Review

Effects of green tea on lipid profile in overweight and obese women

A systematic review and meta-analysis of randomized controlled trials

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Abstract: The effect of green tea administration on serum lipids' concentrations remains unclear as various investigations, which have explored this topic, have produced conflicting results. Gender might be one of the factors influencing the impact of green tea on the lipid profile. Hence, we conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) to assess the effect of green tea intake on the lipid profile in overweight and obese women. We searched five databases (Web of Science, SCOPUS, Embase, PubMed/Medline, and Google Scholar) using a combination of MeSH and non-MeSH terms. Results were expressed as weighted mean differences (WMDs) and 95% confidence intervals (CIs) and synthesized with a random-effects model. In total, 15 eligible RCTs with 16 arms (1818 participants) were included in the meta-analysis. The combined effect size revealed a significant reduction in total cholesterol (TC) (WMD: −4.45 mg/dl, 95% CI: −6.63, −2.27, P<0.001) and low-density lipoprotein cholesterol (LDL-C) (WMD: −4.49 mg/dl, 95% CI: −7.50 to −1.47, P=0.003) concentrations following green tea supplementation in overweight and/or obese women. In addition, a more pronounced reduction of triglyceride (TG) levels occurred when the baseline TG value was ≥150 mg/dL (WMD: −24.45 mg/dL, 95% CI: −40.63 to −8.26, P=0.003). Moreover, a significant decrease in TG concentrations occurred in RCTs conducted on overweight subjects (BMI: 25–29.99 kg/m^2) (WMD: −5.88 mg/dl, 95% CI: −10.76 to −0.99, P=0.01). In the subgroup analyses based on the study population, a notable increase in high-density lipoprotein cholesterol (HDL-C) values was observed in obese individuals (>30 kg/m^2) (WMD: 2.63 mg/dl, 95% CI: 0.10 to 5.16, P=0.041). 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.

Keywords: green tea, LDL-C, TG, TC, women, obesity, polyphenols, dyslipidemia

Introduction

Tea originates from East Asia and is, next to water, one of the most widely consumed drinks throughout the world [1]. Even though there are different types of tea, e.g., black tea, green tea, white tea, oolong tea and Puerh tea, all these varieties come from the plant *Camellia sinensis* [2]. Approximately 20% of the total consumption of tea is of green tea, which is consumed every day in many countries [3].

Green tea contains high amounts of catechin, a polyphenol, and epigallocatechin gallate (EGCG), a type of catechin, both having antioxidant properties [4]. The prevalence and incidence of obesity is on the rise globally and this cardiometabolic disorder is closely linked with hyperlipidemia [5]. Apart from pharmacological agents, research has confirmed that several natural products display propitious anti-obesity and lipid-lowering actions [6, 7, 8, 9, 10, 11, 12]. Green tea, one of the most popular beverages worldwide, has shown promising properties in the prevention and treatment of many diseases, including obesity, dyslipidemia or cancer [13, 14, 15]. Hyperlipidemia is a major risk factor for cardiovascular disease [16]. Moreover, epidemiological data have reported a negative association between the risk of coronary heart disease and the consumption of green tea [17].

A study conducted by Maki et al. reported that EGCG in green tea can help reduce triglycerides (TG) and high-density lipoprotein cholesterol (HDL-C) levels, as well as abdominal fat [18]. In addition, a meta-analysis has revealed that low-density lipoprotein cholesterol (LDL-C) values decreased following green tea intake [19]. It was also demonstrated in an *in vivo* investigation that green tea supplementation results in a significant reduction in TG values in laboratory animals (26–45%) [12]. Moreover, among

individuals with dyslipidemia, an amelioration of the lipid profile was detected in tea consumers. Green tea lowered cholesterol levels by suppressing its absorption and increasing the number of LDL receptors [13].

Several investigations have proven that catechins present in green tea possess antioxidant activities and effectively inhibit the oxidation of LDL [20]. Green tea, or the catechins present in it, may be used as safe and effective lipid-lowering therapeutic agents [21]. Various assessments have concluded that green tea and its major constituent EGCG exhibit lipid-lowering actions, mainly *via* reducing LDL-C and TC concentrations. In addition, a meta-analysis has revealed that green tea causes a significant reduction in both LDL-C and TC values in different populations [22, 23, 24, 25].

Recently, a systematic review has analyzed the potential therapeutic effects of green tea in obesity and dyslipidemia and has reported that green tea consumption led to reductions in TC, TG and LDL-C levels in experimental studies conducted in animals [26]. However, clinical studies have reported conflicting results, green tea has not displayed efficacy in controlling serum lipids' concentrations in humans [26]. Contrastingly, in another investigation, green tea consumption reduced TC and LDL-C levels, but not TG and HDL-C values, in normal and overweight or obese subjects [27]. Additionally, green tea is a cost-effective way to reduce serum lipids' concentrations in postmenopausal women, it is not associated with major side effects, and its consumption has been recommended in women with slight abnormalities of the lipid profile [28].

Research conducted in men with the same amount of overweight as women has delineated that males exhibit elevated TG concentrations and blood pressure values versus females. Moreover, adipose tissue is distributed differently in women with increased amounts of body fat [29]. Apart from its impact on cardiometabolic ailments, green tea has also demonstrated beneficial effects on endocrine disorders, e.g., female reproductive disorders [30].

However, the effect of green tea administration on serum lipids' concentrations remains unclear as various investigations, which have explored this topic, have produced conflicting results. Gender might be one of the factors influencing the impact of green tea intake on the lipid profile. A cohort study conducted in the Chinese population revealed that men consuming green tea had higher risk of developing cardiovascular disease, but such effect was not found in women consuming green tea [31]. Obese women have a high risk of cardiovascular diseases. Obesity even increases the risk of cancers in women [32]. HDL-C 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 [33]. Hence, we conducted this systematic review and meta-analysis of randomized controlled trials (RCTs) to assess the effect of green tea on the lipid profile in overweight and obese women.

Methods

This study was conducted in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [34].

