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Factors influencing weight regain after weight loss programs: insights from recent studies

Faktor-faktor yang mempengaruhi kenaikan berat badan setelah program penurunan berat badan: wawasan dari studi terbaru

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Abstract

Weight regaining is a challenge for most obese individuals who have successfully lost weight. Understanding the underlying factors contributing to weight gain is essential for developing more effective interventions. This study aimed to identify the factors contributing to weight gain in obese individuals after a weight loss program. A literature review was conducted using a narrative method following the PRISMA guidelines. The relevant international research articles used in this study were published in the last five years and retrieved from PubMed, ScienceDirect, and Wiley Online Library databases, resulting in the inclusion of nine studies that met the eligibility criteria, such as involving individuals with a history of weight loss programs, including dietary changes, physical activity, and cognitive behavioral therapy. The findings highlight multiple contributing factors to weight regain, including 1) loss of fat-free mass, 2) psychological, 3) behavioral and food environment factors, 4) weight loss history, 5) breakfast habits, 6) environmental contaminants, and 7) anti-obesity medication. Therefore, effective long-term weight management must consider these behavioral, metabolic, and environmental factors in obesity treatment programs to enhance their effectiveness in preventing weight regain.

Keywords: Weight regain, Weight loss program, Obesity

Abstrak

Weight regain merupakan tantangan bagi sebagian besar individu obesitas yang telah berhasil menurunkan berat badan. Memahami faktor-faktor yang mendasari terjadinya eight regain sangat penting untuk mengembangkan intervensi yang lebih efektif. Studi ini bertujuan untuk mengidentifikasi faktor penyebab weight regain pada individu obesitas setelah program penurunan berat badan. Kajian literatur dilakukan dengan metode naratif berdasarkan pedoman PRISMA. Artikel penelitian internasional yang relevan dalam kajian ini diterbitkan dalam lima tahun terakhir dan diperoleh dari database PubMed, ScienceDirect, serta Wiley Online Library, menghasilkan sembilan studi yang memenuhi kriteria inklusi. Studi-studi tersebut melibatkan individu dengan riwayat program penurunan berat badan, termasuk perubahan pola makan, aktivitas fisik, dan terapi perilaku kognitif, di mana beberapa faktor yang berkontribusi terhadap weight regain telah diidentifikasi. Hasil kajian menunjukkan berbagai faktor yang berkontribusi terhadap weight regain meliputi: 1) penurunan massa bebas lemak; 2) pengaruh psikologis; 3) perilaku dan lingkungan makanan; 4) riwayat penurunan berat badan; 5) kebiasaan sarapan; 6) kontaminan lingkungan; dan 7) penggunaan obat anti obesitas. Dapat disimpulkan bahwa manajemen penurunan berat badan jangka panjang yang efektif harus mempertimbangkan faktor perilaku, psikologis, metabolik, dan lingkungan pada terapi obesitas untuk meningkatkan efektivitas dalam mencegah kejadian weight regain.

Kata Kunci: Weight regain, Program penurunan berat badan, Obesitas

Introduction

Gradual development of obesity occurs when there is a persistent positive energy balance caused by an imbalance between the amount of energy consumed and expended over an extended period (van Baak & Mariman, 2019). Obesity is associated with high morbidity and mortality, ranging from premature death to chronic conditions, which can reduce life expectancy and quality of life (Koliaki et al., 2023).

Obesity management can be addressed through weight loss programs that include regular physical activity, reduced energy and fat intake, and self-monitoring of body weight and food intake (Kinsey et al., 2022). However, the greatest challenge in obesity management is not achieving weight loss but maintaining it in the long term (Nymo et al., 2019).

No more than 20% of obese individuals who successfully lose weight can maintain a 10% reduction in body weight for one year (Zhu et al., 2021). One study reported that the average weight regain in the intensive lifestyle intervention group was 50% of the initial weight loss (van Baak & Mariman, 2019). This phenomenon is known as weight regain, in which obese adults experience significant weight gain after completing a weight-loss program, sometimes even returning to their original weight (Nymo et al., 2019). Weight regain can be caused by many factors, including physiological adaptation, such as reduced energy expenditure or an increased drive to eat (Zhu et al. 2021).

