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Obesity prevention and treatment using probiotics and prebiotics

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Abstract

Obesity and other metabolic disorders are major health problems that can lead to cardiovascular disease, type 2 diabetes, musculoskeletal ailments, and a variety of cancers. There is a link between gut microbiota and metabolic problems, according to recent research. It was shown that the composition of the gut microbiota differs significantly between lean and obese people. The host's metabolism, as well as the immune and endocrine systems, are influenced by gut microorganisms. These microbes can alter the host's ability to store or get energy from food goods by regulating gene expression. To keep the host's health intact, it's critical to maintain a good balance of intestinal microbiota through proper diet and the use of probiotics and prebiotics. In our review, a total of 36 papers were examined (25 human and 11 animal trials). The duration of the trials ranged from four weeks to ten years, with 12 weeks being the most prevalent test period. The impact of gut microorganisms, probiotics, and prebiotics on many processes that contribute to the aforementioned metabolic condition is also examined, providing a comprehensive overview of the subject.

Keywords: Obesity, Human health, Gut microbiota, Probiotics, Prebiotics, Overweight

1 Introduction

Prebiotics were first characterized in the mid-1990s as non-digestible dietary components that aid the growth and/or activity of helpful microbes in a host's gastrointestinal system. Prebiotics were reclassified by the WHO in 2007 as "non-viable dietary components that have a

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health benefit on the host through modification of the microbiota." (Hutkins et al., 2016) A prebiotic is defined as "a substrate that is selectively utilized by host microorganisms giving a health advantage," according to The International Scientific Association for Probiotics and Prebiotics (ISAPP). (Gibson et al., 2017) Plant-derived components are the most common prebiotic sources. These compounds can be found in a variety of foods, including cereals, fruits, vegetables, and other plant-based foods, such as oats, wheat, barley, a variety of berries, onions, garlic, bananas, tomatoes, legumes, honey, and many more. (Schrezenmeir and de Vrese, 2001) Food can be combined with prebiotics to enhance its nutritional content for the host's health. Prebiotic supplements are commonly available on the market. Prebiotics can also be found in human breast milk, which contains oligosaccharides that are identical to galactooligosaccharides but are referred to as human milk oligosaccharides (Rajendran et al., 2017).

1. 1. Probiotics and prebiotics mechanism of action against obesity

Several research groups have looked at the process that links the bacteria in the intestine to energy metabolism. The gut microbiota can induce alterations in the intestinal epithelium, such as increased intestinal capillaries density or altered gut motility, which leads to increased energy extraction from food products. Furthermore, the epithelial cell barrier between the intestinal lumen and the mucosal lymphoid tissue around it in the intestine is only one layer thick, making it vulnerable to disturbance by the bacteria or their metabolites. Such changes can result in increased permeability to pathogenic bacteria and their metabolic products, which can lead to a variety of disorders, including celiac disease, infections, inflammatory bowel disease, and others (Guo et al., 2017).

These diseases are frequently linked to insulin resistance, inflammation, and oxidative stress, all of which are linked to obesity-related problems. Some probiotic strains (mostly Bifidobacteria and Lactobacillus) can help restore correct gut barrier function by promoting mucus secretion or altering the phosphorylation of cytoskeletal and tight junctional proteins, which can have an indirect anti-obesity impact (Brusaferro et al., 2018). The numbers of Gram-negative bacteria and permeability of the intestine rise when the microbiota is altered in such a way that *Lactobacillus, Bifidobacterium, and Prevotella spp*. are reduced. Following its connection with Gram-negative bacteria lysis, increased lipopolysaccharide (LPS) can be seen, which may operate as a precursor to inflammation and oxidative stress. LPS is involved in the activation of the nuclear factor kappa-light-chain-enhancer of activated B cells (NF-kB) protein complex (which regulates DNA transcription, cytokine production, and cell survival), which can result in chronic inflammation, endotoxemia, and fat formation (Ridaura et al., 2013). As a result, probiotics and their immune-modulating properties may play a role in obesity treatment. Some probiotic strains such as *Lactiplantibacillus plantarum* (previously known as *L. Plantarum*) (Zheng et al., 2020) are also able to influence lipid metabolism of the cell (Park et al., 2011). revealed that treatment with *L. plantarum* KY1032-CE notably downregulated accumulation of lipids in maturing 3T3-L1 pre-adipocytes (the effect was proportional to dose of strain extract used). Moreover, the number of lipid-containing rounded cells was reduced. Used strain decreased the mRNA and protein expression of several adipocyte-specific genes: fatty acid synthase, peroxisome proliferator-activated receptor-c2, adipocyte-fatty acid binding protein and CCAAT/enhancer binding protein. These findings show that *L. plantarum* KY1032 CE can influence adipogenesis in maturing pre-adipocytes to regulate fat mass. It is also known that the gut microbiota utilizes non-digested saccharides that accumulate in the intestines to produce a variety of byproducts (SCFAs, cofactors, and vitamins) that are involved in energy metabolism metabolic pathways. The reduction of fat accumulation and body weight has an impact on body composition in addition to reduced appetite. (Wang et al., 2019). These effects are mostly due to changes in energy metabolism generated by the gut microbiota, but they can also be linked to their immune system-supporting function through the production of metabolites that regulate certain metabolic pathways (Ley et al., 2006; Million and Raoult, 2013).

