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REVIEW ARTICLE

Review of Herbal Supplement Intake and Aerobic Physical Activities in Overweight Individuals: Effects of Green Tea on Fat Metabolism

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ABSTRACT

This review investigates the synergistic effects of aerobic physical activity and green tea supplementation on fat metabolism, particularly in overweight or obese adults. Several studies have shown that green tea can significantly improve thermogenesis and fat oxidation. This condition is because it contains many bioactive compounds, including caffeine and catechins. These effects are further exacerbated when combined with aerobic activities such as cycling, jogging, and swimming, which are commonly recognized for their ability to enhance cardiovascular health and increase energy expenditure. The current study delves into recent research on the interaction of green tea, particularly its catechin epigallocatechin gallate, with the body's metabolic processes. Green tea increases fat availability during exercise and prolongs fat decomposition by inhibiting enzymes such as catechol-O-methyltransferase. Additionally, caffeine enhances energy expenditure, which facilitates the prolonged oxidation of fat following exercise. Studies suggest that individuals who consume green tea before moderate-intensity aerobic exercise experience significantly enhanced fat burning compared to exercise alone. This combination offers a comprehensive, natural alternative to pharmacological interventions for weight management, promoting both fat loss and improved metabolic health. The potential cardiovascular protection, reduced inflammation, and enhanced insulin sensitivity of green tea are reviewed in relation to its broader health benefits. Furthermore, it investigates the implications for athletes, suggesting that green tea can boost endurance by optimizing fat utilization during extended aerobic activities. In conclusion, this review emphasizes the potential of integrating aerobic exercise with green tea supplementation as a successful approach to facilitating sustainable weight management, improving overall health, and enhancing fat metabolism.

Introduction

Green tea, a beverage steeped in history and tradition, has been a part of different cultures for thousands of years, owing to its medicinal and therapeutic powers (Deng *et al*., 2022; W. Reygaert, 2017; Tarmast, 2023). This cultural connection to green tea is a fascinating aspect that has garnered international recognition for its numerous health benefits, particularly in lipid metabolism and weight management (Xu *et al*., 2020; Zamani *et al*., 2022). Its initial prevalence in East Asia, particularly in

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countries like China and Japan, adds to its allure (Hinojosa-Nogueira *et al*., 2021; Liu *et al*., 2019). The capacity of green tea to enhance lipid oxidation and activate metabolic processes (Xu *et al*., 2020), particularly when combined with aerobic physical activity, has been extensively researched (Braschi *et al*., 2023; Ghasemi *et al*., 2020; Nobari *et al*., 2021). This type of tea contains some bioactive components, including caffeine and catechins like epigallocatechin gallate (EGCG) (Xu *et al*., 2020). The most abundant catechin in green tea, EGCG, is known for its strong antioxidant properties and has been studied extensively for its role in reducing inflammation, oxidative stress, and supporting metabolic health (Pervin *et al*., 2019; Suzuki *et al*., 2016).

The health benefits of green tea are primarily attributed to its high polyphenol content, particularly catechins, which account for a significant portion of the dried weight of its fresh leaves (Musial *et al*., 2020). The combination of green tea catechins and exercise has been demonstrated to enhance the effects of exercise on body composition, particularly in overweight and obese individuals (Braschi *et al*., 2023). The evidence is, however, inconsistent, and additional research is required to ascertain whether green tea supplementation provides substantial advantages that surpass those of exercise alone. These compounds, mainly EGCG, are linked to various health benefits, such as the prevention of cancer, the improvement of cardiovascular health (Zamani *et al*., 2022), and the presence of anti-inflammatory properties (Musial *et al*., 2020; W. C. Reygaert, 2017). Additionally, green tea is acknowledged for its cholesterol-lowering, antimicrobial, and antioxidant properties (Afzal *et al*., 2015; Musial *et al*., 2020). The unique advantage of green tea lies in the complex amalgamation of its components, which operate synergistically to enhance its stability and potency, unlike isolated substances such as purified EGCG (Cerbin-Koczorowska *et al*., 2021; Vilella *et al*., 2020).

