THE EFFICACY OF GREEN TEA IN MANAGING WEIGHT IN OVERWEIGHT AND OBESE PEOPLE: A SYSTEMATIC REVIEW

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Abstract:

Background: Obesity is defined as the excessive accumulation of adipose tissue resulting from an imbalance between energy intake and expenditure. This pervasive global health challenge affects a population exceeding 2 billion individuals. In addition, green tea, renowned for its health-promoting properties, is being explored as a potential component in weight management interventions for individuals grappling with excess weight. It is noteworthy for its elevated levels of catechins, specifically Epigallocatechin-3-gallate (EGCG), and caffeine, both of which are posited to exert a beneficial influence on energy expenditure.

Methods: The search methodology was applied to two databases, namely PubMed and Medline. The search query incorporated the following keywords: (((Green tea) OR (Polyphenols)) OR (Catechins)) AND (weight loss). The selection of studies adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews (PRISMA, 2020) resulting in six RCTs included.

Results: Six studies investigating the effects of green tea on weight management yielded diverse results: one study observed no substantial weight change, another noted weight reduction in individuals with central obesity, a different study found weight loss associated with low-dose catechin consumption, another reported weight decrease in overweight women diagnosed with PCOS, one trial documented weight loss linked to green tea extract supplementation, and the final study indicated a significant reduction in weight in individuals receiving both green tea extract and engaging in endurance training.

Conclusion: The findings of randomized controlled trials (RCTs) investigating the impact of Green Tea Extract (GTE) on weight reduction suggest potential effectiveness in the short term, especially with higher doses, particularly within specific subpopulations like overweight individuals, those with central obesity, and individuals with Polycystic Ovarian Syndrome (PCOS). Nevertheless, uncertainties exist regarding the long-term effects and broader applicability of these results due to variations in outcomes across diverse populations, varying study durations, and the intricate interplay of factors including dosage, individual metabolic health, and specific health conditions. Consequently, further research is imperative to gain a comprehensive understanding of how green tea influences weight, waist circumference, and fasting insulin levels metabolically.

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Introduction:

Obesity is characterized by an excess accumulation of fat, due to the imbalance between the intake and expenditure of energy, efforts to address the global obesity epidemic, which affects over 2 billion people, involve both public health policies and individual treatment initiatives, also its impact of quality of life is substantial, even among individuals who appear to be in good health. (González-Muniesa et al. 2017). While dietary intervention, increased physical activity, and lifestyle adjustments form the fundamental aspects of obesity management, there is a growing significance in the use of medical interventions and bariatric surgery. (González-Muniesa et al. 2017). The world health organization (WHO 2022) predicts that by the year 2025, around 167 million individuals including all ages will experience a decline in their health due to being overweight or obese. It is a disease that exerts its impact on numerous body systems, including the heart, liver, kidneys, joints, and reproductive system, and it contributes to the development of various no communicable diseases (NCDs), such as type 2 diabetes, cardiovascular disease, hypertension, stroke, different forms of cancer, and mental health disorders. Additionally, individuals with obesity face a heightened risk, being three times more likely, of being hospitalized for COVID-19. (WHO 2022).

