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Review

Potential Regulatory Role of Appetite-Regulating Hormones and Exercise Associated with Emotional Eating: A Narrative Review

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ABSTRACT: Emotional eating denotes the behavior in which individuals regulate their emotions by eating in response to adverse emotions or psychological stress. Emotional eating is tightly linked to health issues such as obesity and metabolic disorders, and may give rise to unhealthy eating habits. The aim of this review is to investigate the psychological and physiological mechanisms of emotional eating, probe the potential impact of exercise as a tool for emotional regulation in emotional eating, and its role in avoiding the development of emotional eating into binge eating disorder. In addition, the review assesses gender differences and the potential risks of exercise interventions, aiming to provide theoretical support for clinical applications. A literature search was performed to assess the literature relevant to the role of appetite-controlling hormones and exercise in emotional eating. The search process covered multiple databases, including PubMed, Web of Science, Scopus, and Google Scholar. It used a combination of keywords such as "emotional eating", "appetite-controlling hormones", "exercise", and "mood regulation" to ensure comprehensive coverage of relevant areas. Inclusion criteria were original research, review articles, and meta-analyses published in English with adult participants. Exclusion criteria included studies relevant to non-emotional appetite changes due to diseases, studies without exercise interventions, and those missing physiological data. The final selected literature was reviewed and considered by independent reviewers to ensure the quality and relevance of the research. Studies suggest that emotional eating is tightly relevant to dysfunction in emotional regulation mechanisms. Specifically, when encountering adverse emotions, individuals may choose high-calorie foods to seek emotional comfort. Exercise, as an effective method of emotional regulation, can reduce emotional eating by modulating appetite hormones (such as leptin and ghrelin) and enhancing emotional well-being. However, the effects of exercise differ by gender, with women generally more likely than men to regulate emotions and lower appetite through exercise. Despite the positive regulatory effects of exercise, intense exercise may also give rise to adverse psychological and physiological effects, such as anxiety, depression, and overtraining syndrome. Hence, exercise interventions should be modified according to individual conditions to avoid excessive risks. Emotional eating overlaps with a binge eating disorder, and if emotional eating is not efficiently managed, it may progress to a binge eating disorder. Thus, exercise interventions could act as an effective means of preventing emotional eating from evolving into a binge eating disorder. In summary, this review emphasizes the importance of emotional regulation in modulating emotional eating, and the positive role of exercise interventions in emotional eating, notably in avoiding binge eating disorder. Future research should further probe the optimal exercise intervention strategies and focus on gender differences and the potential risks of exercise interventions.

Keywords: Emotional eating; Appetite-regulating hormones; Exercise; Leptin; Ghrelin; Insulin

1. Introduction

Emotional eating denotes the behavior of individuals who eat to ease adverse emotions during emotional fluctuations or under stress. This eating behavior is driven not by physiological hunger but by psychological and emotional factors, often accompanied by the consumption of high-calorie, high-sugar, or high-fat foods [1]. With the acceleration of the pace of life in modern society, notably in environments with high work pressure, many people seek

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emotional comfort through eating [2]. In the long term, emotional eating may cause health problems such as obesity and metabolic syndrome, further worsening emotional distress and developing a vicious cycle [3].

The mechanism of emotional eating is complex, concerning various factors in both physiology and psychology. lately, researchers have focused on the role of appetite-controlling hormones in emotional eating. Appetite-regulating hormones, such as leptin, ghrelin, and insulin, not only control energy balance and hunger but are also influenced by emotional fluctuations and stress, playing a crucial role in emotional eating [4]. The fluctuations of these hormones could be the physiological basis of emotional eating, and conversely, emotional eating may interrupt the secretion of these hormones [5]. Hence, recognizing the relationship between appetite-controlling hormones and emotional eating is crucial for investigating potential intervention strategies. In addition to hormone regulation, exercise, as a natural method of emotion regulation, has also gained increasing academic attention recently. Exercise denotes planned and purposeful physical activities, including aerobic exercise, strength training, yoga, Pilates, etc. Regular exercise can enhance cognitive function and emotional state, notably after a four-week exercise program [6]. The enhancement of this emotion may affect an individual's reward response to food, thereby controlling emotional eating behavior to some extent [7]. Existing studies have shown that exercise can enhance emotional states, reduce stress and anxiety, and influence eating behavior by regulating the secretion of appetite-controlling hormones [8,9]. For instance, average exercise can lower leptin levels, notably with long-term exercise, which may help lower body fat and enhance metabolic health [8,9]. Hence, appropriate exercise intervention may supply an effective non-drug intervention method for emotional eating. However, the potential risks that exercise may bring, especially the adverse effects of vigorous exercise, are detrimental to eating [10].

