

# Time restricted eating: A revolutionary approach to combat obesity and enhance metabolic health

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## Abstract

Overweight and obese people are growing in numbers due to the adoption of unhealthy lifestyle. Overweight and obesity leads to morbidity and mortality affecting every organ system within the body. Therefore, overweight and obese individuals modify the lifestyle through dietary changes. One dietary method which gets more recognition is Time Restricted Eating as one of Intermittent Fasting regimens. This past decade, many studies have found its beneficial impact on overweight and obese individuals. This review aims to summarize the effect of TRE on weight loss, body composition, and metabolic health. This review gives a comprehensive understanding on concept of TRE and how could TRE be beneficial. This review also compares TRE to other IF regimens to find the most appropriate IF regimens. Articles from Google Scholar were obtained. A total of 90 articles were then included in this literature review. This review reveals that TRE is a promising dietary method on weight loss and improvement of body composition. On metabolic health, some studies reported changes while others reported otherwise. When compared to other IF regimens, TRE results in no greater impact leading to a similar result of every IF regimen. TRE switches metabolism and improves circadian rhythm and oxidative stress. These findings imply the beneficial impact of TRE on overweight and obese people.

**Keywords:** Time Restricted Eating; Healthy Lifestyle; Weight Loss; Metabolic Health; Body Composition; Obesity

## 1. Introduction

Within these past few years, the number of overweight and obese individuals is increasing. In 2016, WHO mentioned more than 1,9 billion adults above 18 years old are overweight with 650 million within are obese. This number had tripled from 1975 [1]. In 2022, 1 of 8 people is obese [2]. This growing number is due to the shifting of people's lifestyles [3]. Ultra processed foods are widely produced and consumed. Foods and beverages high in sugars and fats and low in fibres are getting popular and consumed worldwide [4]. On top of that, physical activity is getting less adopted due to the sedentary lifestyle [5]. Calories input comes from foods then is used by the body for basal metabolism and physical activity, including exercise. The imbalance of calories input and output plays a major key role in the occurrence of overweight and obesity [6]. Calories surplus means that the input is higher than the output. If the body receives more calories, it will store the excessive calories in a form of glycogen and fats [6]. In male, fats tend to be deposited in the abdomen whereas in female, fats tend to be deposited in the hip and thigh. Accumulation of fats results in weight gain and increase in body mass index [7, 8]. High body mass index is categorized as overweight and obese individuals [9].

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Overweight and obese individuals have five times higher chance in metabolic syndrome [7, 8, 10]. This is where the body has several metabolic abnormalities occurring intracellular and not yet manifest into symptoms. Not only that, overweight and obesity is a risk factor for diseases in every organ system in the body, most importantly, life threatening conditions such as stroke, diabetes, heart disease, and cancer [7, 11, 12]. Overweight and obese conditions lead to the impairment of the body image [13]. People might feel insecure for their body image rather than someone who has normal BMI [14]. This will cause psychological and social problems. Due to aesthetic and health reason, many overweight and obese individuals adopt healthier lifestyle to increase their body image and health. The adoption of healthy lifestyle is getting more recognition due to its sustainability while the instant changes may result in the reversible outcome. Managing the foods and beverages consumed and doing more physical activities can be done to achieve the ideal body weight [12, 15].

Lifestyle which is getting more recognition these past few years is intermittent fasting (IF) [16, 17]. IF allows people to consume foods and beverages within the eating period and pushes people to fast within the fasting period [18, 19]. There are many types of intermittent fasting [20]. The one type which is widely known and adopted is time restricted eating or abbreviated as TRE [20, 21]. TRE allows individuals to consume any foods or beverages without calories counting [19, 20, 21, 22, 23]. During the fasting period, individuals may only consume noncalories foods or beverages such as water, gum, black coffee, and tea [18, 19, 20, 21, 22, 24]. The most popular type of TRE is 16/8 where individuals are allowed to eat during 8 hours of eating period and must fast during 16 hours of fasting period [23, 25]. People do not need to calculate the calories intake and may also consume anything they want within the eating period [20, 21, 23, 25]. There is also no requirement for exercising in TRE dietary method [18, 19, 21, 22, 24, 25]. This dietary method is getting more recognition due to its simple adoption on only limiting the eating window [20, 21, 23, 24].