Adjusting people's diet is a fundamental aspect of managing weight and achieving weight loss fundamentally involves creating a negative energy balance, the optimal method to establish this balance is a topic of considerable debate and ultimately depends on discovering a strategy that individuals can sustain over the long term. (Chao et al. 2021). In clinical practice and medical guidelines, emphasis is placed on Body Mass Index (BMI) and waist circumference as straightforward, objective, and easily replicable tools for assessing weight status and abdominal obesity. Individuals with a BMI equal to or greater than 25 kg/m² are classified as overweight, while a BMI equal to or exceeding 30 kg/m² is categorized as obese, as for waist circumference measurements (WC), men with WC between 94-101.9 cm and women with WC between 80-87.9 cm have moderate central fat accumulation, as for having high central fat accumulation men need to have WC of 102 cm and more, and 88 cm and more for women. (Wiechert and Holzapfel, 2021). Engaging in physical activity alone is not a highly effective approach for achieving initial weight loss, even though many overweight or obese individuals often select for exercise as their primary intervention. (Fock and Khoo, 2013). Green tea has a rich history with various applications, including its potential to assist overweight individuals in losing and sustaining weight, it is thought to enhance energy expenditure in individuals. Green tea weight loss supplements are derived from extracts of green tea, containing a more concentrated amount of ingredients, such as catechins and caffeine, compared to the standard green tea beverage made from a tea bag and boiling water. (Jurgens et al. 2012). Epigallocatechin-3-gallate (EGCG), the predominant catechin present in green tea, constitutes nearly 40% of the total mixture of catechins by weight and it is considered as the primary antioxidants in green tea. (Seeram et al. 2006). Green tea has numerous health benefits because of its inflammatory properties, the health-enhancing properties of green tea can be attributed to the presence of polyphenols, specifically flavonols and flavanols, clinical studies along with in vivo and in vitro experiments, validate their antioxidant and anti-inflammatory effects, catechins are the predominant polyphenols in green tea, exert their antioxidant activities by neutralizing free nitrogen and oxygen radicals, and by their ability to chelate metal ions in redox reactions. (Musial et al. 2020). In a recent systematic review by Jurgens et al. 2012, they investigate the efficacy of green tea supplements on weight loss in obese or overweight people on a total of 18 RCTs, and they concluded that green tea supplements seem might lead to a modest weight loss in overweight or obese adults, but the observed reduction is statistically non-significant. Given the relatively small magnitude of the weight loss, it may not have clinical significance. Furthermore, green tea does not demonstrate a significant impact on the maintenance of weight loss. (Jurgens et al. 2012). In a recent systematic review by (Colonetti et al. 2022), they examined the effects of green tea supplementation in women with polycystic ovary syndrome (PCOS) from four double-blind RCTs involving 169 women (85 in the green tea group and 84 in the placebo group) were included. The analysis showed a significant reduction in body weight in the green tea group compared to the placebo group. However, no significant differences were found in other parameters like BMI, body fat percentage, daily caloric intake, waist circumference, hip circumference, and waist/hip ratio. The review found evidence suggesting green tea could be an effective adjunct therapy for weight reduction in women with PCOS. It was also noted that higher doses of green tea catechins were associated with better outcomes in terms of weight. The primary aim of this research is to critically evaluate the role of green tea supplementation in weight management among overweight or obese individuals, with a focus on its efficacy and

potential as an adjunct therapy. This review will investigate the change in body weight, waist circumference and fasting insulin levels post green tea supplementation.

Methods

The search strategy was used on two databases: PubMed and Medline. The following keywords were used in the search: (((Green tea) OR (Polyphenols)) OR (Catechins)) AND (weight loss). The studies included were selected in accordance with the Preferred Reporting Items for Systematic Reviews guidelines (PRISMA, 2020), as shown in Figure 1.

The PICO model was followed in this review:

- Population: adults who is overweight or obese according to their BMI
- Intervention: Green tea beverages
- Comparison: Placebo
- Outcome: Changes in weight

- Inclusion Criteria

1. RCTs.
2. Published between 2015 and 2023.
3. Adults only.
4. Studies that used green tea or green tea extract as an intervention.
5. Studies written and published in English.
6. Adults with BMI more than 25.

- Exclusion Criteria:

1. Non-RCT studies.
2. Published before 2015.
3. Studies in children.
4. Studies not in English.
5. Adults with BMI less than 25.

Primary Outcome

The focus of this study was primarily on changes in weight (kg).

Secondary Outcomes

The secondary outcomes were changes in waist circumference (cm) and fasting insulin level.

