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Effect of short-term aerobic exercise and green tea consumption on MFO, Fat_{max}, body composition and lipid profile in sedentary postmenopausal women

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ABSTRACT:

Background: Visceral fat accumulation due to the decrease in estrogen levels, and gaining weight after menopause, increases the risk of metabolic syndrome and cardiovascular diseases in postmenopausal women; while physical activity at maximum fat oxidation intensity (Fat_{max}) and green tea consumption are recommended for increasing fat oxidation. The aim of this study was to evaluate the effect of short-term aerobic exercise and green tea consumption on maximum fat oxidation (MFO), Fat_{max}, body composition and lipid profile in sedentary postmenopausal women. **Methods**: 24 sedentary postmenopausal women were divided into two groups: exercise+placebo and exercise+supplement. Exercise tests were performed by gas analyzer device and blood samples were collected after 12 hours of fasting overnight in pre and posttest phases. The subjects had a daily intake of 1,200 mg of green tea or cellulose in capsule form. The training protocol contained two weeks of aerobic exercise at an intensity of about maximum fat oxidation which was performed four times a week and each session took 40 to 50 minutes. **Results**: After two weeks, the amounts of weight, body mass index, waist to hip ratio, average total carbohydrate oxidation and HDL were significantly decreased in both groups ($p \leq 0.05$). The peak oxygen consumption, maximum fat oxidation, Fat_{max} and the average total fat oxidation increased but were not significant ($p > 0.05$). Triglyceride ($P=0.003$) and visceral fat levels ($P=0.044$) only declined significantly in exercise+supplement group and LDL levels ($P=0.043$) only increased in exercise+supplement, significantly. Fat percentage also decreased in two groups which was not significant ($p > 0.05$). **Conclusions**: The findings showed that short-term aerobic exercise at Fat_{max}, alone and along with green tea consumption, reduced body weight and improved average total carbohydrate oxidation in sedentary postmenopausal women and aerobic exercise with green tea was more effective in reducing triglycerides and visceral fat levels.

KEY WORDS Aerobic exercise at Fat$_{max}$, Green tea, Maximal fat oxidation, Lipid profile, Postmenopausal women

INTRODUCTION

Visceral fat accumulation due to the decrease in estrogen levels, as well as gaining weight after menopause, increases the risk of metabolic syndrome and cardiovascular diseases in postmenopausal women [1]. In this regard, the cardiovascular disease prevalence in women over 55 years, has been reported ten times higher compared to women 35-45 years old [2]. Also, it was observed that cholesterol, triglycerides (TG), and low-density lipoprotein (LDL) levels in postmenopausal women were higher than premenopausal women; whereas high-density lipoprotein (HDL) levels in postmenopausal women were lower than the other group [3]. In addition, lack of physical activity is considered as an independent risk factor of cardiovascular disease, while about 30 percent of postmenopausal women do not take part in any regular physical activity [4].

Generally, exercise or physical activity is directly related to a healthy lifestyle [5], and is a useful strategy to improve the living conditions and particularly decrease body fat percent in postmenopausal women [6]. More precisely, the physical activity augments the fatty acids release into the bloodstream through increased blood flow in adipose tissue and the increase in lipolytic enzymes activity such as hormone-sensitive lipase and lipoprotein lipase (LPL) and thus, it improves the fat oxidation [7]. Increased catecholamines during exercise which stimulates adipose tissue lipolysis, is also involved in this issue [8].

Nowadays, a kind of exercise, aerobic exercise at Fat$_{max}$ is taken into consideration in order to increase the fat oxidation. It should be noted that the most amount of fat (maximum fat) which is burned in a physical activity to supply the energy, is called Maximum Fat Oxidation (MFO) [9]. Fat$_{max}$ index also represents an intensity of the exercise where the maximal fat oxidation rate occurs. In total, MFO has been observed in submaximal intensities and about at 31 to 65% VO_{2peak} [9, 10]. In this regard, Brun et al. (2011) in a meta-analysis study showed that training at Fat$_{max}$ levels will be very useful in reducing body fat percentage (BFP) and cholesterol level as well as increasing the ability of mitochondria for oxidation of fatty acids [11]. Plus, increased fat oxidation rate during physical activity is associated with an increase in insulin sensitivity at rest state as well as decreased blood pressure and LDL level [12]. The researchers pointed out that decreased fat oxidation rate in the activities at intensity higher than Fat$_{max}$, may be due to a restriction in the transfer of free fatty acids into the mitochondria by Malonyl - CoA and lactate [11].

