Research Article

The Effect of Aerobic Training and Green Tea Supplementation on Cardio Metabolic Risk Factors in Overweight and Obese Females: A Randomized Trial

Hajar Amozadeh [1], Ramin Shabani [1, *] and Marzieh Nazari [2]

[1]Department of Physical Education and Sport Sciences, Faculty of Humanities, Rasht Branch, Islamic Azad University, Rasht, Iran
[2]Young Researchers and Elite Club, Rasht Branch, Islamic Azad University, Rasht, Iran

*Corresponding author: Associate Professor of Exercise Physiology, Rasht Branch, Islamic Azad University, Rasht, Iran. Tel: +98-9112324796, Email: shabani_msn@yahoo.com

Abstract

Background: The use of exercise along with green tea supplements has been shown to have beneficial effects on obesity and its complications.

Objectives: This study aimed at exploring the effect of aerobic training (AT) and green tea (GT) supplementation on body composition, blood lipids, blood glucose, and cardiovascular risk factors in overweight and obese females.

Methods: Thirty-nine healthy non-athlete overweight and obese females with an average age of 28.11 ± 6.50 years were sampled and randomly assigned to control (n = 13), AT (n = 13), and AT + GT (n = 13). Participants of the latter group received 33 mg of green tea after each main meal every day, and in addition, they were subjected to AT for eight weeks, including three 90-minute training sessions that were progressive, reaching 80% of the target heart rate (THR). Blood samples were taken from participants one week before the initiation of the study and 48 hours after the last training session.

Results: Compared to the control group, body weight, body fat percentage, body mass index (BMI), triglyceride, low-density lipoprotein, blood pressure, and heart rate (HR) significantly decreased in the groups treated with AT and AT + GT ($P < 0.05$). However, no significant changes occurred in FBS, HDL, TC, and WHR ($P > 0.05$).

Conclusions: AT was effective in modifying cardiovascular risk factors, e.g. hypertension, heart rate (HR), triglyceride, and low-density lipoprotein (LDL). However, GT addition was not effective. Considering Iranians' high tendency towards the consumption of plant materials, this finding needs further investigation.

Keywords: Exercise Training, Green Tea, Body Composition, Fasting Blood Sugar, Obesity

1. Background

The prevalence of obesity is considered as a risk factor for cardiovascular diseases and chronic diseases. The increase in LDL, total cholesterol, and triglyceride and their accumulation in arteries causes atherosclerosis and hypertension, which can be said an important risk factor for coronary artery disease in obese females (1). This is directly related to factors such as age, gender, inactivity, and diet. Owing to the direct relationship between lipids and cardiovascular diseases, blood lipids level is perceived as an important factor in health so that non-pharmacological methods, such as exercise training, are recommended for losing weight and fat (2). Evidence suggests that AT could help improve metabolic and cardiovascular factors (2, 3).

On the other hand, GT is an important source of a polyphenolic flavonoid, called catechin, which is extracted from camellia. Extract of GT prevents the activity of the catecholamine-O-methyl transferase (COMT) enzyme, which reduces noradrenaline and increases energy intake and fat oxidation, and reduces body fat mass by regulating sympathetic activity and lipolysis (4).

Although the relationship between GT consumption and risk factors for cardiovascular diseases and also, the positive effects of exercise on stimulating fat and carbohydrate oxidation have been subject to extensive epidemiological studies, the results of these studies are contradictory. Some studies have reported positive effects on blood pressure, dyslipidemia, and blood glucose (5, 6). Most studies have explored the effect of exercise and GT separately (2, 3, 5, 6) and their simultaneous effects have been less often considered. An advantage of the present study was the simultaneous examination of AT and GT.

Similarly, in animal studies, when the use of GT was ac-

companied by exercise, the body fat of rats showed greater decrease than when they were applied individually (7, 8). Overall, some studies have confirmed the effect of GT consumption on fat oxidation, blood glucose, and body composition (9-13), yet others have not (14, 15).