Dietary interventions have been shown to decrease total energy expenditure (TEE) as a result of a reduction in resting metabolic rate (RMR) and non-resting energy expenditure (NREE) due to decreased body mass and increased metabolic efficiency. Additionally, feelings of hunger and ghrelin concentrations increase, whereas satiety decreases in individuals undergoing dietary interventions. A long-term reduction in TEE, increased hunger, and ghrelin secretion can contribute to weight gain (Nymo et al., 2019).

A previous study has also revealed that weight regain can be influenced by glucose homeostasis, insulin sensitivity, eating habits, depressive symptoms, genetics, and satisfaction with weight loss. Furthermore, changes occur in the adipose tissue during weight loss. Reduced fat mass triggers cellular stress, inflammation, changes in adipokine secretion, and decreased lipolysis, which can lead to fat accumulation and an increased risk of weight regain (van Baak & Mariman, 2019).

Nevertheless, few studies have comprehensively discussed the factors that influence weight recovery. Therefore, it is crucial to understand the factors contributing to weight regain in obese individuals after a weight loss program to develop more effective and long-term obesity management strategies. Identifying the various factors that influence weight regain can lead to the development of more targeted approaches, helping individuals with obesity sustain long-term weight loss.

Methods

A narrative method was employed to conduct a literature review in a bid to determine the cause of weight regain in individuals who have undergone a weight loss program. The reference search was conducted using various international databases, such as PubMed, ScienceDirect, and the Wiley Online Library. The research method employed pre-established keywords in addition to Boolean operators: "weight regain OR weight rebound OR weight relapse AND weight loss program AND obesity OR overweight."

Articles were selected based on the pre-established inclusion criteria.

1. Research papers reporting the predictors of weight gain after weight loss intervention.
2. Adult population aged 18 years and older.
3. English-language papers.
4. Research papers from the last five years (September 2019-September 2024)
5. Weight loss interventions consist of dietary changes, physical activity, behavioral therapy, and a combination of these interventions.

A literature search of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model (Figure 1) included four stages: identification, screening, eligibility, and inclusion. In the identification stage, 2062 articles were identified. Articles on qualitative studies, review articles, theses, or dissertations were excluded during screening. At the eligibility phase, full-text articles were critically analyzed for pertinence and those with children, adolescents, or patients with pre-

existing health conditions such as cancer, diabetes mellitus, or post-bariatric surgery were excluded.

To ensure the quality and credibility of the included studies, articles were filtered through standardized quality appraisal instruments specific to their study design (e.g., the Newcastle-Ottawa Scale for observational studies or the Cochrane Risk of Bias tool for randomized trials).