Search strategy

We searched five databases (Web of Science, SCOPUS, Embase, PubMed/Medline, and Google Scholar) using a combination of MeSH and non-MeSH terms. We applied the following search strategy: ("green tea" OR "green tea extract" OR "green tea extract AR25" OR catechin OR "catechins" OR "EGCG" OR "camellia sinensis" OR "tea polyphenols" OR "Catechinic Acid" OR "Catechin" OR "Camellia sinensis" OR "epigallocatechin gallate") AND (women OR female) AND ('Clinical Trials' OR 'controlled trial' OR 'RCT' OR 'intervention' OR 'Trial' OR 'Intervention Studies' OR 'random' OR 'randomized' OR 'placebo' OR 'randomized'). Literature was searched from inception of these databases up to November 30, 2022, with no language restrictions. The reference lists of the relevant original and review articles were manually searched for additional relevant papers.

Eligibility criteria

We included studies meeting the following criteria: (i) overweight/obese women receiving green tea or placebo supplementation, and (ii) RCTs reporting one or more of the next outcome measures: low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) concentrations.

We excluded investigations meeting the following criteria: (i) lack of sufficient data regarding the outcomes, (ii) preclinical studies, retrospective studies, reviews, case-control studies, case series, letters, commentaries, or editorials, and (iii) publications investigating the impact of green tea in combination with other interventions (e.g., other supplements).

Data extraction

Data abstracted from eligible RCTs included: (i) study location, (ii) year of publication, (iii) first author's name, (iv) trial duration, (v) green tea dosage (mg/day), (vi) number of participants in the intervention and control group, (vii) age of

participants, and (viii) outcome measures assessed in the study. Three investigators extracted data from eligible studies and discrepancies were resolved by consensus among the investigators.

Quality assessment

A systematic evaluation of bias of each eligible RCT was executed using the Cochrane's risk of bias tool [35]. This tool examines the following domains: (i) selection bias, (ii) performance bias, (iii) detection bias, (iv) attrition bias, (v) reporting bias, and (iv) other possible sources of bias.

Data synthesis and statistical analysis

The meta-analysis was conducted using the STATA software (version 14; Stata Corporation, College Station, Texas, USA). Results were expressed as weighted mean differences (WMDs) and 95% confidence intervals (CIs). We applied mean, standard deviation (SD), and sample size for outcome measures pre- and post-intervention (LDL-C, HDL-C, TC, and TG) to calculate the combined effect sizes in the random-effects model. When a study reported the standard error of the mean (SEM) instead of SD, standardized formulas were used to calculate the corresponding mean and SD [35, 36]. Heterogeneity among trials for each outcome was assessed using the value of I^2: I^2 <50% (low), 50–75% (moderate), and >75% (high heterogeneity). We carried out predefined subgroup analysis based on the baseline value of serum lipids' concentrations, health status of the participants (e.g., postmenopausal women), baseline BMI (overweight: BMI=25–29.99 kg/m^2; obesity: BMI≥30 kg/m^2), type of green tea (whole green tea and decaffeinated green tea), and length of the intervention (<12 weeks and ≥12 weeks), to detect potential sources of heterogeneity among the RCTs. Publication bias was estimated via visual inspection of the funnel plots and with the Egger's test [37]. When publication bias was perceived, the 'trim-and-fill' method was performed to estimate the impact of missing publications [38]. Finally, a sensitivity analysis was conducted for all assessed outcomes, in which each RCT was removed at a time and the analysis was repeated. P-values <0.05 were considered to be statistically significant.

Results

Study selection

Out of 2173 relevant publications that were initially retrieved in the literature search, 428 duplicate publications were omitted. Of the remaining 1745 articles screened, 1706 papers were excluded based on title and abstract screening. Subsequently, 39 publications were selected for further exploration of full-texts. Of these manuscripts, 24 studies were excluded based on the exclusion criteria. Finally, 15 eligible RCTs with 16 arms were included in the meta-analysis [28, 29, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50]. PRISMA flowchart is depicted in Figure 1.

Study characteristics and risk of bias assessment

The general characteristics of the included RCTs are summarized in Table 1. The studies were performed on women aged 22 years to 60 years. The RCTs were published between 2006 and 2019, and were conducted in Iran, Taiwan, Brazil, USA, Republic of Mauritius, Spain, Italy, China, and The Netherlands. The duration of green tea supplementation varied from 4 weeks to 12 months. The samples sizes of the eligible RCTs ranged from 20 subjects to 936 subjects. The baseline BMI varied from 25 kg/m^2 to 33.4 kg/m^2. The participants were postmenopausal women, patients with prediabetes, subjects borderline for metabolic syndrome, women with breast cancer, obese patients with polycystic ovary syndrome and healthy women. Table E1 in Electronic Supplementary Material (ESM) 1 presents data on the risk of bias evaluation of the eligible RCTs. Collectively, the trials revealed a general unclear to low risk of bias.

Effect of green tea supplementation on serum TG concentrations

In total, 15 RCT arms with 1765 participants were entered into the meta-analysis (green tea group = 889 subjects, placebo = 876 subjects). The combined effect size revealed that green tea consumption does not decrease TG concentrations in overweight/obese women (WMD: −3.43 mg/dl, 95% CI: −7.49 to 0.62, P=0.09). The pooled analysis was heterogeneous (I^2 = 98%, P<0.001) (Figure 2). However, a pronounced reduction of TG levels was discovered when the baseline TG values were ≥150 mg/dL (WMD: −24.45 mg/dL, 95% CI: −40.63 to −8.26, P=0.003) *versus* <150 mg/dL (WMD: −3.02 mg/dL, 95% CI: −7.23 to 1.18, P=0.159). Moreover, a significant decrease in TG levels was noted in overweight subjects (BMI: 25–29.99 kg/m^2) (WMD: −5.88 mg/dl, 95% CI: −10.76 to −0.99, P=0.01) versus obese subjects (≥30 kg/m^2) (WMD: −2.85 mg/dl, 95% CI: −18.19 to 12.48, P=0.71) (Figure E1 in ESM 2).