Since the number of people adopting TRE into this lifestyle is increasing this past decade, it is important to understand the benefits of TRE. This literature review summarizes previous literatures published to comprehend the effect of TRE dietary methods in overweight and obese individuals. It aims to understand its clinical beneficence in decreasing body weight and improving body composition and metabolic health. This review will give comprehensive understanding principles of TRE as one of IF regimens. This review will also compare TRE to other IF regimens to find the best IF regimen to be adopted in the population. The purpose of this study is to give an overview and summary of literatures about the relevance of TRE as dietary methods in overweight and obese adults and the best way to adopt this method into the lifestyle to achieve the best result.

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## 2. Material and methods

This review aims to give comprehensive overview of the effect of TRE dietary methods in overweight and obese individuals as a weight loss program. In this literature review, Google Scholar was accessed as an online database to obtain appropriate literature. Search terms were used to find the eligible literatures. “Time Restricted Eating, Overweight, Obese, Weight Loss, Metabolic Health, Body Composition” were searched in one full sentence in the search box. To understand the detail concept of TRE, “Time Restricted Eating, Metabolic Switching, Circadian Rhythm, Oxidative Stress” were also searched. This study collected literatures from this past decade to compose an updated summary of the effect of time restricted eating dietary methods. Among all articles, some articles had all four thematic keywords while some others only had two or three thematic keywords for “Time Restricted Eating, Overweight, Obese, Weight Loss, Metabolic Health, Body Composition”, for example “Time Restricted Eating, Overweight, Obese” and “Time Restricted Eating and Weight Loss”. As for “Time Restricted Eating, Metabolic Switching, Circadian Rhythm, Oxidative Stress”, some articles had two thematic keywords such as “Time Restricted Eating and Metabolic Switching”, “Time Restricted Eating and Circadian Rhythm”, and “Time Restricted Eating and Oxidative Stress. After collecting all studies, this literature review summarizes literatures altogether to provide comprehensive discussion and conclude the effect of TRE dietary methods in overweight and obese individuals. It aims to understand the clinical beneficence in purpose for individuals to adopt this lifestyle to lose weight and improve the body image.

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## 3. Results

From Google Scholar, after entering thematic keywords, “Time Restricted Eating, Overweight, Obese, Weight Loss, Metabolic Health, Body Composition” and “Time Restricted Eating, Metabolic Switching, Circadian Rhythm, Oxidative Stress”, a total of 3573 articles were obtained from both thematic keywords and sought for retrieval. Using advanced search, from “Time Restricted Eating, Overweight, Obese, Weight Loss, Metabolic Health, Body Composition”, 3490 articles were collected and from “Time Restricted Eating, Metabolic Switching, Circadian Rhythm, Oxidative Stress”, 83 articles were collected. All articles were then reviewed to synthesize the overview of this study. A total of 90 articles were then used in this literature review to give comprehensive understanding about the topic, 60 articles from “Time

Restricted Eating, Overweight, Obese, Weight Loss, Metabolic Health, Body Composition” and 30 articles from “Time Restricted Eating, Metabolic Switching, Circadian Rhythm, Oxidative Stress”. Studies obtained were from 2015-2024. Studies excluded from the screening process were due to the intervention given. Several studies did mention exercise, calorie restriction, and medication use. This study aims to understand TRE dietary method without any additional intervention which may alter the outcome. In this matter, studies with interventions alongside time restricted eating were all excluded.

