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# White tea drink (*Camellia sinensis*) improves endurance and body weight maintenance of rats

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## Abstract

**Purpose** – White tea is an unfermented tea made from young shoots of Camellia sinensis protected from sunlight to avoid polyphenol degradation. White tea contains a high level of polyphenolic compounds known as catechins. Several types of evidence have suggested that tea consumption has benefits in body weight and endurance maintenance. This study was designed to evaluate the effect of white tea on body weight and endurance of animal models.

**Design/methodology/approach** – This research was an intervention design using 20 Wistar white rats (Rattus Norvegicus) in body weight between 150 and 200 g. The rats were randomized into four groups, three groups receiving white tea drink (WTD) with different doses and the other group receiving plain water in equal volume as a control group for four weeks. The forced swim test (FST) was done to measure their struggling capacity, and digital bodyweight to measure the weight.

**Findings** – Intervention (WTD Groups and Control) caused weight gain among except G3 with the highest doses of white tea. The result showed that WTD intake in G3 had a significant difference ($p < 0.05$) on body weight gain compared to control. The authors found that WTD in a specific dose (G3: 0.22 mg) tends to maintain the body weight of animals (219.2 ± 41.96; 212.6 ± 46.90, respectively), while other doses caused weight gain. WTD also significantly increased the swimming and struggling capacity of rats that represented improvements the endurance along with the test. There was a statistically significant difference in endurance among all groups ($p < 0.05$).

**Research limitations/implications** – The results of this study can be followed as human intervention research as an input for nutritionists and sports scientists to explore the beneficial effect of white tea.

**Practical implications** – The results of this study can be followed as human intervention research as an input for nutritionists and sports scientists to explore the beneficial effect of white tea.

**Originality/value** – This study adds more evidence and information about the advantages of white tea as potential beverages in future healthy lifestyles.

**Keywords** White tea, Bodyweight, Endurance

**Paper type** Research paper

## Introduction

Obesity is projected to become a global public health problem and is a severe problem in developing countries [1, 2]. Over one-third of adults in the United States and one-fourth in Indonesia are overweight and obese. The prevalence of obesity is increasing in many countries and is seen as a global pandemic. The consequence of excessive weight is

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associated with various noncommunicable diseases, including type-II diabetes, coronary heart disease and cancer [3].

Physical activity is a factor that might counter obesity issues. Physical activity increases people's total energy expenditure which can help maintain energy balance or even weight loss as long as the individual does not eat more to compensate for the extra burned calories. However, during exercise, the body will quickly lose oxygen so that lactic acid will increase and cause fatigue. Reserved glycogen might decrease, and the ability of muscles to take glucose in the blood can reduce oxidation levels and endurance [4, 5]. The ability to store high glycogen reserves while exercising by increasing the use of fatty acids as an energy source replacing glucose can reduce lactic acid levels associated with fatigue [6].

Consumption of food sources of antioxidants is now widely used to maintain endurance and body weight. One of the natural antioxidants consumed by many Indonesians is polyphenols in tea. The result of a recent study in Indonesia revealed about one-third (31.2%) of Indonesians consumed tea [7]. Consumption of green tea combined with moderate-intensity exercise can increase the proportion of body fat use during exercise, and potentially increase endurance [6, 8, 9].

Tea contains several bioactive compounds that are believed to have a wide range of physiological properties, including anti-inflammatory, antioxidant, antiatherosclerotic and hypolipidemic properties as found in several studies [10–14]. Tea contains many biologically active polyphenolic flavonoids, commonly known as catechins, which make up 30% of the dry weight of its leaves [15]. These catechins include epicatechin, epicatechin-3-gallate, epigallocatechin and epigallocatechin-3-gallate (EGCG). EGCG is a well-characterized antioxidant [16]. Polyphenols contained in tea have an antioxidant potential that is effective at capturing free radicals such as superoxide, hydroxyl and peroxyl. The catechins in white tea (Camellia sinensis) are higher than the catechins in green tea (white tea 4.85 g/kg; green tea 2.90 g/kg) [17]. White tea is made from the buds and the leaves of the tea plant. It is often described as minimally processed and unoxidized. It is plucked and then withered (exposed to low-level warmth to reduce its water content) and dried (in sunlight or with hot air).

