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Probiotics in Obesity Management: Mechanisms, Efficacy and Future Directions

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Abstract

Background. Obesity remains one of the most significant global health challenges. However, it may be cured thanks to the microbiota modulation, as it could affect metabolic regulation. Probiotics have emerged as a potential adjunctive strategy supporting weight management and metabolic health.

Aim. The aim of the study was to evaluate the effectiveness of selected probiotic strains in obesity management, as well as to analyse the mechanisms through which these strains influence metabolic and anthropometric outcomes.

Material and methods. The research was based on a literature review and comparative analysis of randomized controlled trials published before November 2025. The analysis included human studies examining body weight, BMI, waist circumference, visceral fat, and metabolic markers after 8-24 weeks of probiotic supplementation.

Results. The findings indicate that certain strains, such as *Lactobacillus gasseri*, *Lactobacillus plantarum*, and *Bifidobacterium animalis subsp. lactis*, demonstrating clinically relevant benefits – reductions in body weight, as well as improved lipid profiles and enhanced insulin sensitivity. However, the effectiveness varies between strains, and the overall impact remains moderate.

Conclusions. Probiotic therapy remains as supportive intervention in obesity management, particularly when used alongside standard weight-loss strategies. Further well-designed clinical studies are required to determine optimal strains, dosages, and long-term safety profiles.

Key words: probiotics, obesity, microbiota, metabolic health, RCT.

1. Introduction

Obesity is currently one of the major lifestyle-related diseases. According to WHO data from 2022, it is a "complex multifactorial disease defined by excessive adiposity that presents a risk to health." Moreover, due to increasing digitalization trends, this condition affects a growing number of people in society, contributing significantly to reduced physical activity as well as the abandonment of healthy eating and a balanced lifestyle. WHO has even reported that it concerns over 60% of adults in Europe, while among children under the age of five the rate is nearly 8% (World Health Organization Europe, 2022).

Recognizing the following issue, the so-called obesity management is gaining importance. It refers to measures aimed at reducing weight, lowering the need for pharmacological treatment, and preventing further disorders such as diabetes, hypertension, and atherosclerosis (Ghosh, 2024). Obesity management is a subtype of the broader concept of weight management – such activities improve health and reduce the risk of weight regain. These measures are taken holistically and include physical activity, lifestyle modification, and dietary changes. Among the supporting methods are supplements and probiotics, the latter being the focus of this study. Describing this group requires a definitional reference. They are defined as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host." They should not be confused with prebiotics or synbiotics (Guarner et al., 2023). Probiotics therefore include all beneficial bacteria and yeasts that can, in specific ways, modulate the composition of the microbiota, influence metabolic and immunological pathways, and thereby contribute to improving the condition of an individual with obesity. This topic is relatively broad and requires reference both to the mechanisms of probiotic action and to

clinical evidence of their effects and potential future research. Narrowing the discussion solely to individuals with obesity provides a certain simplification.

Before conducting a comparative analysis, it is necessary to consider the ways in which probiotics are used. Beyond supporting individuals with obesity and preventing related diseases, they may counteract the condition through their intrinsic properties. The core of the overall effect results from their ability to modulate the composition of the intestinal microbiota. This, in turn, contributes to the ability to "influence appetite and energy homeostasis through increased SCFA production" (Wiciński et al., 2020). The abbreviation refers to short-chain fatty acids, which affect the sensation of satiety (Czachajda et al., 2024). An additional function of SCFAs is the regulation of energy metabolism, achieved through interactions with GPR41/43 receptors and neurotransmitters. Examples of the latter include GLP-1 (glucagon-like peptide 1) and PYY, that is, peptide YY (Wiciński et al., 2020). Various strains are also used in scientific research, as noted by Wiciński's team. They demonstrated that "some Bifidobacterium spp. and Lactobacillus spp. produce prohealthy conjugated linoleic acid (CLA)." CLA contributes to improved metabolism and directly affects body weight and lipolysis. Thus, it is observed that the mode of action of probiotics particularly in individuals with obesity is chemical, long-term, and effective.

