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The Effect of a Balanced Low-Calorie Diet on Depression Score in Overweight and Obese Patients: A Quasi-Experimental Study

Somaye Yosaee; PhD [1], Mahkameh Ashourpour; PhD [1], Fatemeh Sarvi; PhD [2]& Maryam Ranjbar Zahedani; PhD [*1]

[1] Department of Nutrition, School of Health, Larestan University of Medical Sciences, Larestan, Iran; [2] Department of Public Health, Larestan University of Medical Sciences, Larestan, Iran.

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Corresponding author:
ranjbarmaryam29@yahoo.com
Larestan University of Medical Sciences, behind the Larestan Grand Market, Karmand St,North Ghadir Blvd, Shahr_eJadid, Larestan, Fars, Iran.

Postal code: 7433193514
Tel: +98 9177018120

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ABSTRACT

Background: Obesity and depression are interrelated public health concerns with significant physical and psychological consequences. This study aimed to evaluate the effect of a balanced low-calorie diet on depression scores in overweight and obese individuals. **Methods:** In this 12-week quasi-experimental trial, 78 overweight and obese adults (BMI 25–39.9 kg/m²) with Beck Depression Inventory (BDI) scores >13 were enrolled in Larestan, Iran. Participants received a personalized low-calorie diet (500 kcal/day deficit based on Harris-Benedict equation). Moreover, anthropometric measurements and BDI scores were assessed at baseline and after the intervention. Statistical analysis included paired t-tests and multivariate regression, adjusting for age, sex, and baseline depression scores. Results: Sixty-seven participants (15 men, 52 women, mean age 36.4±10.0 years) completed the study. Significant reductions were observed in weight, BMI, waist circumference, and BDI scores (all $P<0.001$). After adjustment, a one-unit decrease in BMI predicted a 1.19-point reduction in BDI score ($P=0.011$), and a one-centimeter decrease in waist circumference predicted a 0.18-point reduction ($P=0.039$). **Conclusions:** A balanced low-calorie diet significantly reduced both depression scores and anthropometric indices in overweight and obese patients. Thus, dietary intervention may serve as a cost-effective, adjunctive strategy for managing depression levels in this population.

Introduction

Obesity has emerged as a major public health challenge due to its increasing impact on the global burden of disease. In the past decade, the incidence of non-communicable diseases related to obesity has risen sharply, particularly in low- and middle-income countries. According to the Global Burden of Disease Group (GBD Obesity Collaborators, 2017), “the prevalence of obesity has doubled in more than 70 countries since 1980 and has steadily risen in most other countries”. Despite the advances in elucidating the physiological mechanisms that regulate body weight and energy balance, there is a paucity of data on the risk factors that drive the rising rates of

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obesity. Hence, obesity remains a significant global health problem with diverse vascular, metabolic, and psychosocial consequences (Amin and Mercer, 2016). Body weight regulation is influenced by various interactions among genetic, hormonal, and environmental factors. Moreover, some evidence suggests a potential role of psychological factors in the cognitive etiology of obesity (Agustí *et al.*, 2018, Prickett *et al.*, 2015). Conversely, recent findings and reports indicate the detrimental effect of obesity on brain structure and function (Bischof and Park, 2015, D O'Brien *et al.*, 2017). Obesity is often associated with high prevalence of depression (Pereira-Miranda *et al.*, 2017). Based on the research, there is a significant and bidirectional association between obesity and depression. Accordingly, depressed adolescents have a 70% higher risk of being obese, while obese individuals have a 38% higher risk of developing depression. This finding highlights the importance of addressing both obesity and depression in adolescents and adults (Rajan and Menon, 2017). Depression is one of the most prevalent mental disorders and is characterized by symptoms such as low mood, fatigue, feelings of guilt and worthlessness, thoughts of suicide and death, and sleep and appetite disturbances. In addition, the prevalence of depression has been reported to range from 3.3% to %15.3% (Jantaratnotai *et al.*, 2017). Some studies have found a relationship between BMI and depression. The bidirectional relationship between obesity and depression is mediated by complex biochemical and physiological pathways. From a biochemical perspective, chronic low-grade inflammation is a key driver; adipose tissue in obese individuals secretes pro-inflammatory cytokines, such as tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), which can cross the blood-brain barrier and trigger neuroinflammation, subsequently altering mood regulation (Raison and Miller, 2013). Furthermore, dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and alterations in neurotransmitters, particularly serotonin and dopamine, play a critical role in both appetite control and emotional stability. For instance, leptin resistance, common in obesity, not only impairs satiety but is also linked to a decrease in the expression of brain-derived neurotrophic factor (BDNF), which is essential for neuronal plasticity and the prevention of depression (Correia and Vale, 2024). Consequently, weight gain in depressed patients is often attributed to these hormonal imbalances and the compensatory increase in caloric intake due to serotonin deficiency. Conversely, the systemic metabolic dysfunction associated with obesity can exacerbate depressive states, creating a vicious cycle of psychological distress and physical decline (Selman *et al.*, 2025).