Friedenreich et al. (2015) studied the effects of aerobic exercise with moderate volume (150 minutes per week) and high volume (300 minutes per week) on postmenopausal women's lipid profile. Exercise intensity in half the time of each session, was up to 65-75% heart rate reserve. They noticed that exercise with high volume caused further changes in the reduction of total body fat, abdominal fat and waist-to-hip ratio (WHR) compared to the exercise with moderate volume [13]. Venables et al. (2008) mentioned that four weeks of aerobic exercise at Fat$_{max}$, increased the fat oxidation rate and was more effective in improving insulin sensitivity in obese individuals with type 2 diabetes compared with interval training (5-min intervals of 20% Fat$_{max}$) [12]. In contrast, Johannsen et al. (2009) who examined the effect of different exercise volumes on fat oxidation capacity in 260 postmenopausal women, found out that six months of training in different volumes with 50% VO_{2max} failed to improve MFO and Fat_{max} in postmenopausal women [6].

In addition to exercise, taking green tea supplementation (containing polyphenolic compounds) which enhances the fat oxidation rate; has been suggested as a useful method in reducing the fat percentage in several studies [14, 15]. Green tea extract is derived from unfermented dried leaves of the plant, Camellia Sinensis, and mainly contains polyphenolic compounds. These compounds include Epigallocatechin Gallate (EGCG), Epigallocatechin (EGC), Epicatechin Gallate (ECG), and Epicatechin (EC). It is thought that catechins of green tea improve the fat oxidation rate by inhibition of Catechol-O-methyltransferase, an enzyme which degrades norepinephrine level [8]. In this regard, in a review study, Rains Et al. (2011) indicated that green tea consumption between 270 mg to 1200 mg per day could reduce the weight body and fat [15]. Venables et al. (2008) also declared that green tea consumption before and after a cycling exercise at 60% VO_{2max} which lasted 30 minutes, ameliorated the insulin sensitivity and glucose tolerance and fat oxidation rate in young men [14]. More, it was expressed that the appropriate amount of green tea consumption (three cups per day containing 240 to 320 mg polyphenols), will not cause any side effect [16]. In contrast, Haghighi et al. (2013) notified that eight weeks of aerobic training along with green tea consumption, significantly decreased weight in obese and overweight women, but had no effect on serum total cholesterol, TG, HDL-C and LDL-C levels [17].

Considering the unique benefits of exercise and green tea, as well as the paucity of studies on the effect of aerobic exercise at Fat_{max} along with green tea consumption during menopause, this study aimed to investigate the effect of short-term aerobic exercise at Fat_{max} and consumption of green tea on MFO, Fat_{max}, body composition and lipid profile in sedentary postmenopausal women.

METHODS

Study design

This was a quasi-experimental study with two groups (aerobic exercise + placebo, aerobic exercise + supplement) in pre-test and post-test phases. After the initial screening by the researcher and according to the entrance criteria, 28 out of 60 menopausal women participated in present study, voluntarily and eventually, 24 subjects with a mean age of 54 ± 2.7 years, height of 160.2 ± 5.3 cm, weight of 74.4 ± 8.8 kg, and body mass index (BMI) of 28.8 ± 3.2 kg/m^2 attended our study. Present study was approved by the ethics committee of Ferdowsi University of Mashhad by code 61694.