Results:

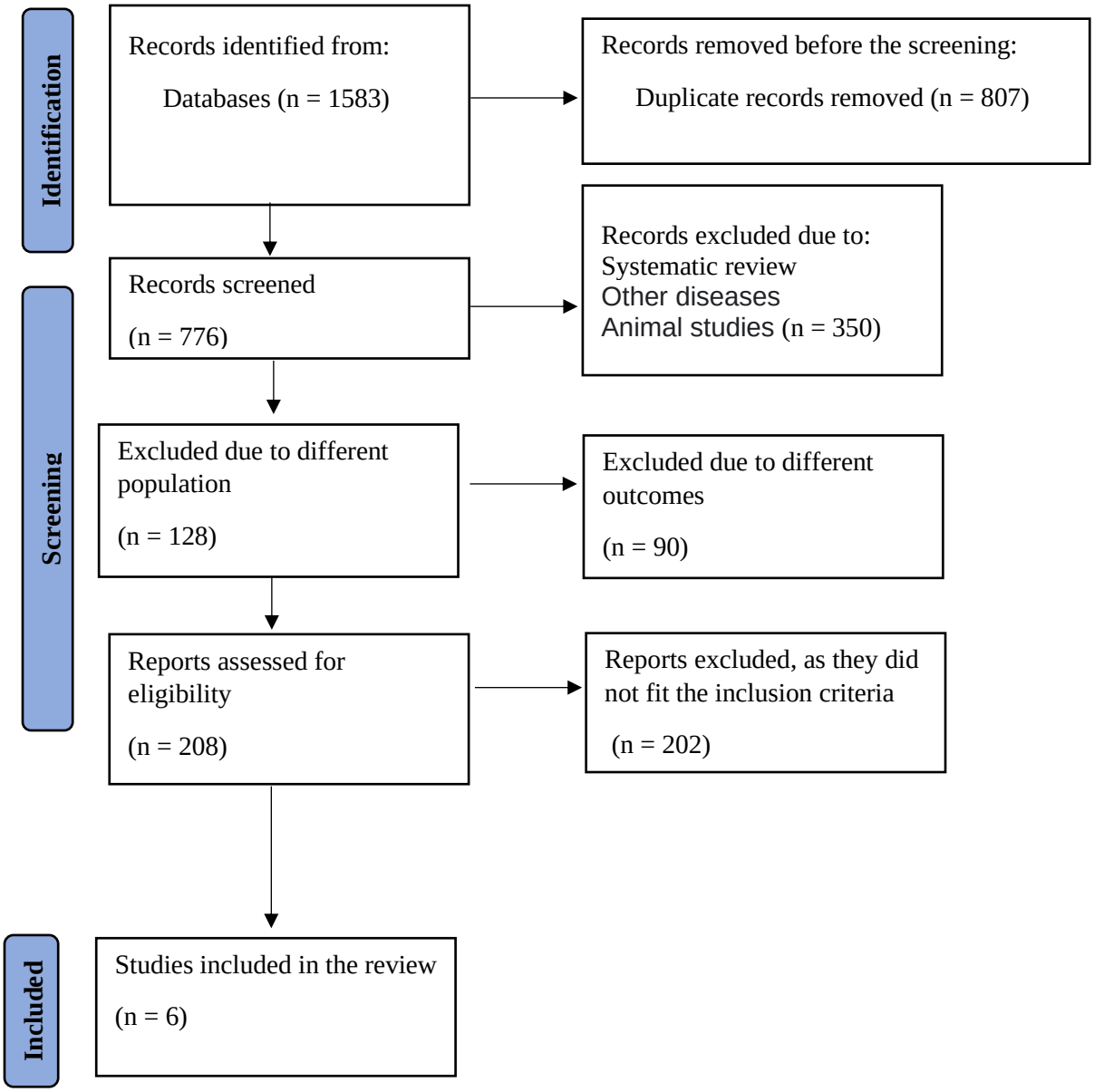
Quality Assessment

The quality assessment was conducted using the modified Cochrane Collaboration tool to evaluate the risk of bias of RCTs (high, low, or unclear) on five domains (randomization process, intended intervention, missing outcome, outcome measurement and selection of results). (Sterne et al., 2019). See table1.