Evidence indicates that supplements such as green tea and aerobic activity can notably enhance fat metabolism during exercise. Research shows that consuming green tea before aerobic exercise increases fat oxidation both during and after exercise. This is achieved by boosting energy expenditure and stimulating lipid breakdown, contributing to more effective fat burning during workouts (Gahreman *et al*., 2015). Ichinose *et al*. (2011) studied the hypothesis that aerobic physical activity supplemented with green tea would further accelerate whole-body fat metabolism during exercise (Ichinose *et al*., 2011; Vuori, 2020). They concluded that green tea ingestion, in combination with moderate-intense exercise, was beneficial to increase the proportion of whole-body fat metabolism during exercise. This promising potential of green tea as a natural weight management strategy, particularly in overweight or obese individuals, is a beacon of hope (Al-Salafe *et al*., 2014; Kovacs *et al*., 2004). The processes that underlie these advantages include the antioxidant properties of catechins, which facilitate lipid metabolism, and the stimulatory effects of caffeine, which increase thermogenesis and energy expenditure. As a result, green tea supplements provide a safe, natural alternative for individuals who wish to lose weight without resorting to pharmaceutical interventions, which occasionally result in adverse side effects. In particular, research highlights that green tea consumption improves fat oxidation during physical activity and increases energy expenditure throughout the day, even at rest (Hodgson *et al*., 2013). This dual action contributes to better overall body composition and metabolic health in individuals struggling with obesity (Rostamian Mashhadi & Hosseini, 2022). Therefore, green tea stands out as a useful tool for those seeking a natural, sustainable approach to weight loss.

Green tea is culturally significant in numerous countries, including Iran, and has health benefits (Sajadi *et al*., 2023; Tarmast, 2023). Although black tea has been the most popular choice in Iran

historically, green tea is now recognized for its health benefits, particularly in lipid metabolism and weight management (Alinia-Ahandani *et al*., 2019; Heshmati *et al*., 2020; Rahmani *et al*., 2023). Green tea is being incorporated into the menus of many Iranians, who recognize its potential to enhance metabolic health and facilitate natural weight loss (Esmaeelpanah *et al*., 2021; Nabi *et al*., 2018). The worldwide rise in green tea consumption, which is driven by its esteemed reputation as a health and culturally beneficial supplement, is reflected in this trend (W. Reygaert, 2017).

Globally, obesity and overweight are significant public health concerns, with significant repercussions for metabolic disorders, cardiovascular diseases, and diabetes (Aziz *et al*., 2024; Welsh *et al*., 2024). According to the World Health Organization, the number of individuals classified as obese is on the rise due to sedentary lifestyles and harmful eating habits, with over 650 million individuals worldwide currently experiencing this condition (Al-Jawaldeh & Abbass, 2022; Loi, 2024). Aerobic exercise, an important method for obesity management, enhances cardiovascular health (Welsh *et al*., 2024), increases energy expenditure (Bellicha *et al*., 2021), and stimulates fat metabolism (Pranoto *et al*., 2024). In weight management programs, individuals are often advised to engage in traditional aerobic activities such as swimming, jogging, and cycling (Lin, 2022; Vuori, 2020). The combination of green tea supplementation and regular aerobic physical activity has been shown to contribute to effective weight management (Ghasemi *et al*., 2020; Liaqat *et al*., 2024). In a study by Liaqat *et al*. (2024) they concluded that green tea intake has an positive result in the weight management (Liaqat *et al*., 2024). In another study by Amozadeh *et al*. (2018) investigated the effects of aerobic training combined with green tea supplementation on body composition, blood lipids, blood glucose, and cardiovascular risk factors in overweight and obese females, revealing significant improvements in body weight, BMI, body fat percentage, triglycerides, LDL, blood pressure, and heart rate compared to the control group (Amozadeh *et al*., 2018). These approaches promote increased fat oxidation during moderate-intensity activities. For those who are interested in natural, non-invasive weight loss methods, this dual strategy, which combines physical exercise with the inherent metabolic benefits of green tea, provides a comprehensive and appealing solution (Sarma *et al*., 2023). The physiological state that is favored for fat oxidation during physical activity is facilitated by the combination of caffeine and catechins in green tea, thereby improving overall health and promoting sustained weight loss (Bellicha *et al*., 2021; Ghasemi *et al*., 2020; Kovacs *et al*., 2004).

Despite the growing body of evidence supporting green tea's function in fat metabolism, it's crucial to stress the need for additional research to evaluate its potential as an adjunct to aerobic exercise thoroughly (Heshmati *et al*., 2020). This emphasis on the ongoing research in the field of natural weight management strategies keeps the audience informed and aware. A sustainable approach to improved health may be achieved by incorporating herbal supplements, such as green tea, into a comprehensive lifestyle modification that includes regular physical activity and a nutritious diet for individuals seeking natural weight management strategies. This approach particularly appeals to individuals who desire to avoid the risks associated with pharmacological therapies, also it provides a brief investigation of different studies to elucidate the function of green tea in enhancing fat metabolism during aerobic physical activity. It provides practical advice for individuals seeking to improve their weight loss by combining exercise with botanical supplements. The incorporation of natural therapies, such as green tea, in conjunction with regular physical activity, enables individuals to attain more effective weight management and promote a healthier lifestyle. This exhaustive, evidence-based methodology is a critical resource for individuals who

are interested in promoting long-term wellness and implementing more effective practices.

