The Role of Stress in Obesity and Relevant Interventions

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Abstract: The prevalence of obesity is on the rise, which significantly increases the burden on global healthcare expenditures and profoundly impacting both physical and mental health. It has become a major public health challenge that urgently needs to be addressed in today's society. Obesity is influenced by multiple factors, including stress, genetics, hormones, and neuroendocrine elements, with lifestyle and epigenetic changes also playing significant roles. Stress impacts various physiological systems, including the brain, memory, cognition, immune response, cardiovascular health, and endocrine function. It can also trigger obesity by affecting appetite regulation, reward sensitivity, and hormonal balance. Understanding the relationship between stress and obesity is crucial for developing effective interventions. Recent research highlights that stress significantly affects eating behaviors, leading to weight gain, while obesity can exacerbate stress and disrupt life balance. Effective interventions include mindfulness training, which improves self-awareness, positive emotions, and psychological flexibility, and reduces stress, anxiety, and depression. Stress management programs and physical activity are also beneficial for weight loss and overall health. However, the limitations of small sample sizes, short intervention periods, limited participant diversity, and reliance on self-reported measures may undermine the generalizability and accuracy of the findings of previous research. Future research should focus on larger, diverse samples, long-term studies, and incorporate both objective measures of stress and self-reported data to better understand and manage obesity and stress.

Keywords: stress, obesity, mindfulness intervention, eating behaviors, physical activity.

1. Introduction

Obesity is characterized by excessive body fat accumulation, typically measured by a Body Mass Index (BMI) over 30, and is associated with various health issues like diabetes and cardiovascular diseases [1]. Stress is the psychological and physiological response to challenges and demands from external or internal sources, leading to feelings of tension and anxiety [2]. Understanding the link between stress and obesity is crucial as it can reveal how stress contributes to unhealthy eating behaviors and metabolic changes, which in turn lead to weight gain. Studying this topic can lead to the development of targeted interventions, such as stress reduction programs, cognitive-behavioral therapy, and supportive environments. These interventions can help individuals manage stress more effectively, thereby preventing obesity and promoting overall health.

Obesity has dramatically increased in recent decades due to a combination of environmental, hormonal, and genetic factors [1]. Environmental contributors include reduced physical activity,

sedentary lifestyles, high-calorie diets, and certain medications. Genetic variations may predispose some individuals to obesity even with similar environmental exposures. Many genes associated with obesity interact with each other, and twin studies show a high heritability for eating behaviors, ranging from 53% to 84%. The fat mass and obesity-associated (FTO) gene, though well-studied, shows modest effects and lifestyle interactions. While monogenic obesity is rare, up to 200 single-gene mutations are known. Syndromic obesity, such as Prader-Willi, Bardet-Biedl, and Cohen syndromes, is uncommon but noteworthy. Neuroendocrine factors, like hypothyroidism and polycystic ovary syndrome (PCOS), also contribute.

Recent research highlights the role of epigenetic factors, including DNA methylation, microRNA expression, and noncoding RNAs, in obesity. Unlike genetic factors, epigenetic changes can occur throughout life due to lifestyle influences such as diet and physical activity. Understanding the central nervous system's role in appetite regulation, beyond the traditional focus on the hypothalamus, is crucial. Recent studies emphasize the importance of reward, emotion, memory, and cognitive control networks. Theories suggest that reduced sensitivity to rewards drives the consumption of high-fat or high-calorie foods, or increased sensitivity to food cues leads to excessive eating. This is supported by lower availability of dopamine D2 receptors and heightened brain activity in response to food cues in obese individuals. Obesity is linked to increased mortality, metabolic syndrome (insulin resistance, dyslipidemia, hypertension, type 2 diabetes), and worsened PCOS through insulin resistance and hyperandrogenism. It exacerbates obstructive sleep apnea (OSA) and raises cancer risk, with higher BMI correlating with greater risk. Addressing obesity is crucial for overall health improvement [1].