Although existing studies have probed the relationship between appetite-controlling hormones and emotional eating and initially revealed the regulatory role of exercise.However, the reviews or meta-analyses on this topic in the current literature are relatively constrained. A network meta-analysis mainly focused on the psychological mechanism of emotional eating [11], and a meta-analysis focused on the impact of exercise on appetite-controlling hormones [12], etc. However, few studies have comprehensively considered the dual effects of appetite-controlling hormones and exercise on emotional eating, and there are still scanty relevant reviews on the interaction between the two, notably on the intervention strategies in clinical applications.

Existing studies suggest that exercise not only enhances emotional well-being and reduces stress and anxiety, but also influences eating behavior by regulating appetite-controlling hormones. By reviewing the existing literature, we hope to offer new insights into the physiological mechanism and intervention strategies of emotional eating, notably to supply a scientific basis for clinical interventions for obesity and metabolic health problems.

2. Methods

2.1. Literature Search Strategy

To systematically assess the literature relevant to appetite-controlling hormones and the role of exercise in emotional eating, we conducted a comprehensive literature search. The search process covered multiple databases and followed a specific search strategy to ensure diversity in sources and breadth of research.

We used the following primary databases for the search: PubMed (including MEDLINE), Web of Science, Scopus, and Google Scholar.

2.2. Search Strategy and Key Words

The design of the search strategy adhered to best practices for literature selection, ensuring that all relevant research areas were covered. The following combination of key words and subject terms were used during the search: Emotional eating or stress eating; Appetite-controlling hormones (such as leptin, ghrelin, insulin); Exercise or physical activity; Mood regulation or emotion regulation; Energy balance. All key words were combined using Boolean operators (AND/OR) to ensure comprehensive coverage of related research areas. The final search string was: ("Emotional eating" OR "stress eating") AND ("Appetite-controlling hormones" OR "leptin" OR "ghrelin" OR "Insulin") AND ("Exercise" OR "physical activity") AND ("Mood regulation" OR "emotion regulation") AND ("Energy balance").

2.3. Literature Selection Criteria

The inclusion criteria for this review were as follows: the study addressed topics related to emotional eating, appetite-controlling hormones, or exercise interventions; the study was published in English; the study was original research, a review article, or a meta-analysis; and the study involved adult participants. The exclusion criteria included studies focusing solely on non-emotional appetite changes due to diseases, such as physiological appetite disorders; studies that were conference abstracts, reviews, opinion articles, or lacked original data; and studies that did not involve exercise interventions or lacked relevant physiological data.

2.4. Literature Filtering Process

Following the initial search, all retrieved literature, encompassing titles, abstracts, and keywords, was screened by two independent reviewers. Each reviewer assessed the articles to determine their compliance with the predefined inclusion and exclusion criteria. In instances of disagreement between reviewers, discussions were conducted to achieve consensus. Should disagreements remain unresolved, a third reviewer was engaged in the decision-making process. This rigorous filtering procedure culminated in the selection of literature for comprehensive analysis and synthesis.

2.5. Search Date

The literature search was completed in September 2024. All results were organized according to this date to ensure the timeliness and relevance of the literature. The selected literature is research conducted between 2000 and 2024.

3. Findings

3.1. Overview of Emotional Eating

3.1.1. Definition and Mechanisms of Emotional Eating

Emotional eating means eating behavior prompted by emotions rather than physiological hunger. Its characteristic is that this eating is not to fulfill the body's energy needs but to ease emotional stress. This type of eating is frequently induced by adverse emotions, such as stress and anxiety, with individuals typically selecting high-energy foods like sweets or fried foods [3]. Emotional eating lacks satiety regulation and often appears as overeating, even when the body does not need additional energy.

Normal eating behavior is typically prompted by the body's energy needs, governed by internal signals like ghrelin. When energy expenditure is high or blood sugar levels drop, the body produces a feeling of hunger to prompt eating and preserve physiological balance [13]. However, emotional eating is more affected by emotional and psychological factors. Under emotional stress, eating behavior boosts substantially [3].

3.1.2. Psychological and Physiological Links between Emotions and Eating Behavior

The mechanisms behind emotional eating are complex, concerning both psychological and physiological aspects. Psychologically, adverse emotions such as stress, anxiety, and depression are typically considered primary causes of emotional eating. Research indicates that under emotional stress, individuals may undergo a decrease in self-regulation and fail to employ normal emotional regulation strategies, resulting in eating high-sugar or high-fat foods as a coping mechanism [14,15]. Such foods can improve mood in the short term, offering a sense of pleasure or comfort, rendering them a quick choice for emotional relief.