Materials and Methods

The current study aims to review the effects of green tea on fat metabolism and the use of herbal supplements on aerobic physical activities among overweight individuals. The assessment aims to evaluate well-documented dietary patterns associated with herbal supplementation and their effectiveness in improving fat utilization during physical exercise. While the study emphasizes green tea, it also considers a diverse range of botanical supplements combined with aerobic exercises. PubMed peer-reviewed articles served as the primary sources for this analysis, with additional research from Google Scholar, Scopus, Ovid MEDLINE, OVID Healthstar, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) supplementing the data. Narrative and systematic reviews, as well as meta-analyses, were integrated into the search, which was finalized in 2024. These studies investigated the impact of herbal supplements on athletic performance and fat metabolism. In this period, the investigated regimens were the most frequently referenced in scientific literature.

Herbal supplements and their effects on fat metabolism

The body converts stored lipids into usable energy through fat metabolism, a critical physiological process. This process involves the hydrolysis of triglycerides into free fatty acids and glycerol, which can be immediately utilized for energy or stored for future use. The efficacy of lipid metabolism may be compromised in individuals with excess weight, resulting in fat accumulation and associated health risks, such as cardiovascular disease, obesity, and type 2 diabetes. As a result, the primary objective of weight control remedies has been improving lipid metabolism, with herbal supplements like green tea generating increased interest due to their potential benefits in this area.

The potential of herbal supplements to enhance fat metabolism and aid in weight management has been thoroughly examined. Green tea, Garcinia cambogia, and yerba mate are widely favored options that have garnered attention for their purported ability to increase fat oxidation, reduce appetite, and increase thermogenesis, the physiological process of generating heat through caloric expenditure. The potential to improve adipose metabolism, facilitate weight management, and maintain a healthy metabolic rate has been demonstrated through these supplements in conjunction with a balanced diet and consistent physical exercise. Green tea has become one of the most extensively researched herbal products regarding its influence on lipid metabolism. Green tea, rich in catechins, a bioactive compound, is believed to enhance fat metabolism, particularly during aerobic exercise. EGCG, a catechin, has been highlighted for its ability to increase the body's rate of lipid oxidation during physical activity. Research suggests that individuals who consume green tea or green tea extract before engaging in aerobic activities, such as running or cycling, exhibit a quicker rate of fat oxidation than those who do not consume green tea supplements. This effect is believed to be enhanced by the synergistic combination of caffeine, a significant component of green tea, and EGCG, which increases energy expenditure and fat utilization.

It is confirmed that the impact of green tea on lipid metabolism provides substantial comprehension. According to research published in the American Journal of Clinical Nutrition, overweight participants experienced more substantial reductions in body fat and waist circumference when green tea extract was combined with moderate aerobic exercise than when they conducted aerobic activity exclusively. This suggests that combining consistent physical activity and herbal supplements creates an optimal metabolic environment for fat reduction, offering individuals a more effective weight management strategy. Many

metabolic pathways are involved in the process by which green tea boosts fat metabolism. One of the primary processes is thermogenesis, which improves the body's capacity to convert stored fat into energy by increasing internal temperature. An additional approach is the improvement of insulin sensitivity, which assists in regulating blood glucose levels and preventing excessive fat accumulation. These pathways facilitate fat oxidation and improve metabolic health, thereby reducing the probability of insulin resistance and inflammation, which are closely linked to metabolic diseases and obesity. Green tea's ability to improve lipid metabolism is especially advantageous for those who engage in aerobic exercise regularly. Once glycogen reserves have been depleted, endurance athletes often turn to fat as their primary energy source. Integrating green tea into the diet plan for athletes may improve their endurance and overall performance in protracted sports, such as marathon running or long-distance cycling, by increasing their access to fat reserves. Green tea is a dietary supplement that benefits athletes aiming to improve their energy efficiency during extended physical exertion and as a possible aid for weight management.

The potential of herbal supplements, such as green tea, to alleviate metabolic issues associated with excess weight is underscored by the increasing interest in their use, particularly when combined with aerobic activity. As research progresses to uncover the mechanisms of these natural substances, including these supplements in fitness and weight management routines may become a widely adopted approach for promoting sustainable health goals and optimizing fat metabolism.

