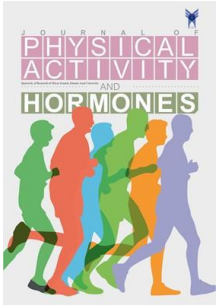
Journal of Physical Activity and Hormones

(J Physic Act Horm)

Journal HomePage: *https://sanad.iau.ir/journal/jpah/*



The effect of parallel aerobic and resistance exercise (PARE) with consumption of green tea on body composition, physical fitness and serum lipids of overweight and obese women

somaye ghanbari[1], Anis Salimi elizei[2]

[1] MA. in Exercise Physiology, Department of Physical Education and Sports Science, Rasht Branch, Islamic Azad University, Rasht, Iran.
[2] MA. in Exercise Physiology, Department of Physical Education and Sports Science, Rasht Branch, Islamic Azad University, Rasht, Iran.

Keywords
Exercises, Lipid, Obese Women, Green Tea.

Correspondence
E-mail address: anis10slm@gmail.com

Received: 5 Sept 2024; **Revised:** 5 Oct 2024; **Accepted:** 28 Nov 2024

DOI:

Abstract

Introduction: This study aimed to determine the effect of aerobic and resistance exercise (PARE) with the consumption of green tea on body composition, physical fitness, and serum lipids of overweight and obese women in Ardabil City.

Material & Methods: In this quasi-experimental study, 45 Eligible volunteer women (age: 25-45 years; BMI>25 kg/m2 randomly divided into 3 equal groups (control group, CG; parallel aerobic and resistance exercise, PARE; and PARE with daily consumption of green tea (PARE+GT). The experimental groups performed three months of progressive PARE training, six sessions per week, Each session consisted of 15 minutes of warming up, and 35 minutes of aerobic exercise(65% of the maximum heart rate, HRmax; Saturday, Monday, Wednesday), or resistance exercise (60-65% one Repetition Maximum, 1RM; Sunday, Tuesday, Thursday). Before and after two months of training, body fat percentage (%BF), blood pressure (BP), Body weight (BW), waist-to-hip ratio (WHR), and blood lipid indices, aerobic and anaerobic power were measured. Statistical information was obtained by one-way analysis of variance (ANOVA) test was performed through SPSS software (version 24) and the significance level was considered as $p<0.05$.

Results: The results of data analysis showed that GT consumption does not have a significant effect on the variables. But in PARE and PARE+GT groups, the variables of %BF, aerobic capacity, aerobic, resting systolic blood pressure (SBP), resting diastolic blood pressure (DBP), blood triglyceride (TG), and low-density lipoprotein (LDL) had a significant difference between the two stages before and after performing the test stages ($p<0.05$). However no difference was observed in body weight indices, body mass index, waist circumference to hip circumference ratio, heart rate Rest, and high-density lipoprotein (HDL).

Conclusion: PARE training probably improves fat percentage, aerobic capacity, aerobic, SBP, DBP, TG, and LDL in overweight and obese women. But green tea consumption does not have more effect.

1. Introduction

Obesity is one of the major health problems in the world due to the rapid increase in its prevalence and the emergence of metabolic comorbidities (1). It was estimated that by 2030, 2.16 billion (38%) individuals of the world's adult population will be overweight and 1.12 billion (20%) will be obese (2). In 2021, the national prevalence of normal weight, obesity, and overweight/obesity in ⩾18-year-old Iranian adults was estimated at 33.61% (95% CI: 32.99 – 34.23), 24.96% (24.39 – 25.53), and 63.02% (62.39 – 63.65), respectively. Compared to women, Iranian men had a lower

