



# Nutritional therapy in obesogenic patients in the light of exosomes/microRNAs: a systematic review

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## Abstract

**Introduction:** In obesogenic patients, epigenetics provides answers to the relationship between hereditary and environmentally acquired patterns that have contributed significantly to the global increase in the prevalence of obesity. In this context, microRNAs (20-24 non-coding nucleotides) stand out as important biomarkers and modulators of post-transcriptional gene expression in obese patients. Understanding these molecules is crucial, as the prevalence of obesity is increasing significantly, and it is estimated that approximately 60% of the global adult population will be overweight or obese by 2030. **Objective:** It was to explore and describe the main considerations of nutritional therapy in obese patients, highlighting the management of inflammatory and metabolic processes through exosomes and microRNAs. **Methods:** The systematic review guidelines of the PRISMA Platform were followed. The search was conducted from July to August 2025 across Scopus, Embase, PubMed, ScienceDirect, Scielo, and Google Scholar databases. Study quality was assessed using the GRADE tool, and risk of bias was analyzed using the Cochrane tool. **Results and Conclusion:** A total of 128 articles were found. A total of 21 articles were fully assessed, and 16 were included in this systematic review. Using the Cochrane risk of bias tool, the overall assessment revealed 22 studies with a high risk of bias and 25 studies that did not meet the GRADE criteria. Most studies presented homogeneous results, with Chi-Square  $X^2=72.7\%>50\%$ . It was concluded that

exosomes and miRNAs, through nutritional therapy, are related to the control of weight gain, glucose homeostasis, and lipid metabolism. Some clinical studies have shown that enteral nutritional therapy is effective and safe before bariatric surgery, with ketogenic enteral nutrition leading to better clinical results than hypocaloric enteral nutritional protocols in glycemic and lipid profiles, in order to satisfy the better regulation of exosomes and microRNAs, mainly originating from the intestinal microbiota, for the control of inflammatory and metabolic processes.

**Keywords:** Obesity. Nutritional therapy. Gut microbiota. Exosomes. MicroRNAs.

## Introduction

In the context of obesity, epigenetics offers insights into the interplay between hereditary and environmentally acquired patterns that have significantly contributed to the global rise in obesity prevalence. Within this framework, microRNAs (non-coding RNAs of 20–24 nucleotides) stand out as key biomarkers and modulators of post-transcriptional gene expression in patients with obesity and metabolic syndrome. Circulating miRNAs have been detected in various body fluids, including blood, plasma, serum, saliva, breast milk, and urine [1-3].

Understanding these molecules is crucial, given the significant rise in obesity prevalence; it is estimated that approximately 60% of the global adult population will be overweight or obese by 2030. A similar trend is

observed in the global incidence rate of type 2 diabetes, which accounts for 90–95% of all diabetes cases [4].

In recent years, extracellular vesicles (such as exosomes) have emerged as major vehicles for intercellular and intermolecular communication—including interactions between the gut microbiota and the mammalian host [5–7]. They possess the potential to regulate cellular function via autocrine or paracrine mechanisms, a particularly relevant factor when considering obese patients undergoing nutritional therapy. Obese patients admitted to the intensive care unit (ICU) often suffer from acute critical illness characterized by severe catabolic stress, which can lead to significant muscle loss and prolonged functional impairment. Providing adequate nutritional therapy with essential nutrients can help mitigate the consequences of this catabolic response. However, determining the optimal timing, dosage, and delivery routes for nutritional support remains a challenge in the ICU setting [8].

In this regard, nutritional therapy limits the risk of energy or protein deficits—which, in previous retrospective studies, have been associated with poor outcomes such as prolonged ICU and hospital stays, extended duration of mechanical ventilation, and a higher incidence of infectious complications, particularly in patients with obesity [9–12].

The risk of complications is even greater in patients identified as being at high nutritional risk upon ICU admission [11]. However, recent randomized clinical trials and meta-analyses have failed to demonstrate any benefit of adhering to nutritional guidelines during the first few weeks of the ICU stay regarding the outcomes studied [13–16].

International guidelines recommend the early introduction of hypocaloric enteral nutrition within the first 48 hours, except in cases of uncontrolled shock, hypoxemia, or acidosis [17–19]. The rationale for these recommendations is based on the results of a meta-analysis reporting the benefits of early enteral nutrition in reducing the incidence of infectious complications; this is attributed to its role in regulating microRNA release, thereby modulating various gene expressions, and in adjusting regulatory T cells (Tregs), which contribute to infection control [18].