The antioxidant activity of polyphenols contained in tea can capture superoxide, and increase the activity of detoxification enzymes glutathione peroxidase, glutathione reductase, glutathione-S-transferase, catalase and quinine reductase in the small intestine, liver and lungs [18]. Catechins could increase oxidation activity in skeletal muscle and increase the concentration of free fatty acids in the blood to reduce lactate levels so that endurance increases. The increase in free fatty acids is in line with the increased use of fat as an energy source. Besides the fact that EGCG is the main component of catechins, it is also believed to be a mediator in increasing endurance capacity by catechins through increased skeletal muscle oxidation and increased translocase/CD36 mRNA fatty acids [6]. Many natural compounds have been proposed as treatments for obesity via enhanced energy expenditure, including caffeine, capsaicin, tea and extracts. Tea containing caffeine and catechin polyphenols have been reported to affect body weight [19, 20]. Almost all the studies with Asian subjects have shown positive results regarding reducing obesity due to the effect of catechins [21].

This study aimed to clarify the effect of the component in white tea that is responsible for the anti-obesity effect and endurance capacity. We investigated the consumption of white tea on weight change and endurance performance.

## Methods

### *Research design*

The research design was a true experimental prepost test control group design. The treatment allowed the researchers to measure the effect of the intervention in the experimental group by

comparing the experimental group with the control group. The dependent variable was concentrations of white tea extract, and the independent variables were body weight and endurance. The research was conducted in the laboratory of the Nutrition and Health Department and Veterinary Departments of Universitas Airlangga, Indonesia.

*Animal and diets*

This research used an intervention design using 20 Wistar white rats (*Rattus Norvegicus*) weighing between 150 and 200 g, male, aged 8–12 weeks, of active and regular movement, and clear eyes. Preceding adaptation treatment was done to soothe the animals inside the individual cages in the position where they could interact audio-visually with each other. All groups were adapted for seven days in a row and given a standard diet. During the adaptation period, body weight was evaluated and animals that experienced an extreme decline in body weight were excluded. The intervention period was of four weeks duration. Food was given *ad libitum* per day with a commercial weft. Twenty rats were divided at random into four groups and fed with different doses of drink. White tea extract was mixed with fresh water at concentrations of 0.15 (G2) mg, 0.19 (G3) mg and 0.22 (G4) mg, respectively. The drink was given daily by using a syringe feeding method.

*Sampling and data collection*

During this feeding period, the body weight of each rat was measured every week by bodyweight weighing scale. Endurance was done by the forced swim method. This experimental method approach measured swimming time (high mobility), struggling time (mobility) and immobility time, which represented the moment (time) when the rats entered into the hopelessness state (without movements fall on the pool) [22, 23]. Rats were placed in a 20 cm diameter × 20 cm height plastic cylinder filled to 25 cm at room temperature. The time was measured by a visual test. The definition of swimming time was based on the high mobility of rats above the water during the test, struggling time was mobility (with movement) of rats on keeping themselves from sinking and immobility was the absence of all movements except for motions required to maintain the animal's head above water [23].

*Data management and analysis*

The quantitative data, including bodyweight and endurance level, were cleaned before the analysis was performed. The results of the analysis were carried out using statistical analysis of variance (ANOVA) and continued with the Smallest Significant Difference comparison test with a confidence interval of 5%.

*Ethical consideration*

This study was approved by the ethics committee of the Faculty of Public Health Airlangga University with No. 645-KEPK.

## Results

*Bodyweight*

The variety of diets affected the animal's body weight. Measurement of body weight was performed during the intervention (baseline-midline-endline). The data on changes in body weight profile during the study can be seen in the following table.

Food intake was not affected by WTD intake (Table 1). As a result, body weight was similar between the groups. There was a significant increase in body weight of all except the group with the highest dose of white tea ($p < 0{,}05$), and there was a statistical difference in the rate of weight loss between treatment groups. This indicated that there are dose responses to body weight, which might affect body weight maintenance.

| Group | Initial BW* (grams) | Week 1 (grams) | Week 2 (grams) | Week 3 (grams) | Final BW (grams) | Weight changes (grams) | Food intake (%) |
|---|---|---|---|---|---|---|---|
| P0 | $210.8 \pm 30.38^{b}$ | $199.2 \pm 32.51^{a}$ | $219.8 \pm 25.05^{b}$ | $232.2 \pm 21.37^{c}$ | $236.4 \pm 26.93^{c}$ | (+) 25.6 ± 3.45 | 83.42 |
| P1 | $192.0 \pm 27.01^{a}$ | $187.2 \pm 34.37^{a}$ | $188.2 \pm 28.02^{a}$ | $191.6 \pm 40.78^{a}$ | $201.4 \pm 31.48^{b}$ | (+) 9.4 ± 4.47 | 84.21 |
| P2 | $198.8 \pm 15.42^{a}$ | $188.8 \pm 12.79^{a}$ | $183.8 \pm 12.79^{a}$ | $196.4 \pm 3.84^{a}$ | $207.0 \pm 26.75^{b}$ | (+) 8.2 ± 11.33 | 82.50 |
| P3 | $219.2 \pm 41.96^{b}$ | $204.6 \pm 35.62^{b}$ | $203.4 \pm 37.16^{b}$ | $203.0 \pm 41.03^{b}$ | $212.6 \pm 46.90^{b}$ | (−) 6.6 ± 4.97 | 84.10 |