The role of aerobic exercise in enhancing fat metabolism

Aerobic exercise has been acknowledged as a critical element in the prevention of obesity and overweight, primarily due to its significant impact on fat metabolism (Pranoto *et al*., 2024; Vuori, 2020). Fat is the primary energy source utilized by the human body during aerobic activities, particularly moderate-intensity exercise (Muscella *et al*., 2020; Zhang *et al*., 2020). When combined with dietary measures, such as the consumption of herbal supplements such as green tea, the physiological mechanisms underlying this are essential for individuals attempting to improve their weight loss efforts (Amozadeh *et al*., 2018; Kovacs *et al*., 2004; Zhang *et al*., 2020).

Table 1. Role of Aerobic Exercise in Enhancing Fat Metabolism.

Factor	Effect on Fat Metabolism
Exercise intensity	Fat oxidation is highest during low to moderate exercise intensity (45%-65% VO_2max). As intensity increases beyond 65%, the body shifts to carbohydrate oxidation. At high intensities (>80% VO_2max), carbohydrates become the primary energy source.
Exercise duration	During prolonged exercise, fat oxidation increases, particularly from plasma free fatty acids (FFA) and intramuscular triglycerides.
Environmental temperature	Heat stress reduces fat oxidation while increasing carbohydrate oxidation. In cold environments, fat utilization may increase, although results vary depending on exercise modality (e.g., cycling vs. running).
Endurance training	Trained individuals demonstrate higher rates of fat oxidation during moderate exercise intensity compared to untrained individuals. Endurance athletes have higher mitochondrial density, enhancing their capacity for fat metabolism.
Plasma free fatty acids	FFA concentration increases during and after exercise, especially in endurance-trained athletes. However, at very high intensities (>85% VO_2max), plasma FFA concentrations decrease.
Intramuscular triglycerides	IMTG utilization increases with exercise intensity. Endurance-trained athletes rely more on IMTG during prolonged or moderate-intensity exercise.
Post-Exercise fat oxidation	Lipolysis remains elevated for up to 24 hours after moderate-intensity endurance exercise, increasing energy expenditure and contributing to fat metabolism post-exercise.
Gender differences	No significant differences between men and women in the overall pattern of fat oxidation during exercise, although trained individuals show greater fat oxidation capacity regardless of sex.
Muscle fiber type	Type I muscle fibers, which are more prevalent in endurance-trained athletes, contain more IMTG and have higher fat oxidation capacity due to the presence of enzymes like adipose triglyceride lipase and hormone-sensitive lipase.

Lipolysis is the process by which the body converts fatty acids into usable energy by utilizing oxygen during aerobic activity (Moro *et al*., 2014; Nandy *et al*., 2023). The duration of exercise increases, which in turn enhances lipolysis and facilitates the oxidation of more fat (Moro *et al*., 2014). The different roles of aerobic physical activity is illustrated in table 1. The degree to which adipose is utilized as an energy source is crucially determined by the intensity of aerobic activity (Purdom *et al*., 2018). Moderate-intensity exercises like jogging, cycling, or swimming facilitate an optimal environment for fat-burning. The effective utilization of stored fat is significantly enhanced under moderate conditions, leading to a marked improvement in the body's overall fat metabolism (Purdom *et al*., 2018). Studies have demonstrated that individuals who engage in moderate-intensity exercise for a minimum of 30 minutes per session experience notable enhancements in fat metabolism, particularly among those who are overweight or obese. A study by Reljic *et al*. (2021) found that both high-intensity and moderate-intensity interval training significantly improved the quality of life in obese individuals (Reljic *et al*., 2021). The results highlight the effectiveness of even low-volume exercise in improving cardiometabolic health. In another study by Themistocleous *et al*. (2022), a moderate-intensity training significantly improved cardiovascular risk factors, body composition, and cardiorespiratory fitness in obese and overweight individuals (Themistocleous *et al*., 2021).

In contrast, high-intensity aerobic exercise, such as high-intensity interval training (HIIT) or sprinting, activates fat metabolism through a different physiological mechanism. Although carbohydrates are the primary energy source during high-intensity activities (Tarmast *et al*., 2021), metabolic activity remains elevated following exercise. The process known as excess post-exercise oxygen consumption (EPOC) results in the prolonged oxidation of fat for several hours following the activity (Sun *et al*., 2024). The body's basal metabolic rate is considerably increased by EPOC, which leads to an increase in fat metabolism during the recovery phase (Sun *et al*., 2024). Research suggests that individuals who are overweight and participate in HIIT, despite shortening their training sessions, can achieve significant fat loss compared to moderate-intensity activities (Reljic *et al*., 2021; Ryan *et al*., 2020).