For this reason, probiotics constitute an integral element of obesity management. Researchers that analyse the literature, including umbrella reviews, note that the benefits of their implementation are documented, yet further analysis is required, particularly because the groups of studied individuals are still too limited. Another factor increasing this cognitive dissonance is the "poor quality design" (Safeghi et al., 2024). This constitutes one of the motives for undertaking the present analysis. It is a fact that probiotics increase the synthesis of proteins and intestinal mucus, preventing gut permeability and the absorption of LPS. However, these effects may be partially inhibited in certain groups depending on co-occurring conditions (Fontane et al., 2018).

Referring again to the findings of Wiciński's team, it is confirmed that the long-term effects of such treatment include improved insulin sensitivity and stimulation of the growth of bacteria that support the maintenance of a lean body composition (Wiciński et al., 2020). All results are compared against animal models. For example, the strains "*Lactobacillus gasseri* (…) over a period of 24 weeks, *L. plantarum* (…) for 12 weeks, *Lactobacillus curvatus* (…) and *L. plantarum* (…) for 18 weeks" were used (Fontane et al., 2018). Research was also conducted on *L. rhamnosus*, for which fat accumulation inhibition was confirmed through reduced storage in animal organisms (Wiciński et al., 2020).

The evaluation of probiotic effectiveness is also carried out through RCTs. The abbreviation stands for Randomized Controlled Trials (Bhatia & Grewal, 2021). These are procedures including meta-analyses that are particularly useful when assessing the moderating benefits of probiotic therapy in individuals with overweight and obesity. However, the chosen research method in this study was comparison and case study, due to the availability of numerous published results relevant to the topic. The latest RCT meta-analyses have demonstrated statistically significant reductions in body weight and waist circumference. These outcomes were compared with placebo. The research was conducted in 2025 and included over 400 participants (Guo et al., 2025). According to the authors, probiotic supplementation led to a greater reduction in body weight ($p < 0{,}00001$) and waist circumference ($p = 0{,}01$) compared to placebo group.

The study showed no significant differences or correlations between BMI and LDL levels among the patient groups. However, this issue requires further investigation, as the lack of information may result from the short duration of the trials or dosage variations, those are factors that had already been mentioned earlier. At the same time, the diversity and number of variables within the study groups do not necessarily lead to divergent results. For example, intake itself is important – administering *L. gasseri* in the form of fermented milk over a period of 12 weeks reduced visceral adipose tissue by nearly 10%. Similar effects were observed for waist and hip circumference (Kadooka et al., 2013).

In summary, the main mechanisms through which probiotics could be used in the context of obesity include:

- modulation of the microbiota through increased SCFA production and reduced LPS, as well as other metabolic pathways,
- strengthening of the intestinal barrier by reducing its permeability and sensitivity, enhancing immunity, as well as affecting adaptation,
- regulation of energy homeostasis and hormone levels – researchers mainly refer to the use of *L. plantarum*, with studies conducted in the form of RCTs (Li et al., 2024),
- reduction of the risk of other lifestyle-related diseases, primarily through antiinflammatory effects.

Considering these aspects, it is possible to formulate a research objective that will constitute the main axis of further analyses. For the purposes of the study, research problems were also formulated in question form, accompanied by corresponding hypotheses expressed as statements. Those will be described in the next paragraphs.

The aim of the study is to assess the effectiveness of selected probiotic strains in obesity management and to analyse the mechanisms underlying their action based on clinical data from RCTs. Some of these theoretical assumptions have already been presented in the literature review. Among the specific objectives is the identification of which probiotics demonstrate the greatest potential for reducing body weight, both in terms of BMI and fat tissue, as well as determining which variables and additional factors may influence the diversity of research outcomes.

The research problems are:

- "do different probiotic strains lead to clinically significant reductions in body weight and metabolic parameters among individuals with obesity or overweight?,"
- "do the mechanisms of probiotic action affect real metabolic effects?,"
- "why do individual strains differ in effectiveness despite having similar mechanisms of action?,"
- "do multi-strain preparations demonstrate greater effectiveness than single-strain preparations?,"

In order to answer these questions, four research hypotheses were formulated:

- H1: The use of selected probiotic strains leads to clinically significant reductions in body weight and improvements in metabolic parameters among individuals with obesity compared to placebo,
- H2: The mechanisms of probiotic action translate into measurable metabolic effects, including reductions in fat tissue, improvements in lipid profiles, and enhanced insulin sensitivity,
- H3: The differing effectiveness of individual probiotic strains results from species and strain-specific differences, distinct metabolic pathways, as well as varying colonization capacities and metabolite production,
- H4: Multi-strain preparations produce greater reductions in body weight and more pronounced improvements in metabolic parameters than single-strain preparations due to synergistic effects between the mechanisms of action of individual bacteria.

