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Review

Green tea and green tea catechin extracts: An overview of the clinical evidence

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ABSTRACT

Background: Tea leaves contain varying amounts of polyphenols of which the majority are catechins. There has been a sizable amount of research on the potential effect of green tea catechins for cancer risk, cardiovascular disease risk and weight loss; all conditions that are relevant to mid-life health.
The aim was to produce an overview of the evidence for green tea for these three important health conditions.
Methods: The databases Medline (& Medline in process) and Embase, were searched for systematic reviews and meta-analyses using customised search strategies performed up until April 2012. Assessment of Multiple Systematic Reviews criteria were used to assess the quality of the included reviews. Relevant data were extracted into predefined tables. The results are described and discussed narratively.
Results: We included eight systematic reviews and meta-analyses covering the topics of cancer risk ($n = 2$), cardiovascular risk ($n = 4$) and weight loss ($n = 2$).
Conclusions: The evidence for green tea and cancer risk is inadequate and inconclusive. However there is some positive evidence for risk reduction of breast, prostate, ovarian and endometrial cancers with green tea. RCTs of green tea and cardiovascular risk factors suggest that green tea may reduce low-density lipoproteins and total cholesterol, although studies are of short duration. There is no robust evidence to support a reduction in coronary artery disease risk in green tea drinkers. There are a considerable number of RCTs to suggest that green tea does reduce body weight in the short term, but this not likely to be of clinical relevance.

Contents

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1. Introduction

Green tea is produced from the leaves of *Camilla sinensis*, which is native to Eastern Asia. Traditional Chinese medicine has recommended drinking green tea for the prevention of disease, and in Asia this is still regarded as a healthy practice [1].

Tea leaves contain polyphenols of which the majority are catechins with smaller quantities of caffeine, theanine, theobromine, theophylline and phenolic acids. The major catechin in green tea is (−)-epigallocatechin gallate, with lesser amounts of catechin, epicatechin, gallocatechin, gallocatechin gallate and epicatechin gallate [1]. Many of the health benefits of green tea are attributed to the antioxidant capacity of these compounds.

Green tea is prepared by drying and steaming whereas black tea is fermented, converting its catechin content into the theaflavins. The addition of milk to tea does not affect the bioavailability of catechins but may alter the antioxidant potential depending on the fat content [1].

Pharmacokinetic studies suggest a daily dosage of 800 mg/day of epigallocatechin gallate capsules for up to four weeks to be safe and well tolerated. A daily intake of 3–5 cups per day (720–1200 ml) of green tea will provide at least 250 mg/day of catechins.

There are no reports of clinical toxicity from daily green tea consumption. However, regulatory agencies in France and Spain suspended market authorization of a weight-loss product containing green tea because of hepatotoxicity concerns [2]. As a result the US Pharmacopeia conducted a systematic review of 216 green tea case reports including 34 reports of liver damage. Clinical and animal studies indicated that green tea concentrated extracts on an empty stomach is more likely to lead to adverse effects than green tea consumption after eating [2]. This review concluded that when a dietary supplement containing green tea extracts is formulated appropriately it is unlikely that there will be significant safety issues.

Evidence from case reports suggests that vitamin K content in green tea may antagonise the anticoagulant effect of warfarin [3]. Green tea reduces the bioavailability of folic acid and therefore is not recommended for pregnant women or with megaloblastic anaemia [4]. There is some evidence that green tea reduces iron absorption [5].

2. Methods

2.1. Inclusion criteria

Systematic reviews and meta-analyses describing studies of green tea beverage or green tea catechin extracts (herein described as green tea) that focused on clinical outcomes as opposed to preclinical studies were included.

2.2. Searches

Relevant publications were sought in Medline, Medline in process and Embase databases using customised search strategies performed up to April 2012 (web appendix one). The Cochrane Library was searched by keywords. English language papers only were included.

2.3. Quality assessment

The Assessment of Multiple Systematic Reviews (AMSTAR) tool was used to assess quality of the included systematic reviews and meta-analyses [6]. AMSTAR is a validated measure of 11 questions which has been designed based on previous tools, empirical evidence and expert consensus.