Effect of green tea supplementation on serum TC concentrations

In total, 14 RCT arms with 1748 participants were entered into the meta-analysis (green tea group= 879 subjects, placebo = 869 subjects). The combined effect size revealed a significant reduction in TC concentrations following green tea supplementation in overweight/obese women (WMD:

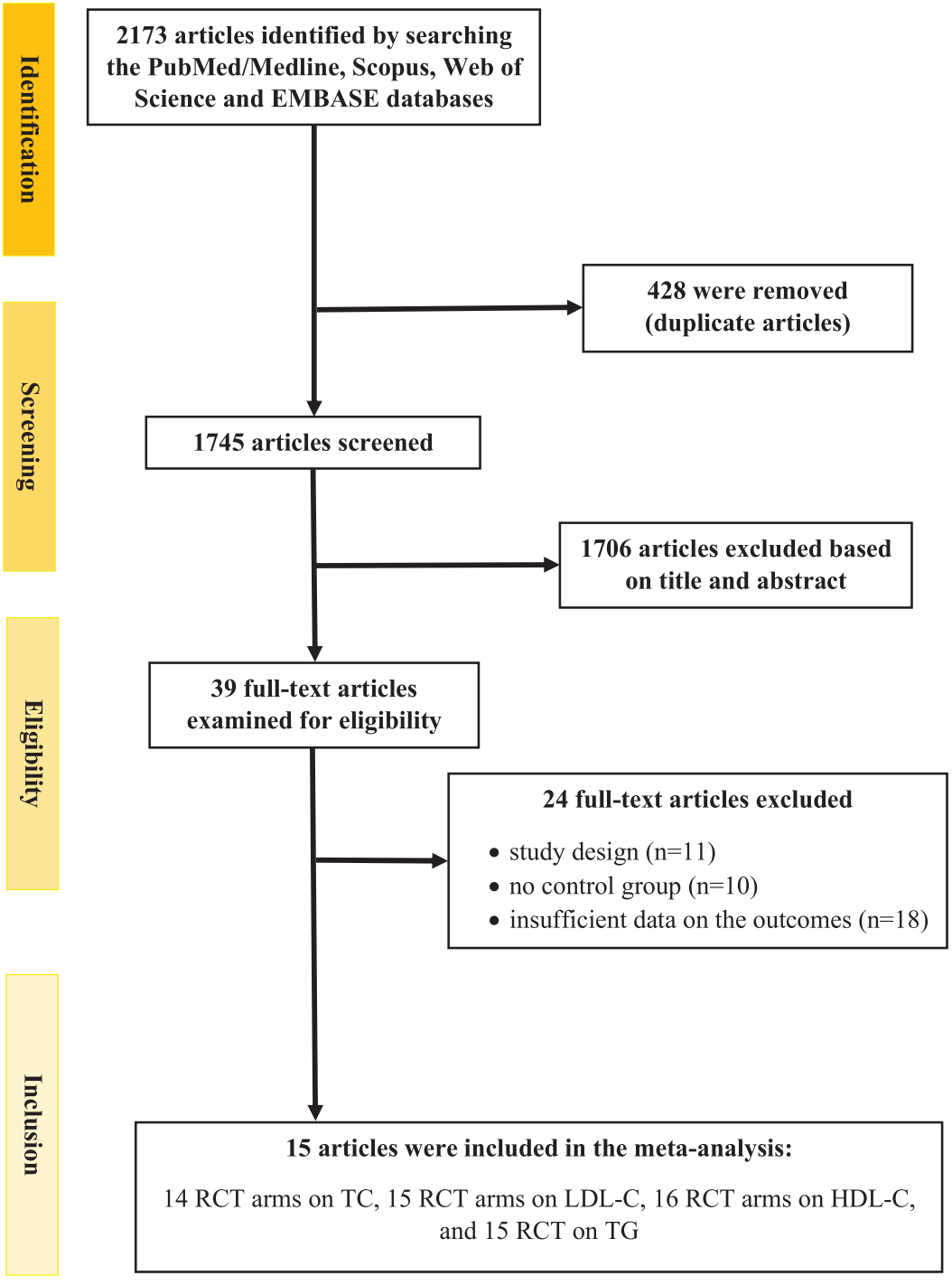

Figure 1. Flowchart depicting the study selection and inclusion processes for the present meta-analysis. HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; TC: total cholesterol; TG: triglycerides; RCT: randomized controlled trial(s).

−4.45 mg/dl, 95% CI: −6.63 to −2.27, P<0.001). The pooled analysis was heterogeneous (I^2=97%, P<0.001) (Figure 3). The subgroup analyses revealed that whole green tea supplementation significantly decreased TC values (WMD: −4.26 mg/dl, 95% CI: −8.28 to −0.24, P=0.03) compared to decaffeinated green tea (WMD: −4.69 mg/dl, 95% CI: −9.49 to 0.09, P=0.055).

A notable reduction of TC levels was discovered when the baseline TC value was ≥200 mg/dL (WMD: −4.78 mg/dL, 95% CI: −7.06 to −2.51, P<0.001) *versus* <200 mg/dL (WMD: −4.41 mg/dL, 95% CI: −17.33 to 8.50, P=0.50). Furthermore, the ordinary meta-analysis indicated greater TC reductions in postmenopausal women (WMD: −8.71 mg/dL, 95% CI: −11.44 to −5.98, P<0.001) than in other subgroups.

Table 1. Characteristics of the eligible trials

Author, year	Country	Population	Participants age (years)	Sample size green tea/ placebo	Duration	Baseline BMI (kg/m^2)	Outcome	Green tea dose (mg/day)
Ghasemi E et al. 2019	Iran	Overweight women	22.47	10/10	10 weeks	29.6	LDL-C, HDL-C, TG	500 mg/daily green tea
Tadayon M et al. 2018	Iran	Postmenopausal women	53.7	39/40	4 weeks	29.1	TC, LDL-C, HDL-C, TG	800 mg/day
Huang LH et al. 2018	Taiwan	Overweight and obese women	53.1	36/37	6 weeks	29.1	TC, LDL-C, HDL-C, TG	4500 mg/d GTE contain 2570 mg/d EGCG
Amozadeh H et al. 2018	Iran	Overweight and obese females	28.14	13/13	8 weeks	33.44	TC, LDL-C, HDL-C, TG	99 mg/d GT
Alves Ferreira M et al. 2017	Brazil	Overweight women	20–45	43/45	12 weeks	>27	TC, LDL-C, HDL-C, TG	1 g/d dry green tea extract
Samavat H et al. 2016	USA	Postmenopausal women	60.02	463/473	12 months	25.16	TC, LDL-C, HDL-C, TG	1315 mg/d catechins
Chen IJ et al. 2016	Taiwan	Women with central obesity	44.1	39/38	12 weeks	31	TC, LDL-C, HDL-C, TG	856.8 mg/d EGCG
Toolsee NA (female) et al. 2013	Republic of Mauritius	Patients with prediabetes	49.3	31/28	14 weeks	25.02	TC, LDL-C, HDL-C, TG	600 ml/d green tea
Mielgo-Ayuso J et al. 2014	Spain	Obese women	nr	39/39	12 weeks	33.7	TC, LDL-C, HDL-C, TG	300 mg/d EGCG
Belcaro G (female) et al. 2013	Italy	Subjects borderline for metabolic syndrome	47.6	25/25	24 weeks	31.0	TC, LDL-C, HDL-C, TG	300 mg/d GSP (Greenselect Phytosome)
Wu AH (a) et al. 2012	USA	Healthy postmenopausal women	59.6	37/32	8 weeks	29.89	TC, LDL-C, HDL-C, TG	400 mg/d EGCG as PPE
Wu AH (b) et al. 2012	USA	Healthy postmenopausal women	59.6	34/32	8 weeks	28.69	TC, LDL-C, HDL-C, TG	800 mg/d EGCG as PPE
Stendell-Hollis NR et al. 2010	USA	Overweight breast cancer survivors	56.6	23/16	6 months	31	TC, LDL-C, HDL-C	950 ml/d decaffeinated GT beverage, contain 400 mg/d catechins
Hsu CH et al. 2008	Taiwan	Obese women	43	41/37	12 weeks	31.2	TC, LDL-C, HDL-C	1200 mg/d green tea extract (GTE)
Chan CCW et al. 2006	China	Obese patients with polycystic ovary syndrome	34.8	18/16	3 months	30.5	TC, LDL-C, HDL-C, TG	540 mg/d EGCG
Diepvens K et al. 2006	Netherlands	Overweight females	41.7	23/23	12 weeks	27.7	TC, LDL-C, HDL-C, TG	1206.9 mg/d GTC