After the invitation and initial registration, necessary information about the nature and manner of conducting the survey, potential risks and essential tips to participate in the study were orally presented to the individuals who were interested in the collaboration. Then, based on information obtained from the demographic questionnaire, medical questionnaire and Kaiser Physical Activity questionnaire and menopausal status questionnaire, 28 postmenopausal women who met the required criteria were selected. Entrance criteria included: The subjects got a natural menopause and it was not due to removal of the uterus and ovaries as well as chemotherapy or radiotherapy. Their age, BMI and BFP were between 50-58 years, 25-30 kg/m^2 and 30-35 percent, respectively. All subjects were healthy with a history of pregnancy; they were not under any kind of hormone therapy in the past six months; they also had at least one year and a maximum of six years' distance from their last menstruation. Before beginning the training program, the subjects were asked to complete the consent form. The height and weight were measured by Seca 220 Stadiometer (Germany) as well as their BFP, visceral fat area (VFA) and BMI were evaluated by body composition analyzer, Inbody 720 (South Korea). Plus, the subjects were asked to note their diet over three days before the primary blood sampling in a recall questionnaire and follow the same diet into three days before the secondary blood sampling. In a meeting, low and moderate glycemic index carbohydrates were introduced to the subjects and they were asked to avoid eating high glycemic index carbohydrates and extra fatty foods; in turn, they were encouraged to consume low and moderate glycemic index carbohydrates along with more vegetables and fruits (fiber). Their diet was checked out by the researcher, every day. The subjects came to Exercise Physiology Lab of Ferdowsi University of Mashhad, 72 hours before the first exercise session and 7 cc blood samples were collected from the brachial vein by an experienced person, after 12 hours of fasting overnight [14].

It should be noted that the tests were performed in two pre-test and post-test phases at the same time (8 am to 10 am) to prevent the impact of circadian rhythms. Exercise test (Fat$_{max}$ Test) was performed with gas analyzer device (QUARK PPT 4 Evo made in Italy) in a breath-by-breath method thorough exercise trial, 24 hours after blood sampling.

At this point, the subjects were randomly divided into exercise + placebo and exercise + supplement groups and 48 hours after the exercise test, they participated in the first training session; the training program also took two weeks. After this period and 48 hours after the last training session, blood samples were collected again and afterwards the body composition indexes were measured. Finally, 48 hours after the blood sampling, the exercise test was performed by the subjects again. Concentration of serum LDL, HDL, Cholesterol and TG were measured after 12 hours of fasting overnight in pre and posttest phases by coronix 801- AT device (in a photometric method) made in Iran as well as Biosystem kit made in Spain, respectively.

Training protocol

The training Protocol contained two weeks of aerobic exercise at an intensity of about maximum fat oxidation (MFO) which had been estimated by gas analyzer device; aerobic exercise was performed four times a week and each session took 40 to 50 minutes. Warm up and cool down phases lasted 5 minutes by doing stretching movements [18]. Exercise intensity was controlled by heart rate monitors (Polar).

Supplementation protocol

The subjects had a daily intake of 1,200 mg of green tea or cellulose in capsule form. They consumed 400 mg of green tea or cellulose, an hour before their meals (in the morning, at noon and at night) [19]. Green tea capsules were provided from CAMGREEN Giah Essence Company, made in Iran with IRC:1228180750. Each capsule consisted of Epigallocatechin Gallate, Epicatechin Gallate, Epigallocatechin and Epicatechin components.

Respiratory gas analysis

The subjects conducted the progressive exercise until exhaustion, including 3 minutes' activities on treadmill to determine Fat$_{max}$ and MFO rate. Treadmill exercise test originated from the method presented by Venables et al. (2005) [20]. After a 5-minute warm-up, the subjects began the exercise activity on treadmill at a speed of 3.5 km/h with a gradient of 1%. The Speed was increased every 3 minutes by 1 km/h, until it reached 7.5 km/h. At this point, the speed was kept unchanged, while the gradient increased every 3 minutes by 2%, until a RER (rate of perceived exertion (VCO_2/VO_2)) reached 1.0. After this stage, the speed increased by 1 km/h every minute until exhaustion. The purpose of this stage was to reach VO_{2max} rate [9]. Data obtained from the device, were put in the following equations to estimate fat and carbohydrate oxidation rate as well as evaluate the percentage of fat or carbohydrate oxidation for energy supply during exercise:

(g/min) Carbohydrate oxidation = $4.585 * VCO_2 - 3.266 * VO_2$

(g/min) Fat oxidation = $1.695 * VO_2 - 1.701 * VCO_2$

The average of VO_2 was calculated in the last 30 seconds of each stage; then, the calculated number was divided by VO_{2max} value and thus the activity intensity at each stage was measured; it was expressed as a percentage of VO_{2max}. The maximum value obtained from fat oxidation equation, was considered as the maximal fat oxidation (MFO), and the corresponding activity intensity was considered as Fat_{max}.