Table1.

Biases / Authors	Randomization process	Intended intervention	Missing outcome	Outcome measurement	Selection of results	Overall risk of bias
Chen et al. (2016)	Low risk	Low risk	Some concerns	Low risk	Some concern	Some concerns
Kobayashi et al. (2016)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Dostal et al. (2016)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Tehrani et al. (2017)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Taghizadeh et al. (2017)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Bagheri et al. (2020)	Low risk	Some concerns	Some concerns	Low risk	Low risk	Some concerns

Figure 1: PRISMA flowchart demonstrating the selection of articles included in the review



6 RCTs reviewed in this paper published between 2015-2023 in different countries that studied the effect of green tea beverage or green tea extracts on changes in body weight, fasting insulin levels and waist circumference. with a total number of 603 obese or overweight people as shown in table2.

Table2:

Author's	Location	N of participants	Intervention	Duration	Outcomes	Comments
Bagheri et al. (2020)	Iran	30 females with BMI from 27.9 and more.	GTE capsule per\d containing at least 225mg EGCG with exercise, other 2 groups placebo with and without exercise	8 weeks	Both groups including exercise show weight loss P=0.001.	Short period. One gender trial.
Chen et al. (2016)	Taiwan	92 females with BMI from 27 and more.	GTE containing 856.8 mg of EGCG per\d or placebo	12 weeks	Weight in GTE group decreased (p=0.0025). WC: reduced in both groups, GTE group P=0.0023, placebo P=0.0017.	Short period. One gender trial. No follow up.
Dostal et al. (2016)	USA	237 females with BMI from 25 and more.	2 GTE capsules per\d containing 422 mg EGCG or placebo	12 months	Weight tend to increase in GTE group and no	Sufficient duration. Higher obese people in GTE

					significant results P=0.16 WC= P=0.26. FI= P=0.001	group (BMI more than 30) than placebo. One gender trial.
Kobayashi et al. (2016)	Japan	124 (53men and 71 women) with BMI from 25 and more.	GTE containing either 84.5 mg of EGCG or 50mg\d per\d or placebo	12 weeks	Weight in low dose P=0.0429, high dose P=0.0465 WC: low dose P= 0.0166 and in high doses P=0.001.	Small amount of EGCG compared to other trials. No regular follow up.
Taghizadeh et al. (2017)	Iran	50 females with BMI of 25 and more	2 capsules per\d containing 125 GT (no specified quantity of EGCG) or placebo	8 weeks	GT group weight loss P=0.001	Small numbers. Short period. Supplements contain other effective nutrient.
Tehrani et al. (2017)	Iran	60 overweight or obese females (BMI not specified)	500 mg GTE capsule per\d (no specified quantity of EGCG) or placebo	12 weeks	GTE group weight loss P= 0.031 and placebo P= 0.00 FI P=0.00 in both.	Small numbers of participants. One gender trial all having the same disease.

Abbreviations: N=number, BMI=body mass index, GTE=green tea extract, EGCG=Epigallocatechin gallate, WC=waist circumference, FI=fasting insulin, GT=green tea.

Primary Outcome:

All of the 6 RCTs measured the changes in weight (kg) for the participants after green tea intervention. In the study by Dostal et al. (2016), a randomized, double-blinded, placebo-controlled trial was conducted in Minnesota, USA, focusing on 237 overweight and obese postmenopausal women. These participants were divided into two groups: one receiving green tea extract (GTE) and the other a placebo. The GTE group was administered 1315 mg of decaffeinated green tea extract daily for a duration of 12 months. Among the 117 participants in the GTE group, the average body weight at baseline was 75.6 ± 0.9 kg, and at the end of the 12th month, it was 75.4 ± 0.9 kg. The total change from the baseline was a decrease of -0.28 ± 2.2 kg, indicating no significant weight changes after the 12-month period.