A compelling aspect of fat metabolism tactics is introduced by the interaction between aerobic activity and botanical supplements, mainly green tea (Dinh *et al*., 2019). Green tea, rich in caffeine and catechins, has been shown to improve fat metabolism during physical activity (Gahreman *et al*., 2015; Hodgson *et al*., 2013; Rostamian Mashhadi & Hosseini, 2022). In a study by Venables *et al*., (2008) it was found that ingestion of green tea significantly increased fat oxidation during moderate-intensity exercise by 17% and improved insulin sensitivity and glucose tolerance in healthy young men. These results suggest that green tea enhance fat metabolism and glucose control during exercise (Venables *et al*., 2008). The ingestion of caffeine is recognized for its ability to increase metabolic rate, while the presence of catechins in green tea has been demonstrated to promote the release of norepinephrine, a hormone pivotal in the process of lipolysis (Ősz *et al*., 2022). These effects are further heightened when coupled with aerobic exercise, suggesting a potentially efficacious approach for addressing lipid metabolism and facilitating weight reduction. It has been shown that the impact of consuming green tea on the body depends on the aerobic activity level, suggesting that green tea may have the potential to augment the body's natural fat-burning processes during low-intensity activities, such as walking or moderate running, where fat serves as the primary source of fuel (Hodgson *et al*., 2013; Nobari *et al*., 2021). Conversely, the impact of green tea extends beyond the immediate exercise session during high-intensity workouts that primarily rely on carbohydrates for energy (Jagim *et al*., 2023). Green tea may prolong fat oxidation during the recovery phase following high-intensity exercise by

heightening metabolic rate and enhancing catecholamine activity (Gahreman *et al*., 2016; Naghizadeh & Hemati Farsani, 2023).

The present study examines the synergistic effects of aerobic exercise and green tea on lipid metabolism. Maki *et al*. (2009) conducted a study that demonstrated that individuals who were overweight experienced a significantly greater reduction in abdominal obesity when they consumed green tea extract while engaging in regular aerobic exercise for 12 weeks, as opposed to those who did not consume green tea extract (Maki *et al*., 2009). These results, backed by scientific evidence, underscore the potential of green tea to enhance the fat-burning benefits of aerobic exercise, particularly in individuals with excess body weight (Maki *et al*., 2009; Nobari *et al*., 2021; Rostamian Mashhadi & Hosseini, 2022). This emphasis on scientific evidence can reassure and instill confidence in the audience.

The combination of aerobic exercise and catechins in biochemistry activates multiple pathways associated with fat metabolism (Braschi *et al*., 2023; Sugita *et al*., 2016). Catechins found in green tea inhibit the enzyme catechol-O-methyltransferase, which breaks down norepinephrine (Shixian *et al*., 2006), thereby extending the hormone's fat-burning effects (Thavanesan, 2011). This is consistent with the elevated lipolysis observed during moderate-intensity aerobic exercise (Moro *et al*., 2014; Nandy *et al*., 2023). Furthermore, caffeine in green tea stimulates thermogenesis (Rostamian Mashhadi & Hosseini, 2022), increasing energy expenditure and fat oxidation during and after physical exercise (Türközü & Tek, 2017; Wang *et al*., 2024). For individuals striving to enhance their lipid metabolism, the incorporation of green tea consumption into a structured aerobic physical activity can be a powerful strategy (Nieri *et al*., 2022). The synergistic benefits of exercise and green tea, when combined with moderate or high-intensity activities (Reljic *et al*., 2021; Ryan *et al*., 2020), offer a compelling, evidence-supported approach to achieving sustainable weight control and improved metabolic health. This empowering potential of the combined approach can motivate and instill hope in those seeking to improve their health.

Combination of herbal supplements and aerobic exercise: a synergistic approach

In recent years, the combination of aerobic exercise and herbal supplements has become a highly effective method for weight management, particularly in overweight or obese individuals (Gahreman *et al*., 2015; Hodgson *et al*., 2013; Liaqat *et al*., 2024). Green tea has garnered interest as an herbal supplement due to its powerful bioactive constituents (Saeed *et al*., 2017), particularly caffeine (Goldner *et al*., 2024) and catechins (Braschi *et al*., 2023), which are crucial for enhancing lipid metabolism (Dinh *et al*., 2019; Rostamian Mashhadi & Hosseini, 2022; Xu *et al*., 2020). The characteristics of green tea synergistically improve metabolic performance and facilitate fat reduction when combined with aerobic exercises such as cycling, swimming, or moderate walking (Nobari *et al*., 2021; Rostamian Mashhadi & Hosseini, 2022; Willems *et al*., 2018).