Therefore, this situation should be monitored and caloric intake of patients should be adjusted as needed. It seems that implementing an appropriate weight loss diet plan can contribute to the reduction of depression and its complications (Milaneschi *et al.*, 2019, Pereira-Miranda *et al.*, 2017). Most of the studies conducted in Iran have focused on the prevalence of overweight and obesity in depressed individuals (Sharafi *et al.*, 2020) and there are limited studies regarding the emotional problems of overweight and obese individuals and therapeutic interventions to reduce them. Therefore, considering the significance of obesity and overweight, as well as depression and their outcomes, this study has investigated the effect of a balanced weight loss diet on improving the mood of obese individuals who refer to the nutrition and diet therapy clinic.

Materials and Methods

Study design and participants

The quasi-experimental study was conducted on overweight and obese individuals in Larestan, Iran in 2023. The study sample size was determined according to the depression questionnaire score of previous studies as the primary outcome (Dehkordi *et al.*, 2016). Based on a similar study by Faulconbridge (Faulconbridge *et al.*, 2009), the mean depression score was assumed to be 8.1 (SD=5.0) before the intervention and 6.0 (SD=4.2) after the intervention. Considering a correlation of 0.5 and d=1.9, using the sample size formula for a

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paired *t-test*, with 90% power and a two sided type I error rate of 0.05, the required sample size was calculated. After accounting for a 10% dropout rate, the final sample size was determined to be 70 participants.

$$\sigma_d = \sqrt{SD_1^2 + SD_2^2 - 2rSD_1SD_2} \approx 4.65$$

$$n = \frac{\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right)^2 {\sigma_d}^2}{d^2} = \frac{(10.5) \times 4.65^2}{1.9^2} = 63$$

$$n_c = \frac{n}{1-0.1} = \frac{63}{0.9} = 70$$

The inclusion criteria of the study were being overweight and obese (BMI 25-39.9 kg/m^2), an age of 20-60 years, a depression score evaluated by Beck questionnaire>13 and willingness to participate in the study (Finer *et al.*, 2014). However, individuals with any severe systemic, endocrine, or metabolic disorders, those taking any type of anti-depressant drugs, individuals who had consumed vitamin-mineral supplements and herbal remedies during the last six months, menopausal women, pregnant and lactating mothers, smokers, and alcohol users were excluded. Overall, 450 participants were screened and 67 eligible ones were found. Then, written informed consent forms for participation in the trial were obtained from all participants. The current study was a 12-week clinical trial with the overall goal of determining the effects of a low-calorie balanced diet on depression score based on Beck's standard questionnaire, anthropometry and body composition in overweight and obese patients. The patients were recruited among the overweight and obese outpatients living in Lar city who referred to health centers with easy non-probability sampling method based on the inclusion criteria. The patients were provided with a balanced weight loss diet based on individual indicators (height, weight, gender and physical activity level). The Total Energy Expenditure (TEE) was calculated using the Harris-Benedict equation, multiplied by the appropriate physical activity level (PAL) coefficient, which was determined based on the participants' self-reported daily activity levels by subtracting 500 kcal/day from their estimated energy requirements for weight loss. The macronutrient composition of the prescribed diet was also designed to provide 55–60% of total daily calories from carbohydrates, 15–20% from proteins, and 25–30% from fats, ensuring a balanced nutritional intake while promoting weight loss.