LDL-C: low-density lipoprotein cholesterol. HDL-C: high-density lipoprotein cholesterol. TG: serum triglycerides. TC: total cholesterol. BMI: body mass index. mg/d: milligrams per day. UK: United Kingdom. USA: United States of America. GT: green tea. GTE: green tea extract. EGCG: epigallocatechin gallate. GSP: greenselect phytosome. PPE: polyphenon E.

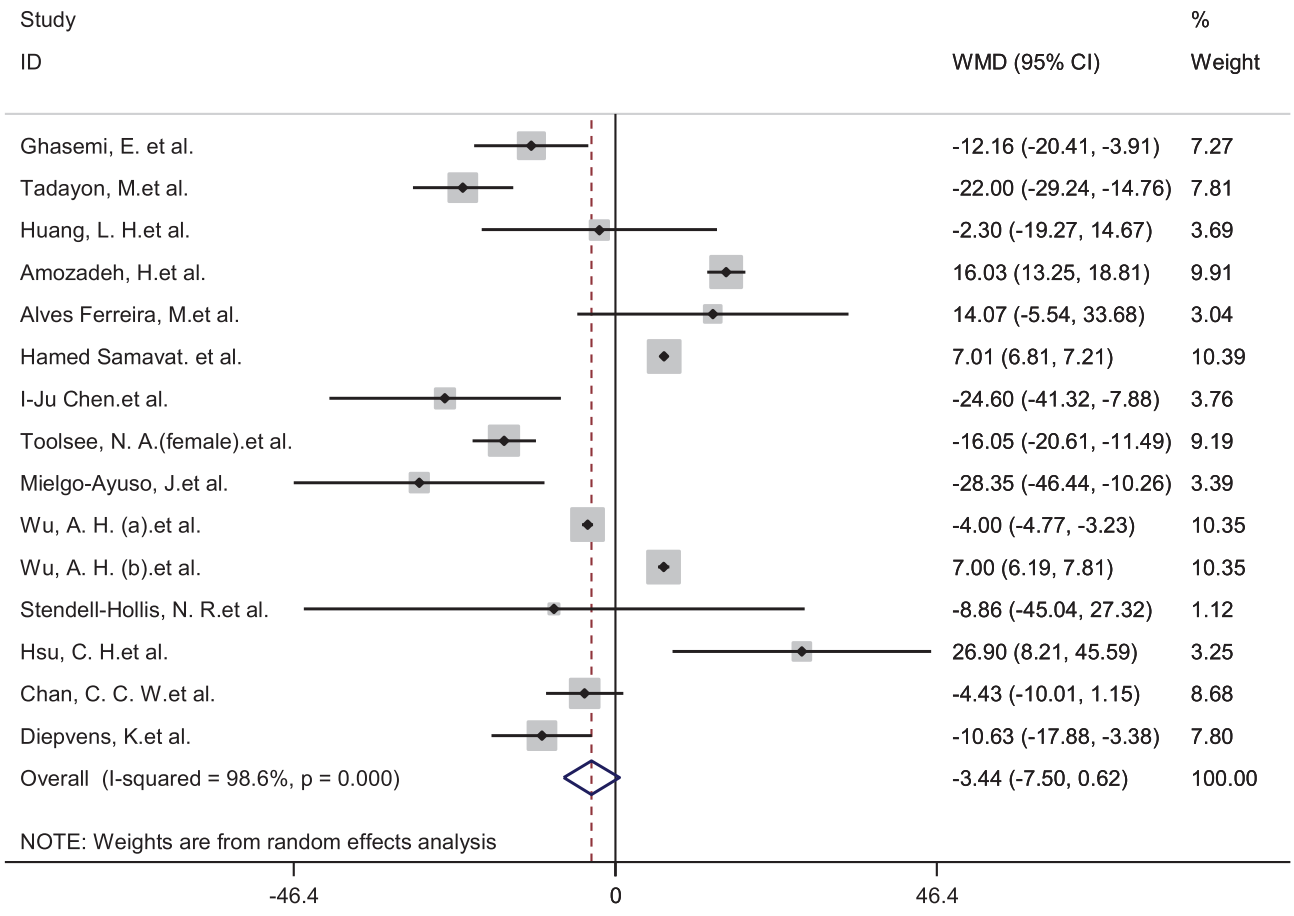

Figure 2. Forest plot of randomized controlled trials investigating the effect of green tea supplementation on serum TG concentrations. TG: triglycerides; WMD: weighted mean difference; CI: confidence interval.