Physiologically, emotional eating is tightly relevant to the brain's reward system. Sugary and fatty foods quickly induce the dopamine system, activating the neural circuits linked to pleasure, like a self-reward process [15]. However, this reward mechanism functions varyingly during emotional lows. Studies have suggested that in emotional eaters, the activation of brain reward regions such as the nucleus accumbens (NAcc), caudate nucleus, and putamen tends to be lower under stress, prompting individuals to compensate by overeating [16].

In addition, the HPA axis (hypothalamus-pituitary-adrenal axis) is involved in emotional eating. Stress boosts cortisol secretion through the HPA axis, which activates the release of hormones such as ghrelin, enhancing the desire for high-calorie foods. Failure of emotional regulation strategies is another core mechanism behind emotional eating. When individuals are unable to regulate adverse emotions, eating often efficiently becomes a substitute coping mechanism [17]. Extended exposure to emotional stress, notably when other regulation methods are missing, makes individuals more likely to turn to eating as an escape from adverse emotional undergoes [17]. These mechanisms

illustrate that emotional eating is not just a direct response to psychological stress but is also affected by complex neurophysiological and emotional regulation mechanisms.

However, emotional eating is not just a direct response to psychological stress. It is also affected by complex neurophysiological and emotional regulation mechanisms. Recent studies indicate that emotional regulation not only influences emotional eating behavior but also plays a key role in gender differences [18]. Specifically, there are significant differences in eating behavior between males and females when facing emotional stress, notably in obese surgical candidates, where gender differences play a progressively prominent role in pathological eating behavior styles. The role of emotional regulation in gender differences has bee n widely studied. Women often rely more on emotional regulation strategies, such as eating when facing adverse emotions, which could be relevant to the flexibility of emotional regulation and the use of strategies [19,20]. In addition, a article has indicated that women exhibit greater strategic diversity and higher situational sensitivity in the process of emotional regulation, which could be one of the reasons why they choose eating as a coping strategy when encountering emotional distress [11]. Conversely, men may use various coping strategies, such as controlling emotions through other behaviors such as exercise or social activities [19]. Hence, comprehension of the impact of gender differences and emotional regulation mechanisms on pathological eating behavior styles can help to more comprehensively clarify the physiological and pathological mechanisms of emotional eating and supply more targeted intervention strategies.

Overall, emotional eating is not only an abnormal manifestation of eating behavior but also a critical component of emotional regulation and psychological coping mechanisms. Understanding the intricate interactions between the psychological and physiological aspects will provide a more comprehensive insight into the driving forces behind this behavior.

3.2. Appetite-Controlling Hormones Relevant to Emotional Eating

This section discusses appetite-controlling hormones relevant to emotional eating. Leptin, produced by fat cells, controls appetite and energy balance through interactions with the hypothalamus, but emotional and psychological stress can cause leptin resistance, disturbing its regulatory mechanism and resulting in overeating. Ghrelin, produced by stomach endocrine cells, is the only known hormone with a strong appetite-motivating effect and is tightly linked to the brain's reward system; emotional fluctuations can lead to abnormal rises in ghrelin levels, promoting emotional eating. Insulin, discharged by the pancreas, controls blood glucose levels and appetite control; insulin resistance in emotional eaters impairs the brain's insulin signaling and boosts the risk of overeating. In addition, gastrointestinal hormones such as GLP-1 and PYY play significant roles in appetite regulation. Still, extended stress and preference for high-energy foods in emotional eaters can interrupt their secretion and further affect appetite control. Table 1 illustrates Appetite-controlling Hormones and Their Roles in Emotional Eating.

Table 1. Appetite-controlling Hormones and Their Roles in Emotional Eating.

Hormone	Mechanism	Manifestation in Emotional Eating	References
Leptin	produced by fat cells, interplays with the hypothalamus to regulate appetite and energy balance. When fat stores rise, it suppresses appetite and promotes energy expenditure; when fat reserves decrease, it activates appetite. Also involved in controlling insulin sensitivity, lipolysis, and energy expenditure.	Emotional and psychological stress often promotes leptin resistance, causing overeating. Stress can activate the HPA axis, modifying leptin secretion and function, making individuals more likely to consume high-calorie foods in response to adverse emotions.	[13–16]
Ghrelin	produced by endocrine cells in the stomach, interplays with hunger receptors in the hypothalamus to activate eating behavior and is tightly linked to the brain's reward system. Levels rise during fasting and drop after eating.	Emotional fluctuations, notably stress and anxiety, cause abnormal rise in ghrelin levels, driving cravings for high-calorie foods even when not hungry. It shapes the brain's reward pathways, creating a positive feedback loop for emotional eating. Emotional eaters have a slower decline in ghrelin levels under stress.	[15,17–19]
Insulin	produced by the pancreas, controls blood glucose levels and helps control appetite by operating on the hypothalamus, activating anorexigenic pathways and blocking orexigenic pathways.	Emotional eaters, notably obese ones, often have insulin resistance, which impairs the brain's insulin signaling and impairs the perception of fullness. Emotional stress and anxiety worsen insulin resistance.	[11,19–21]
GLP-1, PYY	produced by L-cells in the gut after eating, induce insulin secretion, suppress appetite, and enhance feelings of fullness to regulate eating behavior and preserve glucose homeostasis.	Extended stress may interrupt their normal secretion, lowering satiety and making individuals more prone to overeating. Emotional eaters' preference for high-energy foods may modify their secretion patterns and affect appetite control.	[22–24]