The average fat and carbohydrate oxidation rates were calculated at last 30 second of each stage, and the sum of those values in all stages was considered as total fat or carbohydrate oxidation rate.

In the next step, the subjects were randomly divided into two groups of exercise + placebo and exercise + supplement. After two weeks of the intervention, the participants were asked to be present in the exercise lab; similar to the pre-test phase, exercise test was performed by all the subjects again and the data obtained in this step (post-test phase) were put in the equations and analyzed.

Statistical procedures

Using SPSS version 16, the mean and SD of data were calculated by Descriptive Statistics; then, data distribution normality and homogeneity of variance were respectively analyzed by Shapiro-Wilk and Levene's test; afterwards, the paired-sample t-test and independent-sample t-test were utilized to compare the differences within groups and between ones, respectively. Also, Wilcoxon and Mann-Whitney U tests were respectively used for comparing the differences within groups and between groups in variable with the distribution other than normal. The statistical significance was considered at p values ≤0.05.

RESULTS

After two weeks, the amounts of weight (p=0.003), BMI (p=0.008), WHR (p=0.034), average total carbohydrate oxidation (p=0.001) and HDL (p=0.033) decreased significantly in exercise+placebo group. In this group, BFP (p=0.75), VFA (p=0.89) and TG (p=0.12), VO_{2peak} (p=0.65), MFO (p=0.76), Fat_{max} (p=0.18), average total fat oxidation (p=0.40), cholesterol (p=0.80) and LDL (p=0.16) did not change significantly.

In exercise+supplement group, we observed a significant decrease in weight (p=0.001), BMI (p=0.002), WHR (p=0.001), average total carbohydrate oxidation (p=0.028), VFA (p=0.044), TG (p=0.003) and HDL (p=0.001) levels along with a significant increase in LDL level (p=0.043). In this group, BFP (p=0.29), cholesterol (p=0.86), VO_{2peak} (p=0.35), MFO (p=0.15), Fat_{max} (p=0.14) and average total fat oxidation (p=0.11) did not change significantly (Table.1.a & 1.b).

BMI and average total fat oxidation values being presented in table 1.b, were analyzed by nonparametric tests because they were not confirmed by the normality or homogeneity tests.

Table 1.a

Mean±SD, differences of within and between groups, before and after the interventions. *P≤ 0.05 vs before

Variable	Group	Phases		Differences			
		pre-test	post-test	Within Groups		Between Groups	
		Mean ± SD	Mean ± SD	t	Significance Level	t	Significance Level
Mass (kg)	Exercise+placebo	69.2±5.8	68.4±5.7	3.85	0.003*	2.57	0.017*
	Exercise+supplement	73.7±4.2	71.8±5.1	5.23	0.001*		
BFP (%)	Exercise+placebo	40.1±4.5	39.9±3.3	0.32	0.754	0.41	0.68
	Exercise+supplement	43.4±4.0	42.9±3.9	1.09	0.299		
VFA (cm^2)	Exercise+placebo	122.5±11.3	122.0±11.1	0.13	0.89	0.72	0.47
	Exercise+supplement	130.6±15.6	127.7±13.5	2.28	0.044*		

WHR (cm)	Exercise+placebo	0.94±0.03	0.93±0.03	2.41	0.034*	1.67	0.10
	Exercise+supplement	0.97±0.03	0.96±0.03	5.50	0.001*		
VO_{2peak} (ml/kg/min)	Exercise+placebo	23.1±4.9	24.0±3.8	0.46	0.65	0.11	0.91
	Exercise+supplement	20.9±3.2	22.0±4.0	0.96	0.35		
LDL (mg/dl)	Exercise+placebo	125.0±31.6	138.5±31.8	1.48	0.166	0.85	0.18
	Exercise+supplement	113.0±20.4	128.6±31.3	2.29	0.043*		
HDL (mg/dl)	Exercise+placebo	64.5±9.6	56.9±10.0	2.44	0.033*	0.53	0.59
	Exercise+supplement	61.1±6.9	51.5±9.5	5.61	0.001*		
TG (mg/dl)	Exercise+placebo	143.5±47.4	122.3±45.8	1.68	0.12	2.10	0.047*
	Exercise+supplement	160.0±49.3	108.2±26.5	3.78	0.003*		
Cholesterol (mg/dl)	Exercise+placebo	221.6±45.6	224.6±37.3	0.25	0.80	0.30	0.76
	Exercise+supplement	204.1±35.8	202.7±36.6	0.17	0.86		
MFO (g/min)	Exercise+placebo	0.21±0.06	0.23±0.08	0.30	0.76	0.58	0.56
	Exercise+supplement	0.25±0.06	0.29±0.06	1.55	0.15		
Fat_{max}	Exercise+placebo	43.9±3.6	46.1±3.8	1.43	0.18	0.46	0.64
	Exercise+supplement	40.7±5.9	44.3±4.3	1.58	0.14		
Average total carbohydrate oxidation	Exercise+placebo	0.88±0.21	0.67±0.22	4.49	0.001*	0.22	0.82
	Exercise+supplement	0.84±0.18	0.66±0.17	2.57	0.028*		