mean BMI (3). Obesity and overweight indicate excessive and abnormal accumulation of body fat (4) Behavioral risk factors such as unhealthy habits, improper diet, and inactivity can cause it to occur (5). Obesity is a risk factor for major chronic diseases, such as cardiovascular diseases (6), various types of cancer (7), and premature death (8). Simple ways methods to measure overweight and obesity are tables of weight, height, body mass index (BMI), the ratio of waist circumference to hip circumference and the ratio of abdominal circumference to hip circumference (9). The leading standard in this field is BMI (normal: 19-24.9; overweight: 25-30; obese: above 30 (10). Studies show that BMI increases with age, and it is more common in women than in men (11). Physical activity is a key modifiable lifestyle behavior for obesity prevention. The evidence on physical activity for a healthy weight is largely based on studies of aerobic moderate to vigorous physical activity (MVPA) including walking, cycling, or running alone (12). Recent position statements suggested that resistance or combined aerobic and resistance training may also be effective in achieving the same goal (13). Aerobic exercises (AE) by helping to burn fat and resistance exercises (RE) by increasing muscle mass can control blood and visceral fats, and all types of sports may increase the level of physical fitness (14). So both AE and RE are recommended for obesity prevention (15). Excess visceral adiposity contributes to elevated cardiometabolic risk, and waist circumference is commonly used as a surrogate measure of visceral adipose tissue (16). Although regular AE is known to improve abdominal obesity, its effect on waist circumference which is one of the factors for measuring body composition is unclear (17). Elevated or abnormal levels of lipids in the blood, which can result from obesity, are an important risk factor in people with obesity and overweight (18). Abnormalities in lipid profiles can increase the risk of metabolic syndrome and cardiovascular diseases (19). Exercise can lead to weight loss (20) which may improve the lipid profile or some of its variables (21). Interventions that combine high-intensity aerobic and high-load resistance training (RE) exert beneficial effects that are superior to any other exercise modality at decreasing abdominal adiposity and improving lean body mass (22). On the other hand, nowadays, it is thought that dieting with antioxidant properties can play an important role in preventing the risk of obesity-related diseases (23). Exercise conducted simultaneously with the consumption of herbal supplements is one of the suggested methods for controlling obesity and its complications (24). Tea, the second-most popular drink worldwide (25) especially green tea, is an antioxidant with abundant health benefits (26) that may influence fat oxidation, body composition, and blood lipid profile in human subjects (27, 28). Green tea consumption probably leads to better results if combined with physical activity (29). However, several clinical trials have reported no association between obesity indices and GT supplementation (30, 31), but Aixin et al. in their review article, stated that consumption of green tea causes a reduction in LDL-C and TC concentrations in overweight and obese women. The decline in TG levels was notable, particularly in overweight patients with hypertriglyceridemia at baseline. In addition, a significant increase in HDL-C was detected in obese subjects following intake of green tea (32). Hosseini et al. also showed that exercise performed simultaneously with GT consumption in comparison with either alone has a greater effect on improving the lipid profile in overweight women (33). However, it was concluded in a systematic review that in human studies, green tea is not effective in controlling obese lipids (34). Obesity even increases the risk of cancers in women (35). HDL and TG are strong predictors of cardiovascular death. Women having low HDL-C levels and high TG levels had a high risk of cardiovascular death (36). Hence, we conducted this study to assess the effect of PARE training with the consumption of green tea on body composition, physical fitness, and serum lipids of overweight and obese women.

2. Methodology

2.1. Materials and methods

The research was a semi-experimental-applied design with 3 groups with pre and post-test design. 45 overweight and obese women in Ardabil city volunteered to participate, then randomly assigned to three equal groups of CG, PARE, PARE+GT (n=15). 48 hours before and after the three months exercise training program, blood samples were taken from the samples.

2.2. Participants

45 eligible volunteers (aged 25–45 years and with body mass index>25 kg/m2) participated in this study. Inclusion criteria included the diagnosis of chronic diseases (cardiovascular, renal, etc.), musculoskeletal problems, and taking medications or dietary supplements known to affect the primary outcomes of the study. Exclusion criteria were the use of green tea with other herbal medicines and/or drugs and/or any additional therapy, consumption of fermented green tea, and enriched with other substances.

This study was conducted following the Declaration of Helsinki, and Ethical approval was obtained from the Rasht Branch, Islamic Azad University.

2.3. Measurements

2.3.1. Anthropometry

Body weight: The participants stood on a Beurer PS05 scale (manufactured in Germany) with minimal clothing and without any movement. Their weight was measured with an accuracy of 0.1 kg.

Body mass index: Body mass index was calculated based on the ratio of weight (kilograms) to height (meters) squared. *(BMI=kg/m2)*

Body Fat Percent: Subcutaneous body fat percentage was measured and recorded using a Lafayette 01127A caliper (USA) and the three-site Jackson-Pollock method at the upper arm, abdomen, and right thigh.

Waist to Hip ratio: Waist circumference (WC) was measured midway between the lowest rib and the pelvis in position of expiration and hip circumference (HC) was measured at the widest circumference of the hip with a soft tape measure, Then, by dividing the waist circumference by the hip circumference, the waist-to-hip ratio was obtained. (WHR: WC/HC).

2.3.2. Anaerobic power: anaerobic power was measured by standard Wingate test on a Monark bicycle for 30 seconds.

2.2.3. Aerobic power: To measure maximal aerobic power (VO2max), the Storer-Davis maximal test was used on a

Monark 894 ergometer bicycle and the following formula was used:

Women Max Aerobic Capacity=(9.39×Watts)+(7.7×Weight)-(5.88×Age)+1376

2.3.4. Heart rate variables

Blood pressure was measured using ALPK2 V-300EU mercury sphygmomanometers (Japan) and a stethoscope. All measurements were taken from the left arm with the hand positioned parallel to the level of the heart. Heart rate was assessed using a Beurer PM80 pulse monitor (Germany).