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## 4. Discussion

### 4.1. Impact of TRE on Weight Loss

In overweight and obese individuals, previous research studies have shown different results for the impact of TRE on weight loss. TRE results in weight loss, especially in overweight and obese adults [18, 26, 27, 28, 29, 30, 31, 32]. In older adults, TRE also reduces body weight [33, 34, 35]. When combined with intentional calorie restriction, TRE results in effective weight loss [35]. Even so, with only TRE, without intentional calorie restriction, TRE leads to weight loss [36]. This is due to TRE results in limiting the eating period which then indirectly decreases the calories intake and leads to weight loss [31, 37]. In adults, when body weight was reduced, body mass index will automatically be reduced because of growth plate fusion or epiphyseal closure. Body mass index is the calculation of body weight and height. A study of 360 overweight and obese adults mentioned that TRE results in BMI reduction [38]. While most studies mentioned the impact of TRE in weight loss, other study mentioned otherwise. A study mentioned that TRE is no more beneficial rather than eating throughout the day [39]. Compared to daily calorie restriction, TRE results in no greater impact on weight loss [27]. In metabolic syndrome patients, weight loss was reported with approximately 3% of total body weight was reduced [40].

People adopting TRE into their lifestyle can choose the most appropriate type of TRE. Based on the eating period, TRE is divided into early TRE (eTRE) and late TRE (lTRE) [41]. Early TRE allows people to eat early in the morning to afternoon and fast for the rest of the day. Late TRE allows people to eat later in the afternoon and fast until the next day. People who are not used to skipping breakfast may adopt early TRE. From previous research studies, early TRE is more effective for weight loss [18, 41, 42]. Individuals may also choose how long the fasting period is. While the most common form of TRE is 16:8 (16 hours fasting and 8 hours eating), people may choose how many hours they would want to fast, for example 4 hours, 6 hours, 8 hours, or 10 hours. However, fasting period must be above 12 hours because after 12 hours of fasting, the body switches metabolism from utilizing glucose to fats and ketone bodies [26]. A study comparing 4 hours and 6 hours of eating period mentioned that the 4 hours eating period results in no greater impact than the 6 hours eating period [43]. However, another study mentioned that a longer eating period results in less body weight loss [26]. The results for weight loss depend on the adherence of the individuals. A study mentioned that adherence to TRE is high among adults with obesity which resulted in weight loss [18]. This is due to TRE only limits eating window and not calories intake and type of foods and beverages consumed. Therefore, many people likely adhere to TRE dietary method [18].

### 4.2. Impact of TRE on Body Composition

In overweight and obese individuals, TRE alters body composition [25, 31, 44]. A study mentioned reduction of fat mass without a significant reduction of lean mass [45]. Waist circumference was notably decreased after adoption of TRE in overweight and obese adults [25, 26, 39, 41, 42, 46, 47, 48]. However, another study mentioned otherwise. Body compositions did not change in obese adults [49]. In overweight and obese adults, the imbalance of calories input and output results to the deposition of fat throughout the body. In males, fat is mainly stored in the abdomen, whereas in female, fat is mainly stored in gluteofemoral region [42]. Fat is then degraded into energy during fasting period to meet daily calories requirement. This process will slowly decrease the amount of fat in the body which then improve the body composition [25, 26, 33, 42].

### 4.3. Impact of TRE on Metabolic Health

TRE has shown beneficial effects on metabolic aspects including fasting blood glucose, triglycerides, and blood pressure [20, 31, 44, 45, 49]. Insulin resistance was also reported to have improved in overweight and obese individuals [48]. On the other hand, other studies mentioned otherwise, the improvement of metabolic aspect was considered insignificant [39, 41, 43, 50]. Lipid profiles were negatively impacted in overweight and obese individuals [51]. Results of TRE on metabolic aspect may not be observed significantly [39, 41, 43]. This is due to the normal metabolic parameters before the intervention or known as metabolically healthy overweight and obese individuals who have abnormal body mass index and normal metabolic parameters [31, 37, 43, 50]. TRE may have shown significant results in individuals with abnormal metabolic parameters preintervention, for example in metabolic syndrome patients [40, 52]. In patients with

metabolic syndrome, the metabolic parameters were improved after the adoption of TRE dietary method [40, 52]. Therefore, several studies mentioned TRE may decrease metabolic risk disease [40, 53].