*Note(s): BW = body weight; **The means of BW with different letters (a,b,c) in the same column/row differ significantly at $p < 0,05$. Using one-way ANOVA test, while those with similar letters are non-significant

**Table 1.**
Effect of white tea drink at three doses on body weight changes of rats

*Endurance*

In this experiment, rats were tested by a forced swim test (FST). The FST assessed the durability of rats in swimming, struggling and immobility (Figure 2)

Figures. 1–3 revealed the information about the swimming, struggling time and immobility of rats related to endurance capacity. There were significant differences in the duration of survival of the test animals between groups. The treatment group 1 (P1) had the highest average of initial swimming and struggling time, followed by groups P2, P0 and P3. Although they had the lowest average of initial swimming and struggling time, there was a significant increase in final time averages and changes in P2 and P3 among all groups. Moreover, a high dose of WTD significantly ($p < 0.05$) minimized the onset of immobility duration of rats during the test. This finding reinforces the hypothesis of the influence of consumption of white tea containing catechins on the endurance abilities of rats in the FST.

## Discussion

The Factors that influenced the animals' consumption were palatability, form and type of diet [24]. During the adaptation period, the animals consumed commercial weft, which is a

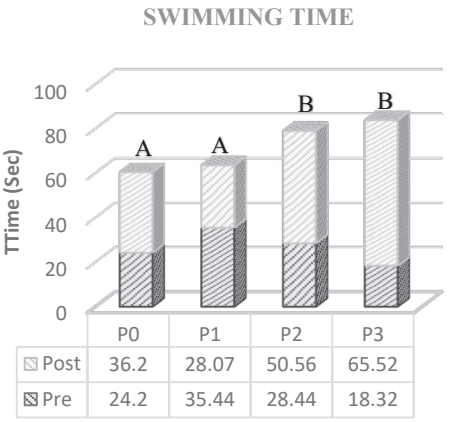


**Figure 1.**
White tea intervention in the rats' swimming time (Different subset (A/B) mean statistically difference $p < 0.05$)

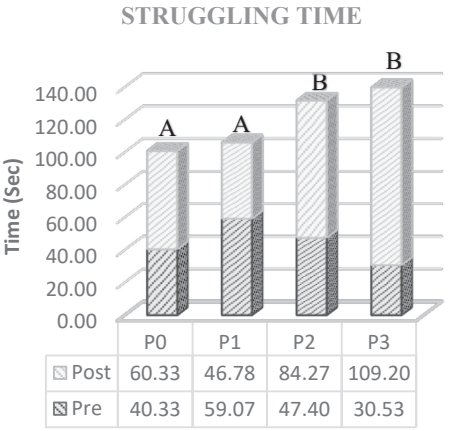


**Figure 2.**
White tea intervention in the rats' struggling time (Different subset (A/B) mean statistically difference $p < 0.05$)

common feed for rats. All diets tend to increase the bodyweight of rats during intervention except in the first week. The environmental adaptation factors of rats, as well as the stress that occurred due to utilizing the syringe feeding method, could be a trigger factor for this initial weight loss. This decline occurred in all groups with no statistical differences. Afterward, the bodyweight of animals increased until the end line of the intervention period except for the highest white tea dose group (P3).

These results suggest that white tea in several doses tends to have a beneficial impact on weight loss and weight maintenance. It was found that approximately 0.22 mg of white tea may have an important role in weight loss effects in this research. The administration of white tea in a certain dose might accelerate fat burning. Some reports revealed that the intake of white tea catechins helped to reduce diet-induced obesity. This effect might be because of the catechin's role in increasing energy expenditure [18].

The mechanism of weight loss by white tea might be related to several factors. Recent studies assumed that the increase of oxygen intake due to sympathetic nerve-induced thermogenesis caused the inhibition of catechol-o-methyltransferase activity by tea [25]. Catechins inhibit small-intestine micelle formation and alfa-glucosidase activity in the animal, and this reduced serum lipids and absorption of sugar [26, 27].