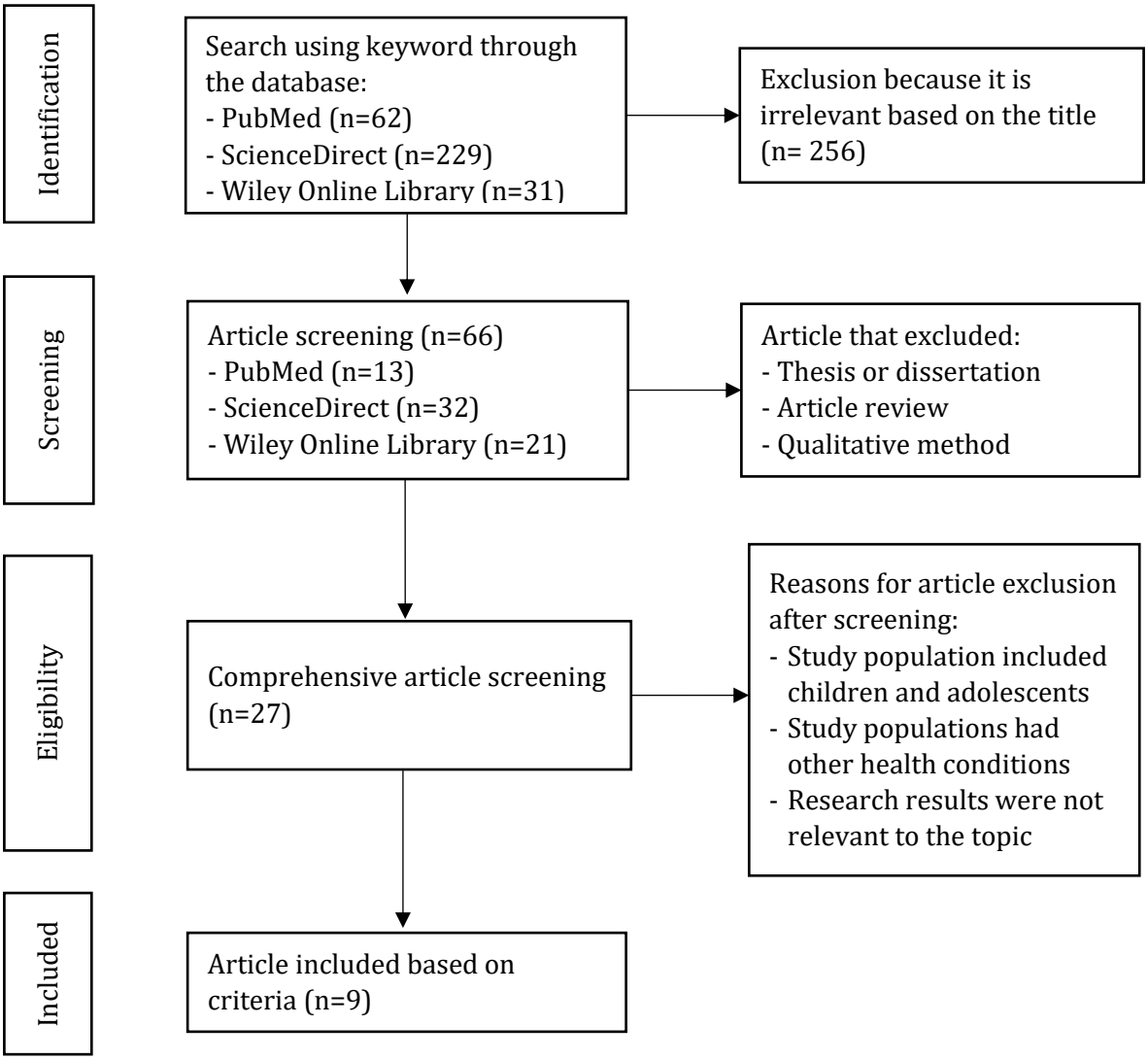

Figure 1. PRISMA diagram article selection scheme

Result and Discussion

Based on a literature review, several factors influence weight regain after a successful weight loss program, including physiological, psychological, behavioral, and environmental influences. Each of these factors plays a significant role in long-term success of weight maintenance.

Fat-free Mass Loss

In individuals undergoing a weight-loss program through lifestyle changes such as dietary modification and physical activity, weight loss is often followed by several physiological changes. Changes, such as a decrease in TEE and appetite, are frequently observed in individuals after weight loss. One of the causes of this phenomenon is a reduction in fat-free mass (FFM) (Jacquet et al., 2020; Nymo et al., 2019).

A study on the connection between the loss of fat-free mass and weight regain following a weight-loss program revealed that a decrease in fat-free mass loss (%FFML) significantly predicted weight regain in overweight women within a year. The findings revealed an inverse

correlation between %FFML after weight loss and subsequent weight regain over the year, indicating that a higher %FFML corresponded to greater weight regain. Furthermore, individuals who experienced a negative %FFML during the weight loss intervention regained significantly more weight after one year. The average difference in weight regain was more than 1,2 kg compared with those with positive %FFML (Martins et al., 2022).

FFM plays an indirect role in modulating energy intake (EI) and body weight through its influence on the TEE and REE (Martins et al., 2023). Additionally, FFM and RMR have been linked to the drive to eat (Casanova et al. 2019). Turicchi et al. (2020) found that a greater percentage of FFML tends to predict more significant weight regain, especially in men. %FFML was also associated with changes in appetite and eating desire in men but not in women.

%FFML can decrease TEE due to the reduction of skeletal muscle, a metabolically active tissue that significantly contributes to RMR. Martin et al. (2022) found that skeletal muscle loss can decrease RMR by 26,7%. Moreover, FFM is considered a primary contributor to RMR; therefore, a large reduction in FFM is expected to slow down metabolic rates. If a decrease in TEE and metabolic rate is not accompanied by dietary adjustments and increased physical activity, achieving a negative energy balance becomes difficult, potentially leading to weight regain (Martins et al. 2022).