2.3.5. Lipid profile

Blood samples for lipid profile analysis (cholesterol, LDL, HDL, and TG) were collected from participants using standard venipuncture procedures. Blood samples were collected at the beginning and end of the study following 8–12 hours of fasting. Serum was separated by centrifugation at 2000 RPM for 15–20 minutes. Lipid parameters were measured using automated laboratory techniques. For consistency, blood was collected from the antecubital vein of the participant's left arm, and samples were processed immediately following collection to ensure accuracy of results.

2.4. Intervention

2.4.1 Exercise program

The progressive parallel aerobic and resistance exercise program used in this study is shown in Table 1 and was performed six days/week by PARE and PARE+GT groups for three months. Aerobic training includes 60 minutes, starting with 65% of the maximum heart rate, (15 min of warm-up with running, stretching, and jumping and 10 min cooling down).

Resistance training sessions included nine movement with three sets(1 min rest between each sets , and 2 min rest between movements), which started with 60-65% of 1 repetition maximum (1RM). Exercise modes included: Bench Press, Leg Press, Seated Row, Shoulder Press, Leg extension, Tricep Extension, Hamstring Curl, Bicep Curl, Calf Raise. 1RM of each participants for each exercise was obtained from the Brzeski formula:

1RM = Weight÷(1.0278−(0.0278×Number of repetitions))

Every two weeks, the intensity of the exercise was increased by 5%.

Table 1. *Exercise training program*

Weeks	Aerobic training		Resistance training		
1-2	Minute	Intensity	Set	Repeat	Intensity
	35	65%	3	10-12	60-65%
3-4	35	70%	3	10-12	65-70%
5-6	35	75%	3	10-12	70-75%
7-8	35	80%	3	10-12	75-80%

2.4.2. Green tea supplement

The participates who were in PARE+GT group consumed green tea, three meals a day (one tea bag per meal) during the research period. Samples added 1 green tea bag to 1 glass (equivalent to 150 ml) of boiling water with a temperature of 80 to 85 degrees and put the lid on it for 6 to 8 minutes.

2.5. Statistical Methods

Data analyses are described based on the mean±standard deviation. After ensuring the normal distribution of research variables using the Shapiro-Wilk test, one-way analysis of variance (ANOVA) and Tukey's post hoc tests were used to determine between-group changes. All calculations and statistical analyses were performed using SPSS software (IBM, SPSS Inc., Chicago, IL, USA) at significance level of 0.05.

3. Results

The Kolmogorov–Smirnov test indicated normal distribution for all of the variables. Results of descriptive analysis (n=15 for each group) and the result of one-way ANOVA were presented in Table 2. Leven test showed the equality of variances (P>0.05).

Table 2. *One way of ANOVA result between different groups (n= 15 in each group)*

Variable	Group	Pre test Mean±SD	Post test Mean±SD	Sum of square	mean square	F	Sig
Body weight (kg)	CG	83.75±12.3	84.54±13.5	345.09	172.54	0.772	
	PARE	83.82±10.1	80.94±8.2				0.341
	PARE+GT	80.90±9.3	74.66±8.1				
BMI(kg/m^2)	CG	33.03±4.3	33.36±3.3	56.95	28.478	2.45	
	PARE	33.02±3.8	31.88±3.4				0.034*
	PARE+GT	32.80±4.1	30.27±4.01				
%BF	CG	41.40±4.2	42.02±4.1	84.412	42.706	4.09	
	PARE	42.01±4.4	39.80±4.1				0.025*
	PARE+GT	41.63±4.1	39.10±4.8				
WHR	CG	0.866±0.03	0.868±0.04	0.001	0.001	0.087	
	PARE	0.850±0.05	0.841±0.11				0.916
	PARE+GT	0.892±0.06	0.882±0.08				
Aerobic power (ml/kg/min)	CG	19.053±2.2	18.86±2.6	3357.26	1678.63	161.54	
	PARE	20.17±2.8	25.0±2.02				0.001*
	PARE+GT	19.56±2.4	26.53±2.5				
Anaerobic power (kg.m/S)	CG	24.533±2.5	19.746±2.2	5574.83	2787.41	314.23	
	PARE	23.238±2.0	31.30±2.4				0.001*
	PARE+GT	23.961±2.1	34.38±2.3				
HR rest	CG	80.40±12.1	79.46±9.1	64.987	32.089	0.149	
	PARE	78.07±12.8	76.53±9.4				0.862
	PARE+GT	81.07±12.5	77.69±9.0				
SBP rest	CG	128.8±18.1	129.47±18.5	32.6617	1633.089	4.113	
	PARE	130.7±18.8	117.38±17.3				0.023*
	PARE+GT	129.31±17.5	118.0±8.0				
DBP rest	CG	80.26±11.1	79.60±11.2	203.33	101.667	2.568	
	PARE	77.76±11.3	73.69±11.8				0.048*
	PARE+GT	77.38±10.8	74.38±12.2				
HDL (mg/dL)	CG	48.53±4.1	47.86±5.1	17.721	8.861	0.143	
	PARE	47.07±4.4	47.84±5.2				0.868
	PARE+GT	48.0±5.1	48.61±4.3				
LDL (mg/dL)	CG	109.93±14.1	106.27±14.7	4052.77	4525.39	2.571	
	PARE	117.85±14.8	98.15±12.1				0.021*
	PARE+GT	113.62±13.4	86.53±11.7				
Cholesterol (mg/dL)	CG	194.27±17.1	193.20±16.4	3122.62	1561.31	0.902	
	PARE	204.62±18.1	188.46±17.7				0.414
	PARE+GT	192.62±17.7	171.38±17.3				
TG (mg/dL)	CG	133.2±14.1	132.27±15.8	9539.72	4769.86	2.849	
	PARE	129.15±13.7	106.38±16.5				0.040*
	PARE+GT	160.0±15.3	98.46±14.9				