Stress triggers a biological response and can act as both a catalyst and an aggravating factor for many diseases and pathological conditions. Its impact is far-reaching, affecting multiple physiological systems including the brain, memory, cognitive learning, the immune system, the cardiovascular system, the digestive system, and the endocrine system. For instance, chronic stress has a profound effect on brain function, leading to brain atrophy and reduced volume, particularly in the hippocampus, which plays a crucial role in memory, cognition, and emotional responses. Stress hormones like cortisol can cause hippocampal atrophy, hinder neurogenesis, and impair both spatial and declarative memory [2].

The effects of stress on memory are complex; it can enhance or impair memory depending on the type, intensity, and duration of the stress. While acute stress, such as that experienced during exams, can temporarily boost memory, chronic stress often leads to memory impairments. Stress also influences cognitive learning by affecting neurotransmitters and neuropeptides, thereby impacting learning, decision-making, attention, and judgment. The immune system is similarly affected, with stress altering immune cell activity and hormone secretion, which can increase susceptibility to infections and diseases. The cardiovascular system is notably responsive to stress. When stress activates the sympathetic nervous system, it causes an elevated heart rate and constriction of blood vessels, subsequently increasing the risk of developing heart disease and hypertension. Stress also affects the digestive system by altering gastrointestinal motility, absorption, secretion, and inflammatory responses, increasing the likelihood of disorders such as irritable bowel syndrome and inflammatory bowel disease. Moreover, stress interacts broadly with the endocrine system, affecting processes related to the hypothalamus, pituitary gland, adrenal glands, and other endocrine organs. Research on stress is essential, as it sheds light on both its beneficial and detrimental effects on health. While stress plays a role in maintaining cellular and species homeostasis, severe or prolonged stress can lead to various pathological conditions. Understanding the intricate ways stress affects the body through hormones, neuroendocrine mediators, and other factors is crucial for developing effective treatments to manage stress-related conditions [2].

The reviewed literature highlights the multifaceted impact of stress on various physiological and psychological systems, including brain function, memory, cognition, immune response, and

cardiovascular health. Concurrently, the mechanisms underlying obesity, such as genetic predispositions, environmental factors, central nervous system regulation, and homeostatic disruptions, are well-documented, along with its associated endocrine disorders and comorbidities. This review aims to bridge these domains by exploring the impact of stress on obesity, additionally, it will examine factors that may mediate the relationship between stress and obesity, providing a comprehensive understanding of their interrelationship.

2. The Relationship between Stress and Obesity

It is suggested that perceived stress among adolescents is significantly associated with higher levels of overweight/ obesity. Roy and his colleagues conducted a questionnaire test with 20 university students, using a stress questionnaire to assess the perceived stress among adolescents. Roy and his colleagues conducted related research using questionnaires to test 20 university students. The test covered six main areas: demographic background, socioeconomic information, physical activity, stress, eating behavior, and anthropometric data. The stress section of the questionnaire assessed ten different aspects of stress: family life, academic performance, school attendance, romantic relationships, peer pressure, teacher-student interactions, uncertainty about the future, conflicts between school and leisure, financial pressure, and emerging adult responsibilities. Additionally, the Dutch Eating Behavior Questionnaire was used to assess students' eating behaviors. This questionnaire measures three main aspects: first, emotional eating, which focuses on overeating in response to emotional stimuli. Second, external eating, which looks at eating in response to food-related cues without considering internal hunger and satiety; and third, efforts to control food intake, which examines restrictive eating behaviors. The students' BMI was also assessed [3]. The experimental data demonstrate that the majority of adolescents are experiencing moderate (55.7%) to extremely severe (61.5%) levels of stress. Among those with high stress, 28.5% are overweight or obese. All three types of eating behaviors are significantly positively correlated with adolescents' perceived stress and BMI. These results suggest that stress significantly influences eating behaviors, potentially leading to weight gain. Notably, among adolescents, only restrained eating behavior has a direct and significant link to overweight and obesity, indicating that efforts to control food intake might be more effective in managing weight than addressing emotional or external eating patterns.