In a randomized, double-blind, placebo-controlled clinical trial conducted in Taiwan by Chen et al. (2016), the focus was on 92 women suffering from central obesity. This condition was characterized by a body mass index (BMI) of 27 kg/m^2 or more, and a waist circumference exceeding 80 cm. The participants were divided into two groups: one received a high dose of green tea extract, administered three times a day, resulting in a total daily intake of 856.8 mg of Epigallocatechin gallate (EGCG); the other group was given a placebo. The duration of this treatment was 12 weeks. The study's findings revealed a significant reduction in weight among participants in the green tea group, with the average weight dropping from 76.8 kg to 75.7 kg.

Kobayashi et al. (2016) conducted a 12-week randomized, double-blind, placebo-controlled trial in Japan involving 124 moderately obese individuals. These subjects were divided into three groups: a placebo group, a low-dose catechin group, and a high-dose catechin group. The low-dose group consumed 500 mL of green tea beverage daily, containing 50 mg of Epigallocatechin gallate (EGCG), while the high-dose group consumed the same volume of green tea but with a higher catechin concentration, providing 84.5 mg of EGCG per day. The study's results indicated an increase in the average body weight of the placebo group, from 72.9 kg to 73.6 kg. In contrast, the low-dose group showed a decrease in weight from 72.7 kg to 72.3 kg, and the high-dose group also experienced a reduction in weight, from 72.5 kg to 71.9 kg.

In the study by Tehrani et al. (2017), a double-blind, randomized clinical trial was conducted in Isfahan, Iran, focusing on 60 overweight women diagnosed with Polycystic Ovarian Syndrome (PCOS). The participants were allocated into two groups. One group was administered 500 mg capsules of green tea, taken twice daily, while the other group received a placebo. This trial lasted for a duration of 12 weeks. The outcomes revealed a decline in the average weight of the green tea group, from 86.68±6.86 kg to 82.9±6.09 kg. Conversely, the control group did not exhibit any significant weight change.

Another randomized, double-blind, placebo-controlled trial was carried out in Kashan, Iran by Taghizadeh et al. (2017) involving 50 overweight women. These participants were split into two groups: one group was given dietary supplements, while the other received placebo capsules. This intervention spanned 8 weeks, during which the

supplements were taken twice daily with lunch and dinner. The supplement group was given capsules that contained 125 mg of green tea extract, 25 mg of capsaicin, and 50 mg of ginger extract. The findings of the study indicated a notable reduction in body weight in the supplement group, with an average loss of 1.8 ± 1.5 kg, in contrast to the placebo group, which saw an average weight gain of 0.4 ± 1.2 kg.

Moreover, Bagheri et al.'s (2020) randomized controlled trial, conducted in Iran and targeting overweight women, sought to investigate the impact of green tea extract (GTE) and endurance training on weight reduction and inflammatory markers. This study included 30 participants, divided into three groups: endurance training with placebo (ET + P), endurance training with GTE (ET + GTE), and a control group receiving a placebo. Spanning 8 weeks, moderate-intensity exercises such as aerobics, circuit training, and walking/jogging, conducted three times a week. The administered GTE dosage was 500 mg per day, inclusive of approximately 225mg of EGCG. Notably, both exercise intervention groups observed substantial weight loss. The ET + GTE group recorded a body weight reduction of 2.27 kg, whereas the ET + P group experienced a notable decrease of 1.61 kg in body weight.

Secondary Outcomes:

Changes in Waist Circumference:

Three out of the 6 RCTs reported on the changes in waist circumference (cm) after green tea intervention, Chen et al. (2016) found that after 12 weeks of EGCG (green tea extract) treatment, the waist circumference in the treatment group decreased from 95.1 ± 9.6 cm to 92.8 ± 9.8 cm.