2.4. Data extraction

We extracted the relevant data from the systematic reviews and meta-analyses into predefined tables.

3. Results

124 references were found. 80 were excluded due to obvious irrelevance leaving 44 full papers to read. Eight papers were included on the topics of cancer risk (2), cardiovascular risk (4) and weight loss (2).

4. Cancer

Data extraction was performed on the two most recent high quality systematic reviews which covered all cancers [7,8] (Table 1). The following data combines studies from both reviews, and four more recent cancer-specific reviews were used to update evidence as necessary [9–12].

Boehm et al. included 50 cohort and case–control studies on all cancer types focussing on risk of cancer and mortality [7]. Sturgeon et al. focused on risk and recurrence of all cancer types with green tea consumption, and included 23 studies of which the majority were case–control studies [8]. Most of these studies involve green tea as a beverage.

Both reviews can be described as high quality as assessed by the AMSTAR measurement tool. (web appendix 2) The vast majority of studies were conducted in Asia. Neither review performed meta-analysis of the data presented citing high clinical and statistical heterogeneity as the reasons, and thus although they discussed publication bias they did not examine it.

Table 1
Characteristics of reviews of interventions.

Author Date Country	Study selection and design	Population	Outcomes of interest	Intervention/control	Included studies	Results, comment and/or analysis
Cancer						
Boehm [7] 2009	Prospective, controlled intervention studies and observational studies Systematic review	Healthy adults and adults with various forms of cancer	No. of people developing cancer No. of people dying from cancers	The consumption of green tea in any format as a mono-preparation Any control treatment	27 case control studies 23 cohort studies 1 RCTof which *n* = 27 digestive tract *n* = 5 breast *n* = 5 prostate *n* = 3 lung cancer *n* = 2 ovarian *n* = 2 urinary bladder *n* = 1 oral *n* = 3 others	*Development of cancer* Lack of consistency in the results of the observational studies generally This was especially the case for cancer of the digestive tract Liver, ovarian and oral cancer-limited evidence Esophageal, gastric, colon, rectum, and pancreatic cancer-conflicting evidence Prostate and breast cancer-conflicting evidence However: Higher methodological quality observational studies and one RCT of prostate cancer suggested a decreased risk in men consuming higher amounts of green tea All nested case–control studies of breast cancer within prospective cohorts suggested no influence of green tea consumption on the risk of breast cancer Lung cancer & urinary bladder cancer-limited to moderate evidence especially in men or that it could even increase the risk in the latter *Dying from cancer* Gastric cancer-moderate to strong evidence Lung cancer, pancreatic cancer, and colorectal cancer-limited to moderate
Sturgeon [8] 2009	Case control, cohort studies, clinical trials and RCTs Systematic review	General population	Risk of developing cancer Slowing progression & preventing recurrence	The consumption of green tea	*n* = 23 were included and grouped according to cancer type *n* = 6 gastric *n* = 2 esophageal *n* = 3 colon, rectal and pancreatic *n* = 1 oral and pharyngeal *n* = 4 breast *n* = 4 prostate *n* = 1 lung *n* = 2 all cancers	Nine studies associated green tea with decreased cancer Nine studies showed no relationship Three studies involving esophageal and GI cancers presented mixed results 2/3 associated green tea with a decreased risk on women and not men The third found an increased risk in men but not women Dose response was reported in nine studies suggesting dose, frequency, concentration & duration of intake important No evidence to date to suggest green tea influences precancerous lesions or abnormalities
Cardiovascular						
Hooper [26] 2008 USA	Published RCTs Systematic review and meta-analysis	Adults non-pregnant, not critically ill, although all stages of CVD included	Primary outcomes: LDL, HDL, SBP, DBP and endothelial function	Intervention: Increased intake of flavanoids or foods rich in flavanoids, including green tea Control: Any control which allowed observed effect to be reasonably ascribed to flavonoids	170 studies of which 12 were green tea 7 studies used in meta-analysis. These 7 studies included 258 intervention/252 control patients By outcome: Endothelial function – no published data SBP – 2 studies, 92 patients DBP – 1 study, 26 patients LDL – 4 studies, 378 patients HDL – 3 studies, 358 patients Study duration ranged from hours to 52 weeks	Endothelial function– no published data Blood pressure – effects of chronic intake SBP: increase of 1.8 mmHg (−1.86, 5.46) DBP: increase of 0.9 (−1.22, 3.02) HDL: decrease of 0.01 (−0.09, 0.07)