Table 1.b
Mean±SD, differences of within and between groups, before and after the interventions. *P≤ 0.05 vs before

Variable	Group	Phases		Differences			
		pre-test	post-test	Within Groups		Between Groups	
		Mean ± SD	Mean ± SD	Z	Significance Level	Z	Significance Level
BMI (kg/m²)	Exercise+placebo	27.3±1.8	26.9±1.7	2.66	0.008*	2.11	0.034*
	Exercise+supplement	30.6±3.4	29.9±3.3	3.06	0.002*		
Average total fat oxidation	Exercise+placebo	0.19±0.04	0.21±0.03	0.82	0.40	0.52	0.60
	Exercise+supplement	0.20±0.07	0.25±0.04	1.58	0.11		

DISCUSSION

The analysis of statistical data on the body composition index indicated that the short-term aerobic exercise at Fat_{max} alone and in combination with green tea consumption decreased the body weight, BMI, and WHR, significantly. In addition, the BFP in both groups was reduced which was not significant; VFA also decreased in both groups, however, it was significant only in exercise + supplement group. These findings are consistent with the results of Haghighi et al. (2013), Suliburska et al. (2012) and Hsu et al. (2008), and are incompatible with the results of Moradi et al. (2014) and Zolfaghary et al (2013) [17, 19, 21-23]. Haghighi et al. (2013) alluded that eight weeks of aerobic training along with green tea consumption decreased body weight in obese and overweight women [17]. Suliburska et al. (2012) noted that daily intake of 379 mg green tea for 3 months reduced BMI and waist circumference in obese individuals (23 males and 23 females aged 30-60 and BMI≤30 kg/m^2) [21]. Current evidences suggest that catecholamine status and growth hormone (IGF-1) levels which enhance lipolysis process, increase during exercise. Furthermore, it was announced that estradiol hormone secretion augments during exercise in women and that's why, fat deposits are applied more than before to supply energy [24].

Exercise in any form, contributes to approximately 20% of total energy expenditure and it boosts the resting energy expenditure. Interestingly, resting energy expenditure remains elevated as long as an individual exercise at least three days a week, on a regular basis. Since resting energy expenditure accounts for 60% to 75% of the calories an individual burns each day, any increase in resting energy expenditure, seems extremely important to a weight-loss effort [25-26].

Acute and chronic exercises have been shown to influence all components of total energy expenditure. It was reported that acute endurance exercise at >70% VO_{2max} increases post exercise resting metabolic rate (RMR) and thermic effect of feeding (TEF). The host variable component of daily human energy expenditure sounds to be thermic effect of activity which may account for as little as 15% or as much as 30% of overall daily energy expenditure. It was observed that TEF was greater in healthy adults who habitually exercise than in their sedentary counterparts. It sounds that regular exercise is able to decrease body weight by affecting the resting metabolic rate (RMR) and thermic effect of feeding (TEF). It is also assumed that acute post-exercise energy expenditure is influenced primarily by total training volume and doing exercise at higher intensities is likely to maximize post-exercise energy expenditure and potentially promote the fat loss; so, decreased body weight is probably justified in this study [25-26].