On the contrary, Dostal et al. (2016) the data for participants given Green Tea Extract (GTE, with a sample size of 117) shows that at the baseline, their waist circumference was 91.9 cm with a standard deviation of ± 0.8 cm. After 12 months, the waist circumference increased to 93.2 cm with the same standard deviation of ± 0.8 cm. This indicates a mean increase in waist circumference of 1.45 cm from the baseline, with a standard deviation of ± 0.5 cm.

Moreover, in Kobayashi et al. (2016) trial, the baseline waist circumference measurements were 93.4 ± 0.8 cm for the placebo group, 93.8 ± 0.7 cm for the low-dose group, and 93.5 ± 0.8 cm for the high-dose group. After 12 weeks, these values changed to 94.0 ± 0.7 cm for the placebo group, 93.3 ± 0.7 cm for the low-dose group, and 92.8 ± 0.8 cm for the high-dose group, suggesting a slight increase in the placebo group and reductions in both the low-dose and high-dose groups.

Fasting Insulin:

In Tehrani et al. (2017) trial, the results after the intervention were that the control group showed a negligible increase in mean fasting insulin levels from 86.28 to 86.37, while the experimental group exhibited a notable decrease from 86.68 to 82.9.

In Dostal et al. (2016) trial, the participants with baseline insulin levels ≥10 mIU/mL experienced a decrease in insulin levels by -21.43 ± 0.59 mIU/mL after 12 months of green tea extract intake, while those on placebo saw an increase of +0.55 ± 0.64 mIU/mL.

Discussion:

The efficacy of green tea extracts in promoting weight loss, as observed in the included studies, presents a complex and multifaceted picture. The variation in outcomes across these studies underscores the nuanced role that green tea might play in weight management, influenced by factors such as dosage, study duration, and participant characteristics.

In the study conducted by Dostal et al. (2016), the lack of significant weight change in overweight and obese postmenopausal women over a 12-month period suggests that the long-term consumption of green tea extract may not be effective in this specific demographic. In contrast, the findings of Chen et al. (2016) and Taghizadeh et al. (2017), showing noticeable weight reductions in shorter-duration studies, point towards a potential immediate impact of green tea, particularly when consumed in higher doses or as part of a combination with other bioactive substances like capsaicin and ginger extract.

The dose-dependent effects observed in Kobayashi et al. (2016) further complicate the picture, indicating that both low and high doses of catechins can lead to weight reduction, but the extent of this effect may vary. This is particularly intriguing as it suggests that even moderate consumption of green tea might contribute to weight management, albeit to a lesser degree than higher doses.

Tehrani et al. (2017) provide an additional layer of insight by focusing on overweight women with Polycystic Ovarian Syndrome (PCOS), a condition often linked with metabolic abnormalities. The significant weight decrease observed in this group following green tea intake hints at the possibility that the metabolic effects of green tea could be more pronounced in populations with certain pre-existing conditions.

Moreover, the study by Bagheri et al. (2020) introduces the concept of combined interventions. In this trial, the incorporation of green tea extract with endurance training demonstrated that while green tea can augment the effects of exercise, the

latter remains a critical factor in effective weight management. This suggests that the benefits of green tea on weight might be maximized when coupled with other lifestyle modifications.

Taken together, these studies paint a picture of green tea's efficacy in weight loss as being contingent on a variety of factors. The differing results point to a complex interaction between the biological effects of green tea compounds and individual characteristics such as metabolic health, baseline weight, and lifestyle factors. While some studies indicate a beneficial role for green tea in weight reduction, particularly in the short term and with higher doses, the overall evidence is heterogeneous. This variability highlights the need for a personalized approach to nutritional interventions and underscores the importance of considering individual differences and specific health conditions when evaluating the potential benefits of dietary supplements like green tea extracts.