A notable decrease in body weight was observed in the RCTs which lasted <12 weeks (WMD: −5.89 mg/dl, 95% CI: −9.92 to −1.86, P=0.004) *versus* ≥12 weeks (WMD: −3.64 mg/dl, 95% CI: −8.71 to 1.43, P=0.16). Moreover, a significant decrease in body weight was also discovered in overweight (BMI: 25–29.99 kg/m^2) (WMD: −6.55 mg/dl, 95% CI: −8.97 to −4.12, P<0.001) versus obese subjects (≥30 kg/m^2) (WMD: −1.44 mg/dl, 95% CI: −9.84 to 6.96, P=0.73) (Figure E1 in ESM 2).

Effect of green tea supplementation on serum LDL-C concentrations

In total, 15 RCT arms with 1766 participants were entered into the meta-analysis (green tea group= 888 subjects, placebo = 878 subjects). The combined effect size revealed a significant reduction in LDL-C concentrations following green tea supplementation in overweight/obese women (WMD: −4.49 mg/dl, 95% CI: −7.50 to −1.47, P=0.003). The pooled analysis was heterogeneous (I^2=98%, P<0.001) (Figure 4). The subgroup analyses revealed that whole green tea supplementation significantly decreased LDL-C levels (WMD: −5.73 mg/dl, 95% CI: −8.82 to −2.63, P<0.001) compared to decaffeinated green tea (WMD: −2.19 mg/dl, 95% CI: −10.47 to 6.09, P=0.60). In addition, a pronounced reduction of LDL-C levels was discovered when the baseline LDL-C value was ≥130 mg/dL (WMD: −4.17 mg/dL, 95% CI: −13.43 to −5.08, P=0.037) *versus* <130 mg/dL (WMD: −3.99 mg/dL, 95% CI: −7.65 to −0.33, P=0.032). The ordinary meta-analysis indicated a greater LDL-C decrease in postmenopausal women (WMD: −9.35 mg/dL, 95% CI: −12.40 to −6.30, P<0.001) than in other subgroups.

A significant decrease in body weight was also noted in overweight (BMI: 25–29.99 kg/m^2) (WMD: −5.99 mg/dl, 95% CI: −8.53 to −3.46, P<0.001) versus obese subjects (≥30 kg/m^2) (WMD: −1.44 mg/dl, 95% CI: −13.44 to 10.54, P=0.81) (Figure E1 in ESM 2).

Effect of green tea supplementation on serum HDL-C concentrations

In total, 16 RCT arms with 1818 participants were entered into the meta-analysis (green tea group = 914, placebo = 904). The combined effect size revealed no impact on HDL-C concentrations following green tea supplementation in

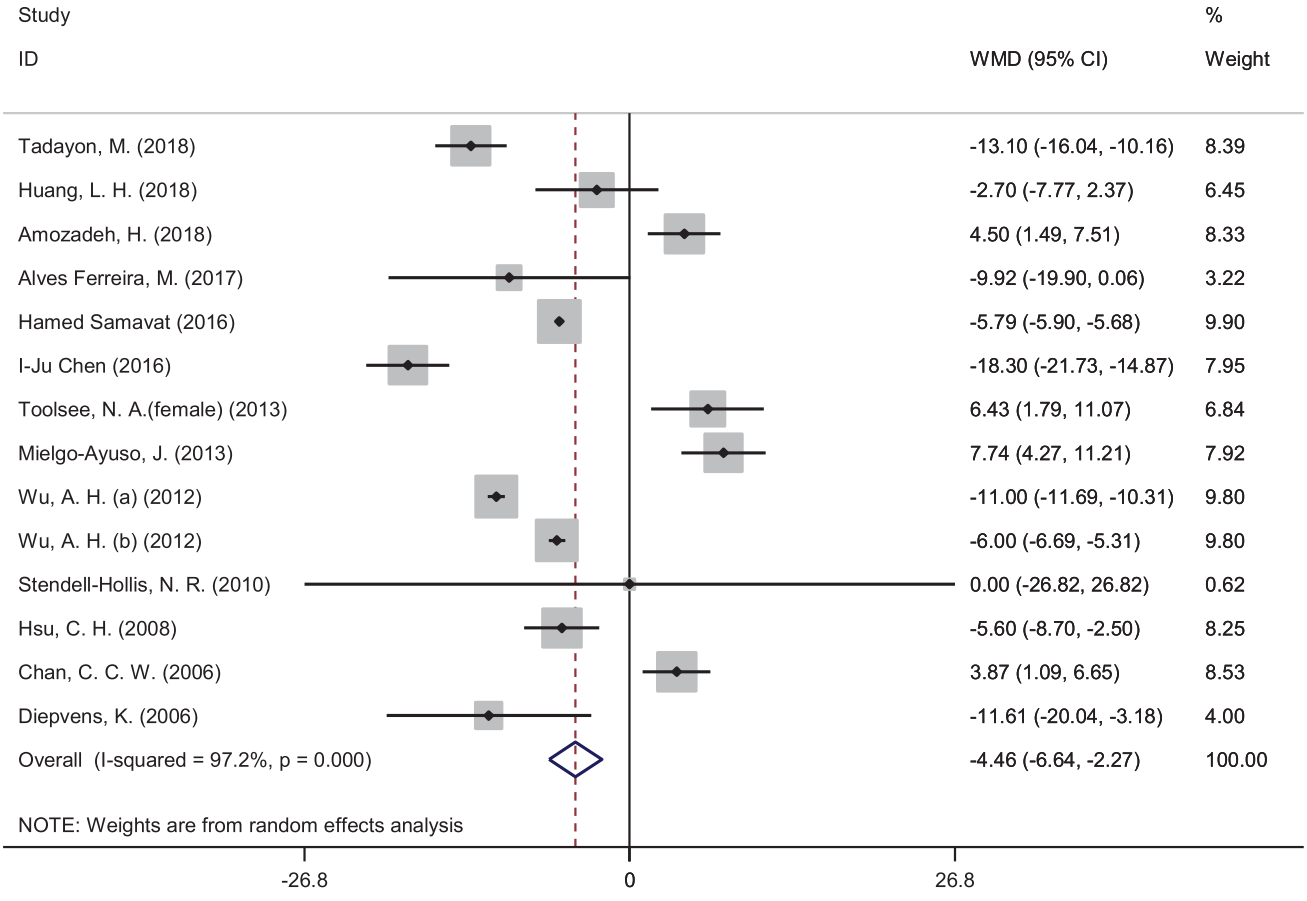

Figure 3. Forest plot of the randomized controlled trials evaluating the effects of green tea on TC. TC: total cholesterol; WMD: weighted mean difference; CI: confidence interval.

overweight/obese women (WMD: 0.607 mg/dl, 95% CI: −0.99 to 2.20, P=0.45). The pooled analysis was heterogeneous (I^2 = 96%, P<0.001) (Figure 5). The subgroup analyses pointed out a significant increase in HDL-C levels in obese (BMI≥30 kg/m^2) (WMD: 2.63 mg/dl, 95% CI: 0.10 to 5.16, P=0.041) versus overweight subjects (BMI: 25–29.99 kg/m^2) (WMD: −0.94 mg/dl, 95% CI: −1.99 to 0.09, P=0.07) (Figure E1 in ESM 2).