Aerobic exercise is widely acknowledged for its weight-control benefits (Jacob *et al*., 2024; Jurgens *et al*., 2012), primarily achieved by increasing energy expenditure (Yuwei, 2024) and improving cardiovascular health (Welsh *et al*., 2024). Nevertheless, the effects on lipid metabolism are exacerbated when green tea is incorporated into the equation. Studies have demonstrated that the primary compounds in green tea, particularly EGCG, enhance lipid oxidation and overall metabolic efficiency. This is particularly crucial for individuals who are dealing with obesity, as it enables them to overcome plateaus that may arise when they exclusively rely on exercise for weight management. Another factor contributing to green tea's potential to reduce fat is its effect on thermogenesis, which is the body's process of generating heat. Im *et al*. (2022) found that green tea improves adipocyte thermogenesis, contributing to fat

loss and improved metabolic health in obese subjects (Im *et al*., 2022). These findings suggest that, when combined with exercise, green tea's thermogenic effects further boost energy expenditure and fat oxidation, potentially amplifying the benefits of physical activity in weight management. The thermogenic effect not only enhances the number of calories expended during physical activity but also prolongs fat oxidation beyond the period of the exercise session. This extended period of fat burning, frequently referred to as the afterburn effect is essential for the long-term management of obesity in individuals (Fatemi *et al*., 2014). The optimal environment for sustained weight loss is established by the fat-mobilizing properties of green tea and the increased energy expenditure (Rondanelli *et al*., 2021; Thavanesan, 2011).

The efficacy of combining aerobic exercise with green tea in overweight and obese populations is substantiated by scientific research (Amozadeh *et al*., 2018). Mielgo-Ayuso *et al*. (2014) conducted a study that showed obese participants who ingested green tea while participating in moderate aerobic exercise experienced more significant reductions in body fat and waist circumference than those who exercised without supplementation (Mielgo-Ayuso *et al*., 2014). This study emphasizes the importance of green tea in enhancing metabolic health by enhancing key parameters, including insulin sensitivity and lipid profiles, which are frequently compromised in individuals with excess body weight. Additionally, the body's norepinephrine levels are elevated during exercise due to green tea's catechins, mostly EGCG (Chen *et al*., 2005). Norepinephrine is a crucial hormone that instructs fat cells to release accumulated fat into the circulation, where it can be utilized as energy (Petkevicius *et al*., 2021). This process is particularly critical during extended aerobic activities, such as cycling or jogging, when the body's energy requirements are elevated. Green tea has been shown to promote fat release and inhibit further fat storage by enhancing fat oxidation. This is particularly beneficial for individuals dealing with obesity, as it addresses a common challenge associated with this condition. In addition to its physiological advantages, the combination of aerobic exercise and green tea consumption provides psychological benefits that can further assist in weight management (Jurgens *et al*., 2012).

Research has demonstrated that consistent physical activity can enhance mood (Zapalac *et al*., 2024), assuage tension (Joniton *et al*., 2024), and reduce fatigue (Tornero-Aguilera *et al*., 2022), which are frequently impediments to the consistent practice of exercise by overweight individuals (Jówko, 2015; Oppert *et al*., 2023). The moderate caffeine content in green tea provides a natural energy boost, which can improve motivation and reduce the sensation of exertion during exercise. Caffeine works by blocking adenosine receptors in the brain, which helps decrease fatigue and increase alertness. This effect is particularly beneficial during aerobic exercise, as it enhances endurance and makes physical effort feel less strenuous. Additionally, caffeine increases the release of neurotransmitters like dopamine and norepinephrine, which can further improve mood and motivation during workouts (Guest *et al*., 2021; Jodra *et al*., 2020). This stimulation of the central nervous system not only supports better performance but also facilitates fat oxidation and thermogenesis, helping individuals burn more fat during and after exercise (Kennedy & Wightman, 2022; Ramírez-Maldonado *et al*., 2021). Thus, green tea offers both mental and physical benefits, making it an excellent supplement for improving exercise performance. This suggests that green tea improves the immediate effects of exercise and contributes to the persistent combustion of fat, a crucial component of long-term weight management. Green tea and physical activity have a dual effect that helps sustain the body in a fat-burning state even after exercise has ended, making it an ideal strategy for individuals attempting to combat obesity.