The relationship between %FFML and weight gain was more significant in men because of differences in body composition between men and women. Men are more prone to FFML because they have a lower fat mass than women, leading to a faster reduction in fat mass (Turicchi et al., 2020). FFM is positively associated with EI through mechanisms that increase the appetite. Increased appetite may occur through changes in the signals released from protein tissues during weight loss and FFM reduction (Martins et al., 2022; Turicchi et al., 2020).

A study on the relationship between fat-free mass loss, appetite changes, and weight regain revealed that %FFML was not a significant predictor of weight regain after one year of weight loss. However, a greater %FFML was associated with increased ghrelin levels under ketogenic conditions, indicating a connection with altered appetite regulation. Additionally, FFML was linked to hyperphagic responses after individuals completed a weight loss program as the body's response to restore lost body mass during the weight loss process (Martins et al., 2023).

Table 1. Summary of articles that meet the research objectives criteria

Article	Method	Intervention	Instrument	Results
Martins et al., 2023	Design: Longitudinal study with repeated measurements Sample: 70 participants (29 males and 41 females with obesity/BMI 30-50 kg/m^2) Location: Norway	Low-energy diet, nutritional counseling, increased physical activity, and cognitive behavioral therapy	Anthropometric data collection using BOD-POD, and appetite changes were measured using Visual Analog Scale (VAS) and blood samples related to appetite hormones	Loss of fat-free mass (%FFML) did not predict weight regain after one year; however, a greater %FFML was associated with increased ghrelin secretion during ketogenic conditions, indicating a relationship with appetite regulation.
Turicchi et al., 2020	Design: Randomized 2-stage dietary intervention trial Sample: 209 participants (77 males and 132 females with BMI 27-45 kg/m^2) Location: Denmark, United Kingdom, and German.	Low-energy diet	Anthropometric data collection using DXA and appetite changes were measured using VAS.	A greater proportion of fat-free mass loss (%FFML) tended to predict greater weight regain, particularly in men. %FFML was also associated with changes in appetite and food cravings in men, but not in women.

Grandjean et al., 2023	Design: Randomized controlled trial Sample: 381 participant (115 males and 266 females). Location: Europe	Low Energy Diet for 8 weeks + Ad Libitum Diet for 26 weeks.	Weight measurements and blood samples related to PFASs.	Increased plasma concentrations of PFAS, particularly PFOA and PFHxS, are associated with significant weight regain. Exposure to PFAS may have obesogenic effects, contributing to long-term weight gain after initial weight loss.
Phelan et al., 2023	Design: Longitudinal observational study Sample: 2,843 individuals who successfully maintained weight loss in the Weight Watchers program. Location: United States	Commercial weight loss programs include diet monitoring, increased physical activity, and behavior change strategies.	Data were collected through an online questionnaire related to behavioral factors, psychosocial factors, and environmental factors.	The factors that most differentiate the group with weight regain from maintainers are a decrease in the ability to manage food cravings, a decrease in self-monitoring, poor body image, and an increase in loss of control over eating.
Palmeira et al., 2023	Design: Observational longitudinal study Sample: 870 participants with BMI > 5 kg/m^2 who successfully lost more than 5% of their body weight Location: UK, Denmark, and Portugal.	Self-regulation, motivation-emotion regulation, and a combination of self-regulation and motivation-emotion regulation.	Anthropometric data were collected using a SECA scale. An online questionnaire was used to assess motivation and self-regulation.	Factors such as basic psychological needs satisfaction, self-regulation, including action planning, coping planning, and action control, are related to the prevention of weight regain.
Martins et al., 2022	Design: Retrospective study Sample: 141 premenopausal overweight women (BMI 25-30 kg/m^2) Location: England	Diet nly, diet and aerobic exercise, diet and resistance exercise.	Body composition was measured using DXA	Loss of fat-free mass (% FFML) is a significant predictor of weight regain within one year in overweight women.
Cifuentes et al., 2023	Design: Retrospective study Sample: 206 individuals with obesity Location: United States	Total meal replacement very low-calorie diet program.	Body weight was measured using an electronic scale. Documentation of anti-obesity medication (AOM) use and dietary records.	The use of AOM is associated with less weight regain after 18 months compared to the group without AOM.
Elahy et al., 2023	Design: Hypothetical randomized trial design Sample: 372 participants aged 18-35 years with	Behavior Change Intervention for 6 Months.	Anthropometric measurements and body composition were assessed using DXA and a digital scale. Data on	Regular breakfast consumption (5-7 times/week) was associated with lower weight regain (0,59 kg less compared to irregular

	BMI 25,0 to <40,0 kg/m^2 Location: United States	breakfast frequency and nighttime snacking were obtained observationally from the IDEA study.	breakfast consumption). Additionally, avoiding nighttime snacks (0-2 times/week) reduced weight gain by 0,83 kg compared to the group that frequently consumed nighttime snacks (3-7 times/week).