Overall, research on the positive role of exercise and dietary supplements emphasize the importance of these two factors in weight loss programs and cardiovascular diseases and their metabolic risks, especially considering the difficulty of exercise and individuals' willingness to use medicinal herbs (3, 11). In this respect, studies differ in supplement type, dosage (8, 15), and exercise design, particularly in terms of intensity and duration (8, 16) and also, have reported contradictory findings (6, 15). Furthermore, the contradictions in relevant research are explored and an effective approach is suggested for weight loss and health enhancement in the society. Thus, the objective of the present study was to explore the impact of AT and GT supplement on body composition and cardiovascular risk factors of overweight and obese females.

2. Objectives

The aim of this study was to explore the effect of AT and green tea supplementation on cardio metabolic risk factors in overweight and obese females.

3. Methods

3.1. Subjects

Out of 50 volunteers, 39 overweight and obese inactive females (mean $\pm$ SD: age, 28.11 $\pm$ 6.50 years and weight, 85.47 $\pm$ 11.22 kg) were randomly divided to three groups: AT with green tea (AT + GT), AT, and control (C). The subjects in the control group did not take part in sports activities and only performed their daily activities. They were recommended to observe a constant diet.

The sample size seemed sufficient considering previous studies (17, 18). Participant recruitment was started in June and ended in August 2016. The study duration was eight weeks. Before the training protocol was conducted, the participants were invited to a gym to fill out the forms of personal characteristics, medical record, and consent. To control the diet, they were asked to record their daily food consumption in special forms for 72 hours (one weekend and two weekdays). The researchers suggested that appropriate food items could be added to their dietary regimen and junk food items could be removed.

The inclusion criteria were being a healthy female. Also, exclusion criteria were the presence of cardiovascular and joint diseases. The research was approved by Human Studies Review Committee of Islamic Azad University in advance by IR.IAU.RASHT.REC.1395.25 number and was registered at IRCT with reference number IRCT20150531022498N17.

3.2. Measurements

The participants' height and weight were measured using a digital height and weight scale (SECA, Germany). The BMI was calculated as the body weight (kg) divided by the square of height. Three points subcutaneous fat was estimated by a SAEHAN caliper (SH5020, South Korea) in triceps brachia, quadriceps, and thigh. Body fat percentage was calculated using the Siri equation.

The resting blood pressure of the participants was measured in sitting position, after a minimum five-minute rest by a blood pressure device (ALPK2, model 300-V-EU, Japan). Waist circumference (WC) was measured at a point midway between the lowest rib and the iliac crest with the participant in standing position.

At the beginning and end of the study, 5 mL of subject's blood was taken from the elbow vein after 12 hours of fasting. Blood sampling was performed from 8 to 10 am.

Baseline blood glucose hemostasis tests included Fasting Blood Sugar (FBS) (mg/dL).

Blood glucose test was carried out with a bio system kit (Spain), using glucosidase/peroxidase method and with an auto-analyzer (Hitachi, Japan) using a full automation procedure.

Blood lipid tests, such as high-density lipoprotein (HDL), LDL, total cholesterol (TC), and triglycerides were performed using the photometric method and by Pars Azmoon kit (Iran).

3.3. Exercise Protocol and Supplements

Aerobic progressive training composed of eight weeks of 80 - 90-minute sessions (three time/week), in which training intensity was started with 40% to 50% of target heart rate (THR) and was finished with 70% to 80% of THR (19). The THR was calculated by the Karvonen formula. Heart rate was measured during the work with a polar heart rate meter.

Participants in GT supplement group received three capsules daily (Giah Essans Pharmaceutics Company, Iran), after their main meals.