Table 1. Commonly used probiotic microorganisms (Zheng et al., 2020; BIOHAZ, 2013; BIOHAZ, 2017; Heyman and Ménard, 2002)

Lactobacillus Species	Bifidobacterium Species	Other Bacteria	Yeasts
*L. acidophilus (a)**	*B. adolescentis (a)*	*Bacillus cereus (b)*	*Saccharomyces boulardii (a)**
*L. amylovorus (b)**	*B. animalis (a)**	*Bacillus clausii (a)*	*Saccharomyces cerevisiae (a)**
*L. bulgaricus (b)**	*B. bifidum (a)*	*Clostridium butyricum (b)*	
*Lacticaseibacillus casei (a, b)**	*B. breve (b)*	*Enterococcus faecalis (a)*	
*L. gasseri (a)**	*B. infantis (a)*	*Enterococcus faecium (a)*	
*L. helveticus (a)**	*B. lactis (a)**	*Escherichia coli (a)*	
*L. johnsonii (b)**	*B. longum (a)**	*Lactococcus lactis (b)**	
*Lacticaseibacillus paracasei (b)**		*Streptococcus thermophilus (a)**	
*Lactiplantibacillus pentosus (b)**			
*Lactiplantibacillus plantarum (b)**			
*Limosilactobacillus reuteri (a)**			
*Lacticaseibacillus rhamnosus (a,b)**			
*Ligilactobacillus salivarius (b)**			

a Used often as pharmaceuticals (b) Used mostly as food additives; *fulfilling QPS standards (Qualified Presumption of Safety)

1. 2. Prebiotics, their influence on weight and summary of clinical trials

In Table 2, The results of 12 clinical research looking at the effects of prebiotics on body composition were reported. The most prevalent type of prebiotic related with the anti-obesity effect, according to the research, is oligofructose-based prebiotics. Others, such as inulins, xylo, and galacto-oligosaccharides, are less common, making it harder to make conclusions about their effects. The most common effect of prebiotics, however, was an increase in satiety. Furthermore, all prebiotics have an influence on the makeup of the gut microbiota by stimulating the proliferation of specific species (e.g., *Bifidobacterium spp.*, *Lactobacillus spp.*) including those with anti-obesity properties and raising their concentration several times (Nicolucci et al., 2017).

Table 2. The summary of clinical trials, which investigated the effect of prebiotics on body composition and obesity-related matters.