3.2.1. Leptin and Emotional Eating

Mechanism of Leptin and Its Role in Controlling Appetite and Energy Balance

Leptin is a hormone produced by fat cells that mainly controls appetite and energy balance through interactions with the hypothalamus. Its mechanism entails complex signal transduction pathways. When body fat stores rise, leptin levels rise and bind to receptors in the hypothalamus, sending a signal to the brain that energy is sufficient, thereby curbing appetite and promoting energy expenditure. Conversely, when fat reserves decrease, leptin levels drop, increasing appetite to preserve energy balance [21]. Leptin performs a core role in controling appetite and energy balance by impoperating both orexigenic (appetite-motivating) and anorexigenic (appetite-curbing) neurons in the hypothalamus. It is also involved in controlling insulin sensitivity, lipolysis, and energy expenditure by activating the JAK-STAT signaling pathway and other related metabolic pathways [21].

How Emotional and Psychological Stress Affect Leptin's Role in Emotional Eating

In the context of emotional eating, although leptin should theoretically suppress eating, emotional and psychological stress often interrupts this regulatory mechanism. Research indicates that prolonged stress and emotional fluctuations can lead to leptin resistance, meaning that even with elevated leptin levels, the brain fails to interpret the signal, resulting in overeatingResearch properly [22,23]. This theory is like leptin resistance in obese individuals, resulting in overeating. Moreover, stress can activate the hypothalamic-pituitary-adrenal (HPA) axis, modifying leptin secretion and function, making individuals more likely to consume high-calorie foods in response to adverse emotions. This response is evident in individuals more sensitive to stress, where stress boosts impulsive eating and changes dietary preferences, often resulting in higher intake of sugary and fatty foods [24].

3.2.2. Ghrelin and Emotional Eating

The Core Role of Ghrelin in Controlling Hunger

Ghrelin is a hormone produced by endocrine cells in the stomach, particularly P/D1 cells in the gastric fundus in humans. It is currently the only known hormone with a strong appetite-motivating effect. Ghrelin interacts with hunger receptors in the hypothalamus to trigger eating behavior and is closely linked to the brain's reward system. Studies indicate that ghrelin levels rise during fasting and drop rapidly after eating, aiding individuals to perceive hunger and satiety [25,26]. Ghrelin's role in motivating appetite extends beyond energy needs and is also linked to neural regulation and the brain's reward system. By binding to growth hormone secretagogue receptors (GHSR), ghrelin shapes food intake, gastric acid secretion, and gastrointestinal motility [25,26].

How Emotional Fluctuations Affect Ghrelin Levels and Promote Emotional Eating

Emotional fluctuations, particularly stress and anxiety, substantially affect ghrelin secretion. Research suggests that during periods of high stress or adverse emotions, ghrelin levels rise abnormally, a theory tightly relevant to emotional eating. Specifically, when individuals undergo stress, the increase in ghrelin triggers cravings for high-calorie, high-fat, or sugary foods, even in the absence of hunger [23–27]. Ghrelin is not only a key hormone in appetite regulation but also closely connected to the brain's reward system. It shapes the central nervous system's reward pathways, prompting individuals to seek comfort foods when feeling down, creating a positive feedback loop that boosts the frequency and intensity of emotional eating [27]. Furthermore, ghrelin's appetite-motivating effects are notably pronounced during stress responses. Studies have found that emotional eaters do not experience the same rapid decline in ghrelin levels under stress, which explains their tendency to use eating as a way to relieve stress [23].

3.2.3. Insulin and Emotional Eating

The Role of Insulin in Glucose Regulation and Appetite Control

Insulin, produced by the pancreas, mainly controls blood glucose levels. When blood sugar rises, insulin promotes glucose uptake into cells for energy, lowering blood sugar levels [28]. Furthermore, insulin helps regulate appetite by operating in specific regions of the brain, particularly the hypothalamus. It activates anorexigenic pathways (e.g., POMC neurons) while blocking orexigenic pathways (e.g., NPY/AgRP neurons), resulting in a feeling of fullness [29]. This mechanism emphasizes insulin's crucial role in appetite control and weight regulation.