Each capsule contained 33 mg d^{-1} of GT. The GT pills were delivered every seven days to better control the subjects. Each volunteer received eight packs of GT tablets at the end of eight weeks. During the work, the consumption of the pills was pursued regularly using social networks and SMS. To prepare the capsules, the GT pills containing the main polyphenols of GT were powdered and then, the capsules were filled with them.

Dietary intake was individually prescribed by a three-day recall technique before and during the research. The participants were asked to report the kinds and amounts of food and beverage items that they consumed both at home and away from home on a three-day recall basis so that appropriate food items could be added to their dietary regimen and junk food items could be removed. Since the food regimen was influential on the research variables, the three groups were recommended to use a certain diet, from which harmful material had been removed. In spite of the recommendations of diet, the quantity of food intake was unknown. Therefore, it is recommended to control diet in future works.

Mean daily intake for total energy was 1900 kcal (20). This research used a diet including carbohydrates, protein, fat, fruits, and vegetables. Reduced fat spread (not polyunsaturated) was the most commonly consumed fat spread. The total consumption of vegetables was about 186 grams per day (20). These items were given as a brochure, in which the values of the indexes were mentioned (Table 1).

Table 1. The Range of Nutrient Intake of Obese and Overweight Females[a]

	NDNS
Energy, kcal	1900
Fat, %E	35
Protein, %E	18
Carbohydrate, %E	47

Abbreviations: %E, percentage of energy intake; NDNS, national diet and nutrition survey (Ruston et al 2003).
[a] Data from females aged 19 to 64 years.

3.4. Statistical Analyses

Normal distribution of the data was checked using the Kolmogorov-Smirnov test and since they were found to be normally distributed, parametric statistics were used. Data were analyzed by multi-group covariance (ANCOVA) test amongst the groups. The LSD test was applied for the pairwise comparison of the groups. Data were statistically analyzed with the SPSS software package (ver. 22). Significance level of the hypotheses was set at P < 0.05.

4. Results

Fifty overweight and obese females were assessed for eligibility before the intervention. Thirty-nine female participants were randomly assigned to either AT (n = 13), AT + GT (n = 13), or C (n = 13) group.

Baseline characteristics of the participants are reported in Table 2. There was no significant difference in anthropometrics, blood pressure, and biochemical variables between the groups.

The results of covariance analysis showed that body weight, body fat percentage (BF%), and body mass index, triglyceride, LDL, and cardiovascular parameters were significantly different between the groups (P < 0.05; Table 2), yet there were no significant differences in other parameters (P < 0.05).

The LSD test revealed that there was a significant difference in weight, body mass, subcutaneous fat, triglyceride, LDL, and cardiovascular parameters between the C group and AT and AT + GT (Table 3). Significant differences were observed between groups 1 and 3 and between groups 2 and 3, yet groups 1 and 2 did not differ significantly. It can be suggested that exercise was effective but green tea was ineffective.

However, in C group, no change was observed in parameters between the pretest and posttest.

5. Discussion

Results of the present study showed that AT reduced body fat percentage, triglyceride, low-density lipoprotein, blood pressure, and HR in eight weeks. However, no significant changes occurred in FBS, HDL, TC, and WHR (P > 0.05). These findings are consistent with that of Cardoso et al. (8), Contro et al. (21), Lee et al. (22), Taghizadeh et al. (23), and Martin et al. (24), and inconsistent with Zhou et al. (14) and Narayani et al. (2).

In a study by Contro et al. on different AT regimen in overweight adults, reductions were reported in TG and LDL (21). Another study on a four-week intake of GT diet supplemented with resistance training reported that GT consumption with resistance training reduced triglyceride reserves (8). In contrast, a study on the effect of GT on overweight females showed no significant differences in LDL and HDL (23).

Also, Martin et al. (24) examined the short-term effect of GT on insulin and plasma glucose in sedentary males and revealed no significant influence on blood glucose levels. These studies are consistent with the current study. In contrast, a study by Zhou et al. showed a reduction in blood glucose concentrations after GT consumption (14). These studies are inconsistent with the current study, which is likely to be related to differences in participants' gender (females in the current study versus males in Zhou's study), GT consumption dosage, intervention duration (two months versus six months), study designs, and forms.