In summary, the combination of aerobic exercise and green tea consumption has been scientifically proven

to offer a comprehensive approach to weight management for overweight individuals. This approach not only improves metabolic health and promotes fat loss but also provides psychological benefits that motivate individuals to maintain an active lifestyle. By simultaneously addressing the physical and mental aspects of obesity, this dual approach offers a holistic solution for those struggling with excess weight. As a result, the synergistic effects of aerobic exercise and green tea present an evidence-based approach for overweight individuals looking to improve their physical health and reduce body fat. This approach is both practical and sustainable, as it enhances fat oxidation, increases calorie expenditure, and supports overall metabolic health (Jacob *et al*., 2024; Jodra *et al*., 2020; Jówko, 2015).

Future perspectives and practical recommendations

Green tea, an herbal supplement, has shown efficacy in enhancing fat metabolism and combating obesity when used with aerobic physical activity (Im *et al*., 2022; Sarma *et al*., 2023). In light of the global surge in obesity rates, it is imperative to explore sustainable, natural, and pragmatic approaches to enhance metabolic well-being (Bashir & Qureshi, 2023). Green tea has generated considerable interest due to its capacity to augment lipid oxidation and overall energy expenditure, mainly when used with physical activity. This can be attributed to the diverse bioactive components present in green tea. This interplay necessitates a comprehensive investigation of both the physiological mechanisms and the practical ramifications to gain a complete understanding of its benefits.

The fat-burning properties of green tea are significantly influenced by its active components, including caffeine and catechins (Jówko, 2015). Catechins, a class of flavonoids, have been shown to enhance the body's heat production and calorie expenditure. Caffeine, a well-known stimulant, facilitates the breakdown of fat cells, leading to increased energy expenditure by raising adrenaline levels. Collectively, these compounds promote fat oxidation, making green tea a desirable supplement for individuals looking to optimize fat loss through aerobic exercise. Research indicates that green tea's influence is particularly pronounced during physical activity, as the increased energy demands promote fat oxidation. Aerobic activities like running, cycling, or swimming are the most effective methods for enhancing fat metabolism. During protracted aerobic exercise, the body transforms its primary energy source from carbohydrates to lipids, particularly in moderate-intensity activities. This transformation is indispensable for the improvement of metabolic health and the maintenance of sustained fat reduction. Adding green tea to one's diet can improve the mechanism of fat metabolism.

As previously noted, research indicates that consuming green tea before exercise significantly enhances fat burning compared to individuals who do not. Consequently, this natural supplement can enhance the advantages of physical exercise. Aerobic physical activity and green tea are intricately linked and influenced by various factors. Green tea compounds and fat metabolism can be influenced by genetic distinctions, which can lead to varying levels of supplementation effectiveness among individuals. In addition, the extent to which green tea influences lipid oxidation may be influenced by metabolic rates and fitness levels. For example, highly proficient athletes may exhibit distinct responses to green tea administration than novice exercisers or have a significantly slowed metabolism. By examining these individual variations, future research may produce more efficient and customized weight management strategies.

This comparative analysis of various herbal medications administered with varying intensities and durations of aerobic exercise provides significant insights for those interested in natural weight control strategies. Green tea offers additional advantages in terms of physical performance, mainly due to its caffeine content. In addition to enhancing endurance

and attention during exercise, caffeine improves post-exercise fat oxidation, aiding recovery and allowing individuals to recommence their training regimens with less fatigue. This is especially beneficial for those who engage in HIIT, as recovery and fat oxidation are critical components of success. The potential of green tea to improve post-exercise fat oxidation provides reassurance about its recovery benefits.

The optimal benefits of green tea are best realized when incorporated into well-balanced, nutrient-rich diets. A dietary regimen rich in unprocessed, whole foods such as lean proteins, whole grains, fruits, and vegetables provides essential nutrients that support fat metabolism and promote overall health. Incorporating green tea supplementation establishes an advantageous metabolic environment, which facilitates fat oxidation during physical activity. In addition, the stabilization of insulin levels, crucial for regulating fat accumulation and utilization, can be achieved by minimizing the consumption of processed foods and refined carbohydrates.