#### 4.4. TRE Shifts Metabolism Within The Body

One of the key mechanisms in the TRE dietary method is “metabolic switching” [54, 55, 56, 57]. Our body utilizes glucose to produce energy [54]. Glucose might be derived directly from the gut. When glucose intake exceeds the body's needs, glucose is then stored in a form of glycogen in the liver. Other sites storing glycogen are muscle and brain. During fasting, glycogen is then broken down into glucose to produce ATP [54, 55]. This process is called glycogenolysis. In the adipose tissue, the uptake of glucose aims to synthesize and store lipid or known as lipogenesis. The body prefers utilization of glucose as the primary resource of energy. However, during fasting period of TRE, the body prefers free fatty acid (FFA) and fatty acid-derived ketones or ketone bodies [54, 55]. This occurs when glycogen storage depletes and lipolysis generating FFA happens in the adipose tissue. Metabolic switching happens within 12-36 hours after food consumption, depending on the liver glycogen and the body's energy expenditure [54, 55, 57]. This explains why fasting period must exceed 12 hours to achieve metabolic switching state [26, 54].

FFA derived from the lipolysis occurring in the adipose tissue is then released into the blood. FFA can be uptaken by the liver and enters  $\beta$  oxidation to produce  $\beta$  hydroxybutyrate or known as ketone bodies [55].  $\beta$  hydroxybutyrate is then utilized by the muscle cell to produce ATP. This happens during prolonged fasting or vigorous exercise [54]. Muscle cells also store triglycerides in a form of lipid droplets, providing source of energy locally. Muscle cells prefer energy production from glucose. However, this preference is observed shifted to energy production from FFA and ketones [54]. A study revealed that the muscle cells prefer FFA and ketones as source of energy rather than glucose [54, 55]. During fasting period of TRE, the muscle uses FFA and ketones to produce ATP [54, 55]. The usage of FFA will deplete lipid storage in adipose tissue [54]. The depletion causes adipose tissue to shrink and decrease in size and volume [46, 47]. This explains after adoption of TRE, fat mass is decreased whereas lean mass is preserved [45]. When fasting, the body burns fat and this results in weight loss and improvement of body composition [25, 26, 33, 42, 54].

$\beta$  hydroxybutyrate is then transported from the blood into the neurons [54, 56]. Along with acetoacetate,  $\beta$  hydroxybutyrate is metabolized to produce ATP. Within the neurons, ATP is then used for cells activity. FFA can be utilized directly by astrocytes to produce  $\beta$  hydroxybutyrate. It plays a key role in ketogenesis, making sure neurons have adequate reservoir of  $\beta$  hydroxybutyrate [56]. This guarantees neurons for ATP production even when glucose intake is inadequate. When glucose can no longer be utilized, ATP is then derived from ketones [54, 55]. This will help neurons survive longer in an environment [56].

#### 4.5. TRE Improves Circadian Rhythm

Circadian rhythm is an internal clock synchronized within our body which regulates alertness or wake and sleep cycle [57, 58, 59, 60]. The core pacemaker of the body's circadian rhythm is suprachiasmatic nucleus (SCN) located in the hypothalamus [57]. Our body synchronizes its circadian rhythm through in vivo and in vitro synchronization. In vivo synchronization is then divided into central and peripheral clocks [58]. Central clock is mainly affected by light whereas the peripheral clock is affected by meals, temperature, and arousal stimuli including stress, exercise, and substances like caffeine [58, 60]. Central clock regulates peripheral clock through autonomic innervations, endocrine signals, and body temperature [60].

Feeding and fasting state affects circadian rhythm through the presence of foods [57]. Circulating macronutrients is a potent stimulus to several hormones. Insulin is then released into the blood after the ingestion of foods [58, 60]. Not only that, in insulin sensitive organs, such as liver, muscle, and adipose tissue, foods ingestion induces gene expression involving transcriptions and translations [60]. A study comparing eTRE and lTRE mentioned that eTRE results in greater improvement of insulin resistance than lTRE [41]. High cortisol in the morning appears to be inhibiting the secretion of insulin and stimulating glucagon secretion [62]. Feeding and fasting state resets circadian rhythm [57, 63]. Metabolism related hormones, like insulin, leptin, and ghrelin which are released within the body, may be involved in synchronizing the SCN [60].