Table 1 (*Continued*)

Author Date Country	Study selection and design	Population	Outcomes of interest	Intervention/control	Included studies	Results, comment and/or analysis
Wang [27] 2011 China	Case control or cohort studies Systematic review and meta-analysis	Not specified in inclusion criteria	CAD incidence or mortality MI, CAD, non-stroke cardiovascular disease, other coronary events	Intervention: Tea consumption (black and green) Control: Not specified in inclusion criteria	Green tea/black tea analysed separately 5 studies of green tea included in meta-analysis 3 case–control, 2 prospective cohort 899 cases/2988 controls in case control studies 49,082 patients in cohorts All conducted China or Japan Follow-up in cohort studies 7 years and 13 years Little details on the populations included	RR CAD 0.72 (95% CI 0.58, 0.89) (highest green tea consumption vs. lowest green tea consumption) RR CAD (routine green tea drinking vs. non-drinkers/occasional drinkers) 0.83 (95% CI 0.71, 0.97) In subgroup analysis protective effect in case–control studies and males, not in cohort studies and female drinkers Increase in green tea consumption of 1 cup/day associated with 10% decrease in risk of developing CAD (RR 0.9, 95% CI 0.82, 0.99)
Kim [28] 2011 USA	Randomised trials (both parallel and crossover) Systematic review and meta-analysis	Not specified on inclusion criteria	Lipids: Total cholesterol, LDL, HDL, triglycerides	Intervention: Green tea in any form (extracts or beverages) Control: Any control treatment	20 trials included (19 each reporting on each outcome) 4 were crossover trials, remaining were parallel 1415 participants Mean ages ranged from 11 to 65 years Mixed populations, with a range of cardiovascular risk, mostly healthy populations but some at high cardiovascular risk (e.g. diabetics) Follow-up ranged between 2 and 23 weeks Dose of tea varied widely between studies.	Study duration 3–24 weeks Compared to control, green tea reduced total cholesterol (−5.46 mg/dL WMD [−0.14 mmol/L], CI −9.59, −1.32 mg/dL [−0.25, −0.03 mmol/L]) Reduced LDL cholesterol (WMD −5.30 mg/dL [−0.138 mmol/L], CI −9.99, to −0.62 mg/dL [−0.26, −0.02 mmol/L]) No signif. effect on HDL (WMD −0.27 mg/dL [−0.007 mmol/L], CI −1.62,1.09 mg/dL [0.042,0.03 mmol/L]) or on trigylcerides (WMD 3.00 mg/dL [0.034 mmol/L], CI −2.73, 8.73 mg/dL [−0.031, 0.10 mmol/L])
Zheng [29] 2011 China	Published RCTs Systematic review and meta-analysis	Adults	Total cholesterol, LDL, HDL	Intervention: green tea beverage or extract, not as part of a multicomponent supplement Control: not specified Specified that food-intake control regimens of experimental groups should be consistent with those of control groups.	14 RCTs with 1136 subjects Study duration from 3 weeks to 3 months Dose of green tea catechins ranged from 150 to 2500 mg/day Study populations ranged from healthy adults to those with cardiovascular risks 11 studies were placebo controlled; other studies control arm took lower dose green tea, or oolong tea.	Total cholesterol significantly reduced in subjects supplemented with green tea (−7.20 mg/dL, CI −8.19, −6.21 mg/dL; $p < 0.001$) than in controls, with low heterogeneity for this outcome ($I^2 = 9.1\%$). LDL was significantly decreased by 2.19 mg/dL (CI −3.1, −1.21 mg/dL; $p < 0.001$) in intervention groups with no heterogeneity ($I^2 = 25.4\%$). For intervention groups the mean change in blood HDL was not significant (+0.25 mg/dL 95% CI −0.73, 1.23 mg/dL; $p = 0/62$). Subgroup analyses showed that differences remained when analysed by type of intervention
Weight loss						
Phung [31] 2010 USA	RCTs Systematic review Meta-analysis	Children, healthy adults and adults with co morbidities such as overweight or obesity, hyperlipidemia, or diabetes mellitus	Anthropometric variables BMI, BW, WC and WHR	Green tea, consumption with and without caffeine 3 analyses (1) Green tea catechins (GTC) with caffeine vs. caffeine-matched control (2) GTCs with caffeine vs. caffeine-free control (3) Caffeine-free GTCs vs. caffeine-free control	$n = 15$ ($n = 1243$ patients) 7 GCT plus caffeine vs. caffeine control 6 GCT plus caffeine vs. caffeine-free control 2 caffeine-free GCT vs. caffeine-free control	GTC with caffeine decreased BMI (−0.55; CI −0.65, −0.40) and BW (−1.38 kg, 95% CI −0.72, −0.15) but not WHR, compared with caffeine alone GTC ingestion with caffeine significantly decreased BW (−0.44 kg, CI −0.72, −0.15) vs. caffeine-free control No benefit was shown in studies that evaluated GTC without concomitant caffeine administration on any of the measures.