Moreover, the participants were asked to complete a study questionnaire, which included questions regarding their demographic and socioeconomic characteristics (age, sex, occupation, education level, marital status, and family history of Diabetes Mellitus (DM), Hypertension (HTN), and Cardiovascular Diseases (CVD)). The participants were also asked not to change their physical activity levels and refrain from initiating any new medication or nutritional supplement or avoid changing their food habits during the follow-up period. Patients were followed up weekly by telephone and every two weeks through in-person visits to assess their adherence to the diet, answer their questions and prevent samples from attrition. To evaluate the participants' mood state, the Beck Depression Inventory (BDI) was administered at the beginning and end of the intervention. Moreover, to ensure the accuracy of the responses and provide necessary clarifications, the questionnaires were administered by the primary investigator through a guided interview process with each participant. Weight, height, and waist and hip circumferences (WC; HC) of participants were measured based upon standard protocol at the time they were enrolled in the study (to the nearest 0.1 Kg and 0.5 cm for weight, height, WC and HC respectively). Both WC and HC were measured using a flexible non-elastic tape above the iliac crests and at the maximal buttocks, respectively. Body mass index (BMI), defined as weight (kg) divided by square of height (m^2), was then calculated from these measures (Lohman *et al.*, 1988).

Ethical considerations

This trial was registered at http://www.irct.ir/ (Trial Id. IRCT20230316057733N1). The study protocol received ethical approval from the Ethics

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Committee of Larestan University of Medical Sciences. (Ethical code number: IR.LARUMS.REC.1401.010). Moreover, the participants were informed about the aim and procedures of the study and written informed consent was obtained from each of them in accordance with the guidelines of the medical ethics committee.

Data analysis

Data processing and analysis were conducted using the SPSS statistical software, version 21 for Windows (SPSS Inc, Chicago, USA). Furthermore, all the participants who had completed an initial assessment were included in the final analysis. The results were expressed as mean±Standard Deviation (SD) or frequency and percentages. When the data were normally distributed, independent and paired t-tests were performed to make statistical comparisons between and within groups, respectively. A 2-sided p-value<0.05 was considered to be statistically significant.

Results

In this study, 450 patients were initially identified. Of these patients, 352 were ineligible, and 31 declined the follow up process/ did not follow the diet fully and correctly. The results were based on data from the remaining 67 patients including 15 men and 52 women (**Figure 1**). Moreover, the age range of the patients was from 17 to 64 years, with a mean±SD of 36.36±10.02 years.

The characteristics of patients at baseline and after receiving the diet are given in **Table 1**. Also, **Table 1** shows the comparison between the characteristics of the patients before and after receiving the diet. As shown, there is a significant difference before and after the intervention in terms of weight, BMI, WC, and depression score (P<0.001).

In the next step, the changes in BMI and WC before and after the dietary intervention were calculated. The effect of these changes on depression score after intervention is considered with a multiple regression model after adjusting for the effect of age, sex and depression score before intervention.

As shown in **Table 2**, after adjusting for age, sex, and baseline depression score, each one-unit decrease in BMI was associated with a 1.19-point decrease in the mean post-intervention depression score. This association was statistically significant. (P=0.011). By adjusting the effect of other variables, with decreasing one unit in waist circumference, the mean of depression score after the intervention has decreased as 0.18 (P= 0.039).

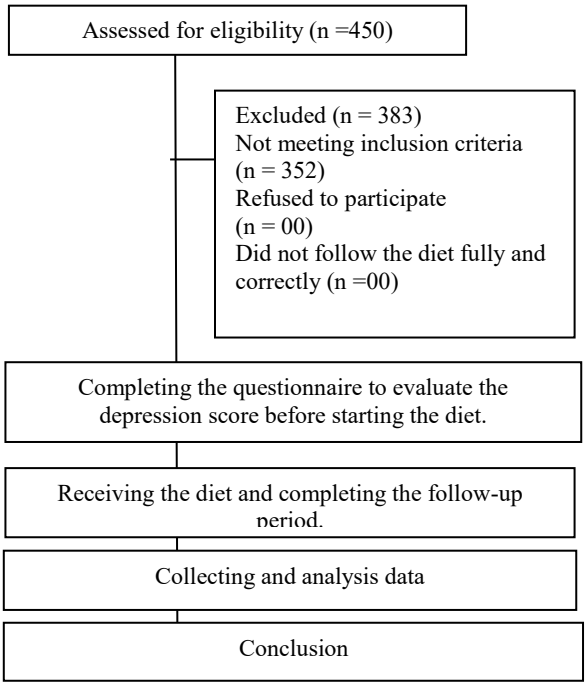


Figure 1. Flowchart of progress through the trial.