These aspects represent only an outline of the research and its direction, which will be specified more precisely in the methodology section.

2. Research materials and methods

The subject of the study was the effectiveness and mechanisms of action of seven categories of probiotics. These included, as previously outlined to some extent, *Lactobacillus gasseri*,

Lactobacillus plantarum, Lactobacillus rhamnosus, Bifidobacterium animalis subsp. lactis, Bifidobacterium breve, Saccharomyces boulardii, as well as a general group of multistrain preparations, including combinations of *Lactobacillus* and *Bifidobacterium.*

The chosen research method consisted of a literature review and comparative analysis. To achieve this, documentation and study results were examined. The author's own analysis included all available RCT findings that demonstrated a high degree of representativeness. In each study, the effects of probiotics were assessed in relation to variables such as body weight reduction, BMI, waist circumference, visceral adipose tissue, and metabolic parameters.

2.2. Procedure

The procedure involved a comparative analysis of probiotic effectiveness based on data from RCTs. The data were collected in November 2025, that is, after the publication of all relevant articles. More precisely describing the target research group, the probiotics were supplemented for a minimum period of 8 weeks and a maximum of 24 weeks. The dosages also varied. The selection of individual probiotic types was not dependent on the form in which the substances were administered – sachets, capsules and fermented milk were included.

To confirm the presence of measurable outcomes, the analysis required the inclusion of a placebo control group, which was incorporated in several of the referenced studies. In each study, results before and after supplementation were compared, as well as differences between the study and control groups, which further broadened the scope of the analysis.

2.3. Data collection and analysis

Data collection encompassed the analysis of several key aspects. The data were recorded in Excel, and the criterion for including specific outcomes was their relevance to the verification of the research hypotheses. The primary focus was on the effects related to body weight reduction and BMI. Additional criteria included changes in metabolic parameters and alterations in the composition of the gut microbiota. The information was analysed both qualitatively and quantitatively, taking into account the effects of individual strains, sample sizes, group characteristics, and the statistical significance reported in the RCTs.

3. Research results

As noted earlier, the effects of several probiotic strains with beneficial impacts for individuals with obesity were already discussed in the theoretical chapter. Based on these findings, a table 1 was developed. It presents selected probiotic strains used in obesity management. The comparative criteria included mechanisms of action, clinical effectiveness, as well as the

advantages and disadvantages of their use, together with potential barriers. The data are derived from human studies and meta-analytical research.

Table 1. Comparative analysis of probiotics used in case of obesity treatment

Probiotic	**Mechanism of Action**	**Clinical Effectiveness**	**Advantages**	**Disadvantages and risks**
Lactobacillus gasseri	Enhanced fat oxidation, increased SCFA and CLA, reduced inflammation, improved gut barrier	12-week RCT using fermented milk, 8–9% visceral fat reduction, weight and waist decrease	Well-tolerated, natural milk-derived strain, strong visceral-fat reduction	Effect depends on strain, BNR17 showed no significant weight loss in another study
Lactobacillus plantarum	Modulates microbiota, anti-inflammatory, lowers cholesterol	9-week RCT metaanalysis, significant BMI and weight reduction comparing to placebo group	Common in fermented foods, improves lipid profile and inflammation	No long-term studies, strain and dose variability, food presence limits controlled data
Lactobacillus rhamnosus	Strengthens gut barrier, reduces endotoxemia; inhibits fat storage	Mixed results – waist reduction in pregnancy ($p < 0,001$), better insulin sensitivity	Well-studied, representative findings, safe strain	Anti-obesity effect is uncertain, some studies show no weight loss, depends on sex and age
Bifidobacterium animalis subsp. lactis	Increases ANGPTL4 and SCFA, improves lipid profile	3-month RCT, BMI amd waist reduction, improved *Akkermansia*, better insulin markers	Documented metabolic benefits, different methods of using it	Modest effect (1–2% BMI reduction), often combined with diet
Bifidobacterium breve	Increases ANGPTL4, supports adiponectin, alters microbiota	12-week trial, no significant weight loss, subgroup fat-parameter improvement	Infant-derived (high tolerability), improves lipid and inflammatory markers	High doses are required, long treatment, inconsistent results
Saccharomyces boulardii	Strengthens gut barrier, reduces inflammation, improves metabolic profile	60-day RCT, significant weight, BMI & fat reduction ($p < 0,05$)	No antibiotic resistance, no side effects reported yet	May require SOD coadministration, fewer studies than in case of bacteria
Multi-szczepowe preparaty probiotyczne – hybryda *Lactobacillus* i *Bifidobacterium*)	Combined mechanisms and synergistic metabolic effects	6-month RCT, around 1,3 kg weight loss ($p < 0,0001$), metabolic wellbeing improvement	Synergy, broad metabolic pathways	Hard to identify active strain, higher costs, sometimes lower efficiency