The Association between Insulin Resistance and Emotional Eating

Emotional eaters, notably those who are obese, often undergo insulin resistance. This insulin resistance impairs the brain's insulin signaling, hindering the perception of fullness. Studies suggest that insulin's role in the brain not only regulates metabolism but also interacts with the dopamine system, influencing appetite and emotional behavior.Insulin resistance reduces the brain's response to insulin, making it harder for emotional eaters to feel full, increasing the risk of overeating [30]. In addition, emotional stress and anxiety are believed to worsen insulin resistance, which is relevant to dysfunction of the stress axis. Chronic stress boosts cortisol secretion, which enhances inflammation and promotes fat accumulation, a process tightly linked to insulin resistance, creating a vicious cycle [31]. Consequently, emotional eaters may struggle to feel satisfied even after consuming sufficient food, eventually increasing the risk of obesity and metabolic disorders.

3.2.4. Other Relevant Hormones: GLP-1, Peptide YY (PYY), and Others

In addition to leptin, ghrelin, and insulin, gastrointestinal hormones such as glucagon-like peptide-1 (GLP-1) and peptide YY (PYY) play important roles in appetite regulation. Research has indicated that GLP-1 and PYY are produced by L-cells in the gut after eating. These hormones induce insulin secretion and suppress appetite, enhancing feelings of fullness, thus aiding in regulating eating behavior [32]. Beyond their role in appetite control, these hormones are also vital in preserving glucose homeostasis [33].

In the context of emotional eating, extended stress may interrupt the normal secretion of GLP-1 and PYY, resulting in diminished feelings of fullness and making individuals more prone to overeating [32]. Furthermore, emotional eaters tend to prefer high-energy foods, which may modify the secretion patterns of these hormones, further operating appetite regulation [34].

These findings suggest that the interaction between GLP-1, PYY, and emotional stress plays a crucial role in understanding the physiological drivers of emotional eating.

Table 1 summarizes several appetite-controlling hormones linked to emotional eating and their mechanisms of action. Leptin, gastric hunger hormone, insulin, along with GLP-1 and PYY play core roles in controlling appetite and energy balance. Emotional stress and psychological volatility can give rise to dysfunction of these hormones, which in turn prompts individuals to develop strong cravings for high-calorie foods, especially in anxious or stressful situations, often resulting in overeating. The table describes in detail how these hormones affect eating behavior and food choices by interfering with the brain's appetite control system.

3.3. Exercise's Impact on Emotional Eating via Appetite-Controlling Hormones

Exercise not only improves physical fitness and promotes overall health but also helps regulate appetite hormones and combat emotional eating. By modulating appetite-controlling hormones like leptin, ghrelin, and insulin, exercise may play an important role in intervening in emotional eating. In addition, the positive effects of exercise on emotional well-being can indirectly lower the occurrence of emotional eating, notably with long-term adherence to exercise routines. Figure 1 depicts the role of exercise on emotional eating via appetite-controlling hormones.

This figure illustrates the mechanism by which exercise affects emotional eating by controlling appetite hormones. The diagram centers on the "effect of exercise on emotional eating". It proceeds downward to illustrate how different types and intensities of exercise affect each of the three main appetite-controlling hormones: Leptin, Ghrelin, and Insulin. Further describe how these hormonal changes eventually modulate emotional eating behavior by increasing leptin sensitivity, curbing gastric hunger hormone secretion, and strengthening insulin sensitivity.