Consistent with this, the most recent meta-analysis conducted by the Cochrane group, which included seven randomized clinical trials published between 1993 and 2012, also reported "very low-quality evidence" regarding early versus late enteral nutrition in ICU patients [20]. Furthermore, early initiation combined with rapid achievement of energy targets has not demonstrated significant benefit and

may even cause harm. Additionally, a recent study by Ortiz-Reyes et al. [21] showed no benefit of early enteral nutrition compared to late enteral nutrition in ventilated patients receiving vasopressor or inotropic therapies, after adjusting for disease severity. Finally, concerns have recently emerged regarding a potential increase in the risk of digestive complications, such as mesenteric ischemia, associated with early enteral feeding [22–24].

In this context, microRNAs contribute to the maintenance of immune responses and obesity-related processes within adipose tissue. Resident T cells, macrophages, and adipocytes secrete various miRNAs and communicate with other cells, potentially influencing metabolic organ crosstalk. Resident macrophages and T-cell-associated miRNAs play a prominent role in the regulation of obesity by targeting various signaling pathways [25–27].

Thus, enteral and parenteral nutritional therapy is fundamental to obesity treatment, as it acts to modulate gene expression via microRNAs and, downstream, helps regulate inflammatory and meta-inflammatory processes in patients with obesity. Weight-loss diets are available that incorporate various combinations of energy restriction, macronutrients, specific foods, and dietary intake patterns. Caloric restriction is a common pathway for weight loss, but different diets can induce weight loss through various additional mechanisms, including by facilitating dietary adherence [28].

Given this context, this study aimed to explore and describe key considerations regarding nutritional therapy for patients with obesity, highlighting the management of inflammatory and metabolic processes via exosomes and microRNAs.

## Methods

### Study Design

This study followed an international systematic review model, adhering to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Available at: <http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1>.

Accessed on: July 19, 2025. It also adhered to the AMSTAR 2 (Assessing the Methodological Quality of Systematic Reviews) standards for methodological quality. Available at: <https://amstar.ca/>. Accessed on: July 19, 2025.

### Search Strategy and Sources

The literature search process was conducted from July to August 2025 using Web of Science, Scopus, Embase, PubMed, LILACS, EBSCO, SciELO, and Google

Scholar, covering scientific articles published from various periods up to the present. The following descriptors (DeCS/MeSH terms) were used: "Obesity," "Nutritional therapy," "Gut microbiota," "Exosomes," and "MicroRNAs," employing the Boolean operator "AND" between MeSH terms.

### Study Quality and Risk of Bias

Quality was classified as high, moderate, low, or very low based on risk of bias, clarity of comparisons, precision, and consistency of analyses. Priority was given to systematic reviews or meta-analyses of randomized clinical trials, followed by randomized clinical trials. Low evidence quality was attributed to case reports, editorials, and brief communications, in accordance with the GRADE instrument. Risk of bias was analyzed using the Cochrane tool via funnel plot analysis (sample size versus effect size) and Cohen's d test.

## Results and Discussion

### Summary of Findings

A total of 128 articles were identified and subjected to an eligibility analysis; subsequently, 16 articles were selected for inclusion in this systematic review. The selected studies demonstrated moderate to high quality (Figure 1), based on the level of scientific evidence from study designs such as meta-analyses, consensus statements, and randomized clinical, prospective, and observational trials. Biases did not compromise the scientific foundation of the studies. According to the GRADE instrument, the majority of studies showed homogeneity in their results (Chi-Square  $X^2 = 72.7\% > 50\%$ ). Based on the Cochrane risk-of-bias tool, the overall assessment identified 22 studies with a high risk of bias and 25 studies that did not meet the GRADE and AMSTAR-2 criteria.

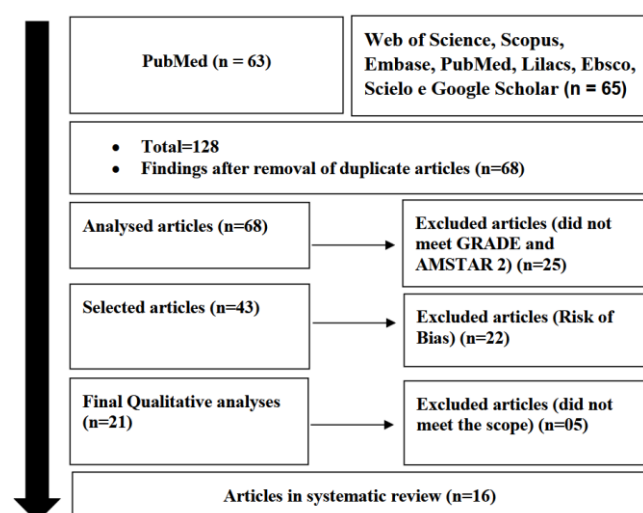


Figure 1. Flowchart showing the article selection process. Source: Own Authorship.