Source: (Wiciński et al., 2020; Kadooka et al., 2013; Li et al., 2024; Jung et al., 2013; Pedret et al., 2019; Rondanelli et al., 2021; Michael et al., 2020; Merenstein et al., 2023.

As outlined earlier, the effects of some probiotics beneficial for individuals with obesity were already discussed in the theoretical chapter. Based on this comparison, two key pillars of the primary data analysis become apparent. The first concerns ethical considerations and the safety of probiotic use. Within the scope of this study, probiotics were examined in healthy adults, which excludes adverse outcomes associated, for instance, with advanced age. They are generally considered relatively safe. None of the reviewed publications reported complications

caused by the probiotic strains discussed. At the same time, “for the total population, the probiotic reduced the incidence of URTI symptoms by 40%” (Michael et al., 2020). The most frequently mentioned side effects were mild gastrointestinal symptoms. Allergic reactions or even bacteremia are also possible, but only in extremely rare and exceptional cases (Sobhi & Rai, 2024). It is possible that the likelihood of complications increases proportionally with the number of strains used, due to potential interactions, although this remains a logical assumption rather than a confirmed fact. Conversely, some complications (such as diarrhoea) are themselves treatable with probiotics (Zielińska, 2024).

With regard to adverse effects, despite their limited occurrence, it is necessary to discuss the issue of infection-induced bacteremia in more detail (Kullar et al., 2023). This concerns primarily individuals with severe immunosuppressive diseases and may also occur in cases of organ damage. Reducing this risk is possible not only by discontinuing probiotic use or selecting strains in consultation with a physician, but also by preventing contamination of products with pathogenic microorganisms. Safety considerations should remain a priority for pharmaceutical and nutritional supplement manufacturers, as the risk strongly depends on production quality (Merenstein et al., 2023).

Nevertheless, bacteremia requires a holistic perspective. The safety of each strain is assessed based on full genome sequencing and available clinical data. However, certain cases may be more complex – “in one case of preterm neonatal bacteremia, a probiotic-containing *Lsb. reuteri* (strain not reported) had been given, but the blood isolate was only tested using biochemical methods, and thus, the specific strain of *Lsb. reuteri* could not be identified.” In many cases, such events are influenced by mechanical factors and laboratory preparation.

Another criterion involves the advantages of probiotic therapy, considered alongside potential barriers and limitations. The benefits arise from the fact that probiotics are easy-toadminister dietary supplements or components of functional foods (Jach et al., 2013). This makes them widely accessible, although at times underestimated by the general public. They may complement conventional weight-loss strategies and are often used without medical supervision, sometimes even perceived as substitutes for lifestyle modification. The comparative analysis of numerous studies demonstrated that selected strains not only support fat reduction but may also improve biochemical markers such as glucose levels, lipid profiles, inflammatory markers, and metabolic indicators. The latter are assessed, for example through reductions in insulin resistance and cholesterol levels (Pedret et al., 2019).

As highlighted earlier, probiotics also directly influence intestinal motility and bowel regularity, which may support weight reduction by improving patient comfort. Clinical studies confirm

high tolerability, with low dropout rates due to side effects (Wiciński et al., 2020). Another advantage lies in their ability to modulate immune responses and promote immunoregulation (Jagacka, 2023). Probiotics are therefore used not only in obesity management, as the cited author indicates.