In terms of stress assessment, Roy and his group primarily studied university students. Whether the impact of stress on eating behaviors and obesity can be generalized to a broader population requires further research. It has been shown that similar conclusions can be reached when the study population includes adult men and women from diverse backgrounds. Qiu and his colleagues did not find a direct association between stress life events and obesity. However, unhealthy eating behaviors, such as binge eating, dining out, irregular meal times, and eating before bedtime, significantly influenced the relationship between stress and obesity. They used a stress life events scale related to life events to assess the stress life events of Chinese civil servants. The scale includes 48 items, divided into several dimensions, including family-related events, work-related events, study-related events, health-related events, accident-related stress events, legal disputes, and economic issues. The study evaluated the dietary patterns of Chinese civil servants through four items. The questionnaire also assessed whether employees exhibited any of the following unhealthy eating behaviors in the past year: irregular meal times, binge eating, frequent dining out, and eating before sleep [4]. The data reveal that stressful life events among government employees are significantly associated with overeating, eating before bedtime, and eating out, all of which are significantly related to the risk of obesity. Stressful life events indirectly influence obesity through irregular meal timing. Overeating and eating out have significant mediating effects between stress and obesity, while the mediating effect of eating before bedtime is not significant for baseline obesity but is significant for obesity at follow-up. These results suggest that stress influences eating patterns, leading to unhealthy behaviors

that contribute to obesity. Consequently, interventions aimed at reducing obesity among government employees should focus not only on stress management but also on promoting healthier eating habits.

In studying the impact of stress on obesity, it has also been thoroughly investigated whether obesity itself increases stress and affects life. Kathleen and his associates found that obesity and conditions limiting physical activity negatively impact life balance and increase stress [5]. The research focused on adults aged 18 to 49 with self-reported medical conditions that restrict physical activity. Life balance was measured using a scale assessing alignment between the time spent on 53 activities and the time desired for these activities. This scale includes four subscales corresponding to demand dimensions: Health, Relationships, Identity, and Challenge. Perceived stress was measured with the questionnaire, which asked respondents about their feelings and thoughts over the past month, including four key items: feeling unable to control important aspects of life, confidence in handling personal issues, the perception that things are improving, and feeling that difficulties are piling up and are insurmountable.

The data signify that the obese group experienced higher perceived stress compared to the normal BMI group, with a larger mean difference in the life balance scale, indicating a more significant negative impact of obesity on life balance. Individuals with physical activity limitations had lower life balance scores and higher perceived stress compared to those without such limitations. The study highlights the need for interventions that promote balanced lifestyles and effective stress management, especially for those affected by obesity and restrictive medical conditions.

Research indicates that perceived stress is correlated with levels of overweight and obesity. While stress affects eating patterns and leads to weight gain, further research is needed to generalize these findings across different populations. Additionally, obesity itself increases stress and disrupts life balance, highlighting the need for interventions that combine stress management with promoting healthy eating habits and balanced lifestyles.

3. Effective Interventions for Individuals with Obesity

Research shows a direct link between perceived stress and obesity. Addressing this connection highlights the need for effective interventions to manage stress and its impact on weight. There is a significant relationship between stress and obesity, suggesting that effective stress management should significantly improve weight loss outcomes and mental health in this population. Niovi and his colleagues conducted relevant research in this area. This study involved 45 adults with obesity, divided into two groups: an experimental group (22 participants) and a control group (23 participants). All participants received standard healthy lifestyle guidance, but the experimental group also attended stress management sessions. These sessions were led by a professional with expertise in stress management, covering techniques such as progressive muscle relaxation, diaphragmatic breathing, and guided visualization. The study also utilized the Greek version of the PSS 14 to assess participants' stress levels, which measures perceived stress in response to life situations. This self-report tool was designed to evaluate the frequency of certain emotional states and thoughts over the past month [6]. The data show that significant differences were observed between the intervention and control groups in terms of BMI, stress levels, and eating habits before and after the intervention. These statistically significant differences suggest that the intervention may help in weight reduction. Additionally, the intervention group showed a significant decrease in perceived stress levels, positive changes in eating habits, notable improvements in physical activity, and increased satisfaction in various aspects of life. The research results indicate that incorporating stress management into obesity treatment can be more effective than standard lifestyle counseling alone.