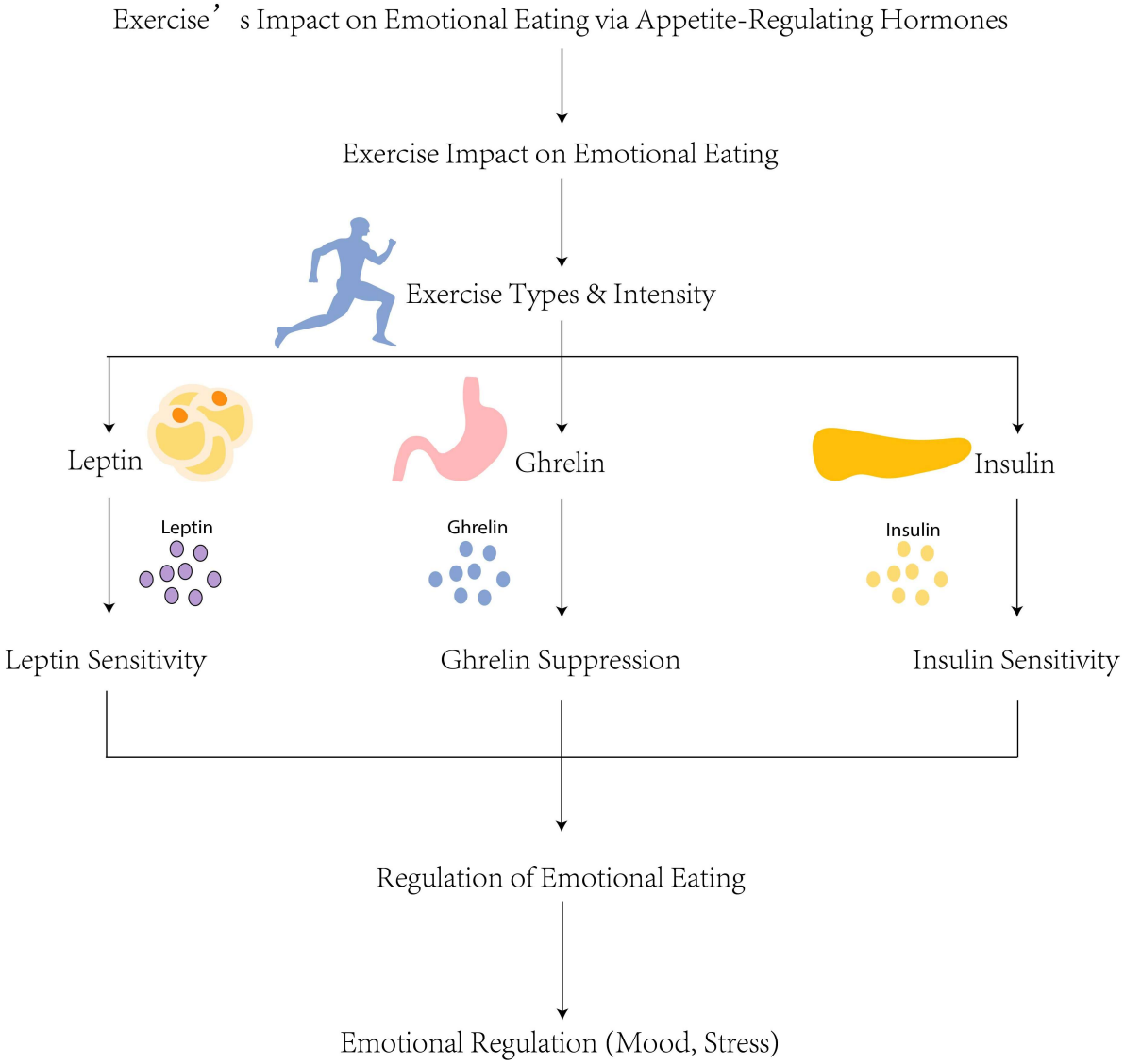

Figure 1. Role of exercise on emotional eating via appetite-controlling hormones.

3.3.1. The Direct Impact of Exercise on Appetite-Controlling Hormones

How Different Types and Intensities of Exercise Affect Leptin, Ghrelin, and Insulin Levels

Research indicates that exercise, notably average to high-intensity aerobic exercise and strength training, substantially shapes the secretion of hormones like leptin and ghrelin. Regular exercise can improve leptin sensitivity, meaning that although leptin levels may temporarily decrease after short-term exercise, long-term exercise helps restore its regulatory function. Moderate to high-intensity aerobic exercise and strength training, particularly after at least 12 weeks of training, have been shown to significantly reduce leptin levels in obese individuals, thereby improving appetite control [35,36].

In addition, the secretion of ghrelin is tightly relevant to exercise intensity. Short-term high-intensity exercise tends to suppress ghrelin secretion, lowering hunger, while light exercise has a lesser effect on ghrelin. For instance, one study observed that short bouts of high-intensity interval training (HIIT) in obese individuals efficiently suppressed ghrelin levels [35]. Moderate to high-intensity aerobic exercise and strength training, particularly after at least 12 weeks of training, have been shown to significantly reduce leptin levels in obese individuals, thereby improving appetite control [37]. These findings emphasize the different effects of various intensities and types of exercise on appetite regulation, notably in lowering the risk of overeating by modulating leptin and ghrelin levels.

Can Exercise Act as an Effective Means to Regulate Emotional Eating by Modifying Hormone Levels?