While the mechanisms underlying the effect of exercise on the lipid profile are unclear, exercise appears to enhance the ability of skeletal muscles to utilize lipids as opposed to glycogen, thus reducing plasma lipid levels. Skele-

Table 2. Baseline Characteristics of the Study Participants and Results of Measuring Parameters Related to Body Composition and Biochemical Parameters at Pre and Post Intervention (n = 39)

	Aerobic + Green Tea[a] (n = 13)	Aerobic Training[a] (n = 13)	Control[a] (n = 13)	Sig	ANCOVA	
					F	P Value[b]
Age, y				0.1	-	-
Pre	28.14 ± 7.48	27.12 ± 6.50	28.13 ± 6.54			
Post	-	-	-			
Weight, kg				0.2	13.60	< 0.001*
Pre	85.46 ± 11.65	84.50 ± 11.22	85.46 ± 11.65			
Post	81.69 ± 11.17	82.41 ± 10.52	87.84 ± 13.87			
BMI, kg.m^{-2}				0.4	14.18	< 0.001*
Pre	33.44 ± 3.78	32.77 ± 5.42	33.87 ± 4.25			
Post	31.96 ± 3.59	31.91 ± 5.12	33.87 ± 4.25			
Body fat, %				0.5	33.07	< 0.001*
Pre	39.90 ± 2.11	38.81 ± 2.47	39.89 ± 2.27			
Post	36.90 ± 1.99	36.80 ± 2.28	40.21 ± 2.70			
WHR, cm				0.07	0.76	0.4
Pre	0.86 ± 0.05	0.85 ± 0.09	0.85 ± 0.08			
Post	0. 82 ± 0.04	0.81 ± 0.07	0.86 ± 0.08			
WC, cm				0.6	0.64	0.9
Pre	85.8 ± 12.0	85.9 ± 12.1	86.9 ± 12.2			
Post	82.8 ± 11.2	77.00 ± 8.26	86.8 ± 12.0			
FBS, mg.dL^{-1}				0.06	0.11	0.8
Pre	81.53 ± 7.55	81.8 ± 10.0	85.23 ± 11.00			
Post	76.92 ± 9.35	77.00 ± 8.26	85.23 ± 11.00			
LDL, mg.dL^{-1}				0.7	2.57	0.02*
Pre	113.62 ± 13.4	117.85 ± 14.8	109.93 ± 14.1			
Post	86.53 ± 11.7	98.15 ± 12.1	109.27 ± 14.7			
TC, mg.dL^{-1}				0.8	1.61	0.2
Pre	213.69 ± 18.92	210.66 ± 18.92	188.92 ± 16.70			
Post	201.61 ± 17.73	194.08 ± 17.28	188.30 ± 16.68			
TG, mg.dL^{-1}				0.2	0.66	0.04*
Pre	135.0 ± 15.3	129.15 ± 13.7	133.3 ± 14.1			
Post	128.26 ± 14.9	106.38 ± 16.5	133.27 ± 15.18			
HDL, mg.dL^{-1}				0.1	0.09	0.9
Pre	39.23 ± 2.61	38.58 ± 2.84	40.92 ± 3.90			
Post	40.53 ± 2.53	40.33 ± 1.87	40.84 ± 3.86			
Rest heart rate				0.09	53.23	< 0.001*
Pre	78.92 ± 11.44	77.50 ± 10.99	77.50 ± 10.99			
Post	72.46 ± 9.31	71.00 ± 8.80	78.92 ± 9.75			
SBP, mmHg				0.1	4.11	0.02*
Pre	127.69 ± 6.95	127.91 ± 6.98	113.84 ± 6.17			
Post	108.84 ± 5.82	106.66 ± 4.92	113.80 ± 6.16			
DBP, mmHg				0.9	2.56	0.04*
Pre	72.30 ± 3.88	71.20 ± 3.10	77.30 ± 4.83			
Post	72.30 ± 3.88	71.20 ± 3.10	77.30 ± 4.83			

Abbreviations: BMI, body mass index; DBP, diastole blood pressure; FBS, fasting blood sugar; HDL, high density lipoprotein; LDL, low density lipoprotein; SBP, systole blood pressure; TG, tri glyceride; WHR, waist to hip ratio.