Table 1 (*Continued*)

Author Date Country	Study selection and design	Population	Outcomes of interest	Intervention/control	Included studies	Results, comment and/or analysis
Hursel [32] 2009 The Netherlands	RCTs Systematic review Meta-analysis	General population	BW regulation: WL and WM	A green tea EGCG and caffeine mix supplement Intervention: 2 WL studies EGCG-caffeine mixture for 12 weeks 9 WM studies: 4 week low energy diet then EGCG-caffeine mixture supplementation for 12 or 13 weeks Control: 7 studies used "true placebo group"	*N* = 11 9 WL studies 2 WM studies	Modest but positive effect of catechins on WL/WM ratio ($\mu = -1.31$ kg, CI −2.05, 0.57 kg; $p < 0.001$) Authors state results were heterogeneous and suggest that habitual caffeine intake and ethnicity may be moderators

Key: BMI, body mass index; BW, body weight; CAD, coronary artery disease; CI 95%, confidence intervals; CVD, cardiovascular disease; DBP, diastolic blood pressure; EGCG, epigallocatechin gallate; GTC, green tea catechins; HDL, high density lipoproteins; LDL, low density lipoproteins; MI, myocardial infarction; RCT, randomised controlled trial; RR, relative risk; SBP, systolic blood pressure; WC, weight control; WHR, waist to hip ratio; WL, weight loss; WM, weight maintenance; WMD, weighted mean difference.

4.1. Oral/pharyngeal cancer

One cohort study showed no association between green tea and risk reduction of cancer in men but a trend towards risk reduction in women [13].

4.2. Esophageal cancer

There were two cohorts, five case–control studies and one randomised controlled trial (RCT) described. Three of the seven non-randomised studies showed a reduction in risk with green tea of which in two the effect was restricted to women. The remaining four studies did not show any risk reduction. The RCT of 200 participants investigating decaffeinated green tea also did not show any risk reduction [14]. There is some evidence to suggest very hot green tea consumption results in an increased risk of esophageal cancer [15].

4.3. Gastric cancer

Seventeen case–control studies were identified of which approximately half showed a risk reduction and half no risk reduction. One cohort study showed an increased risk of gastric cancer with green tea overall but a reduced risk in women [16]. Three case–control studies showed that green tea is not associated with gastric cancer specific mortality.

4.4. Pancreatic cancer

One large nested case–control study of 102,137 Japanese patients with pancreatic cancer showed green tea not to be associated with pancreatic cancer mortality [17]. The results of four retrospective case–control studies were mixed, but a further one also found green tea was not related to pancreatic cancer specific mortality.

4.5. Colorectal cancer

There were three prospective and three retrospective case–control studies for colorectal cancer. One of the prospective studies showed no association, one showed an increased risk for men with green tea but not for women; the third study of women only, showed a risk reduction for colorectal cancer. In the retrospective studies, one study showed no association, another showed a decreased risk of colon cancer but not rectal cancer, and one showing a decreased risk for women but not men. A further case–control study showed no effect on colorectal cancer specific mortality.