Discussion

The present 12-week quasi-randomized trial examined the effect of a balanced weight loss diet on depression scores and adiposity indices among overweight/obese adult participants. The authors reported significant reductions in weight, BMI, and waist circumference in the study group after the intervention (P<0.001). There was also significant improvement in the self-reported depressive symptom scale assessed by the Beck Depression Inventory (P<0.001). These changes were evident independent of various body composition measures.

According to some studies, weight loss regimens improved depression scores compared to control

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groups (García-Toro *et al.*, 2012, Jacka *et al.*, 2017). Other studies reported no intervention effect (McMillan *et al.*, 2011). No studies showed that the control group produced better outcomes. Also, previous evidence suggests that the involvement of a dietitian in both the design and implementation of nutritional interventions can enhance their effectiveness (Rocks *et al.*, 2022). In the present study, both the design of the intervention and its face-to-face delivery were conducted under the direct supervision of a dietitian, which may have contributed to the favorable outcomes observed. Barnett *et al*. reported a high level of participant error during dietary assessment when dietary data were collected using a digital food record method. In contrast, as noted before, in the present study dietary information was obtained through face-to-face interviews conducted by a nutritionist (Barnett *et al.*, 2025).

Table 1. Comparison between the characteristics of the patients before and after the nutritional intervention.

Variables	Baseline	After receiving diet	P-value[b]
Weight (kg)	89.85±14.68[a]	80.28±13.80	< 0.001
Height (cm)	160.74±7.73	- -	-
Body mass index (kg/m^2)	34.70±4.63	31.04±4.78	< 0.001
Waist circumference (cm)	110.52±11.06	97.58±12.66	< 0.001
Depression score	18.91±8.93	9.22±7.13	< 0.001

[a]: Mean±SD; [b]: Paired t-test.

Table 2. The results of fitting multiple linear regression to consider the effect of BMI change and waist circumference on depression.

Variable	Coefficient	SE	95% CI	P-value
Age (y)	0.027	0.76	-0.12 : 0.18	0.718
Sex	1.46	1.82	-2.18 : 5.01	0.425
Body mass index change (kg/m^2)	-1.19	0.45	-2.09 : -0.27	0.011
Waist circumference change (cm)	-0.18	0.82	-0.33 : -0.01	0.039
Depression score before intervention	0.41	0.084	0.24 : 0.58	0.002

It is believed that face-to-face interactions in the individual setting of the present study were a key element in the success of this study. In contrast, previous studies that reported no significant effects employed other modes of communication. Another factor in the success of the present study was that a dietitian was responsible for the facilitation of nutrition education and counseling, as opposed to studies with no beneficial effect.

Over the past few years, the impact of caloric restriction on the neuroendocrine system and mood is becoming increasingly noticeable (Zhang *et al.*, 2015). Caloric restriction, which is defined as lowering calorie intake without causing malnutrition, has favorable outcomes at both organismic and cellular levels (Hornsby *et al.*, 2016).

Previous studies suggested a direct relation between body fat percentage, especially visceral fat, and the level of depression. Moreover, they showed that depressive symptoms can lead to increased obesity, and a pathophysiological mechanism links depression to increased abdominal fat accumulation (Almeida *et al.*, 2009). Since the experimental group in this study experienced statistical reductions in obesity and body fat index following the intervention, it seems logical that their depression levels would also decrease. In another study that examined the effects of physical activity and diet on depression, the physical activity group had a greater reduction

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in depression due to a greater reduction in fat (body fat percentage and visceral fat) compared to the diet group, and therefore, a greater improvement in depression levels compared to the other group (US Department of Health Human Services, 2008).