Publication bias and sensitivity analysis

Visual inspection of the funnel plots and Egger's linear regression test revealed no evidence of publication bias in the meta-analysis of green tea effects on TG, LDL-C, and TC concentrations (Figure 6). However, there was a significant publication bias confirmed by the Egger's regression test for HDL-C value (P=0.02). The trim-and-fill sensitivity method estimated the impact of unpublished studies for the HDL-C variable (n=23, (WMD: −1.79 mg/dL, 95% CI: −3.31 to −0.26, P=0.02). The direction and magnitude of the overall pooled estimates was not considerably influenced by removing a single study each time, denoting that the data were not excessively influenced by a particular study.

Discussion

Our systematic review and meta-analysis of 15 RCTs on the effect of green tea on the lipid profile in overweight and obese women revealed that green tea consumption causes significant reductions in TC and LDL-C concentrations. This may be related to EGCG present in green tea which inhibits the absorption of cholesterol and decreases LDL-C levels *via* stimulation of LDL receptors [51]. In our investigation, HDL-C concentrations did not increase following green tea supplementation in overweight/obese women. Similar findings have been obtained in other assessments in which HDL-C levels did not change in the green tea intervention group versus controls [27, 52]. The reason behind this result might be that HDL-C concentrations are not affected by antioxidant supplements.

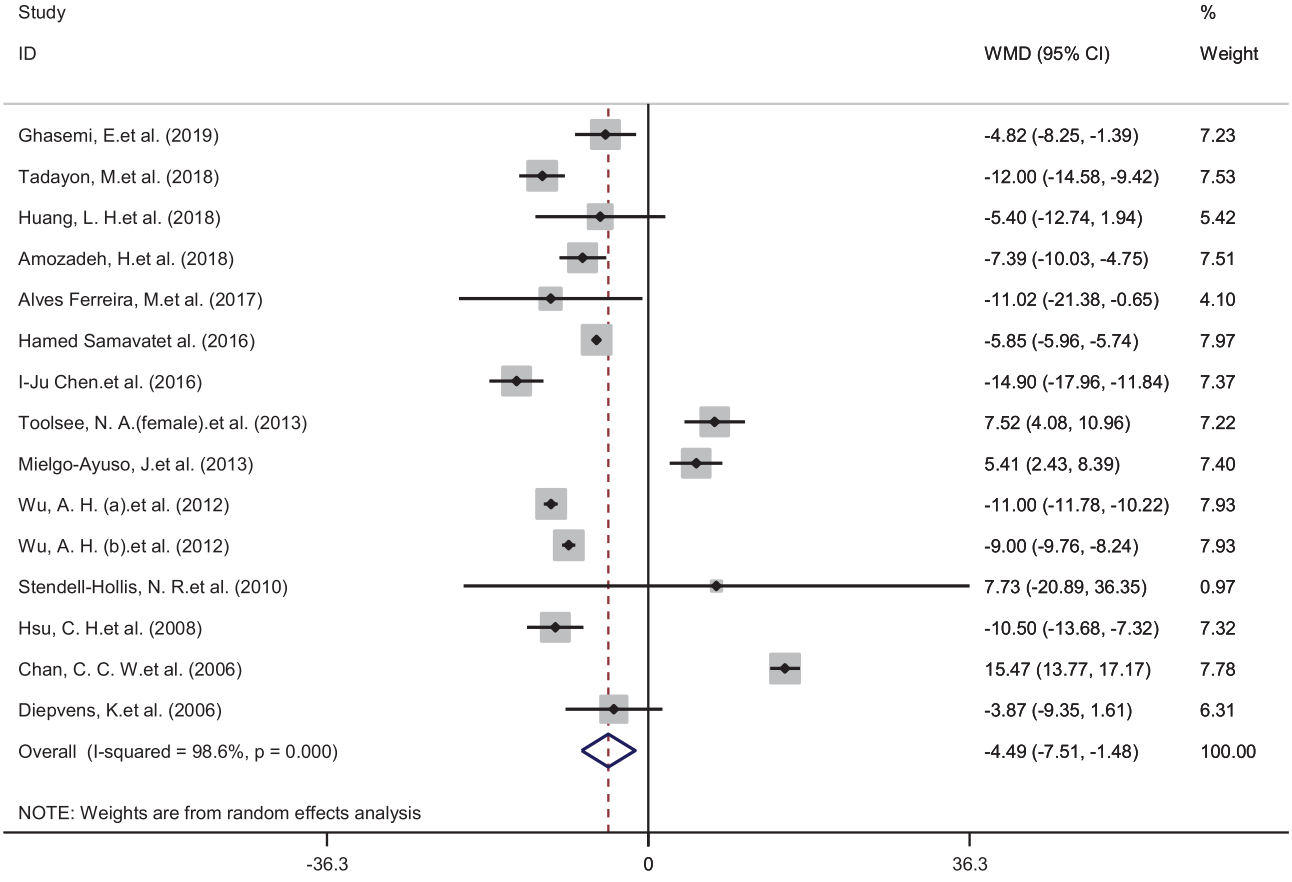

Figure 4. Forest plot of the randomized controlled trials investigating the effects of green tea administration on LDL-C. LDL-C: low-density lipoprotein cholesterol; WMD: weighted mean difference; CI: confidence interval.