Figure 2 presents the results regarding the risk of bias across the studies using a funnel plot, showing the calculation of effect size (magnitude of difference) via Cohen's d. Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). The plot exhibited a symmetrical pattern, suggesting no significant risk of bias among either studies with small sample sizes (lower precision), shown at the base of the plot—or studies with large sample sizes, shown at the top.

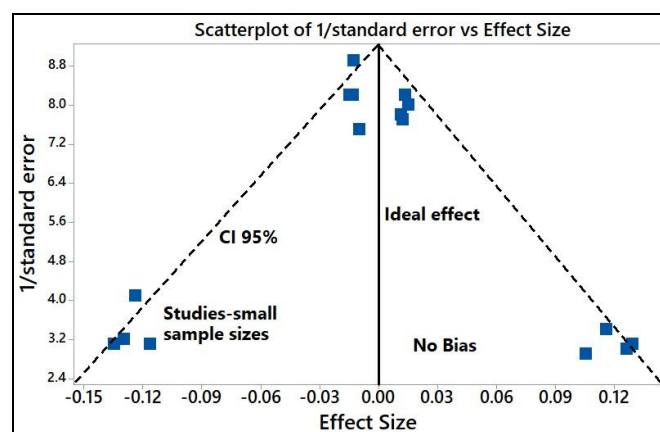


Figure 2. The symmetrical funnel plot suggests no risk of bias among studies with small sample sizes, which are shown at the bottom of the plot. Studies with high confidence and high recommendation levels are shown at the top of the plot (n=16 studies). Source: Own Authorship.

### Main Clinical Outcomes – Nutritional Therapy for Obesity

In the context of nutritional treatment for patients with obesity, precision nutrition aims to personalize dietary interventions based on genetic and molecular profiles. miRNAs serve as biomarkers for predicting dietary response and obesity risk, while siRNAs provide a targeted approach to silencing obesity-related genes. miRNAs, such as miRNA-33 and miRNA-103/107, regulate gene expression related to lipid metabolism, adipogenesis, and insulin sensitivity. Small interfering RNAs (siRNAs) offer precise gene silencing for targets such as SREBP-1c and PPAR $\gamma$ , addressing metabolic pathways that are resistant to dietary interventions [29].

Against this backdrop, Metabolic Syndrome (MetS) is recognized as a complex, multifactorial condition characterized by risk factors, such as abdominal obesity, insulin resistance, dyslipidemia, and hypertension, that contribute significantly to the development of cardiovascular disease (CVD). Various biomarkers associated with metabolic syndrome (MetS), including lipid profile markers (triglyceride/high-density lipoprotein cholesterol (TG/HDL-C) ratio and apolipoprotein B/apolipoprotein

A1 (ApoB/ApoA1) ratio), inflammatory markers (interleukin-6 (IL-6), tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ), plasminogen activator inhibitor-1 (PAI-1), C-reactive protein (CRP), leptin/adiponectin ratio, omentin, and fetuin-A/adiponectin ratio), oxidative stress markers (lipid peroxides, protein and nucleic acid oxidation, gamma-glutamyl transferase (GGT), uric acid), and microRNAs (miRNAs) such as miR-15a-5p, miR-17-5p, and miR-24-3p—have been targets for the treatment and management of obesity and MetS [30].

In the context of nutritional therapy for patients with obesity, dietary manipulation of the gut microbiota has been proposed as a promising therapeutic target. In this regard, the secretion of gut microbiota-derived extracellular vesicles (EVs) is attracting special attention, emerging as key factors that may mediate gut microbiota-host communication. EVs derived from gut microbiota and probiotic bacteria can encapsulate a wide range of bioactive molecules (such as proteins and nucleic acids) capable of traveling short and long distances to modulate important biological functions, thereby impacting overall host health. EVs derived from specific bacteria induce distinct physiological responses. It is necessary to understand the potential role of the gut microbiota and probiotic-derived extracellular vesicles (EVs) in the onset, progression, and management of obesity and diabetes through the modulation of inflammation, metabolism, and intestinal permeability [28,31].