A notable strength of the present study was its relatively adequate follow-up duration of 12 weeks. According to the previous research, nutritional interventions were associated with significant improvements in depressive symptoms (Bayes *et al.*, 2022, Jacka *et al.*, 2017, Parletta *et al.*, 2019). This was while longer intervention durations had also been associated with improvements in depressive symptoms; they did not demonstrate significantly greater benefits compared with interventions of 12 weeks (Bot *et al.*, 2019, Cabrera-Suárez *et al.*, 2024, Okereke *et al.*, 2021).

Furthermore, dietary quality was not assessed before and after the intervention in this study; however, since a balanced low-calorie diet was used, it can be concluded that dietary quality was likely improved compared to before the intervention. One study suggested an association between the severity of depressive symptoms and the diet quality (Paans *et al.*, 2019). Similarly, encouraging individuals to change their eating habits and physical activity may be beneficial in reducing depressive symptoms (Ljungberg *et al.*, 2020). There are many biological pathways through which an improved diet may affect depressive illness. Berk et al. focused on inflammatory (Berk *et al.*, 2013) and oxidative stress (Moylan *et al.*, 2014) pathways as well as brain plasticity (Jacka *et al.*, 2015), and new evidence stressed the gut microbiota (Dash *et al.*, 2015). In general, each of the mentioned pathways was implicated in depression and was also influenced by dietary quality. Some dietary supplements showed promising effects in animal studies, providing insight into the therapeutic target of future antidepressant research (Fan *et al.*, 2017, Oliveira *et al.*, 2017).

The findings of the present study also had implications for patient treatment. Since antidepressant treatment often has side effects such as weight gain, diabetes, and cardiovascular problems (Himmerich *et al.*, 2015), the preliminary results of this study suggest that weight loss treatment for patients with both obesity and depression using a balanced LCD may be considered. On the other hand, body weight is affected by most antidepressants, with most leading to weight gain and weight loss which were caused by only a few including fluoxetine and bupropion, through the use of BDNF signaling (Marosi *et al.*, 2016). Due to the negative side effects of current antidepressants at effective doses, it would be likely to reduce side effects with reducing the effective dose. The findings suggest that diet may be used to enhance the effectiveness of antidepressants in humans while minimizing the side effects of currently used antidepressants. Therefore, calorie restriction may have the potential to reduce both body weight and hyperglycemia, not just because of a reduction in food intake, but also because of the biochemical effects of increased BDNF levels. Moreover, energy restriction therapy is less costly and easier to administer than other treatments for patients who have become drug-resistant (Fond *et al.*, 2013). On the other hand, certain individuals such as the elderly population (Volkert *et al.*, 2022) or those who are at risk of or experiencing an eating disorder (Goldschmidt *et al.*, 2012), may be contraindicated for certain dietary restrictions. Hence, future studies should focus more on weight loss and maintenance strategies, especially in the vulnerable groups, and the results of these studies should be taken into consideration by healthcare providers when choosing the best strategy.

Since the present study was conducted in clinical settings, it was not possible to assign a control group to this study. Thus, the researchers suggest randomized controlled studies including elderly populations from different racial/ethnic groups. Comparisons of diet quality before and after the intervention and the effect of increased physical activity on outcomes are also warranted.

Moreover, the present study did not assess baseline caloric and macronutrient intake of the

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participants. Therefore, the authors were unable to tailor the low-calorie diet to individual baseline dietary patterns. Future studies are recommended to include comprehensive baseline dietary assessments prior to implementing nutritional interventions

Conclusions

This 12-week quasi-experimental trial demonstrated that a balanced low-calorie diet not only improved anthropometric indices such as weight, BMI, and waist circumference, but also significantly reduced depressive symptoms in overweight and obese adults. These findings highlight the potential of dietary interventions as a cost-effective, accessible and non-pharmacological strategy for managing both obesity and depression. While the absence of a control group and limited generalizability are notable limitations, the results support the integration of structured nutritional counseling into routine care for patients struggling with obesity and mood disorders. Future randomized controlled trials with diverse populations, longer follow-up and consideration of diet quality and physical activity are warranted to confirm these results and further elucidate the biological mechanisms linking weight reduction and mental health.

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Authors' contributions

Yosaee S contributed to study design and data collection. Sarvi F assisted with data collection. Ranjbar Zahedani M and Ashourpour M revised the manuscript critically, and approved the final version. All authors read and approved the final manuscript.

Conflict of interest

The authors declared no conflict of interest.

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