On the other hand, in many studies, the effect of green tea on the weight loss has been investigated. Some potential mechanisms to the weight loss include modifications in appetite, up-regulation of enzymes involved in hepatic fat oxidation, and decreased nutrient absorption [15]. In addition, the catechin compounds in green tea inhibit the activation of pancreatic lipase and also prevent the intestinal absorption of fat, after eating [27-28]. Thus, the improvement in body composition indexes in this study becomes justified. However, Zolfaghary et al. (2013) showed that 12 weeks of aerobic training with and without green tea consumption did not change the body composition indexes such as body weight, BMI, BFP and WHR in obese women [23]. In latter study, we witnessed that exercise intensity increased from 60% to 85% heart rate and exercise time ascended from 20 minutes in the first session to 50 minutes in the last session. It seems that the intensity and duration of the exercise are of very effective factors in the results.

The analysis of statistical data on VO_{2peak} value revealed that short-term aerobic exercise at Fat_{max} alone and in combination with green tea consumption, ameliorated VO_{2peak} level, but it was not significant. These findings were inconsistent with the results of Lanzi et al. (2015) and Nayebi far et al. (2011) [18, 29]. Lanzi et al. (2015) observed that two weeks of aerobic training at Fat_{max} as well as interval training increased the aerobic fitness in obese men [18]. In general, the endurance trainings lead to a series of metabolic and physiological adaptations. The most notable adaptations include an increase in the number and size of mitochondria and the number of capillaries, an increase in transmitting proteins of substrate and an increase in enzymes activities involved in metabolic pathways [30]. Also, it is stated that increased VO_{2max} may be due to an improvement in the transport and delivery of oxygen to skeletal muscles by increasing the stroke volume and capillary and mitochondria density. More, regardless of the type of training (interval or continuous), aerobic phosphorylation rate increases after exercise [31-32]; nevertheless, in most studies it was observed that aerobic fitness improved only after long-term trainings. Here, an exercise at Fat_{max} for two weeks has failed to boost VO_{2peak} and it seems that two weeks of exercise was not enough to create expected adaptations.

The analysis of statistical data on the lipid profile indexes revealed that the short-term aerobic exercise at Fat_{max} alone and in combination with green tea consumption, significantly decreased TG and HDL values; while LDL levels increased significantly only in exercise + supplement group. Plus, there were no significant changes in cholesterol level in any of the groups.

Decreased TG in this study is consistent with the results of Moradi et al. (2014) and Hsu et al. (2008) [19, 22]. No study was found on reduction in HDL levels and increase in LDL levels following green tea consumption or aerobic training; but the results of this study were inconsistent with the ones of Fathi et al. (2015), and Izadi Chahfarokhi et al. (2015) [33-34]. Izadi Chahfarokhi et al. (2015) observed that ten weeks of aerobic training and green tea consumption did not change the levels of TG, cholesterol and LDL, but a combination of green tea and exercise could increase HDL value [34]. The researchers believe that HDL and LDL and especially HDL are highly influenced by the intensity of the training, and probably the intensity and duration of exercise are the crucial factors to affect HDL and LDL values [29]. Increased LDL and decreased HDL in this study as unfavorable changes after the intervention, may emphasize this fact that if the duration of exercise is not long enough, the adverse changes may occur and this fact must be taken into consideration. More, in this study, the diet was under the control as the subjects were encouraged to consume low and moderate glycemic index carbohydrates along with more vegetables and fruits (fiber); they were also asked to avoid eating high glycemic index carbohydrates and extra fatty foods. It seems that an acute control diet induced some undesirable effects on HDL and LDL levels which its mechanism has not been yet justified and more investigations are required to clarify these changes.

In relation to decreased TG, it can be explained that regular endurance trainings increased the gene expression and function of lipolytic enzymes. TG is the most important source of energy in endurance activities. Lipoprotein lipase enzyme contributes to break down TG and releases the free fatty acids from TG to supply energy during aerobic activities. Totally, there is a high correlation between lipoprotein lipase activity and blood triglyceride levels (removal of TG from the blood); hence, the decline of TG following aerobic exercise is justified in our study [24].