Waist circumference, a key indicator of central obesity and associated metabolic risks, showed differing responses to green tea intake across the studies. Chen et al. (2016) reported a reduction in waist circumference following green tea extract treatment, aligning with the notion that green tea may favorably influence body composition. However, the findings from Dostal et al. (2016) present a contrasting scenario where an increase in waist circumference was observed, albeit in a different population and over a longer duration. This disparity could be attributed to varying intervention lengths and demographic factors, highlighting that the effect of green tea on central obesity may not be uniform across different groups or time frames.

Similarly, the impact on fasting insulin levels, a marker of insulin sensitivity, was not uniformly reported but showed promising trends in the studies that did. For instance, in the Tehrani et al. (2017) trial, a notable decrease in fasting insulin levels was observed in the green tea group, suggesting an improvement in insulin sensitivity. This finding is particularly relevant given the relationship between insulin resistance and conditions such as PCOS, obesity, and type 2 diabetes. Dostal et al. (2016) also reported a decrease in insulin levels among participants with higher baseline insulin, further supporting the potential metabolic benefits of green tea in certain subgroups.

Jurgens et al. (2012) investigated the efficacy and safety of green tea preparations in aiding weight loss and maintaining weight in this demographic. The review includes an analysis of several randomized controlled trials, assessing various aspects like the impact on body weight, body mass index (BMI), and waist circumference, alongside potential adverse effects and the quality of evidence, and they suggested that green tea preparations might cause a small reduction in body weight in overweight and obese adults. However, they demonstrated that this effect was not statistically significant, leading to uncertainty about its clinical relevance. However, the paper has notable limitations, such as the considerable heterogeneity among the included studies, which may affect the generalizability of the findings. Some of the studies incorporated into the review might have biases, potentially influencing the overall conclusions.

Given the mixed and highly variable results from these studies, it's prudent to be cautious about endorsing green tea supplements as a reliable method for weight loss. The evidence suggests that while green tea may have some short-term effects, especially in specific populations or when combined with other substances or lifestyle changes, its long-term effectiveness and impact on broader demographics are uncertain. The complex interplay of factors like dosage, individual metabolic health, and existing conditions makes it challenging to generalize the benefits of green tea for weight loss.

Moreover, focusing on supplements like green tea extracts might divert attention from more established, holistic approaches to weight management, such as dietary changes and regular exercise. It's essential to prioritize methods with more consistent and well-documented results. In light of the current evidence, it is advisable to approach green tea supplements with caution and not to overly rely on them for weight loss, especially considering the potential for varied responses based on individual characteristics and health conditions.

Conclusion:

The results from these RCTs studying the influence of Green Tea Extract (GTE) on weight reduction offer a detailed and complex perspective, highlighting its potential efficacy, particularly in the short term and at higher doses, and especially among specific groups like overweight and obese individuals, women with central obesity, and those with Polycystic Ovarian Syndrome (PCOS). These studies suggest that green tea, in conjunction with other bioactive substances or lifestyle modifications, may offer benefits in weight management. However, the long-term effects and broader applicability of these findings are less clear, given the variability in outcomes across different populations and study durations. The complex interplay of dosage, individual metabolic

health, and specific health conditions complicates the ability to generalize the benefits of green tea for weight loss. Additionally, the impact of green tea on waist circumference and fasting insulin levels, while promising in some studies, further underscores the need for a more comprehensive understanding of its metabolic effects.

Future research should therefore focus on long-term studies to assess the sustained impact of GTE, explore the dose-response relationship of green tea catechins, and expand trials to more diverse populations for greater generalizability. Understanding the biological mechanisms underlying the effects of green tea on weight and metabolic health is crucial. Moreover, investigating the synergistic effects of green tea with diet, exercise, and other lifestyle changes could provide deeper insights into its role in holistic weight management strategies. Given the mixed and variable results, a cautious approach is warranted in endorsing green tea supplements for weight loss, emphasizing the importance of established weight management methods such as dietary changes and regular physical activity.

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