[a]Values are expressed as mean ± SD.

[b]P value calculated from ANCOVA test (*P ≤ 0.05).

tal muscle is the most important regulator of fat oxidation and can have a positive impact on fat-mass balance (22).

On the other hand, cardiovascular parameters, such as HR and blood pressure, were improved significantly, which is inconsistent with the study of Roberts et al. (10) yet in agreement with Nogueira et al. (3), Potenza et al. (11), and Eichenberger et al. (25). An experiment on the effect of green tea consumption and trainings with ergometer bike

Table 3. Between Group Comparisons of Study Variables at the End of the Intervention[a]

Variable	Mean Difference	P Value[b]
Weight, kg		
Between groups 1 and 2	1.62	0.1
Between groups 1 and 3	5.57	0.000*
Between groups 2 and 3	4.15	0.002*
BMI, kg.m^{-2}		
Between groups 1 and 2	0.61	0.1
Between groups 1 and 3	2.24	0.000*
Between groups 2 and 3	1.62	0.000*
Body fat, %		
Between groups 1 and 2	0.81	0.10
Between groups 1 and 3	3.40	0.000*
Between groups 2 and 3	2.58	0.000*
LDL, mg.dL^{-1}		
Between groups 1 and 2	4.33	0.90
Between groups 1 and 3	38.75	0.02*
Between groups 2 and 3	24.33	0.04*
TG, mg.dL^{-1}		
Between groups 1 and 2	4.03	0.80
Between groups 1 and 3	43.3	0.03*
Between groups 2 and 3	38.33	0.03*
Rest heart rate		
Between groups 1 and 2	0.20	0.70
Between groups 1 and 3	6.46	0.000*
Between groups 2 and 3	6.71	0.000*
SBP, mmHg		
Between groups 1 and 2	4.53	0.90
Between groups 1 and 3	17.80	0.04*
Between groups 2 and 3	18.33	0.04*
DBP, mmHg		
Between groups 1 and 2	5.98	0.80
Between groups 1 and 3	14.98	0.03*
Between groups 2 and 3	15.33	0.04*

Abbreviations: BMI, body mass index; DBP, diastole blood pressure; FBS, fasting blood sugar; HDL, high density lipoprotein; LDL, low density lipoprotein; SBP, systole blood pressure; TG, tri glyceride; WHR, waist to hip ratio.
[a] Group1: aerobic + green tea; Group2: aerobic training; Group 3: control.
[b] * P $\leq$ 0.05

on male athletes showed a significant reduction in HR [3]. Another study by Broeder et al. [26] showed a significant reduction in peak heart rate after exercise.

Aerobic training reduces HR by increasing the power of the heart pump in each shot, dilating the vessels, and reducing the resistance to blood flow from the heart. It has been shown that active and trained people with high physical fitness have a lower HR. This is usually ascribed to their higher parasympathetic activity and/or lower sympathetic activity. However, the venous return and high systolic volumes in people with better endurance have been implicated as the likely reasons for their lower HR.

Roberts et al. [10] investigated the impact of four-week GT consumption on males, who exercised irregularly and did not show any significant differences in blood pressure between the two groups. It can be said that the differences in the current study compared with that of Roberts et al. lie in longer interventions, gender, and distinct way of exercise training.

