studies have been conducted on the effect of ginger on glycemia with inconsistent findings.[3,10,22] Most of these studies investigated ginger supplementation.

Increased BFP plays a significant role in the pathogenesis and development of diabetes as well as increase in insulin resistance.[10] ElRokh et al. study demonstrated that fat decreased significantly in mice treated with ginger supplementation.[23] In addition, Shirdel et al. Study on anti-diabetic and anti-lipidemic effects of ginger in mice with alloxan monohydrate-induced diabetes reported that the levels of fat decreased significantly in the diabetic mice compared to the diabetic control mice.[24] Singh et al. study indicated that FBS decreased and oral glucose tolerance test increased significantly in mice with type 2 diabetes. In addition, plasma triglyceride levels, total cholesterol, and plasma insulin levels decreased significantly.[25]

Alizadeh et al. study on patients with hyperlipidemia demonstrated that after 45-day treatment with pulverized ginger (3 g/day in three administrations), triglyceride and cholesterol levels decreased significantly, which is not consistent with the current study.[26]

An important finding of the current study was decrease in insulin resistance in the G + AT group. Improvement of insulin resistance due to exercise and ginger supplementation is in agreement with other studies. Atashak et al. suggested that obese people can experience desirable changes in lipid peroxidation and insulin resistance by the long-term use of ginger and resistance exercise.[10] They reported that 10-week progressive exercise and use of ginger caused significant effect on malondialdehyde concentration that is a marker for lipid peroxidation in obese people. By improving antioxidant systems and eliminating plasma free radicals ginger can exert potent antioxidant effects.[27,28]

Colberg et al. reported that 8-week resistance exercise did not cause any significant change in insulin resistance in diabetes patients, which is consistent with our study. Yousefipoor et al. study demonstrated that practicing 8-week aerobic or combination exercise could be helpful for patients with type 2 diabetes via improving insulin resistance and FBS.[29,30] The main causes of inconsistency in such findings and our results can be the intensity and duration of the exercise as well as age, physical conditions, BMI, and the measured indices. Although it was reported that the use of ginger could improve insulin resistance,[31,32] insulin levels and insulin resistance decreased insignificantly in our study. Different doses of ginger and durations of treatment can explain inconsistency in the findings. Most studies on the effects of ginger on glycemia and plasma insulin levels have investigated the high doses of this plant while in the current study, it was used low doses.[31]

Aerobic power, namely cardiorespiratory endurance or cardiopulmonary fitness, refers to ability to uptake, transfer, or consume

oxygen. Aerobic exercise is closely associated with athletes' performances in aerobic activities and prevents fatigue in intense and elongated exercise sessions. With increase in aerobic power, certain physiological changes such as change in heartbeat and myocardium size, increase in the blood volume and hemoglobin, hypotension, blood distribution, maximal oxygen uptake, and decrease in lactic acid. In the present study, aerobic exercise caused increase in aerobic power that is in agreement with Trovati et al. study.[7] Assessing aerobic power before and after the exercise showed that this index increased significantly after the exercise, and therefore the practiced exercise (in the experimental group) can serve as a dependent variable and cause changes in the blood and the body's performance.[6]

A limitation of our study was that the patients' drugs and diets were not controlled for strictly. These variables can affect the effects of exercise interventions and tests results. Besides that, the patients' psychological conditions on the days of taking tests is an additional limitation of this work.

CONCLUSION

Taken together, the current study demonstrated that 10-week aerobic exercise alongside ginger supplementation led to improvement of aerobic power in obese women with diabetes mellitus. Because despite recommendations about diet and completion of Food Frequency Questionnaire, the participants' adherence to diet could not be definitely ensured and also the sample size was small, further studies with adjustment for these drawbacks, could help to achieve more reliable evidence. Overall, the effects of aerobic exercise and ginger supplementation have not been adequately studied on inflammation factors particularly in diabetes patients, and therefore deserve further investigation.

The implications of the study

The use of ginger (1 g/day) for 10 weeks can decrease mean FBS and insulin resistance during exercise in patients with diabetes mellitus. This supplementation is therefore suitable for these patients. However, additional effects of this drug need to be further studied.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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