Exercise can regulate appetite-controlling hormones like leptin, ghrelin, and insulin, aiding control of appetite and lower emotional eating. Studies indicate that moderate exercise can significantly lower ghrelin levels, reducing hunger,

while also enhancing insulin sensitivity to help maintain stable blood sugar levels and prevent binge eating triggered by emotional fluctuations [38]. In addition, long-term regular exercise has increased leptin sensitivity, enhancing feelings of fullness and efficiently curbing non-physiological appetite [39]. These mechanisms illustrate that exercise, as a natural and effective intervention, can help control excessive eating behavior by controlling hormone balance.

3.3.2. The Role of Exercise in Emotion Regulation and Its Indirect Impact

Exercise's impact on emotional eating extends beyond hormonal regulation and is tightly linked to its positive effects on emotional states. Studies suggest that regular exercise can substantially reduce adverse emotions such as anxiety and depression by controlling neurotransmitters like dopamine and endorphins. These "feel-good hormones" act through the brain's reward system, boosting mood and well-being, which helps reduce the impulse to engage in emotional eating. [40]. In addition, exercise helps individuals manage stress more efficiently by controlling stress responses, lowering the likelihood of binge eating during emotional breakdowns [11,17–40]. For instance, studies suggest that emotional dysregulation is tightly linked to impulsive behaviors like binge eating, and exercise can efficiently reduce such impulsive behaviors [11,17–40]. Regular physical activity not only improves mental health but also significantly reduces the tendency to use eating as a way to cope with negative emotions.

3.3.3. The Long-Term Effects of Exercise: Avoiding Emotional Eating

How Ongoing Exercise Habits favorably Impact the Long-Term Prevention of Emotional Eating

Long-term commitment to exercise performs a significant role in controlling appetite hormones and avoiding emotional eating. Regular exercise helps enhance the sensitivity of leptin and insulin, both of which are crucial in controlling appetite and energy metabolism. Studies suggest that long-term exercise can enhance insulin sensitivity and lower the risk of insulin resistance, thereby strengthening metabolic function [41]. In addition, exercise has a notable effect on leptin regulation. Leptin, a hormone produced by fat tissue, controls appetite and energy balance by operating on the hypothalamus. Regular exercise can reduce leptin resistance, improve leptin sensitivity, and help the body better recognize fullness, thereby reducing emotional eating [42]. Meanwhile, exercise helps preserve body weight, avoiding obesity and metabolic issues caused by emotional eating [35–41]. Hence, long-term exercise not only promotes physical health but also helps prevent and manage emotional eating by stabilizing appetite hormones and enhancing metabolic function.

The Effectiveness of Specific Exercise Types and Frequencies in avoiding Emotional Eating

Research indicates that average-intensity aerobic exercise (such as running, swimming, or cycling), coupled with strength training and flexibility exercises (like yoga or Pilates), is extremely effective in avoiding emotional eating. These forms of exercise not only enhance emotional regulation but also help individuals better cope with adverse emotions and lower the urge to eat on impulse. Exercising 3 to 5 times a week for at least 30 min per session is considered the most effective strategy for avoiding emotional eating [43,44].

Ongoing exercise not only enhances self-efficacy but also boosts psychological resilience and reduces negative emotions like depression and anxiety, helping individuals develop healthier lifestyle habits and further decreasing the likelihood of emotional eating [45,46].

3.3.4. Individual Differences and Exercise Intervention Strategies

When investigating the impact of exercise on emotional eating, individual differences in response to exercise are significant. Studies indicate that genetic variations, age, sex, and lifestyle factors all influence the effectiveness of exercise interventions. For example, genetic factors may complicate the body's response to exercise, with some studies suggesting that certain genes affect weight management and appetite regulation in response to exercise [47,48]. In addition, age and sex are also indicated to affect dietary patterns and responses to exercise, notably in dealing with emotional eating [49].

In addition, counting exclusively on exercise interventions to control emotional eating could be insufficient, notably for individuals with severe emotional eating or co-occurring emotional disorders. Cognitive-behavioral therapy (CBT) combined with exercise interventions is regarded as a more effective strategy. CBT helps individuals identify and change adverse emotional coping patterns, and when coupled with exercise, it substantially lowers the frequency of emotional eating while strengthening mental health [50]. Hence, personalized intervention plans are crucial, requiring

adjustments to exercise duration and intensity based on individual differences, alongside the integration of psychological interventions, such as CBT, to achieve more significant outcomes.

4. Limitations

4.1. Limitations of the Review Itself

4.1.1. Limitations of Review Methods

As this review is a narrative review, it usually focuses on outlining and discussing existing literature rather than strict filtering and quantitative analysis. Although we have thoroughly reviewed the relevant literature, we cannot guarantee that all pertinent studies are included, and the filtering criteria may introduce subjective biases. Compared to systematic reviews, this review failed to conduct a detailed literature quality assessment and data extraction, thus constraining the generalizability and reliability of its conclusions. We did not follow systematic review guidelines, such as PRISMA, nor did we perform rigorous quantitative literature analysis. As a result, our conclusions are primarily based on narrative summaries rather than a comprehensive analysis supported by higher levels of evidence.