TG: Triglyceride; LDL1: low-density lipoprotein; HDL: high-density lipoprotein; DBP rest: resting diastolic blood pressure; SBP rest: resting systolic blood pressure
*: P<0.05

The results of the one-way ANOVA showed that the BF%, BMI, aerobic and anaerobic power, resting systolic and diastolic BP, LDL, and TG had a significant difference between the groups.

Table 3. *Mean comparisons (Tukey) between different groups*

Variables	Group 1	Group 2	Average difference (d)	standard error	Significant level
BMI	CG	PARE	15.33	2.538	0.032*
	CG	PARE+GT	14.98	3.538	0.021*
	PARE	PARE+GT	5.98	1.538	0.592
%BF	CG	PARE	2.728	1.122	0.049*
	CG	PARE+GT	3.467	1.122	0.010*
	PARE	PARE+GT	0.738	1.122	0.789
Aerobic power (ml/kg/min)	CG	PARE	18.053	1.617	0.001*
	CG	PARE+GT	16.446	1.617	0.001*
	PARE	PARE+GT	1.606	1.617	0.585
Anaerobic power (kg.m/S)	CG	PARE	22.853	3.040	0.001*
	CG	PARE+GT	17.770	3.040	0.001*
	PARE	PARE+GT	5.08	3.040	0.228
SBP rest	CG	PARE	18.33	7.276	0.041*
	CG	PARE+GT	17.80	7.24	0.048*
	PARE	PARE+GT	4.53	2.297	0.974
DBP rest	CG	PARE	15.33	6.32	0.049*
	CG	PARE+GT	14.98	6.24	0.032*
	PARE	PARE+GT	5.98	2.11	0.875
LDL-C (mg/dL)	CG	PARE	24.33	15.489	0.041*
	CG	PARE+GT	38.75	15.489	0.028*
	PARE	PARE+GT	4.33	15.489	0.975
TG (mg/dL)	CG	PARE	38.33	14.865	0.035*
	CG	PARE+GT	43.20	14.865	0.016*
	PARE	PARE+GT	20.86	14.865	0.348

CG: control group; PARE: parallel aerobic and resistance exercise; PARE+GT: parallel aerobic and resistance exercise with consumption of green tea

The results of Tukey's comparisons showed that a significant difference was observed between the CG and experimental groups (PARE+GT and PARE groups). The result showed a decrease in BMI, BF %, resting SBP and DBP, LDL-C, TG, and an improvement in aerobic and anaerobic power. However, no significant difference was observed between the PARE and PARE+GT groups in these variables.