Also, patients with obesity are at higher risk for community-acquired and nosocomial infections. Obesity may be associated with an increased incidence of ventilator-associated pneumonia (VAP). A study by Nseir et al. (2021) [32], an open-label, randomized, controlled trial conducted in 44 French ICUs, analyzed the impact of early enteral nutrition versus parenteral nutrition on mortality in patients requiring mechanical ventilation and catecholamines (the NUTRIREA2 trial). The study included adults receiving invasive mechanical ventilation and vasopressor support for shock, along with either parenteral or enteral nutrition. Obesity was defined as a BMI  $\geq 30$  kg/m<sup>2</sup> upon ICU admission. VAP diagnosis was adjudicated by an independent, blinded committee based on all available clinical, radiological, and microbiological data. A total of 699 (30%) of the 2,325 enrolled patients had obesity. There were 224 first episodes of VAP diagnosed (60 in the obese group and 164 in the non-obese group). The incidence of VAP at day 28 was 8.6% versus 10.1% in the two groups (hazard ratio, 0.85; 95% CI 0.63–1.14;  $p=0.26$ ). After adjustment for sex, McCabe score, age, anti-ulcer treatment, and Sequential Organ Failure Assessment score at randomization, the incidence of VAP remained non-significant between obese and non-

obese patients (hazard ratio, 0.893; 95% CI, 0.66–1.2;  $p=0.46$ ). Although no significant difference was found regarding the duration of mechanical ventilation and ICU length of stay, 90-day mortality was significantly lower in obese patients than in non-obese patients (272 of 692 [39.3%] patients vs. 718 of 1,605 [44.7%];  $p=0.02$ ). In a subgroup of patients ( $n=123$ ) with available measurements of pepsin and alpha-amylase, no significant difference was found in the rate of massive microaspiration of gastric contents or oropharyngeal secretions between patients with and without obesity.

In the context of enteral and parenteral nutritional therapy, a study demonstrated that microRNAs, within the scope of nutritional therapy designed for patients with obesity, regulate gene expression in adipose tissue, impact the regulation of metabolism and energy homeostasis, regulate adipogenesis signaling pathways in white, beige, and brown adipose tissue, and influence adipocyte (mesenchymal stem cell) transcription and differentiation [27].

In 2023, it was identified that microRNA (miR-143) also promotes brown adipose tissue thermogenesis and inhibits white adipose tissue adipogenesis [28]. In this context, microRNAs that interact with obesity-associated bacteria regulate the expression of genes involved in various metabolic and obesity-related pathways, such as carbohydrate and lipid metabolism, as well as endocrine and inflammatory signaling pathways. Most miRNAs do not regulate a specific or single target gene; rather, they modulate the expression of a large number of genes, demonstrating their importance in regulating various metabolic processes [31].

Moreover, accumulating evidence indicates that circulating miRNAs are associated with obesity [32,33]. Certain miRNAs have been implicated in the control of body weight gain, glucose homeostasis, insulin resistance, and lipid metabolism [34–37]. A meta-analysis found that miR-21-5p, miR-103a, and miR-221-3p were downregulated in blood samples from individuals with obesity [38]. Furthermore, miRNAs dysregulated in obesity are associated with various metabolic processes, such as glucose intolerance, maintenance of pancreatic beta-cell mass, adipocyte development and adipose tissue physiology, inflammatory pathways, and cardiomyocyte survival [39,40].

Medical nutrition therapy based on the latest scientific evidence should be offered to all patients with obesity as part of obesity treatment interventions. Medical nutrition therapy aims to achieve positive health outcomes, rather than merely weight changes. A diverse range of nutritional interventions has proven

effective in treating obesity and its comorbidities, primarily through the modulation of microRNAs via nutritional therapy. Although interventions based on caloric restriction are effective in promoting weight loss, long-term adherence to behavioral changes may be better supported by alternative interventions focused on dietary patterns, food quality, and mindfulness [41,42].

### Limitations and Future Prospects

Future research should focus on large-scale randomized clinical trials and meta-analyses to better understand and identify microRNAs, thereby establishing a robust database for the reliable analysis of these biomarkers and gene expression modulators within the context of nutritional care.

### Conclusion

It is concluded that the synergistic integration of miRNAs as biomarkers and siRNAs as therapeutic tools enhances the personalization and efficacy of obesity management. Exosomes and miRNAs, through enteral/parenteral nutritional therapy, play a role in controlling weight gain, glucose homeostasis, and lipid metabolism. Some clinical studies have shown that enteral nutritional therapy is effective and safe prior to bariatric surgery, with ketogenic enteral nutrition yielding better clinical outcomes, regarding glycemic and lipid profiles, than hypocaloric enteral nutrition protocols; this approach optimizes the regulation of exosomes and microRNAs (primarily derived from the gut microbiota) to control inflammatory and metabolic processes.

### CRedit

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Not applicable.

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It was performed.

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