Although in our investigation we noted a tendency of TG levels to decrease and of HDL-C values to increase following green tea supplementation, only LDL-C and TC concentrations decreased significantly following green tea supplementation in overweight/obese women. Similar results were obtained in another study in which there was a significant decrease in LDL-C values but no significant changes in HDL-C and TG levels, respectively [50]. These findings are in agreement with a previous meta-analysis which also highlighted significant reductions in LDL-C and TC values after green tea consumption [22]. Green tea associated variations in the lipid profile have been assessed in several interventional studies of different durations [47, 53, 54]. The mechanism behind the favorable effect of green tea on the lipid profile may be related to the high content of catechins present in green tea. EGCG ameliorates endothelial dysfunction linked to the action of oxidized LDL, inhibiting thus the development of atherosclerotic plaques in mice [55]. Catechins present in green tea exert antioxidant properties that prevent the oxidation of LDL [56]. These mechanisms enhance the binding activity of LDL receptors [57]. In addition, green tea inhibits the intestinal absorption of lipids by interrupting the formation of micelle [21]. In our study, there was a significant reduction in TC concentrations following green tea supplementation in overweight/obese women. An *in vitro* assessment has highlighted that EGCG, most abundantly present in green tea, strongly inhibits hydroxyl-3-methylglutaryl-CoA reductase which is the rate-controlling enzyme in cholesterol synthesis [58].

The aforementioned significant decrease in LDL-C and TC levels might be of aid in the prevention of cardiovascular disease. An investigation has concluded that a 1% decrease in LDL-C or TC concentrations results in a 1% and a 2–3% reduction of the risk of cardiovascular disease, respectively [59]. However, green tea consumption does not exert an impact on HDL-C values. Hence, green tea supplementation has a positive impact on LDL-C and TC levels and does not exhibit a negative impact on HDL-C concentrations. Several RCTs have been conducted to assess the effectiveness of green tea supplementation on the lipid profile, however, their results were conflicting. Some assessments concluded that green tea intake reduces LDL-C and TC values [60, 61]. Contrastingly, other assessments highlighted that there are no beneficial effects of green tea consumption on LDL-C and TC levels [54, 62]. In addition, other papers

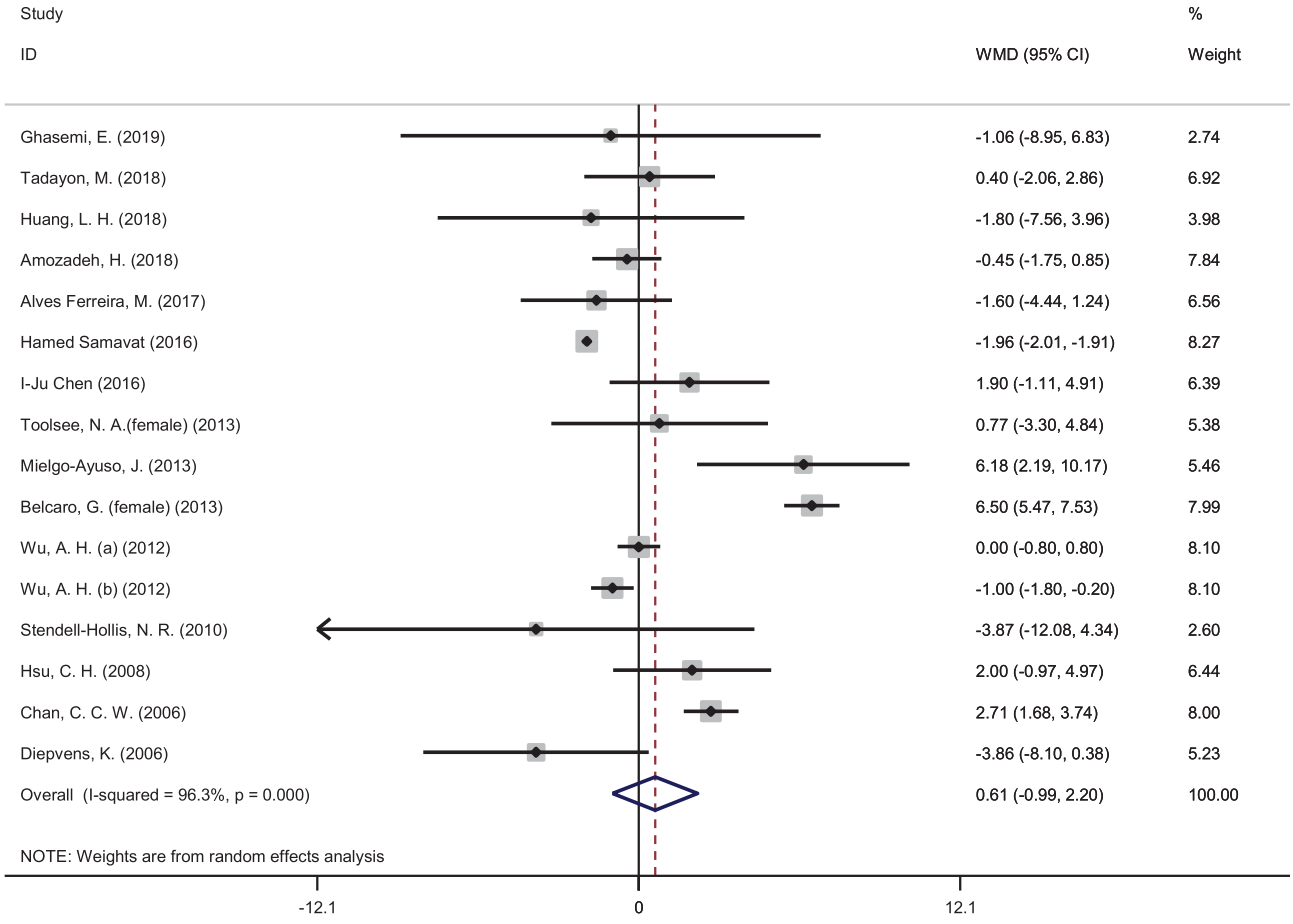

Figure 5. Forest plot of the randomized controlled trials investigating the effects of green tea administration on HDL-C. HDL-C: high-density lipoprotein cholesterol; WMD: weighted mean difference; CI: confidence interval.

have delineated that green tea use does not lead to any variations of TG and HDL-C concentrations [63, 64]. Beneficial actions of green tea consumption on TG and HDL-C levels were only depicted in one study [60].

In the subgroup analyses, whole green tea supplementation significantly decreased TC and LDL-C levels compared to decaffeinated green tea. Thus, we may infer that caffeine, naturally present in green tea, helps in the reduction of TC and LDL-C values. This finding is, however, contradictory to the results of another investigation [27].