4.6. Breast cancer

There were three cohort studies and three case–control studies of breast cancer. All of the cohort studies and one of the case control studies showed no association with risk reduction of breast cancer with green tea. Two case–control studies showed a positive risk reduction of breast cancer with green tea [18,19].

Two of the case–control studies also investigated the role of genotypes and suggested that differing angiotensin converting enzyme and folate metabolism activity genotypes in women may play a role in the risk reduction of breast cancer with green tea [20,21].

A more recent meta-analysis of studies of breast cancer risk (7 studies) and recurrence (2 studies), encompassing 5617 cases of breast cancer showed that increased green tea consumption (more than three cups a day) was inversely associated with breast cancer recurrence (pooled relative rate of 0.73, CI 0.56, 0.96) [9]. An

analysis of five case–control studies (three extra studies in addition to previous reviews) of breast cancer incidence suggested an inverse association with a pooled relative rate of 0.81 (CI 0.75, 0.88). No association was found among cohort studies of breast cancer incidence. Whilst some of their methodological approaches were criticised by others, both parties concluded that increased green tea consumption may be inversely associated with risk of breast cancer recurrence [22].

4.7. Lung cancer

One cohort study and two case–control studies showed that green tea had no effect on risk reduction of lung cancer. A further study showed green tea was not related to lung cancer specific mortality. A more recent review specific to lung cancer included no extra studies [10].

4.8. Prostate cancer

There were two cohort studies and two case–control studies of green tea or placebo treatment. Two studies showed no association and two showed a risk reduction. One RCT investigated the treatment of 60 men (45–75 years) with high grade prostate intraepithelial neoplasia [23]. After 1-year, there was one tumour case in the green tea group and six in the placebo group. A more recent meta-analysis which included 4 cohorts and three case–control studies (i.e. three extra studies) has shown that for prostate cancer risk, the pooled estimate reached statistically significant level for case–control studies odds ratio (OR) = 0.43; CI 0.25, 0.73, but not for prospective cohort studies (OR = 1.00; CI 0.66, 1.53).[24] The authors report a border-line significant association with Asian populations.

4.9. Bladder cancer

One cohort and one case–control study showed conflicting results with the cohort showing no association and the case–control showing an increased risk with green tea.

4.10. Liver cancer

One case control study was included in the reviews which suggested green tea reduces the risk of liver cancer especially amongst alcohol drinkers [25].

4.11. Ovarian cancer

Two case–control studies of women found an association with green tea and a reduced risk of ovarian cancer. In a more recent review inverse associations were reported for green tea and risk of ovarian cancer from four case–control studies (i.e. two extra studies) (OR 50.66; CI 0.54, 0.80), and for green tea and risk of endometrial cancer from six case–control studies (OR 50.78; CI 0.62, 0.98) [11].

5. Cardiovascular

Four systematic reviews were identified, three reviewed the effect of green tea on cardiovascular risk factors, and one reviewed the effect of green tea on coronary heart disease (CHD) incidence and mortality [26–29]. A further review was excluded as it added no extra studies [30].

These reviews were assessed by AMSTAR. All but one of the studies used the status of publication as an inclusion criterion [27] (web appendix 2). None of the reviews gave a comprehensive list of excluded studies, with only one study clearly citing references for any excluded studies [28]. Only one study listed the country of origin of the study (all studies conducted in China or Japan) [29].

5.1. Risk factors

Hooper et al. included RCTs in which the intervention was an increased intake of flavanoids or foods rich in flavanoids, vs. a control diet [26] (Table 1). There were 12 green tea trials, of which seven trials provided data on the primary outcomes of cardiovascular risk markers: low and high density lipids (LDL and HDL), systolic blood pressure (SBP), diastolic blood pressure (DBP) and endothelial function.