4. Discussion

The results of our research showed that there was a significant decrease in BF% and BMI experimental groups. But other selected indices of body composition did not show any significant difference. There is a growing body of evidence showing that intake of GT improves anthropometric indices by reducing BMI, body weight, WHR, and BFP (37). Nanri et al (38) and Yonekura et al (39) reported that daily GT consumption was inversely associated with high BMI, BF%, in middle-aged Japanese women .But Roberts et al In body composition and heart markers in healthy and overweight people who had regular physical activity, no significant effect was found with green tea consumption (40). Maki et al reported that green tea consumption combined with aerobic exercise did not significantly impact total body fat mass (29). This discrepancy in results may be related to the duration of the study, the amount of green tea consumed. The main effects of green tea on body composition is proposed to be due to catechins (41) Potential mechanisms for the effect of green tea on body weight and BFP involves inhibition of adipocyte differentiation and proliferation, reduced fat absorption, inhibition of catecholo-methyl-transferase, increased energy expenditure, increased utilization of fat, and increased energy expenditure and thermogenesis (42) .During moderate-intensity exercise, energy expenditure is several times greater than at rest, and absolute rates of both lipolysis and fat oxidation are also increased (43). The possible reason why RT can induce positive changes in body composition is that it increases skeletal muscle mass, further improving the basal metabolic rate and energy expenditure (44). Our results showed that there was a significant difference in blood triglycerides between the studied groups, but other blood lipid indices did not show significant differences. Also, the results showed there is no significant difference between the PARE and PARE + GT. Asbaghi et al investigated the effect of green tea extract on lipid profile and the results that long-term GT intervention may reduce serum concentrations of TG and TC (45) but Xu et al reported that consumption of green tea lowers LDL cholesterol, but not HDL cholesterol or triglycerides in both normal weight subjects and those who were overweight/obese (46). Rostamian et al. reported that resistance training combined with GT consumption may have potential benefits in enhancing body composition, lowering triglyceride, and increasing high-density lipoprotein in sedentary obese/overweight people (27). Wood et al reported Aerobic exercise training positively changes the standard lipid profile of sedentary and otherwise healthy adults with $\geqslant$3 MetS factors (47). The reasons for the inconsistency could be the lack of control over participant's diet, type and intensity of exercise. incorporation of green tea into exercise training does not seem to exert additional benefits on lipid profile and it warrants further investigations in the future (48). The HRV indices (resting SBP, and DBP) have a significant decline. As HRV declines with age, it is easy to speculate that the promotion of physical activity should be recommended, as it can improve autonomic cardiac modulation (49). one of the explanations for the observed associations of lower physical activity with lower HRV could be that it decreases blood volume and left ventricular stroke volume to result in an increased heart rate on account of increased sympathetic activity (50). Such activity would aid in preventing chronic diseases, such as diabetes, cardiac events, stroke, and so forth, to accordingly lead to a better quality of life. In our study both aerobic and anaerobic power had a significant improvement in PARE and PARE + GT in comparison with CG group. Concerning exercise, Bellicha et al. research exercise led to a significant weight loss, fat loss, and visceral fat loss but No difference in weight, fat, and visceral loss was found between aerobic and high-intensity (51). Muscle mass significantly increased in the RE (52) and AE groups, also, a significant decrease was observed in the body fat percentage in all group, Dianatinasab et al found that muscle mass significantly increased in the RE and PE groups, And a significant decrease was observed in the body fat percentage in all groups (53). the current results suggest that Combined training (AE and RE) is the best exercise modality for improving body composition and inflammatory status in overweight and obese individuals (20). Furthermore, lipolytic activation is delayed in obese individuals, and RT may play a role by up-regulating adipose tissue lipolysis and by increasing energy expenditure (54). AE has been stated as an integral component of interventions to reduce obesity (55). so In a word, we recommend that overweight and obese people adopt AE combined with RT as their primary form of exercise, while paying attention to caloric restriction (56). This study faced several limitations. It was conducted exclusively on women, without accounting for their menstrual cycles, which might influence the results due to hormonal and gender differences. Additionally, participants were not provided with a specific diet plan, nor was their dietary intake controlled.

5. Conclusion

The results of this study showed that parallel exercises (aerobic-resistance) improve biological indicators in both aerobic and anaerobic power variables, as well as improve blood triglyceride levels and reduce body fat percentage and improve body mass index (BMI), However it does not make

a significant difference in other selected indicators of body composition and lipid profile. But adding consumption of green tea did not cause any additional effects. These changes probably depend on the intensity and type of exercises.

6. Acknowledgment

We would like to extend sincere appreciation to the people who participated in the study.

Conflict of interests: The authors declare that they have no conflict of interest relating to the publication of this manuscript.

References

[1] Palmas V, Pisanu S, Madau V, Casula E, Deledda A, Cusano R, et al. Gut microbiota markers associated with obesity and overweight in Italian adults. Scientific reports. 2021;11(1):5532.

[2] Pinart M, Dötsch A, Schlicht K, Laudes M, Bouwman J, Forslund SK, et al. Gut microbiome composition in obese and non-obese persons: a systematic review and meta-analysis. Nutrients. 2021;14(1):12.

[3] Djalalinia S, Yoosefi M, Shahin S, Ghasemi E, Rezaei N, Ahmadi N, et al. The levels of BMI and patterns of obesity and overweight during the COVID-19 pandemic: Experience from the Iran STEPs 2021 survey. Frontiers in Endocrinology. 2022;13:1043894.