The combination of green tea supplementation and aerobic activity presents practical but also feasible and enduring approaches to managing weight, offering easily integrated daily regimens. Whether a novice or an elite athlete, engaging in moderate-intensity exercises and consuming green tea daily can provide a consistent and sustainable method for fat loss. Green tea can be used as an adjuvant to optimize fat oxidation during rigorous exercises, including HIIT or endurance training. The psychological benefits of caffeine, such as increased mood and drive, can stimulate commitment and consistency in regular exercise, which is a critical component of long-term success.

Extensive benefits may be achieved by advocating for incorporating aerobic exercise with green tea supplementation as a public health campaign. The ongoing burden of obesity on global healthcare systems necessitates the provision of consumers with affordable, natural alternatives for weight control. Incorporating green tea into public health initiatives that are designed to improve metabolic health and reduce obesity is an optimal choice due to its accessibility, affordability, and safety for the majority of individuals. Furthermore, by improving comprehension of the synergistic advantages of physical activity and herbal supplements, individuals may be able to adopt a more proactive approach to their health and wellness. Combining personalized strategies, practical implementation, and scientific inquiry is essential for maximizing the benefits of aerobic exercise and green tea in fat metabolism. Exploring this combination demonstrates that natural, comprehensive weight control strategies have significant potential for combating the global obesity pandemic in a sustainable and accessible manner.

Conclusions

The evidence from this study suggests that green tea, renowned for its extensive history and numerous health benefits, has exhibited a substantial enhancement in fat metabolism, particularly when combined with aerobic physical activity. The effects of the bioactive constituents in green tea, such as caffeine and catechins, like EGCG, on lipid oxidation and energy expenditure have been extensively studied. These substances are believed to improve fat-burning mechanisms when included in a weight management regimen in conjunction with regular aerobic activity, making them a beneficial resource for obese individuals.

Cardiovascular disease and type 2 diabetes are among the substantial health risks associated with the global obesity epidemic. Aerobic exercise is a fundamental method for weight loss, as it improves energy expenditure and fat metabolism. Nevertheless, research has demonstrated that incorporating green tea supplementation can provide additional benefits. Research has shown that consuming green tea extract prior to moderate-intensity exercise, such as running or cycling, can significantly increase fat metabolism compared to conducting the exercise alone. This

suggests that vigorous exercise and green tea may be an effective strategy for combating obesity. The mechanisms by which green tea facilitates lipid metabolism are intricate. Caffeine increases thermogenesis, which boosts overall energy expenditure. However, catechins, including EGCG, impede enzymes that degrade norepinephrine, a hormone that aids in fat degradation. This leads to a prolonged period of fat oxidation during and after aerobic exercise. Additionally, green tea has been shown to improve insulin sensitivity, which assists in effectively utilizing fat, reduces fat storage, and improves blood sugar management. These characteristics make it an invaluable supplement for improving the metabolic health of rotund patients.

Its cardiovascular and anti-inflammatory properties enhance green tea's importance in weight management. Green tea's thermogenic and antioxidant properties promote fat loss and protect against metabolic disorders like insulin resistance and type 2 diabetes. Green tea is a critical element of a comprehensive weight management strategy due to its extensive health benefits extending beyond fat loss. These benefits are supported by empirical data, which suggests that the combination of moderate aerobic activity and green tea supplementation significantly improves the metabolic health and body composition of obese individuals. Research indicates that incorporating green tea consumption with aerobic activity yields more pronounced reductions in body fat and waist circumference among obese individuals. This highlights the essential role of green tea in conjunction with physical exercise in enhancing insulin sensitivity and facilitating fat loss, which is particularly beneficial for those with obesity-related metabolic disorders.

Additionally, the enhanced fat mobilization facilitated by the catechins in green tea guarantees the effective utilization of fat reserves during prolonged cardiovascular exercises, such as swimming or walking. This is particularly beneficial for obese individuals who frequently have elevated fat deposits. The role of green tea in reducing the probability of further fat accumulation provides a sense of security and control, promoting fat oxidation during physical activity. Additionally, the caffeine content of green tea, which provides a natural energy boost, aids in compliance with exercise regimens, a common challenge for individuals who are obese. A clinically validated, comprehensive strategy for weight management is provided by the combined influence of aerobic exercise and green tea. This comprehensive approach reassures obese individuals that they are on the right path to long-term weight management. Green tea is a critical component of this strategy, as it enhances metabolic health and accelerates fat metabolism during physical activity, instilling confidence in its effectiveness.

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Ethical consideration

This study is registered in the Iranian Clinical Trials Registry under the number IRCT20240618062168N1 and complies with the ethical standards delineated in code IR.IAU.DAMGHAN.REC.1403.002.

Conflict of interests

The authors declare that they have no conflicts of interest.

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