Four RCTs (378 participants) contributed data on the effect of green tea on LDL, and three RCTs (358 participants) on the effect on HDL. These trials showed a decrease in LDL (−0.23; CI −0.34 to −0.12) and a non-significant decrease of 0.01 in HDL (CI −0.09, 0.07). Two trials (92 participants) contributed data on the effect of green tea on SBP, and one trial (26 participants) on the effect of DBP. These trials showed a non-significant change in blood pressure: an increase in SBP of 1.8 mmHg (−1.8, 5.46), and increase in DBP of 0.9 mmHg (−1.22, 3.02). There were no data on endothelial function. A high level of heterogeneity is noted amongst the green tea trials, and industry funding is reported in half.

Two more recent reviews have focused on the effect of green tea on lipid profiles [27,28] (Table 1).

Kim et al. reviewed RCTs of green tea in any form and lipid outcomes: total cholesterol (TC), LDL, HDL and triglycerides [27] (Table 1). It included 20 trials (1415 participants), of which four were crossover trials. Compared to control, green tea reduced TC (−5.6 mg/dL weighted mean difference (WMD), CI −9.59, −1.32 mg/dL [−0.14 mmol/L, CI −0.25, −0.03 mmol/L]), reduced LDL (WMD −5.30 mg/dL, CI −9/99, −0.62 [−0.138 mmol/L, CI −0.26, −0.02 mmol/L]), and had no significant effect on HDL (WMD −0.27 mg/dL, CI −1.62, 1.09 mg/dL [−0.007 mmol/L, CI 0.042, 0.03 mmol/L]) or on triglycerides (WMD 3.00 mg/dL, CI −2.73, 8.73 mg/dL [0.034 mmol/L, CI −0.031, 0.10 mmol/L]).

Zheng et al. included 14 RCTs of green tea in any form (1136 participants) on lipid outcomes (TC, LDL and HDL) with a trial duration of three weeks to 3 months [28] (Table 1). Nine of these trials had been included in the review by Kim et al. [27].

TC was significantly reduced in subjects supplemented with green tea (−7.20 mg/dL, CI −8.19, −6.21 mg/dL; $p < 0.001$) than in controls, with low heterogeneity for this outcome ($I^2 = 9.1\%$). LDL was significantly decreased by 2.19 mg/dL (CI −3.1, −1.21 mg/dL; $p < 0.001$) in intervention groups with modest heterogeneity ($I^2 = 25.4\%$). For intervention groups the mean change in blood HDL was not significant (+0.25 mg/dL, CI −0.73, 1.23 mg/dL; $p = 0/62$). Subgroup analyses showed that differences remained when analysed by intervention, cardiovascular risk, study length, dose, and study quality.

5.2. Coronary artery disease (CAD)

Wang et al. systematically reviewed case–control and cohort studies in which tea consumption (black and green tea) was compared against an unspecified control, with the outcome of CAD incidence or mortality [29] (Table 1).

The studies of green tea were three case–control studies (899 cases, 2988 controls) and two prospective cohort studies (49,082 participants). All studies were conducted in China or Japan and the follow-up for the cohort studies were 7 years and 13 years respectively. Meta-analysis of the green tea data compared the highest green tea consumers with the lowest. The analysis suggested a risk ratio of 0.83 (0.71, 0.97) for CAD in routine green tea drinkers vs. non-drinkers or occasional drinkers. Subgroup analyses showed this protective effect to be only seen in case–control studies and

males, not in cohort studies or female drinkers, and the authors conclude that there are no robust data to support the finding of reduced CAD risk in green tea drinkers.

6. Weight loss

Two relevant reviews on green tea and weight loss were found [31,32] (Table 1).

The Phung review can be described as high quality as assessed by the AMSTAR measurement tool [31] (web appendix 2). The authors stated that certain trial characteristics contributed to both clinical and statistical heterogeneity and was a limitation to the meta-analysis. Location of the studies was not clear. The Hursel review conducted a meta-analysis and contained detail regarding participant ethnicity (4 Caucasian, 11 Asian), but quality assessment of papers was not clear [32].