Reference	Number Of Participants	Time And Type Of Study	Prebiotic Used / Dosage	Outcomes
Canfora et al., 2017	44 overweight or obese adults	12 weeks/double blind, placebo controlled	Galactooligosaccharide / 15 g daily	No significant effects on body composition
Drabińska et al., 2018	34 pediatric patients with celiac disease	3 months/ randomized, placebo controlled	Oligofructose-enriched inulin / 10 g daily	Significant increase of Bifidobacterium counts and SCFA levels – potential antiobesity effects
Hume et al., 2017	42 overweight children	16 weeks/ randomized, double blind, placebo controlled	Oligofructose-enriched inulin / 8 g daily	Increased satiety of subjects, lower prospective food consumption, and reduced energy intake. Increased fasting adiponectin and ghrelin
Lambert et al., 2017	50 overweight or obese adults	12 weeks/ randomized double blind, placebo controlled	Yellow pea fibre / 15 g daily	Reduction of body fat. Reduction in energy intake. Increased insulin levels
Liber and Szajewska, 2014	79 overweight and obese children	12 weeks / randomized, double blind, placebo controlled	Oligofructose / 8 g daily for children 7-11 years old, 15 g daily for children aged 12-18	No effect on body weight and composition.
Machado et al., 2019	26 overweight adults	6 weeks/randomized, double blind, placebo controlled	Yacon flour (fructooligosaccharide) 25 g daily – 0.1 g FOS/ kg body weight	No adverse effects. Reduction of body weight, body fat, waist circumference, waist to height ratio. Improved bowel function.
Nicolucci et al., 2017	42 overweight children	16 weeks / single center, double blind, placebo controlled	Oligofructose-enriched inulin / 8 g daily	Decreased body weight, fat mass, abdominal fat. Reduced interleukin 6. Significant increase in the population of Bifidobacterium spp.
Pol et al., 2018	55 overweight or obese adults	12 weeks / parallel, triple blind, placebo controlled	Oligofructose / 16 g daily	Reduced appetite. No significant effect on body composition
Reimer et al., 2017	125 overweight and obese adults	12 weeks/, randomized, double blind, placebo controlled	Inulin-type fructans / 16 g daily	Increased satiety. Alterations in intestinal microbiota (e.g. increased Bifodobacterium spp.)

In the same way as probiotic research produces inconsistent outcomes, these studies do as well. Animal trials, on the other hand, produce far more consistent results. It's likely due to the same problems, such as a lack of control over test volunteers and interspecies variances. However, meaningful conclusions can only be drawn once a large number of detailed investigations have been carried out.

1. 3. Anti-obesity effect of probiotics in clinical trials

Tables 3 and 4 describe the results of multiple clinical investigations (on people and animals, respectively) conducted using various probiotic strains and their impact on metabolic parameters (mainly obesity). The duration of the trials ranged from four weeks to ten years, with 12 weeks being the most prevalent test period. A total of 36 papers were examined (25 human and 11 animal trials). In some cases, the results were ambiguous and contradictory (*L.*

casei, L. rhamnosus, B. longum); however, several probiotic strains (*L. gasseri, L. plantarum*) were easily connected to an anti-obesity impact and can thus be utilized to treat obesity. In animal trials, inconsistency is far less obvious, which appears to be related to scientists' ability to 'manage' the examined subjects. This could be a problem in human trials, as many of them depend only on nutritional advice or sets of dietary recommendations to be followed by study participants. It is, nevertheless, tough to break one's habits, particularly those involving eating. The findings of the experiments are inconsistent if participants do not follow the specific directions, making it difficult to draw any conclusions. It is significantly easier to monitor a subject's activity and diet in animal studies, such as on rodents, resulting in higher consistency and more trustworthy results. However, it is clear that probiotics may have different effects on various animals than they do on people, thus human trials are essential. Therefore, to prevent research errors, the test groups should be closely supervised.

Table 3. Clinical human trials which investigated the effect of probiotics on body composition.