The probable mechanism by which aerobic exercise and green tea could decrease blood pressure may be the fact that blood pressure could be regulated by nitric oxide and prostanoid systems, which are substances for blood vessel dilation and can be influenced by aerobic exercise training [27] and green tea [28]. Besides, improving insulin sensitivity may be another potential mechanism of AT on blood pressure reduction [28].

The effect of GT on body composition has been evaluated in different studies by various methods. In some studies, the supplementation of exercise training with GT consumption has changed body composition [10, 13], whilst some have not observed any significant changes [15, 17]. Another study showed that the consumption of GT plus exercise reduced body fat in rats as compared to green tea consumption or exercise alone [29].

In the current study, the researchers witnessed a significant difference in body composition by AT after eight weeks. This finding is inconsistent with the study of Chen et al. [9], which may be caused by high-dose GT and exercise design, such as long duration in their study (12 weeks). According to the results, it could be concluded that even AT alone has a modest effect on weight loss. The mechanism of the effect of AT on body fat can be attributed to the increased fat oxidation by the increase in β-oxidation enzymes and, eventually, the increase in fat metabolism [29].

Limitations of this research were the lack of close examination of the participants' diet. Thus, it is recommended to use accurate dietary measurements in similar studies.

5.1. Conclusion

Overall, findings of this study demonstrated that the AT was effective in alleviating cardiovascular risk factors, e.g. hypertension, HR, triglyceride, and low-density lipoprotein. However, GT addition was not effective. Considering Iranians' high tendency towards the consump-

tion of plant materials, this finding needs further investigation.

Acknowledgments

Footnotes

Authors' Contribution: Ramin Shabani designed and coordinated the research. Hajar Amozadeh collected the data. Marzieh Nazari wrote the manuscript and performed the statistical analyses. All authors revised the manuscript and contributed to improving the paper.

Conflict of Interests: The authors declare that there was no conflict of interest.

References

1. Hassanzadeh J, Mohammadbeigi A, Eshrati B, Moemenbellah-Fard MD. Estimation of the regional burden of non-communicable diseases due to obesity and overweight in Markazi province, Iran, 2006-2007. *J Cardiovasc Dis Res*. 2012;**3**(1):26–31. doi: 10.4103/0975-3583.91600. [PubMed: 22346142]. [PubMed Central: PMC3271677].

2. Narayani U, Sudhan PR. Effect of aerobic training on percentage of body fat, total cholesterol and HDL-C among obese women. *World J Sport Sci*. 2010;**3**(1):33–6.

3. Nogueira LP, Nogueira Neto JF, Klein MR, Sanjuliani AF. Short-term effects of green tea on blood pressure, endothelial function, and metabolic profile in obese prehypertensive women: A crossover randomized clinical trial. *J Am Coll Nutr*. 2017;**36**(2):108–15. doi: 10.1080/07315724.2016.1194236. [PubMed: 27797683].

4. Kris-Etherton PM, Keen CL. Evidence that the antioxidant flavonoids in tea and cocoa are beneficial for cardiovascular health. *Curr Opin Lipidol*. 2002;**13**(1):41–9. [PubMed: 11790962].

5. Onakpoya I, Spencer E, Heneghan C, Thompson M. The effect of green tea on blood pressure and lipid profile: A systematic review and meta-analysis of randomized clinical trials. *Nutr Metab Cardiovasc Dis*. 2014;**24**(8):823–36. doi: 10.1016/j.numecd.2014.01.016. [PubMed: 24675010].

6. Peng X, Zhou R, Wang B, Yu X, Yang X, Liu K, et al. Effect of green tea consumption on blood pressure: a meta-analysis of 13 randomized controlled trials. *Sci Rep*. 2014;**4**:6251. doi: 10.1038/srep06251. [PubMed: 25176280]. [PubMed Central: PMC4150247].