Another study reported that catechins synergically enhanced thermogenesis and fat oxidation and that both green tea components might be applied to the management of obesity. The diet containing catechins strongly prevented the accumulation of triglyceride and synthesis in 3T3-L1 cells [25, 28]. Our results supported the hypothesis and indicated that it might be possible to prevent obesity by continuous and long-term administration of catechins. Catechin intake decreased body weight. These results suggest that catechins contributed to the prevention of improvement in various lifestyle-related diseases, particularly overweight. These findings also suggest that white tea has a potential effect on body weight maintenance benefits.

In this study, we examined the effect of WTD on the struggling time of swimming in the force swim method. The use of the force swim method has been used by several researchers in rat trials [22, 29] and is one of the most commonly utilized models for assessing potential antidepressant compounds. This model is often used in rodents to evaluate antidepressant-like activity by assessing the decrease in immobility time [30, 31]. Although not an animal that has a living habitat in water, mice/rats can survive, which makes it possible to swim when submerged in water. In this condition, the rats release all their energy to survive and not sink so that they need energy/units very optimally compared to resting.

Endurance is the capability of the human body to maintain a certain output of power or repeat certain activities. Three important factors that require endurance activity consist of oxygen consumption (VO2-max), lactate threshold and efficiency. The lactate threshold

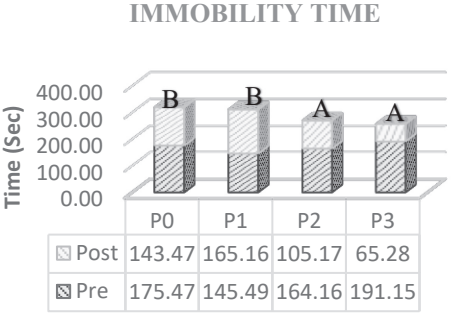


**Figure 3.**
White tea intervention in the rats' immobility test (Different subset (A/B) mean statistically difference $p < 0.05$)

interacts to measure the performance of oxygen consumption along a period of time [4]. Endurance exercise can increase nitric oxide (NO) and decrease superoxide dismutase, which plays a role in vasodilator heart muscle so that it can increase oxygen flow to all tissues, including muscle tissue. The availability of high oxygen results in reduced lactic acid [32].

Physical activity (swimming) will activate anaerobic metabolism in muscle cells to produce energy and increase intracellular lactic acid levels. Accumulation of lactic acid in muscle cells caused intracellular acidosis and fatigue. The lactic acid in muscle cells diffuses into the blood and increases plasma lactic acid levels. Increased levels of lactic acid in the blood are directly proportional to the ability to struggle because the more severe physical activity carried out increased the anaerobic metabolic process so that lactic acid levels also increased [33].

Endurance capacity (swimming and struggling time) was improved by the consumption of WTD in certain doses. Drinking white tea is thought to increase oxidation activity in skeletal muscle and increase the concentration of free fatty acids in the blood to reduce lactate levels and increase endurance. Caffeine can increase the use of free fatty acids and or intramuscular triacylglycerol, which plays a role in decreasing the rate of muscle glycogenolysis so that $O_2$ is minimized and there is an increase in endurance during exercise.

The effect of giving stimulant drinks to mice proved to be able to improve struggling abilities compared to the control group [34–37]. During exercise, skeletal muscle mainly relies on fat and carbohydrate for its energy. It has been recognized that enhancing fatty acid oxidation during exercise reduces the rate of glycogen depletion, resulting in an improved endurance capacity [37, 38]. Several studies suggested that tea improves endurance capacity by stimulating lipid catabolism. Consumption of catechins in tea adds fat oxidation, indicating the increase in fat use in animals [6, 39]. Other studies revealed that ECGC related to the upregulation of genes involved in $\beta$-oxidation in muscle and lipid metabolism [40–42] and *L*-theanine in white tea significantly increases activity in the alpha frequency band which indicates that it relaxes the mind without inducing drowsiness [43].

The disadvantages and limitations of this study were the absence of measurement of lactic acid levels before swimming and the increase in lactic acid due to struggling. It should be able to complement the analysis of the effect of white tea consumption on the endurance of experimental animals (white tea). However, clinical trial studies are needed to prove the benefits of consuming white tea.

## Conclusions

The provision of WTDs in rats successfully improved body weight maintenance and endurance ability compared to the control group. It illustrated the role of substances found in white tea (catechins) in improving the performance of endurance in animals. For this reason, it is necessary to perform further research on the influence of the use of white tea consumption drinks, particularly relating to the endurance of the human body (athletes).

*Conflict of interest:* There is no conflict of interest.

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