Reference	Number Of Participants	Time And Type Of Study	Microorganisms Used And Dosage	Outcomes
Bernini et al., 2016	51 subjects	45 days / randomized, double blind, placebo controlled	*Bifidobacterium animalis ssp. lactis HN019* (3.4x108 CFU mL-1) / 80 ml of probiotic milk daily	Reduction in BMI, total cholesterol, low-density lipoprotein. Decrease in tumor necrosis factor α and interleukin
Famouri et al., 2017	64 obese children with NAFLD	12 weeks / randomized, triple blind, placebo controlled	*L. acidophilus ATCC B3208* (3x109 CFU), *L. rhamnosus DSMZ21690* (2x109 CFU), B. lactis DSMZ (6x109 CFU), *B. bifidum ATCC SD6576* (2x109 CFU) / 1 capsule daily	No significant changes in BMI and body weight, Lower waist circumference
Gomes et al., 2020	32 obese women	12 weeks / randomized, double blind, placebo controlled	*Probiotic mix: L. acidophilus, L. casei, L. lactis, B. bifidum and B. lactis* / 4x109 CFU of each strain daily	Correlation of BMI, weight, fat mass, lean mass (and more) with microbiome composition was found
Hibberd et al., 2019	134 subjects	6 months / randomized, double blind, placebo controlled	*Bifidobacterium animalis subsp. lactis 420*™ / 1x1010 CFU daily	Negative correlation with waisthip ratio, alterations of the gut microbiota and its metabolism
Huang et al., 2019	54 men and women	6 weeks / randomized, double blind, placebo controlled	*L. plantarum TWK10* / 3x1010 CFU and 9x1010 CFU daily	Noticeably increased sport performance in dose dependent manner, significant decrease in body fat, elevated muscle tissue increase
Jung et al., 2015	120 obese adults aged 20-65 years	12 weeks / randomized, double blind, placebo controlled	*L. curvatus HY7601, L. plantarum KY1032* / *5x109* CFU of each strain daily	Lower body weight, waist circumference and body fat
Kadooka et al., 2013	87 subjects with high BMI	12 weeks / randomized, double blind, placebo controlled	*Lactobacillus ga*sseri SBT2055 / 5x1010 CFU in 100 g of yoghurt daily	Significant decrease of body fat mass, waist and hip size, BMI
Kassaian et al., 2020	120 patients with prediabetes	6 months / randomized, double blind, placebo controlled	*Lactobacillus acidophilus, Bifidobacterium lactis, Bifidobacterium bifidum, Bifidobacterium longum* / 1.5×109 CFU of each strain daily	Increased abundance of microbiota associated with antiobesity effects. (Bacteroides fragilis to E. coli ratio increased, while ratio of Firmicutes to

				Bacteroidetes reduced).
Kim et al., 2017	66 overweight subjects	12 weeks / randomized, double blind, placebo controlled	*L. curvatus HY7601* and *L. plantarum KY1032 / 5x109* CFU of each strain daily	Weight loss and adiposity reduction associated with increase in medium-chain acylcarnitines
Kim et al., 2018	90 adults with BMI range 25-35	12 weeks / randomized, double blind, placebo controlled	*Lactobacillus gasseri BNR17* / 109 and 1010 CFU daily	Significant reduction of visceral fat tissue, waist circumference
Kobyliak et al., 2020	54 subjects	8 weeks / randomized, double blind, placebo controlled	10 g of Multiprobiotic Symbiter Forte Omega containing: *Lactobacillus (1x1010 CFU), Bifidobacterium (1x1010 CFU), Lactococcus (1.0x109 CFU), Propionibacterium (1.0x109 CFU), Acetobacter (1.0x106 CFU)*	Reduction of HOMA2-IR, improved insulin sensitivity. Significant reduction of body weight, BMI and other markers of chronic systemic inflammation
Lim et al., 2020	114 adults (BMI ≥ 25)	12 weeks / randomized, double blind, placebo controlled	*Lactobacillus sakei CJLS03* / 1x1010 CFU daily	Significantly reduced body fat mass and waist circumference
Lorenzo et al., 2020	20 subjects (BMI ≥ 30)	10 weeks / pilot study, randomized, placebo controlled	*L. plantarum LP115, B. brevis B3,* and *L. acidophilus LA14 / 2x109 CFU of each strain daily*	Improved balance of gut microbiota, significantly better parameters such as weight loss, blood pressure, glycemic and lipid profiles
Minami et al., 2018	80 pre-obese adults (20-64 years)	12 weeks / randomized, double blind, placebo controlled	*Bifidobacterium breve* B-3 / 2x1010 CFU daily	Decreased total body fat mass
Mokhtari et al., 2019	46 morbidly obese patients after one-anastomosis gastric bypass	9 months / randomized, double blind, placebo controlled	*Lacticaseibacillus casei* (3.5 × 109 CFU daily), *Lacticaseibacillus rhamnosus* (7.5 × 108 CFU daily), *Streptococcus thermophiles* (1 × 108 CFU daily), *Bifidobacterium breve* (1 × 1010 CFU daily), *Lactobacillus acidophilus* (1 × 109 CFU daily), *Bifidobacterium longum* (3.5 × 109 CFU daily), *Lactobacillus bulgaricus* (1 × 108 CFU daily)	Reduced the elevation of lipopolysaccharides-binding protein levels, improved serum TNF-α, vitamins B12 and D3. Increased weight loss.
Moludi et al., 2021	44 patients with coronary artery disease	12 weeks / randomized, double blind, placebo controlled	*L. rhamnosus* GG 1.6x109 CFU daily	Significant reduction in total cholesterol and LDL cholesterol levels. No effects on anthropometric indices.
Nagata et al., 2017	34 children	6 months / randomized, double blind, placebo controlled	*Lacticaseibacillus casei strain* Shirota / up to 4x1010 CFU daily	Significant decline in body weight, improvement of lipid metabolism
Narmaki et al., 2020	64 obese women	12 weeks / randomized, double blind, placebo controlled	*Lactobacillus acidophilus*(1.8 × 109 CFU capsule-1), *Bifidobacterium bifidum* (1.8 × 109 CFU capsule-1), *Bifidobacterium lactis* (1.8 × 109 CFU capsule-1), *Bifidobacterium longum* (1.8 × 109 CFU capsule-1), *Lacticaseibacillus rhamnosus* (1 × 109 CFU/ capsule), *Limosilactobacillus reuteri* (1 × 109 CFU capsule-1) / 2 capsules daily	Significant reduction of bodyweight, BMI, waist circumference, waist to hip ratio and body fat percentage. Improved eating behavior. Improved appetite regulating hormones.