In the sub-group analysis, a notable reduction in body weight was observed in the RCTs which lasted <12 weeks versus ≥12 weeks. Moreover, a significant decrease in body weight was also discovered in overweight subjects. This result is contradictory to the findings of other studies in which the authors did not depict significant reductions in body weight after 12 weeks of green tea intake [42, 47, 65]. The mechanisms of green tea impact on body weight may be due to the increase in the oxidation of fat and thermogenesis which was stressed out by a pilot study conducted in obese men [66]. In addition, caffeine present in green tea regulates the appetite by increasing the activity of sympathetic nervous system, reducing the absorption of nutrients [67].

In our assessment, a pronounced decrease of TC and LDL-C concentrations was detected in subjects with elevated TC and LDL-C values at baseline. This finding was also confirmed by another investigation [41]. Abnormal lipid profiles increase the risk of cardiovascular diseases, with women exhibiting an increased tendency to suffer from heart ailments following the menopause [68]. The aforementioned phenomenon is mainly explained by the lack of estrogen production which characterizes the postmenopausal period [69]. Furthermore, increased serum lipids' concentrations have been depicted in postmenopausal females [70].

In our assessment, there was a notable reduction in TG in overweight individuals. However, in some investigations, BMI was not shown not to be an independent predictor of cardiovascular risk [71].

The present meta-analysis has several strengths and limitations. Firstly, in our meta-analysis, we used data derived from RCTs only, which confirms the robustness of our findings. In addition, there was no evidence of publication bias.

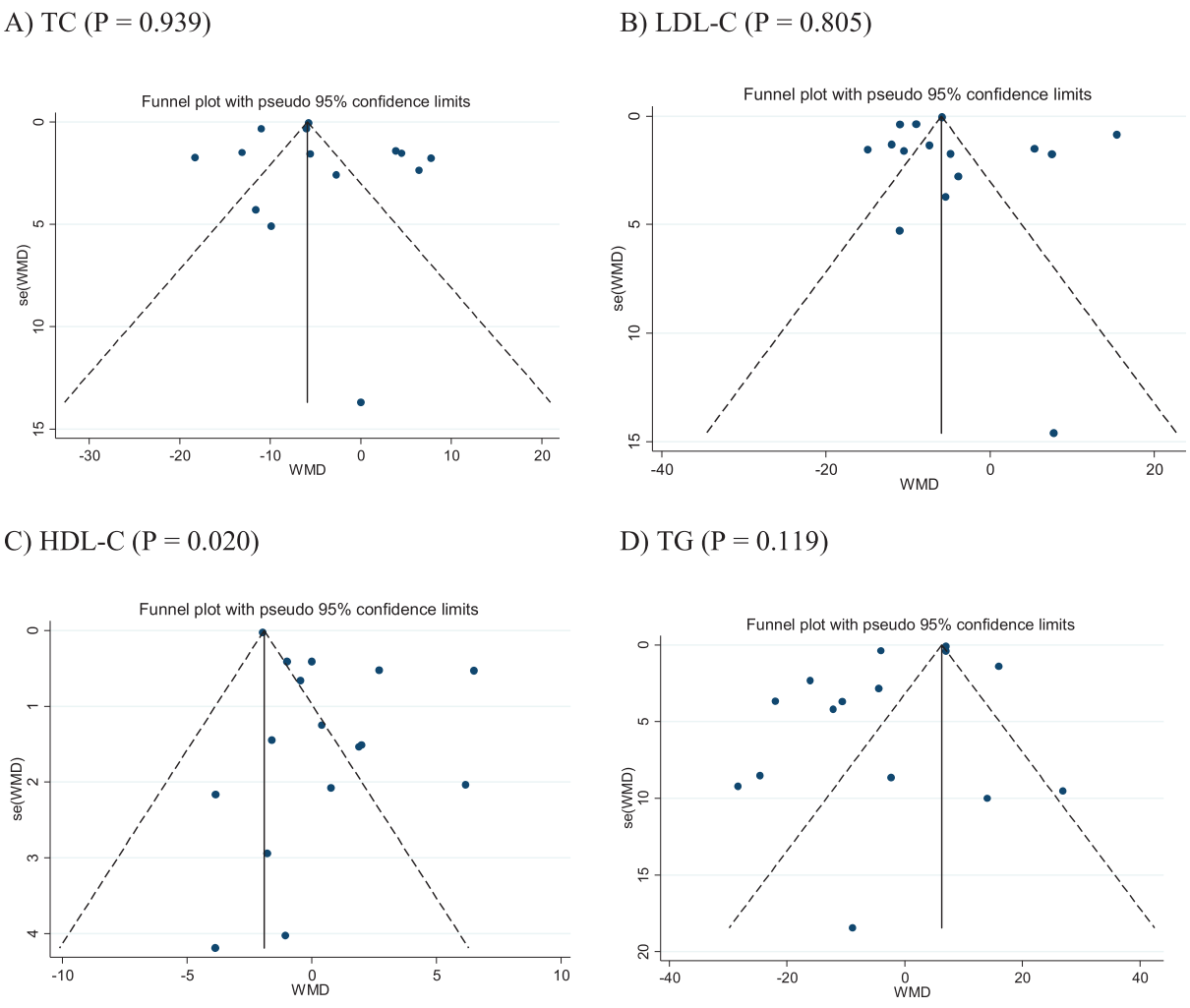

Figure 6. Funnel plot of the weighted mean difference (WMD) versus the standard error (se) of the weighted mean difference. HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; TC: total cholesterol; TG: triglycerides; WMD: weighted mean difference; CI: confidence interval.

Several limitations must also be considered. The RCTs included in our meta-analysis had short durations, i.e., from 4 weeks to 12 months. Hence, the benefits of green tea administration beyond this study period remain unclear. Moreover, the exact dose of green tea that could lead to a decrease in LDL-C and TC concentrations was not determined. In addition, the safety of green tea supplementation was not evaluated. Several RCTs have reported, however, mild side effects following the intake of this beverage [47, 53].

Conclusion

Green tea consumption 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. A significant increase in HDL-C values was noted in obese subjects. Therefore, we emphasize that serum lipid levels be monitored routinely in females and in particular in postmenopausal women. Based on our findings, green tea administration can be recommended to females with dyslipidemia.

Electronic Supplementary Material

The electronic supplementary material (ESM) is available with the online version of the article at https://doi.org/10.1024/0300-9831/a000783

ESM 1. Subgroup analyses (PDF).

ESM 2. Sensitivity analysis (PDF).

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