Feeding state upregulates anabolic phase and downregulates catabolic phase while fasting state does otherwise and affects cellular redox state [60]. Feeding activates mTOR pathway which leads to the phosphorylation of CK1 and GSK3 which alters PER1 and PER2 in fibroblasts whereas fasting activates AMPK which leads to the phosphorylation of CRY. MTOR and AMPK pathway modulates the downstream of proteins including the transcriptional regulators of genes mainly in the liver. On the other hand, NAD and sirtuins, both affect circadian rhythm, correlated with the amount of energy within the cells. Feeding and fasting state upregulates the oscillation of circadian rhythm through its activators

and repressors causing gene expression resulting in healthier phenotypes [64]. Also, restricted feeding entrains peripheral clock but gives no effect to central clock [60].

Intermittent fasting affects circadian rhythm through gut microbiome [61,65]. The presence and absence of foods ingested determine nutrient availability. Fluctuations of nutrients cause  $\beta$  diversity to be increased and compositions of gut microbiome to be determined. Gut microbiome undergoes metabolism which causes accumulations of bacterial metabolites like tryptophan derivatives, short chain fatty acids, and bile acids to be fluctuated. These give signals to the body central and peripheral clocks in circadian rhythm [65]. Feeding and fasting rhythms causing gut microbiome diversity robust the circadian clock [64].

#### 4.6. TRE Improves Oxidative Stress

Oxidative stress is a condition where production of reactive oxygen species (ROS) exceeds its detoxification or the production of antioxidants is low which then results in the imbalance of oxidants and antioxidants [66]. Oxidative stress leads to cells and tissue damage. ROS is produced by our body through oxygen metabolism and may play physiologic roles, for example in cell signaling. Although ROS has functional effects on the body, the production needs to be kept low. Some stressors may contribute to a greater production of ROS, causing massive production without equivalent detoxification, such as UV light, radiations, pollutants, cigarettes smoke, alcohol, heavy metal (iron, arsenic, cadmium, lead, and mercury), and drugs (gentamycin and cyclosporin) [67]. The name ROS itself comes from an oxygen receiving or losing an electron which causes the molecules to be reactive due to the unpaired electron. The form of ROS can be as superoxide ( $O_2^-$ ) and hydroxyl radical ( $OH^\cdot$ ). These two are free radicals. Another form can be a nonradical or known as hydrogen peroxide ( $H_2O_2$ ). Other than ROS, free radicals in our body might be in a form of reactive nitrogen species ( $ONOO^-$ ). Aside from electron transport chain, ROS is generated through several metabolism. Several enzymes produce ROS in a major amount, such as xanthine oxidase, nitric oxide synthetase, lipoxygenase, cyclooxygenase, and cytochrome P450. Oxidative stress may be caused by low production of antioxidants [67]. Several substances have already been identified to be antioxidants, such as vitamin a, vitamin e, vitamin c polyphenols, flavonoids, uric acid, theaflavin, carotenoids, and glutathione [66, 68]. These are all nonenzymatic antioxidants. Enzymatic antioxidants include superoxide dismutase (SOD), glutathione peroxidase (GPx), and catalase (Cat). These three are the most abundant enzymes within the body [69]. Our body mainly relies on enzymatic antioxidants within the cells for the detoxification of ROS [67].

Oxidative stress is correlated to several diseases, including cardiovascular disease, neurodegenerative disease, inflammatory disease, cancer, and diabetes [70, 71, 72]. It affects every organ within the body. Oxidative stress is also closely linked to aging. Oxidative stress can be measured directly by measuring ROS and indirectly by measuring levels of DNA/RNA damage, protein oxidation or nitration, and lipid peroxidation [73]. The most common used DNA damage marker is 8-hydroxydeoxyguanosine (8-OHdG). Malondialdehyde (MDA) is a commonly used lipid marker for measuring oxidative stress [74]. Damage to proteins can be measured by protein carbonylation and protein nitration (3-nitrotyrosines) [75]. Other than that, products like advanced glycation end products (AGE) and advanced oxidation protein products (AOPP) can be measured [76]. Another useful indicator for oxidative stress is antioxidants. Low level of GSH/GSSG ratio is associated with high level of free radicals within the body [75].