In addition to common stress management techniques such as progressive muscle relaxation and diaphragmatic breathing, mindfulness interventions are also considered to play a crucial role in stress relief. Mindfulness refers to a mental state and practice defined as focusing on and accepting present-

moment experiences. It involves paying full attention to current sensations, thoughts, and emotions without judgment. Hooker and his research team found that for adults with obesity, mindfulness interventions can enhance mindfulness, positive emotions, psychological flexibility, and reflective thinking while reducing perceived stress, anxiety, depressive symptoms, and rumination [7]. The study enrolled 194 participants with BMI levels ranging from 30 to 45.9 kg/m², randomly assigning them into two groups. One group, consisting of 100 participants, received the mindfulness intervention, while the other group, with 94 participants, served as an active control. Both groups underwent changes in diet, exercise, and stress management, with the key difference being that one group received mindfulness training. To measure mindfulness, the researchers used the Five Facet Mindfulness Questionnaire (FFMQ), which includes 39 items covering five core facets: (1) observing sensations and thoughts; (2) describing with words; (3) acting with awareness; (4) non-judging of inner experience; and (5) non-reactivity to inner experience. Additionally, the 10-item Perceived Stress Scale was used to assess how stressful participants perceived their environment to be over the past month. The results showed that participants in the mindfulness group experienced significant improvements in overall mindfulness at both 6 and 12 months, as well as increased positive emotions at the follow-up point (conducted at 4 months). The study suggests that integrating mindfulness training into weight loss programs can foster positive psychological changes and improve mental health, highlighting the potential long-term benefits of mindfulness for psychological well-being in individuals with obesity.

Hooker 's questionnaire offered a broad assessment of mindfulness but did not thoroughly explore the finer details and specific applications of mindfulness skills. Therefore, Cotter and her research team employed a more detailed mindfulness scale for evaluation and investigation. Using data from 3,708 participants in the MIDUS II study, researchers first recorded whether participants had experienced any of 20 possible stress events during adulthood, such as being fired, losing a child, losing a sibling, or sexual assault. A psychosocial stress score was also created based on three independent stress domains: family stress, friend stress, and financial stress. Participants were asked to answer questions about their eating behaviors when experiencing stress. The researchers used a mindfulness scale to assess participants, the assessment mainly includes: (a) being more involved in the present, (b) being more sensitive to the feelings of others, (c) being more open to new ideas, (d) becoming a better listener, (e) being more patient, (f) noticing small changes in the environment, (g) being more tolerant of differences, (h) being more aware of different ways to solve problems, (i) seeing things in new ways [8]. The data highlight that stress-related eating mediates the relationship between stressful life events and BMI, with a more significant effect observed in women. Weight status also moderates the relationship between stress and stress-related eating, with a more pronounced effect in individuals with obesity. Mindfulness did not have a significant moderating effect in these models. This conclusion differs somewhat from Hooker’s findings [7-8]. A possible reason is that Hooker 's questionnaire may better reflect the deeper traits of mindfulness, which could directly influence an individual's psychological state and, in turn, affect stress and obesity. On the other hand, Cotter’s questionnaire focuses more on changes in behavior resulting from mindfulness rather than its direct psychological regulatory effects, which may lead to less significant results regarding the relationship between stress and obesity.

It is well known that physical activity triggers the release of endorphins, natural chemicals that improve mood and reduce pain. Therefore, in addition to the stress-relieving effects of mindfulness practices, physical activity is also likely to have a role in regulating stress. Andrea and her colleagues conducted related research and found that higher stress levels reduce physical activity, and increased physical activity reduces stress [9]. The research involved 74 adult participants (average BMI of 31.2 kg/m²) enrolled in a 3-week Internet-based weight loss program followed by a 9-month observational maintenance period. Participants, aged 18-70 years. At the end of each week, participants were

required to report their weekly physical activity time on the study website and complete an assessment question about their stress levels to measure the stress they experienced over the past week. The data suggest that there is a significant negative correlation between stress levels and physical activity within the same week. Additionally, higher stress levels significantly predict a decrease in physical activity in the following week, while physical activity levels in the current week significantly predict a reduction in stress levels in the following week. The study results indicate that managing stress is crucial for promoting physical activity in this population, and that engaging in regular physical activity can help mitigate stress, creating a positive feedback loop for better health outcomes.