Psychological Factors

Disinhibition

Disinhibition is the tendency to overeat in response to certain stimuli, and can occur in various situations (Waliłko et al., 2021). Long-term weight maintenance can be achieved by sustaining sufficient physical activity, self-monitoring, and disinhibition (Chopra et al. 2020).

In a study by Phelan et al. (2023), it was found that individuals experiencing weight regain also experienced increased disinhibition, such as loss of self-control, overeating, and inability to ignore food cravings. In this study, disinhibition posed a greater challenge in maintaining eating regulation in external situations such as social settings. A similar finding was reported by Bajerska et al. (2020), who revealed that disinhibition was the second factor to predict weight regain. Individuals who experience weight regain tend to have poor dietary adherence and show increased disinhibition such as a tendency to overeat. This study also found that individuals with weight regain tended to have decreased daily intake of nuts, seeds, and legumes but experienced increased consumption of sweets, biscuits, cakes, and pastries over time compared to those without weight regain.

Body Image

The discrepancy between ideal body image and actual body image can lead to dissatisfaction with one's body, which may become a risk factor for psychological decline in individuals with excess weight (Liberska & Boniecka, 2024). Poor body image was linearly correlated with increased symptoms of depression and low self-esteem. A study by Phelan et al. (2023) reported that individuals experiencing weight regain experienced a decline in body image, leading to reduced motivation to maintain weight.

Furthermore, in line with body image, individuals who regained weight experienced an increase in negative self-judgment over time. Negative self-judgment refers to the internal process of criticizing oneself for perceived shortcomings or failures, leading to a tendency to evaluate oneself as inferior to others. This condition has a bidirectional relationship with the body image. Negative self-judgment is also associated with dissatisfaction with body shape, which leads to a decrease in motivation to make behavioral changes due to the feeling that all efforts are in vain (Phelan et al., 2023).

Behavioral and Environmental Factors

Dietary Adherence

Dietary adherence is a crucial aspect of successful weight management and higher adherence is associated with greater weight loss (Stinson et al., 2020). Adherence during the weight loss phase can predict weight maintenance at two years post-intervention. Individuals with high adherence experience only 50% weight regain from weight loss, whereas respondents with poor dietary adherence experience 99% weight regain from weight loss (Gibson & Sainsbury, 2017).

Bajerska et al. (2020) found that dietary adherence among individuals experiencing weight regain was lower than that among those able to maintain their weight. In addition, individuals who regained weight experienced a significant decrease in food restrictions over time. Psychological factors such as self-efficacy, depression, self-motivation, stress, and body image can influence dietary adherence because individuals facing issues in these areas often experience pessimism and cognitive disturbances that reduce their willingness and ability to follow treatment recommendations (Gadde et al., 2021).

Unhealthy Food Environment

The food environment encompasses all conditions surrounding individuals when enjoying food, including the atmosphere, efforts to obtain food, social interactions during meals, and distractions while eating (Neve & Isaacs,

2022). An unsupportive food environment is one of the many challenges faced by individuals striving for a healthier weight (Kegler et al., 2021). Phelan et al. (2023) found that in individuals experiencing weight regain, an unhealthy food environment can trigger intrinsic urges to consume foods that contradict the weight loss goals.

The eating environment is closely related to the obesogenic environment. An obesogenic environment refers to a collection of environmental factors, opportunities, and living conditions that influence obesity (Guo et al. 2022). The prevalence of advertising, ease of access, and affordability of fast food and ultra-processed food (UPF) contribute to the increased consumption of high-calorie but low-nutrient processed foods. This ease of access can lead to overeating, especially in low-income areas, which often lack healthy food options, thereby increasing the risk of obesity (Heindel et al. 2024; Temple 2023). Lack of parks, recreational facilities, and safe walking paths also hinders individuals from exercising, contributing to a sedentary lifestyle and weight gain (Temple, 2023).