The changes in the expression of fat metabolism genes could be brought about with chronic exercise training; the expression of fat metabolism genes could include the upregulation of fat metabolism enzyme gene in skeletal muscle and down regulation of hepatic adipogenic gene expression [35]. Plus, green tea has cholesterol-lowering property. Epicatechin Gallate (ECG) and Epigallocatechin Gallate (EGCG) decrease the solubility of cholesterol in mixed micelles and reduce the cholesterol absorption from the intestine and therefore regulate the blood cholesterol [36]. In our study, cholesterol level decreased in exercise + supplement group insignificantly; it seemed that longer duration of intervention may induce a positive effect on cholesterol level.

The analysis of statistical data on MFO, Fat_{max}, average total fat oxidation and average total carbohydrate oxidation indexes indicated that short-term aerobic exercise at Fat_{max} alone and in combination with green tea consumption did not change MFO, Fat_{max} and average total fat oxidation in sedentary postmenopausal women, significantly; whilst, average total carbohydrate oxidation significantly decreased in both groups. These results are consistent with the findings of Johannsen et al. (2009) and inconsistent with the results of Besnier et al.

(2015) and Gahreman et al. (2015) [6, 8, 37]. Johannsen et al. (2009) suggested that aerobic exercise at 50% VO_{2max} and about Fat_{max} has failed to change MFO level and Fat_{max} in 260 postmenopausal women [6]. In contrast, Besnier et al. (2015) observed that exercise at Fat_{max} for 5 months increases MFO level in 130 overweight/obese women [37].

It is generally assumed that fat and carbohydrate are the main substrates for energy supply during exercise. The rate of carbohydrate oxidation ascends by increasing exercise intensity, while fatty acid oxidation is increased progressively from resting state up to almost 60% VO_{2max}, and then, fat oxidation gradually descends [38]. In other words, when exercise intensity is low to moderate, the supply of energy heavily depends on lipid oxidation and by increasing the activity intensity and beginning of lactate and H+ accumulation, release of fatty acids from fat tissues declines and therefore lipid oxidation rate diminishes. It should be noted that blood lactate is a mediator of carbohydrates oxidation and is able to directly inhibit the release of free fatty acids from the fat tissues [30].

It is fairly well accepted that lipolysis process amends the release of fatty acids into the bloodstream; then fatty acids bind to albumin protein and transform into non-esterified fatty acids and then were utilized in energy production pathways. The binding of epinephrine and norepinephrine to beta-adrenergic receptors influences lipolytic activity in the adipose tissue and stimulates the lipolysis process, acutely. In sum, adipose tissue lipolysis is related to beta-adrenergic stimulation by the catecholamines as well as insulin inhibition. It is mentioned that during exercise activities, a reduction in insulin levels and increased catecholamine boosts lipolysis process by 4 to 5 times [30]. This probably increases the fat mobilization from the adipose tissue in order to provide required energy during exercise.

In the present study, the MFO, Fat_{max} and the average total fat oxidation did not change in both groups, significantly. This finding is in line with Johannsen et al. (2009) who examined the effect of different exercise volumes on fat oxidation capacity in 260 postmenopausal women; they expressed that exercise at 50% VO_{2max} failed to improve MFO and Fat_{max} in postmenopausal women [6]; in contrast, Venables et al. (2008) indicated that four weeks of aerobic exercise at Fat_{max}, increased the fat oxidation rate in obese individuals with type 2 diabetes [12]; in another study from Venables et al. (2008), it was observed that green tea consumption before and after a cycling exercise at 60% VO_{2max} improved the fat oxidation rate in young men. As we know polyphenolics ingredients of green tea probably influence sympathetic nervous system (SNS) activity; promoting energy expenditure and elevating the fat oxidation. Caffeine, naturally presented in green tea (almost 3% to 5% of its dry weight), also affects SNS activity, and may act synergistically with catechins to increase energy expenditure and fat oxidation [15]. It seems that exercise at about Fat_{max} and green tea consumption for two weeks has failed to create desired adaptations in this regard and the exercise duration should have been longer.

In the following, it was observed that short-term aerobic exercise at Fat_{max} alone and in combination with green tea consumption decreased the average total of carbohydrates oxidation, significantly. To justify that, it can be noted that regular exercise increases the gene expression of lipolytic and electron transport chain enzymes; it also improves the mitochondria density and the mobilization of fat instead of carbohydrates, to produce energy. Therefore, carbohydrate mobilization rate will be declined during exercise, and adipose tissue will be the dominant energy source [24].

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