In the past, stress assessment has typically been conducted using self-report questionnaires, which can be influenced by subjective perceptions. Therefore, identifying a physiological marker that reflects individual stress levels could significantly enhance the credibility of research. Cortisol is considered a potential marker in this regard. Cortisol is a hormone secreted by the adrenal cortex and is one of the key hormones involved in the stress response. Its levels increase with rising stress, making it a physiological indicator of the body's stress response. Consequently, some researchers have studied stress responses through cortisol measurements and analyzed whether cortisol patterns differ between obese individuals and those of normal weight. Benedict and his team found that psychological stress interventions revealed differences in cortisol patterns between the obese group and the normal-weight group. Obesity is associated with lower cortisol activity, which may indicate functional changes in the Hypothalamic-Pituitary-Adrenal (HPA) axis in obese individuals [10]. This study involved stress testing and cortisol concentration measurement in both obese and normal-weight participants. A total of 64 participants were recruited, including 32 obese individuals (17 females, with an average age of 33.94 years) and 32 normal-weight individuals (17 females, with an average age of 29.09 years), all aged between 18 and 65 years.

Researchers measured cortisol levels using a luminescence immunoassay method. They also assessed participants' stress states, focusing on four cognitive appraisal processes: Threat, Challenge, Self-Efficacy, and Control Expectancy. After stress induction, saliva samples were collected, and participants completed a questionnaire. The data indicate that the normal-weight group had significantly higher cortisol levels than the obese group 15 minutes before the stress test. Both groups experienced a substantial increase in cortisol concentration due to stress induction; however, the normal-weight group’s cortisol levels remained higher than those of the obese group. Over time, the pattern of cortisol changes was similar for both groups. The results showed dysregulation of the HPA axis in the obese group, suggesting that obesity may affect stress response mechanisms. Therefore, obesity interventions should not only focus on weight management but also integrate psychological strategies, such as stress management. A comprehensive approach may be more effective in balancing HPA axis function.

4. Conclusion

Studying the relationship between stress and obesity is crucial for developing targeted interventions that address both psychological and physiological factors, ultimately helping to prevent obesity and promote overall health. Research on the relationship between obesity and stress indicates that stress significantly influences eating behaviors, leading to weight gain. At the same time, obesity can negatively impact life balance and increase stress levels. These findings suggest that it is important not only to focus on stress management but also to promote healthier eating habits. Additionally, it is essential to implement appropriate interventions for individuals who are obese and have limited physical activity. Interventions for managing stress and obesity include several key approaches. Mindfulness training has been shown to enhance overall mindfulness, positive emotions, and psychological flexibility while reducing stress, anxiety, and depressive symptoms. Stress management programs incorporating techniques such as progressive muscle relaxation and guided

visualization also improve weight loss outcomes and mental health. Physical activity is crucial for reducing stress and promoting better health. Additionally, research indicates that addressing cortisol patterns and HPA axis dysregulation through comprehensive psychological and behavioral strategies can be effective in managing obesity and stress.

Recent research highlights the significant role of stress in influencing obesity and eating behaviors, and the potential benefits of interventions such as mindfulness and stress management. However, there are notable limitations. Many studies involve small sample sizes and short intervention and follow-up periods, which may not provide a objective and comprehensive understanding of long-term effects. Additionally, the diversity of participant backgrounds is often limited, potentially affecting the generalizability of the findings. Many studies also rely on self-reported measures, which can introduce biases and inaccuracies in assessing stress and eating behaviors. Future research should focus on overcoming these limitations by incorporating larger and more diverse samples to improve generalizability. Longitudinal studies with extended follow-up periods are necessary to evaluate the long-term effectiveness of interventions. Furthermore, incorporating objective measures of stress and physiological responses, such as cortisol levels, alongside self-reported data can provide a more accurate picture of the relationship between stress and obesity. Exploring the combined effects of stress management and dietary modifications in various populations can also yield valuable insights for developing more effective obesity interventions.

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