TRE decreases oxidative stress and increases antioxidants [24, 28, 67, 69, 76, 77]. However, it is still unclear how TRE could affect oxidative stress [78]. A study mentioned that intermittent fasting alleviates antioxidants levels and decreases the generation of ROS which reduces oxidative stress. During fasting periods, IF increases GSH levels as antioxidants [79]. Total antioxidants capacity is also reduced [69]. IF is thought to be beneficial in mitigating lipid peroxidation by decreasing MDA and triacylglycerols levels [68, 69]. Different IF regimens including TRE and ADF are found to be able to upregulate protective enzymes like Nrf2 and SOD2 [79]. TRE results in significant reductions of AOPP and AGE [76]. In obese adults, 8-isoprostane levels are significantly decreased after adoption of eTRE [40]. Oxidative stress seems to have a circadian rhythm. Many important antioxidants peak in the morning, whereas oxidants peak in the evening/nighttime [78]. Therefore, TRE and other IF regimens may help preventing and managing chronic diseases [80, 81]. Furthermore, IF can delay aging by improving oxidative stress [82].

#### 4.7. TRE vs Other Regimens of IF

There are several types of intermittent fasting. As mentioned above, the most popular type of IF is TRE or limiting eating window into a particular period of time. Other than TRE, IF regimens include alternate day fasting (ADF), 5:2 diet, warrior diet, and weekly 24 hours fast or also known as eat stop eat [83, 84, 85, 86, 87, 88]. Although the most popular form of TRE is 16/8 (16 hours fasting and 8 hours eating window), there are also variations of TRE, including 14/10 (14 hours of fasting and 10 hours of eating window) and 20:4 (20 hours of fasting and 4 hours of eating window) [40, 43]. This can be adjusted into individuals' preferences based on habits and activities. The most important thing of TRE

is minimal hours of fasting. Based on the concept of metabolic switching, 12 hours is the minimal time for our body to switch from glucose utilization to fats and ketone bodies utilization [26]. Alternate day fasting allows individuals to fast every other day (fasting and eating day by turns). A 5:2 diet allows individuals to eat throughout the first 5 days of the week and limits calories intake into 500-600 calories the next 2 days. Warrior diet requires individuals to eat raw fruits and vegetables and eat one large meal at night. A weekly 24 hours fast or eat stop eat requires individuals to fast for 24 hours once or twice a week [83, 84, 85, 86, 87, 88].

Different regimens of IF were compared to understand the beneficial effect on weight loss, body composition, and metabolic parameters. Even without calorie restriction, TRE itself gives positive results in terms of weight loss and cardiometabolic health [36]. Compared to calorie restriction, different regimens of IF do not lead to superior changes in weight loss, body composition, and metabolic aspect [89]. Different types of IF, including TRE, ADF, and 5:2 diet, were compared. These result in no greater weight loss between one another [90, 91, 92]. For metabolic aspect, different regimens of IF result in no superior changes between one another [91, 92]. Therefore, individuals may choose any type of intermittent fasting regimens based on their preference without notable different outcome.

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## 5. Conclusion

From several literatures mentioned above, TRE is thought to have a beneficial impact on weight loss, especially on overweight and obese people. Though TRE only limits eating window into several hours, the weight loss resulted is significant. Aside from weight loss, TRE also improves body composition, reduces fat mass while still preserves lean mass. On metabolic aspects, the amelioration caused by TRE is still inconclusive. Some literatures mentioned positive effect while others mentioned otherwise. This is due to the normal metabolic aspects preintervention on overweight and obese individuals. Further studies studying impact of TRE on metabolic syndrome patients need to be conducted. The three concept of TRE as one of the most popular regimen of intermittent fasting is switching metabolism and improving circadian rhythm and oxidative stress. When compared to other intermittent fasting regimens, beneficial effect of each IF regimen shows similarity, without notable differences. In conclusion, overweight and obese individuals may adopt TRE into their lifestyle as weight loss program and to improve body composition and metabolic aspect.

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## Compliance with ethical standards

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### *Disclosure of conflict of interest*

All of the authors declare no conflict of interest to disclose.

### *Statement of ethical approval*

This study is a literature review collecting previous studies therefore no ethical approval is required in this study.

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