[4] Okati-Aliabad H, Ansari-Moghaddam A, Kargar S, Jabbari N. Prevalence of obesity and overweight among adults in the Middle East countries from 2000 to 2020: a systematic review and meta‐analysis. Journal of Obesity. 2022;2022(1):8074837.

[5] Chatterjee A, Gerdes MW, Martinez SG. Identification of risk factors associated with obesity and overweight—a machine learning overview. Sensors. 2020;20(9):2734.

[6] Carbone S, Canada JM, Billingsley HE, Siddiqui MS, Elagizi A, Lavie CJ. Obesity paradox in cardiovascular disease: where do we stand? Vascular health and risk management. 2019:89-100.

[7] Pischon T, Nimptsch K. Obesity and risk of cancer: an introductory overview. Obesity and cancer. 2016:1-15.

[8] Kim M-H, Yun KE, Kim J, Park E, Chang Y, Ryu S, et al. Gut microbiota and metabolic health among overweight and obese individuals. Scientific reports. 2020;10(1):19417.

[9] Shakespear-Druery J, De Cocker K, Biddle SJ, Gavilán-Carrera B, Segura-Jiménez V, Bennie J. Assessment of muscle-strengthening exercise in public health surveillance for adults: A systematic review. Preventive Medicine. 2021;148:106566.

[10] Alsannan B, Laganà AS, Alhermi J, Almansoor S, Ayed A, Venezia R, et al. Prevalence of overactive bladder among overweight and obese women: A prospective cross-sectional cohort study. European Journal of Obstetrics & Gynecology and Reproductive Biology. 2024;295:59-64.

[11] Cooper AJ, Gupta SR, Moustafa AF, Chao AM. Sex/gender differences in obesity prevalence, comorbidities, and treatment. Current obesity reports. 2021:1-9.

[12] Said M, Lamya N, Olfa N, Hamda M. Effects of high-impact aerobics vs. low-impact aerobics and strength training in overweight and obese women. J Sports Med Phys Fitness. 2017;57(3):278-88.

[13] Bennie J, De Cocker K, Pavey T, Stamatakis E, Biddle S, Ding D. Muscle strengthening, aerobic exercise, and obesity: a pooled analysis of 1.7 million us adults. Obesity 28 (2), 371–378. 2020.

[14] Willis LH, Slentz CA, Bateman LA, Shields AT, Piner LW, Bales CW, et al. Effects of aerobic and/or resistance training on body mass and fat mass in overweight or obese adults. Journal of applied physiology. 2012.

[15] Villareal DT, Aguirre L, Gurney AB, Waters DL, Sinacore DR, Colombo E, et al. Aerobic or resistance exercise, or both, in dieting obese older adults. New England Journal of Medicine. 2017;376(20):1943-55.

[16] Ross R, Neeland IJ, Yamashita S, Shai I, Seidell J, Magni P, et al. Waist circumference as a vital sign in clinical practice: a Consensus Statement from the IAS and ICCR Working Group on Visceral Obesity. Nature Reviews Endocrinology. 2020;16(3):177-89.

[17] Armstrong A, Jungbluth Rodriguez K, Sabag A, Mavros Y, Parker HM, Keating SE, et al. Effect of aerobic exercise on waist circumference in adults with overweight or obesity: A systematic review and meta‐analysis. Obesity Reviews. 2022;23(8):e13446.

[18] Muscella A, Stefàno E, Marsigliante S. The effects of exercise training on lipid metabolism and coronary heart disease. American Journal of Physiology-Heart and Circulatory Physiology. 2020;319(1):H76-H88.

[19] Silveira Rossi JL, Barbalho SM, Reverete de Araujo R, Bechara MD, Sloan KP, Sloan LA. Metabolic syndrome and cardiovascular diseases: Going beyond traditional risk factors. Diabetes/metabolism research and reviews. 2022;38(3):e3502.

[20] Wang S, Zhou H, Zhao C, He H. Effect of exercise training on body composition and inflammatory cytokine levels in overweight and obese individuals: a systematic review and network meta-analysis. Frontiers in immunology. 2022;13:921085.

[21] Doewes RI, Gharibian G, Zaman BA, Akhavan-Sigari R. An updated systematic review on the effects of aerobic exercise on human blood lipid profile. Current problems in cardiology. 2023;48(5):101108.

[22] O'Donoghue G, Blake C, Cunningham C, Lennon O, Perrotta C. What exercise prescription is optimal to improve body composition and cardiorespiratory fitness in adults living with obesity? A network meta‐analysis. Obesity Reviews. 2021;22(2):e13137.