Self Regulation

Self-regulation focuses on how individuals maintain their behavior by successfully controlling, monitoring, and managing their actions and can engage in effective strategies to cope with difficulties. Regulation is closely linked to self-monitoring (Frie et al., 2020). A study by Palmeira et al. (2023) regarding motivation and self-regulation factors in preventing weight regain emphasized self-regulation in action planning, coping planning, and action control, revealing that self-regulation is a mediator in the occurrence of weight regain.

Research has found that climate care and supportive environments have an indirect effect on weight change, where higher climate care scores also enhance action planning, coping planning, and actions, leading to better weight regain and prevention management (Palmeira et al., 2023).

Self Monitoring

Self-monitoring in weight loss programs aims to enhance self-awareness, encourage behaviors that support weight loss, and reduce obstructive habits, thereby helping achieve desired outcomes (Tang et al., 2024). The study by Phelan et al. (2023) revealed that a significant difference between individuals experiencing weight regain and those who do not is a decrease in self-monitoring. A combination of high frequency (≥3 days/week) and consistency in eating self-monitoring can enhance long-term weight loss success. The frequency of completing self-monitoring records is more important than the accuracy and completeness (Phelan et al. 2023).

Self-monitoring, as a weight loss strategy, plays a role in fostering intrinsic motivation by helping individuals set realistic goals and track their progress towards achieving them. When engaging in self-monitoring, individuals can see tangible results from their efforts, thereby enhancing their motivation to continue healthy behaviors (Palmeira et al., 2023). There are various reasons for neglecting self-monitoring among individuals with weight loss. In a study by Tang et al. (2024), the frequency of self-monitoring in weight-loss programs decreased as weight loss progressed. This aligns with Phelan et al. (2023), who revealed that individuals stop self-monitoring after reaching their weight target or regain weight to avoid negative experiences.

Weight Loss History

The success of weight loss achieved in weight loss programs plays an important role in long-term weight management. According to Chopra et al. (2020), the greater the weight loss achieved during a program, the more it can motivate patients to comply and build self-confidence in following the program. This motivation and self-confidence ultimately enhance individual engagement in the program through greater attendance frequency, application of health education, maintenance of self-monitoring, and other factors.

Small weight changes during weight loss programs have been identified as the primary factor leading to weight gain. Individuals who lose more weight during a weight-loss program are more likely to maintain long-term weight loss than those who experience less weight loss. Lower weight loss during dieting was associated with decreased satisfaction with the results, leading to disturbances in eating control and weight regain. Additionally, individuals with less weight loss during the program were perceived as less motivated and less engaged in changing their eating habits (Bajerska et al. 2020).

Breakfast Habit

The role of breakfast as a component of behavioral change interventions for weight loss has been extensively studied. Bajerska et al. (2020) stated that the habit of skipping

breakfast before a weight loss program is a final predictor of weight regain. This is because in that study, individuals who regularly skipped breakfast tended to have poor dietary adherence.

Research shows that breakfast can increase satiety hormones and reduce glucose and insulin levels in subsequent meals compared to individuals who skip breakfast (Duan et al., 2022). Skipping breakfast increased the risk of overeating the next meal. Additionally, a unique phenomenon occurs when someone skips breakfast, as genes referred to as "weight loss-related genes" remain inactive, resulting in higher blood sugar levels at lunch compared to individuals who eat breakfast (Eom et al., 2022).

A study by Elahy et al. (2023) found that limiting or avoiding eating after dinner and maintaining breakfast consumption habits could reduce the risk of weight and body fat regain. The study indicated that individuals who regularly have breakfast 5-7 times per week experience 0,59 kg less weight regain compared to those with irregular breakfast frequency (0-4 times per week). The study also reported that meal timing can reduce the risk of weight and body fat regain through metabolism and circadian rhythms. Skipping breakfast can disrupt fasting lipid levels and postprandial insulin sensitivity, leading to increased fat accumulation.