4.1.2. Researcher Bias

The writing of this review is based on a review of existing literature, which could be affected by researchers' bias. For instance, research in certain fields could be overcited due to the bias of researchers' interests or funding sources. In contrast, some more peripheral or emerging research may not be thoroughly considered. Additionally, while we aimed for a comprehensive literature filtering process, resource and time constraints may have led to the exclusion of some relevant studies, affecting the completeness of the conclusions.

4.2. Limitations of Literature

4.2.1. Research Design and Methodological Limitations of Literature

Most of the literature relied on in this review is cross-sectional studies, observational studies, or small sample experimental studies. Although these studies supply precious insights, the extrapolation and reliability of their results are constrained due to methodological limitations such as sample selection bias, lack of control groups, or randomized designs. Most studies only supply a correlation between emotional eating and exercise interventions, rather than proof of causality. In addition, studies have not taken into account other potential shaping factors such as genes, lifestyle, socioeconomic status, etc., which may result in biased research results.

4.2.2. Differences in Types of Exercise Interventions

This review includes a variety of studies on exercise interventions, such as aerobic exercise, strength training, and yoga. However, there are significant differences in experimental design, intervention intensity, duration, and frequency among different types of exercise interventions. For instance, some studies use high-intensity interval training (HIIT), while others use low to average-intensity continuous exercise. Due to the lack of unified intervention standards, it is difficult to form universal conclusions between different studies. In addition, some studies lack clear descriptions of specific details of exercise interventions, such as intensity, duration, and frequency, further enhancing the possibility of inconsistent intervention effects.

4.2.3. Limitations of the Sample Population

Most studies in existing literature focus on specific sample groups, such as obese individuals, obese surgical candidates, or individuals with metabolic disorders. Although these studies supply precious insights for specific populations, their results could be difficult to apply to a wider population. For instance, emotional eating may have different manifestations among people of different ages, genders, and cultural backgrounds, and existing research has not thoroughly considered these differences. In addition, recent studies only focus on a single psychological or physiological factor, without considering the complexity of emotional eating, including environmental, socio-cultural background, and individual differences.

Limitations of Gender Differences

This review probes gender differences in emotional eating, but existing research is inconsistent in gender analysis. Some studies only analyze female or male populations, and supply constrained in-depth discussions on comparative studies of different genders. Hence, although we stated in the review the impact of gender differences on the effectiveness of emotional eating and exercise interventions, there is still some uncertainty in this conclusion due to the limitations of existing literature. Future research should strengthen systematic analysis of different gender groups to reveal the specific role of gender in emotional eating.

Short-Term Nature of Research Results

Although studies have investigated the short-term effects of exercise on emotional eating, there is scanty long-term follow-up research. Hence, existing research concentrates more on immediate intervention effects and fails to supply data on the long-term effects of exercise intervention on emotional eating. The lack of long-term effects makes it difficult for us to evaluate the ongoing effectiveness and sustainability of exercise as an emotional regulation tool.

5. Conclusions and Outlook

The relationship between emotional eating, appetite-controlling hormones, and exercise is a complex interactive process. Emotional eating is driven not only by psychological and emotional factors but also by physiological mechanisms, particularly changes in appetite-regulating hormones such as leptin, ghrelin, and insulin. These hormones play crucial roles in controlling appetite and energy balance, but their functions are often interrupted under emotional stress, resulting in increased eating impulses. Exercise, as a natural emotion-regulation strategy, effectively addresses emotional eating by improving leptin sensitivity, reducing ghrelin secretion, and enhancing insulin sensitivity. It also helps reduce adverse emotions through neurotransmitter regulation.

Future research could further explore the specific regulatory mechanisms of various hormones in emotional eating, particularly the interaction between hormones and the brain's reward system, as well as individual differences in hormonal responses. In addition, investigating how different types and intensities of exercise can optimize hormone regulation is a precious area for further study. In practical applications, research findings can guide public health policies, enhancing exercise as an intervention for emotional eating while supplying individuals with personalized health strategies according to hormone assessments. Combining exercise with psychological interventions, such as cognitive-behavioral therapy (CBT), may offer a more effective way to help individuals manage emotions, control appetite, and eventually promote overall health.

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Author Contributions

Conceptualization, J.K.; Methodology, J.K. and R.F.; Validation, J.K.; Investigation, R.F.; Writing–Original Draft Preparation, R.F.; Writing–Review & Editing, J.K.; Supervision, J.K. and Y.X.; Project Administration, J.K.

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