Ogawa et al., 2015	30 adults	4 weeks / randomized, double blind, placebo controlled	*Lactobacillus gasseri* SBT2055 / 5x109 CFU daily	Increased fat emulsion droplet size leading to suppression of fat hydrolysis, suppression of lipid absorption and promotion of fecal fat excretion
Pedret et al., 2019	126 obese adults	12 weeks / randomized, parallel, double blind, placebo controlled	*Bifidobacterium animalis subsp. Lactis CECT* 8145 / 1010 CFU daily	Decreased BMI and waist circumference to height ratio
Razmpoosh et al., 2020	70 overweight women	8 weeks / randomized, double blind, placebo controlled	*L. acidophilus* La5 (9.25x107 CFU daily) *B. lactis* Bb12 (8.95x107 CFU daily)	Significantly decreased triglycerides and low density lipoprotein cholesterol. Increased effectiveness of losing body weight, body fat percentage and waist circumference.
Sanchez et al., 2017	105 obese men and women	12 weeks / randomized, double blind, placebo controlled	*Lacticaseibacillus rhamnosus* CGMCC1.3724 / 3.2x108 CFU daily	Increased weight loss and satiety, reduced food craving and appetite
Sanchis-Chordà et al., 2019	48 obese children with insulin resistance	13 weeks / randomized, double blind, placebo controlled	*Bifidobacterium pseudocatenulatum* CECT 7765 / 109 - 1010 CFU daily	Lower body weight
Song et al., 2020	50 subjects (BMI>25)	12 weeks / randomized, double blind, placebo controlled	*B. breve* CBT BR3, *L. plantarum* CBT LP3 / 1.5x1010 CFU of each strain daily	Waist circumference, total fat area, visceral fat significantly reduced
Vajro et al., 2011	20 children with hypertransaminasemia and ultrasonographic bright liver	8 weeks / randomized, double blind, placebo controlled	*Lacticaseibacillus rhamnosus* GG / 1.2x1010 CFU daily	Decreased BMI and visceral fat tissue

Table 4. Studies which investigated the effect of probiotics on body composition of rodents.

Reference	**Animal Subject**	**Time Of Study**	**Microorganisms Used / Dosage Probiotics**	**Outcomes**
Kang et al., 2010	Sprague-Dawley Rats	12 weeks	Lactobacillus gasseri BNR17 / 2x 109 CFU mL-1	Decreased gain of weight and white adipose tissue in diet-induced overweight
Kang et al., 2018	40 ICR mice	9 weeks	Bifidobacterium longum BORI and Lacticaseibacillus paracasei CH88 / 5x108 CFU mL-1 of the two probiotics daily	Decrease of adipose tissue, improved fasting glucose levels and total cholesterol excretion in feces
Karimi et al., 2015	40 Sprague-Dawley Rats	15 weeks	Lacticaseibacillus casei strain Shirota and Bifidobacterium longum / 108 and 109 CFU of each strain daily	Significant reduction of weight, fat mass and triglycerides. Better results were observed in the case of B. longum
Kondo et al., 2010	18 C57BL/6 mice	8 weeks	Bifidobacterium breve B3 / 108 and 109 CFU daily	Reduction in diet-induced weight gain; improved levels of total cholesterol, insulin and fasting glucose
Lee et al., 2018	21 C57BL/6 mice	5 weeks	Lactiplantibacillus plantarum Ln4 / 5x108 CFU daily	Reduction of diet-induced fat mass gain and type-2 diabetes-related biomarkers
Park et al., 2018	C57BL/6 mice	12 weeks	Lactobacillus acidophilus NS1 / 1x108 CFU daily	Significantly reduced diet-induced obesity and hepatic lipid accumulation; improved