[23] Ghasemi E, Afzalpour ME, Nayebifar S. Combined high-intensity interval training and green tea supplementation enhance metabolic and antioxidant status in response to acute exercise in overweight women. The Journal of Physiological Sciences. 2020;70:1-9.

[24] Hosseini Z, Ghaedi H, Ahmadi M, Hosseini SA. Lipid-lowering effects of concurrent training and green tea consumption in overweight women. Journal of Obesity & Metabolic Syndrome. 2020;29(4):313.

[25] Tavares CT, Lobo ACS, Almeida CCB, Lima-Silva AE, Ferreira SMR. Effectiveness of green tea extract (Camellia sinensis) capsule supplementation for post-exercise muscle recovery in healthy adults: A systematic review protocol. JBI Evidence Synthesis. 2022;20(4):1150-7.

[26] Saeed M, Naveed M, Arif M, Kakar MU, Manzoor R, Abd El-Hack ME, et al. Green tea (Camellia sinensis) and l-theanine: Medicinal values and beneficial applications in humans—A comprehensive review. Biomedicine & Pharmacotherapy. 2017;95:1260-75.

[27] Rostamian Mashhadi M, Hosseini SRA. The interaction effect of green tea consumption and exercise training on fat oxidation, body composition and blood lipids in humans: a review of the literature. Sport Sciences for Health. 2023;19(2):461-77.

[28] Chen I-J, Liu C-Y, Chiu J-P, Hsu C-H. Therapeutic effect of high-dose green tea extract on weight reduction: A randomized, double-blind, placebo-controlled clinical trial. Clinical nutrition. 2016;35(3):592-9.

[29] Hematinezhad Touli M, Elmieh A, Hosseinpour A. The Effect of Six-Week Aerobic Exercise Combined with Green Tea Consumption on PON1 and VO2max Increase and Apelin, Blood Pressure, and Blood Lipids Reduction in Young Obese Men. Archives of Razi Institute. 2022;77(6):2115-23.

[30] Quinhoneiro DCG, Nicoletti CF, Pinhel MAS, Noronha NY, Braga CBM, Oliveira BAP, et al. Green tea supplementation upregulates uncoupling protein 3 expression in severe obese women adipose tissue but does not promote weight loss. International Journal of Food Sciences and Nutrition. 2018;69(8):995-1002.

[31] Janssens PL, Penders J, Hursel R, Budding AE, Savelkoul PH, Westerterp-Plantenga MS. Long-term green tea supplementation does not change the human gut microbiota. PloS one. 2016;11(4):e0153134.

[32] Li A, Wang Q, Li P, Zhao N, Liang Z. Effects of green tea on lipid profile in overweight and obese women: A systematic review and meta-analysis of randomized controlled trials: Hogrefe AG; 2024. 239–51 p.

[33] Hosseini Z, Ghaedi H, Ahmadi M, Hosseini SA. Lipid-Lowering Effects of Concurrent Training and Green Tea Consumption in Overweight Women. Journal of obesity & metabolic syndrome. 2020;29(4):313-9.

[34] Macêdo APA, Gonçalves MdS, Barreto Medeiros JM, David JM, Villarreal CF, Macambira SG, et al. Potential therapeutic effects of green tea on obese lipid profile–a systematic review. Nutrition and health. 2022;28(3):401-15.

[35] Hu FB. Overweight and obesity in women: health risks and consequences. Journal of women's health. 2003;12(2):163-72.

[36] Phan BA, Toth PP. Dyslipidemia in women: etiology and management. International journal of women's health. 2014;6:185-94.

[37] Alipour M, Malihi R, Hosseini SA, Abbasnezhad A, Ghavami A, Shahmohammadi HA, et al. The effects of catechins on related risk factors with type 2 diabetes: a review. Progress in Nutrition. 2018;20(1):12-20.