Another explanation is that breakfast can lead to fewer calories consumed in the evening. This is because breakfast synchronizes food intake with circadian metabolism, allowing most food intake to occur during biologically active hours according to endogenous circadian rhythms. Nevertheless, breakfast alone is not sufficient for successful weight loss; this habit can contribute to healthier eating patterns and physical activity, which are crucial for weight loss (Duan et al., 2022).

Environmental Contaminants

The pathogenesis of obesity is also influenced by obesogenic substances resulting from exposure to certain environmental toxins such as air pollutants and some industrial chemicals (Wang et al., 2022). Perfluorooctanoic acid (PFOA) and perfluorinated alkylates (PFAS), identified as obesogens, are among the most persistent bioactive substances (Grandjean et al., 2023). PFAS are chemicals that can resist fats, oils, water, and heat. The widespread use of PFAS and their presence in the environment have resulted in contamination of air, water, and soil (Dias et al., 2024). Study by Grandjean et al, (2023) related to weight loss relapse found that increased plasma concentrations of PFAS, particularly PFOA and perfluorohexanesulfonic acid (PFHxS), were associated with significant weight regain. In fact, the relationship between PFAS exposure and weight regain may be considered equal to or greater than that in the relationship and dietary trials.

PFAS exposure from food and the environment may have obesogenic effects that contribute to long-term weight gain following the initial weight loss. Grandjean et al. (2023) also found that weight regain after weight loss programs occurred in individuals exposed to double the PFAS levels. Individuals with doubled exposure to perfluorooctanoic acid (PFOA) were associated with the largest weight gain in that study (approximately 1,5 kg), whereas an increase of approximately 1 kg occurred in individuals with doubled exposure to other types of PFAS.

PFAS can cause obesity because they are classified as endocrine-disrupting chemicals (EDCs), leading to hormonal system disturbances (Frangione et al., 2024). PFAS interact with nuclear transcription factors, such as peroxisome proliferator-activated receptors (PPARs) and estrogen receptors. This interaction can disrupt metabolic processes, leading to changes in adipose tissue metabolism, including increased lipogenesis, decreased lipolysis, and insulin sensitivity disturbances, thereby increasing the risk of weight regain (Averina et al. 2021). Additionally, a cohort study found that PFAS can cause weight regain due to an inverse RMR (Frangione et al., 2024).

Anti-Obesity Medications

The term anti-obesity medication refers to drugs that have demonstrated significant weight loss effects (>5%). However, the use of antiobesity medications cannot be separated from a combination of lifestyle change interventions (Park et al., 2022). Anti-obesity medications optimize weight loss by affecting the body's physiology and helping individuals avoid or manage cravings for high-carbohydrate and high-fat foods as well as fast-processed foods. Previous studies have indicated that a combination of a Very Low-Calorie Diet (VLCD) and anti-obesity medications such as orlistat, sibutramine,

topiramate, and phentermine can lead to an average weight loss of 6,1 kg after one year of the program (Cifuentes et al., 2023). Antiobesity medications deemed safe by the FDA, such as orlistat, lorcaserin, bupropion/naltrexone-SR, phentermine/topiramate-ER, liraglutide, and semaglutide, have been studied and confirmed for their efficacy and safety for long-term use (Ghusn et al., 2022).

A study by Cifuentes et al. (2023) regarding the differences in weight regain among individuals with and without anti-obesity medications after weight loss programs revealed that individuals consuming anti-obesity medications exhibited better weight maintenance and significantly less weight regain than those not taking anti-obesity medications. In individuals taking anti-obesity medications, the average weight regained after the weight-loss program was 3,29 kg. This value is 4,32 kg less than that of individuals who did not take anti-obesity medications after the weight loss program (Cifuentes et al., 2023).

Conclusion

Weight regain occurs due to various factors, including changes in lean body mass, psychological factors such as decreased body image, disinhibition, and influences from food behavior, and environmental factors such as dietary adherence, unhealthy food environment, self-regulation, self-monitoring, weight loss history, breakfast habits, the presence of environmental contaminants, and the use of anti-obesity medications. Therefore, effective long-term weight loss management should consider these factors to prevent weight gain in obese individuals.

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Author Contributions

Annisa Farhah Ghinaa was responsible for the literature search, article screening, data collection from relevant studies, data collection from relevant studies, data analysis, and synthesized the findings into a narrative format. Annisa Rizky Maulidiana provided supervision and reviewed the final manuscript

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