				insulin sensitivity
Cho et al., 2018	60 C57BL/6J mice	9 weeks	Polyphenol-rich Grape Seed Flour (5% and 10% of caloric daily intake)	Reduction of weight gain induced by high-fat diet. Reduced adipose tissue, plasma lipid concentrations, insulin resistance and glucose intolerance.
Dai et al., 2017	50 ICR IGS mice	12 weeks	α-GOS from Chickpea (0.083 g / 0.42 g / 0.83 g daily)	Significant increase in the number of Bifidobacterium and Lactobacillus. Increased production of SCFA (propionic and butyric acids).
Huazano-García et al., 2017	42 C57BL/6 mice	5 weeks	Agavins + oligofructose (0.38 g day-1 per mouse)	Improved ratio of Firmicutes/Bacteroides after its alteration by high-fat diet. Higher levels of SCFA. Weight loss.
Jiao et al., 2019	C57BL/6J mice	12 weeks	Blueberry polyphenol extract (200 mg kg-1 body weight daily)	Inhibition of body weight gain and normalization of lipid metabolism after high fat died induction. Modulation of specific bacterial species such as Proteobacteria, Deferribacteres, Actinobacteria, Bifidobacterium, Desulfovibrio, Adlercreutzia, Helicobacter, Flexispira, and Prevotella
Li et al., 2020	Wistar rats and C57BL/6J mice	8 weeks	Oligofructose (10% wt/wt) + metformin (150 mg kg-1)	Positive effect on host's metabolism. Reduced side effects of metformin while improving metabolic outcomes such as glycemic control and reduction of weight.

Despite the large number of probiotic strains available, there are still an insufficient number of studies on the effects of probiotics on body composition and metabolic diseases. Some strains have been thoroughly researched (for example, Lactobacillus gasseri), but there are few studies on the impact of other probiotics on the obesity problem (e.g. Bifidobacterium infantis). Given that society is on the approach of an obesity epidemic, such gaps in knowledge on such an important subject should be filled as soon as possible.

2 Meta-analyses

Meta-analyses, the statistical method of combining data from a large number of research to draw an overall conclusion, are now possible in the era of bioinformatics, thanks to a great amount of scientific data available online. While the latter is the most significant benefit, such reviews do have drawbacks. Comparing research with the same purpose but different techniques and conditions can be difficult, and statistics can be incorrect. To avoid erroneous results, data should only be acquired from studies conducted under the same conditions. Nonetheless, this form of research could provide a useful summary of a subject or assist in determining whether or not it is a worthwhile issue to investigate. Table 5 lists a handful of these prebiotic and probiotic reviews. In the case of both probiotics and prebiotics, the outcomes of these research are highly promising. They have a significant impact on human body composition. Probiotics have been shown to have a direct anti-obesity impact in most cases, lowering BMI, body weight, and body fat in participants. In the preceding sections of this article, possible methods of action were discussed. Furthermore, probiotics' potential to lower

LDL cholesterol, fasting glucose, and insulin levels was shown to be considerable, demonstrating their anti-obesity and health-promoting effects. The data on the anti-obesity effects of probiotics versus prebiotics, on the other hand, is significantly different. As a result, the contradictions are obvious, and it is clear that more research in the subject of prebiotics is required. Nonetheless, the findings show that prebiotics have a lot of potential in the treatment of obesity and obesity-related disorders, and that they have good impacts on body composition. As a result, more study into the anti-obesity effects of probiotics and prebiotics is highly recommended. It should be emphasized, however, that each study highlights a considerable variation amongst tested clinical reviews. Furthermore, certain probiotics and prebiotics strains exhibit the desired anti-obesity effect while others do not, leading to even further inaccuracy. (e.g. *L. gasseri* have a strong positive effect on body composition, while *L. acidophilus* aids weight gain).