7. Shimotoyodome A, Haramizu S, Inaba M, Murase T, Tokimitsu I. Exercise and green tea extract stimulate fat oxidation and prevent obesity in mice. *Med Sci Sports Exerc*. 2005;**37**(11):1884–92. [PubMed: 16286857].

8. Cardoso GA, Salgado JM, Cesar Mde C, Donado-Pestana CM. The effects of green tea consumption and resistance training on body composition and resting metabolic rate in overweight or obese women. *J Med Food*. 2013;**16**(2):120–7. doi: 10.1089/jmf.2012.0062. [PubMed: 23140132].

9. Chen IJ, Liu CY, Chiu JP, Hsu CH. Therapeutic effect of high-dose green tea extract on weight reduction: A randomized, double-blind, placebo-controlled clinical trial. *Clin Nutr*. 2016;**35**(3):592–9. doi: 10.1016/j.clnu.2015.05.003. [PubMed: 26093535].

10. Roberts JD, Roberts MG, Tarpey MD, Weekes JC, Thomas CH. The effect of a decaffeinated green tea extract formula on fat oxidation, body composition and exercise performance. *J Int Soc Sports Nutr*. 2015;**12**(1):1. doi: 10.1186/s12970-014-0062-7. [PubMed: 25650043]. [PubMed Central: PMC4307170].

11. Potenza MA, Marasciulo FL, Tarquinio M, Tiravanti E, Colantuono G, Federici A, et al. EGCG, a green tea polyphenol, improves endothelial function and insulin sensitivity, reduces blood pressure, and protects against myocardial I/R injury in SHR. *Am J Physiol Endocrinol Metab*. 2007;**292**(5):E1378–87. doi: 10.1152/ajpendo.00698.2006. [PubMed: 17227956].

12. Sae-Tan S, Grove KA, Kennett MJ, Lambert JD. (-)-Epigallocatechin-3-gallate increases the expression of genes related to fat oxidation in the skeletal muscle of high fat-fed mice. *Food Funct*. 2011;**2**(2):111–6. doi: 10.1039/c0fo00155d. [PubMed: 21779555]. [PubMed Central: PMC3400462].

13. Westerterp-Plantenga MS, Lejeune MP, Kovacs EM. Body weight loss and weight maintenance in relation to habitual caffeine intake and green tea supplementation. *Obes Res*. 2005;**13**(7):1195–204. doi: 10.1038/oby.2005.142. [PubMed: 16076989].

14. Zhou J, Kong C, Hou X, Zhang Z, He F. Green tea effects on the levels of serum glucose and lipid profiles. *Am J Med Sci Med*. 2016;**4**(3):59–62. doi: 10.12691/ajmsm-4-3-3.

15. Lonac MC, Richards JC, Schweder MM, Johnson TK, Bell C. Influence of short-term consumption of the caffeine-free, epigallocatechin-3-gallate supplement, Teavigo, on resting metabolism and the thermic effect of feeding. *Obesity (Silver Spring)*. 2011;**19**(2):298–304. doi: 10.1038/oby.2010.181. [PubMed: 20725062].

16. Rahimi R, Falahi Z. Effect of green tea extract on exercise-induced oxidative stress in obese men: A randomized, double-blind, placebo-controlled, crossover study. *Asian J Sports Med*. 2017;**8**(2). e55438. doi: 10.5812/asjsm.55438.

17. Racil G, Ben Ounis O, Hammouda O, Kallel A, Zouhal H, Chamari K, et al. Effects of high vs. moderate exercise intensity during interval training on lipids and adiponectin levels in obese young females. *Eur J Appl Physiol*. 2013;**113**(10):2531–40. doi: 10.1007/s00421-013-2689-5. [PubMed: 23824463].

18. Roxburgh BH, Nolan PB, Weatherwax RM, Dalleck LC. Is moderate intensity exercise training combined with high intensity interval training more effective at improving cardiorespiratory fitness than moderate intensity exercise training alone? *J Sports Sci Med*. 2014;**13**(3):702–7. [PubMed: 25177202]. [PubMed Central: PMC4126312].