Turning to limitations, that probiotic efficacy in weight management is typically moderate and highly dependent on the specific strain, dosage, duration of therapy, and the characteristics of the patient population. Not every probiotic strain produces significant effects – some studies reported statistically insignificant results, such as *L. rhamnosus* in the second trimester of pregnancy or *L. reuteri* in individuals with type 2 diabetes (Wiciński et al., 2020). Selecting the optimal strain requires further research. Moreover, effective outcomes often demand high doses and long-term supplementation, which may generate financial barriers, showing that limitations also arise from production and cost-related factors.

The variability observed across studies suggests that probiotic effectiveness may depend on the individual's gut microbiota composition. Furthermore, most commercial products are multi-strain mixtures, complicating the identification of the most active component. At the same time, the universal nature of probiotics might also pose risks and limitations. For instance, the study by Sadeghi, Ansari and Jalili demonstrated a direct association between probiotic use and infection in groups such as pregnant women, immunocompromised individuals, and children (Sadeghi, Ansari & Jalili, 2018).

The presented comparison and conclusions allow for the verification of the hypotheses:

- H1: The use of selected probiotic strains leads to clinically significant reductions in body weight and improvements in metabolic parameters in individuals with obesity compared with placebo.

This hypothesis was partially confirmed. Data from RCTs and meta-analyses indicate that certain strains, such as *Lactobacillus gasseri, Lactobacillus plantarum* and *Bifidobacterium animalis subsp. lactis*, lead to significant reductions in body weight, BMI, or waist circumference, as well as improvements in lipid profiles and insulin sensitivity. However, this effect is not universal across all studies – several strains (for example *L. rhamnosus* or *B. breve*) demonstrate effectiveness only in specific populations or subgroup analyses,

- H2: The mechanisms of action of probiotics translate into measurable metabolic effects, including reductions in fat mass, improved lipid profiles, and enhanced insulin sensitivity.

This hypothesis was confirmed. Researchers show that the key mechanisms, mainly SCFA production, increased ANGPTL4 expression, modulation of the gut microbiota, improved intestinal barrier integrity, and reduced inflammation, are directly associated with measurable

metabolic outcomes. For instance, with *L. gasseri* this included effects on visceral fat, for *B. animalis* improvements in lipid markers and insulin resistance; and for *S. boulardii* general metabolic benefits,

- H3: The varied effectiveness of individual probiotic strains results from species and strain-specific differences, distinct metabolic pathways, varying colonization abilities, and divergent metabolite production.

This hypothesis was confirmed. Effectiveness differs not only between species (just like *Lactobacillus* and *Bifidobacterium*), but also between strains of the same species. A clear example is the contrast between *L. gasseri* SBT2055 and the ineffective BNR17 strain. The differences arise from variability in enzyme expression, adhesion capacity to the intestinal epithelium, and divergent influence on the production of SCFAs, CLA, or ANGPTL4. This hypothesis is directly interconnected with the conditions described under H2,

- H4: Multi-strain preparations produce greater reductions in body weight and more pronounced improvements in metabolic parameters than single-strain preparations due to synergistic effects between the mechanisms of individual bacteria.

This hypothesis was partially confirmed. Studies on multi-strain formulations demonstrate statistically significant effects in reducing body weight; however, these effects are not always stronger than those observed in single-strain interventions. It is also difficult to determine which strain contributes to which effect, and some hybrids do not demonstrate synergy, resulting in lower overall effectiveness.

The fact that none of the hypotheses were rejected confirms the validity and representativeness of the conducted review and highlights the need for further research.

Before that, however, a comprehensive discussion is necessary.

4. Discussions

It should be noted that, due to the specific nature of this study, the development of the discussion section proved challenging. This difficulty results from the fact that most research focuses on probiotics and their properties rather than on the literature review process or comparative analysis itself.

The analysis showed that probiotics differ both in their mechanisms of action and in their effectiveness. The strains with the most documented impact on weight reduction are *L. gasseri* SBT2055, *L. plantarum*, and, to some extent, multi-strain formulations in which a synergistic effect is observed. Strains whose action is mainly metabolic, but with limited impact on body weight, include primarily *B. animalis, B. breve*, and *L. rhamnosus*.