The Phung review included 15 RCTs (1243 participants) of green tea with and without caffeine on body mass index (BMI), body weight (BW), waist circumference (WC) and waist to hip ratio (WHR) [31] (Table 1). Green tea with caffeine significantly decreased BW (6 RCTs) when compared with caffeine-free control (WMD −0.44 kg, CI −0.72, −0.15) but did not significantly affect any other anthropometric measures. Green tea with caffeine decreased BMI (−0.55, CI −0.65, −0.40) and BW (−1.38 kg, 95% CI −0.72, −0.15) but not WHR, compared with caffeine alone (7 RCTs). No benefit was shown in trials that evaluated green tea without concomitant caffeine administration on any of the measures (2 RCTs). The authors concluded that ingestion of green tea with caffeine may positively affect BMI, BW and WC but that the magnitude of effect over a median of 12 weeks is small and not likely to be clinically relevant.

The Hursel review included 11 RCTs of green tea compared to placebo on weight loss (WL) and weight maintenance (WM) [32] (Table 1). All the included studies were 12–13 weeks in duration, the majority included a mixture of male and female participants aged between 18 and 65 years. Seven of 11 RCTs were recruited from Asian populations.

All 11 RCTs were included in a meta-analysis. Catechins had a small positive effect on BW and WM after a period of weight loss (mean weight change (MWC) = −1.31 kg, CI −2.05, −0.57; $p < 0.001$), although high heterogeneity was reported. Further analysis suggested that ethnicity and habitual caffeine intake were moderators of this effect. The average effect was larger for trials with Asian participants (MWC −1.51 kg, CI −2.37, −0.65) than for Caucasian participants (MWC −0.82, CI −2.13, 0.50); but the difference was not significant ($p = 0.19$). Habitual caffeine intake did not influence WL (low caffeine MWC −1.6 kg, 95% CI −2.38, −0.83; moderate-high MWC −0.27 kg, CI −1.63, 1.10) except in combination with ethnicity ($p = 0.04$).

In a related paper, the same investigators reviewed metabolic studies that showed that both catechin-caffeine mixtures (CCM) and caffeine only (CO) supplementation stimulates daily energy expenditure dose dependently by 0.4–0.5 kJ mg^{-1} administered [33]. Daily fat oxidation was only significantly increased after CCM ingestion and not CO supplementation when compared with placebo.

7. Summary and conclusions

The evidence for green tea consumption and risk reduction, associated mortality and recurrence of all cancer types is limited in both quantity and quality. For most cancer types, the direction of effect is unclear. There are data to suggest that metabolic genotype and gender are modulators of the effects of green tea. Meta-analysis of data for risk reduction of breast, prostate, endometrial and ovarian cancer suggests there is a positive effect of green tea. These studies generally measured tea consumption in cups, comparing low/no consumption vs. higher consumption (1–10 cups per day).

Green tea trials of cardiovascular risk are heterogeneous and of variable quality. Short term RCTs (maximum duration 24 weeks) suggest beneficial effects on lipid profiles: a reduction in LDL and TC, with no significant effects seen on HDL and triglycerides. RCTs of green tea on blood pressure are very small, and show non-significant increases in both systolic and diastolic blood pressure. Evidence from observational studies in Asian populations is mixed, with case–control studies suggesting a possible protective effect of green tea on CAD, but cohort studies failing to show this effect.

Green tea consumption does help reduce body weight and aid weight management as shown in short term RCTs (12 weeks) but not to a clinically relevant level. Green tea consumption did not influence other anthropometric measures. Data showed that ethnicity and caffeine may be moderators of any effect. There was a great degree of clinical and statistical heterogeneity in the included trials.

None of the included reviews focussed on safety, but other data suggests that there are no real safety concerns with normal green tea consumption for most people.

In conclusion, whilst there is a considerable body of evidence for green tea with some of it suggesting a positive effect, it is difficult to be definitive as to its health benefits.

Contributors

Rachel Johnson was responsible for screening references and clinical knowledge, and is the main author for cardiovascular section of this paper. Susan Bryant is the main author of weight loss section of this paper. Both Johnson and Bryant revised and made crucial comments on the whole paper. Alyson Huntley contributed towards literature searches, screening references and overall management of review, and is the main author of cancer section of this paper. All authors were involved in the editing of whole paper.

Competing interest

None.

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Provenance and peer review

Commissioned and externally peer reviewed.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.maturitas.2012.08.008.

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