19. Naseri N, Hojjat S, Khaledan A. Effect of a periodic aerobic and anaerobic selective training with use of green tea on certain inflammatory factors and oxidative stress of male athletes. *Biosci Biotech Res Comm*. 2016;**9**(2):317–26.

20. Food Standards Agency in Northern Ireland; Public Health England. *National diet and nutrition survey results from years 1, 2, 3 and 4 (combined) of the rolling programme (2008/2009 – 2011/2012)*. London: Public Health England; 2014.

21. Contro V, Bianco A, Cooper J, Sacco A, Macchiarella A, Traina M, et al. Effects of different circuit training protocols on body mass, fat mass and blood parameters in overweight adults. *J Biol Res-Bollettino della Societa Italiana di Biologia Sperimentale*. 2017;**90**(1). doi: 10.4081/jbr.2017.6279.

22. Earnest CP, Artero EG, Sui X, Lee DC, Church TS, Blair SN. Maximal estimated cardiorespiratory fitness, cardiometabolic risk factors, and metabolic syndrome in the aerobics center longitudinal study. *Mayo Clin Proc*. 2013;**88**(3):259–70. doi: 10.1016/j.mayocp.2012.11.006. [PubMed: 23391253]. [PubMed Central: PMC3622904].

23. Taghizadeh M, Farzin N, Taheri S, Mahlouji M, Akbari H, Karamali F, et al. The effect of dietary supplements containing green tea, capsaicin and ginger extracts on weight loss and metabolic profiles in overweight women: A randomized double-blind placebo-controlled clinical trial. *Ann Nutr Metab*. 2017;**70**(4):277–85. doi: 10.1159/000471889. [PubMed: 28595182].

24. Martin BJ, McGlory C, MacInnis MJ, Allison MK, Phillips SM, Gibala MJ. Green tea extract does not affect exogenous glucose appearance but reduces insulinemia with glucose ingestion in exercise recovery. *J Appl Physiol (1985)*. 2016;**121**(6):1282–9. doi: 10.1152/japplphysiol.00657.2016. [PubMed: 27763877]. [PubMed Central: PMC5206383].

25. Eichenberger P, Colombani PC, Mettler S. Effects of 3-week consumption of green tea extracts on whole-body metabolism during cycling exercise in endurance-trained men. *Int J Vitam Nutr Res*. 2009;**79**(1):24–33. doi: 10.1024/0300-9831.79.1.24. [PubMed: 19839000].

26. Broeder CE, Burrhus KA, Svanevik LS, Wilmore JH. The effects of either high-intensity resistance or endurance training on resting metabolic rate. *Am J Clin Nutr*. 1992;**55**(4):802–10. doi: 10.1093/ajcn/55.4.802. [PubMed: 1550062].

27. Nyberg M, Jensen LG, Thaning P, Hellsten Y, Mortensen SP. Role of nitric oxide and prostanoids in the regulation of leg blood flow and blood pressure in humans with essential hypertension: effect of high-intensity aerobic training. *J Physiol*. 2012;**590**(6):1481–94. doi: 10.1113/jphysiol.2011.225136. [PubMed: 22271868]. [PubMed Central: PMC3382335].

28. Murase T, Haramizu S, Shimotoyodome A, Tokimitsu I, Hase T. Green tea extract improves running endurance in mice by stimulating lipid utilization during exercise. *Am J Physiol Regul Integr Comp Physiol*. 2006;**290**(6):R1550–6. doi: 10.1152/ajpregu.00752.2005. [PubMed: 16410398].

29. Wang H, Wen Y, Du Y, Yan X, Guo H, Rycroft JA, et al. Effects of catechin enriched green tea on body composition. *Obesity (Silver Spring)*. 2010;**18**(4):773–9. doi: 10.1038/oby.2009.256. [PubMed: 19680234].