Another point of discussion is that probiotics operate through different metabolic pathways. For instance, SCFAs regulate appetite and energy metabolism, ANGPTL4 decreases fat storage and CLA enhances fat oxidation. Improvements related to inflammation result from reduced LPS concentrations, while modulation of the microbiota leads to increased *Akkermansia* abundance. The limitations of the reviewed studies arise from the fact that they were conducted by various research institutions. This article did not examine methodological differences between studies beyond the duration of supplementation and the characteristics of the study population. It also did not assess whether the results could be replicated in other populations or in repeated trials with the same group. Considerable heterogeneity was observed in doses, strains, lengths of supplementation, and the influence of diet and lifestyle. Evaluating probiotic effects requires distinguishing between the outcomes attributable to lifestyle modification and those produced directly by probiotic intake.

Based on the conducted analysis, the following potential directions for future development of probiotics in the detection, prevention, treatment, and management of obesity can be identified:

- identification of the most effective strains and combinations – a research direction that provides opportunities to compare various single-strain and mixed formulations. The resulting knowledge will help determine optimal compositions, with implications for both medical and scientific practice,
- optimal dosage and duration of administration – as noted, the minimum effective dose and duration of supplementation remain unclear. The goal is to establish regimens that ensure sustained effects. Current evidence suggests that benefits may diminish after discontinuation, as shown in the *L. gasseri* trial (Kadooka et al., 2013). Because many interacting factors influence outcomes, a hybrid methodological approach is advisable,
- personalization of therapy – identifying optimal strains lays the foundation for tailored supplementation strategies. Future approaches may involve metabolic matching of specific strains to a patient's microbiota profile. Research on colonization mechanisms suggests that not all patients respond equally, which should be considered in the design of future RCTs (Merenstein et al., 2023),
- ensuring long-term safety – although probiotics are considered important in obesity treatment, there is insufficient evidence on their long-term effects, particularly regarding safety. Continuous monitoring is recommended, especially for vulnerable populations, such as individuals with obesity and immunosuppression,
- establishing microbiota balance in obesity treatment – research should aim to deepen understanding of probiotic-based therapies. Initial studies should focus on specific strains, as

demonstrated in trials involving *Bifidobacterium animalis subsp. lactis* (Pedret et al., 2019). Considering particular population groups will allow for more targeted research and innovation. Bringing these elements together, and following the findings of Tiwari's team, it becomes clear that the use of probiotics in medicine and dietetics particularly in the treatment of obesity is highly promising. This influence extends to the broader therapeutic potential of probiotics, especially given that "probiotic therapy has already made its way in the treatment of a number of conditions—infectious, inflammatory, neoplastic, and allergic" (Tiwari et al., 2012). Furthermore, despite the beneficial effects of certain strains, it is essential to consider issues of availability: even if a probiotic is effective, demand may arise from populations who cannot access or safely use it. Still, this one is more related to economic aspects of supply and demand than to the clinical treatment of obesity itself.

5. Conclusions

Probiotic therapy represents a promising, although supplementary, approach to supporting weight reduction in individuals with obesity. The reviewed literature highlights several *Lactobacillus* and *Bifidobacterium* strains that exhibit beneficial effects on metabolic and anthropometric parameters in humans. However, the effects are generally moderate and strongly dependent on individual factors. In the comparative overview of strains, the key differences concerned both the mechanisms of action and the degree of documented clinical effectiveness. While some strains have been validated in RCTs, others require further investigation.

Probiotics also offer a range of additional benefits – they improve lipid profiles, enhance glycaemic control, and reduce inflammation. These effects are particularly advantageous for individuals with obesity and contribute indirectly to improved health outcomes. The choice of a specific probiotic preparation should be based on scientific evidence relevant to the target population, rather than on subjective beliefs or recommendations circulating in the general public. When used alongside conventional methods, probiotic therapy can meaningfully support weight reduction. Nevertheless, further well-designed clinical studies that consider a wide range of variables, including population characteristics and research settings, are essential to fully evaluate the potential of probiotics as a tool in obesity management.

Disclosure

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