[38] Rondanelli M, Riva A, Petrangolini G, Allegrini P, Perna S, Faliva MA, et al. Effect of acute and chronic dietary supplementation with green tea catechins on resting metabolic rate, energy expenditure and respiratory quotient: A systematic review. Nutrients. 2021;13(2):644.
[39] Yonekura Y, Terauchi M, Hirose A, Odai T, Kato K, Miyasaka N. Daily coffee and green tea consumption is inversely associated with body mass index, body fat percentage, and cardio-ankle vascular index in middle-aged Japanese women: A cross-sectional study. Nutrients. 2020;12(5):1370.
[40] Roberts JD, Willmott AG, Beasley L, Boal M, Davies R, Martin L, et al. The impact of decaffeinated green tea extract on fat oxidation, body composition and cardio-metabolic health in overweight, recreationally active individuals. Nutrients. 2021;13(3):764.
[41] Asbaghi O, Fouladvand F, Gonzalez MJ, Aghamohammadi V, Choghakhori R, Abbasnezhad A. Effect of green tea on anthropometric indices and body composition in patients with type 2 diabetes mellitus: a systematic review and meta-analysis. Complementary medicine research. 2021;28(3):244-51.
[42] Bagheri R, Rashidlamir A, Ashtary‐Larky D, Wong A, Alipour M, Motevalli MS, et al. Does green tea extract enhance the anti‐inflammatory effects of exercise on fat loss? British journal of clinical pharmacology. 2020;86(4):753-62.
[43] Alghannam AF, Ghaith MM, Alhussain MH. Regulation of energy substrate metabolism in endurance exercise. International Journal of Environmental Research and Public Health. 2021;18(9):4963.
[44] Leite RD, Durigan RdCM, de Souza Lino AD, de Souza Campos MV, das Graças Souza M, Selistre-de-Araújo HS, et al. Resistance training may concomitantly benefit body composition, blood pressure and muscle MMP-2 activity on the left ventricle of high-fat fed diet rats. Metabolism. 2013;62(10):1477-84.
[45] Asbaghi O, Fouladvand F, Moradi S, Ashtary-Larky D, Choghakhori R, Abbasnezhad A. Effect of green tea extract on lipid profile in patients with type 2 diabetes mellitus: A systematic review and meta-analysis. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2020;14(4):293-301.
[46] Xu R, Yang K, Li S, Dai M, Chen G. Effect of green tea consumption on blood lipids: a systematic review and meta-analysis of randomized controlled trials. Nutrition journal. 2020;19:1-15.
[47] Wood G, Taylor E, Ng V, Murrell A, Patil A, van der Touw T, et al. Determining the effect size of aerobic exercise training on the standard lipid profile in sedentary adults with three or more metabolic syndrome factors: a systematic review and meta-analysis of randomised controlled trials. British journal of sports medicine. 2022;56(18):1032-41.
[48] Gholami F, Antonio J, Iranpour M, Curtis J, Pereira F. Does green tea catechin enhance weight-loss effect of exercise training in overweight and obese individuals? a systematic review and meta-analysis of randomized trials. Journal of the International Society of Sports Nutrition. 2024;21(1):2411029.
[49] Farah BQ, Andrade-Lima A, Germano-Soares AH, Christofaro DGD, de Barros MVG, do Prado WL, et al. Physical activity and heart rate variability in adolescents with abdominal obesity. Pediatric Cardiology. 2018;39:466-72.
[50] Dias RM, Moraes ÍA, Dantas MT, Fernani DC, Fontes AM, Silveira AC, et al. Influence of chronic exposure to exercise on heart rate variability in children and adolescents affected by obesity: a systematic review and meta-analysis. International journal of environmental research and public health. 2021;18(21):11065.
[51] Bellicha A, van Baak MA, Battista F, Beaulieu K, Blundell JE, Busetto L, et al. Effect of exercise training on weight loss, body composition changes, and weight maintenance in adults with overweight or obesity: An overview of 12 systematic reviews and 149 studies. Obesity Reviews. 2021;22:e13256.
[52] Grgic J, Mcllvenna LC, Fyfe JJ, Sabol F, Bishop DJ, Schoenfeld BJ, et al. Does aerobic training promote the same skeletal muscle hypertrophy as resistance training? A systematic review and meta-analysis. Sports Medicine. 2019;49:233-54.
[53] Dianatinasab A, Koroni R, Bahramian M, Bagheri-Hosseinabadi Z, Vaismoradi M, Fararouei M, et al. The effects of aerobic, resistance, and combined exercises on the plasma irisin levels, HOMA-IR, and lipid profiles in women with metabolic syndrome: A randomized controlled trial. Journal of Exercise Science & Fitness. 2020;18(3):168-76.
[54] Kang S, Park K-M, Sung K-Y, Yuan Y, Lim S-T. Effect of resistance exercise on the lipolysis pathway in obese pre-and postmenopausal women. Journal of Personalized Medicine. 2021;11(9):874.
[55] Hamila A, Younes M, Cottin F, Amor YB, Shephard R, Tabka Z, et al. Effects of walking exercises on body composition, heart rate variability, and perceptual responses in overweight and obese adolescents. Science & Sports. 2018;33(5):e191-e202.
[56] van Baak MA, Pramono A, Battista F, Beaulieu K, Blundell JE, Busetto L, et al. Effect of different types of regular exercise on physical fitness in adults with overweight or obesity: Systematic review and meta‐analyses. Obesity Reviews. 2021;22:e13239.