Table 5. The summary of several meta-analyses done on the topic of prebiotics, probiotics.

Reference	Total Number Of Subjects/Trials	Duration Of Assessed Studies	Topic Studied	Outcomes
Beserra et al., 2015	8 trials, 276 subjects	Not specified	Effects of prebiotics and synbiotics on glycaemia, insulin concentrations and lipid parameters in adult patients with overweight or obesity.	No significant LDL cholesterol differences were found after prebiotic supplementation Significant reduction of total cholesterol after prebiotic supplementation No significant effect on fasting glucose and insulin levels after prebiotic supplementation
Borgeraas et al., 2018	15 studies, 957 subjects	3-12 weeks	Effects of probiotic supplementation on body composition (body weight, BMI, fat mass, fat percentage) of overweight subjects	Significantly improved rates of positive body composition changes compared with placebo
John et al., 2018	41 full articles were assessed	Not mentioned	Effects of probiotics, prebiotics and synbiotics on body composition	Probiotics were associated with noticeable BMI, body and fat mass decrease Prebiotics were associated with reduction in body weight Synbiotics had no significant effects on body composition
Koutnikova et al., 2019	105 articles, 6826 subjects	At least 14 days, not longer than 3 years	Effects of probiotics on obesity, diabetes and non-alcoholic fatty liver disease	Significant improvements in body composition (body weight, BMI, waist circumference, fat mass, visceral adipose tissue) Reduced fasting glucose levels, glycated haemoglobin in diabetic patients Reduced alanine and aspartate aminotransferase in subjects with fatty liver disease The most efficient strains were *B. breve, B. longum, S. salivarius ssp. thermophilus, L. acidophilus, L. casei, L. delbruecki*
López-Moreno et al., 2020	6 clinical trials, 9 animal clinical studies	5-11 weeks	Administration pattern of probiotic strains and effective doses for obesity-related disorders	Positive effects of the probiotics group vs. placebo on the reduction of BMI, total cholesterol, leptin, and adiponectin Effective intervention total doses were

			according to their capacity of positively modulating key biomarkers and microbiota dysbiosis	determined as 2x106 CFU of tested strains *of Bifidobacterium spp, Lactobacillus spp.*
Million et al., 2012	17 randomized clinical trials on humans 51 studies on farm animals	Not mentioned	Effects of Lactobacillus spp. containing probiotics on body composition	*L. gasseri, L.plantarum* identified as species with anti-obesity effects *L. reuteri, L. casei, L. rhamnosus* associated with inconsistent effects *L. acidophilus, L. fermentum, L. ingluviei* identified as species promoting weight gain
Park and Bae, 2015	350 subjects	Range from 3 to 24 weeks	Effects of probiotics on body composition	No significant effects on weight and BMI
Thompson et al., 2017	609 subjects	Range from 2 to 17 weeks	Effects of soluble fiber supplementation on body weight	BMI reduction by 0.84 Body weight reduction by 2.52 kg Body fat reduction by 0.41 % Fasting glucose and insulin levels reduction
Wang et al., 2019	12 randomized clinical trials, 821 subjects	8-24 weeks	Probiotics and Weight Loss (Body Weight, BMI, Waist Circumference, Fat Mass, and Fat Percentage	Significant body weight and BMI reduction Reduction of fat mass and fat mass percentage Significant reduction in total cholesterol and LDL cholesterol Reduction of insulin levels Reduction of fasting plasma glucose
Zhang et al., 2016	1931 subjects	Range from 3 to 24 weeks	Effects of probiotics on body composition	Body weight reduction by 0.59 kg BMI reduction by 0.49

3 Conclusion

Obesity have erupted in recent years, and health issues associated to metabolic diseases have become increasingly visible. As a result, it is critical to consider all available remedies in order to prevent such a spread. The gut microbiota is a factor that should not be overlooked, as there is strong evidence linking it to metabolic diseases. Maintaining a healthy gut microbiota will not only help you lose weight, but it can also help you avoid diseases like type 2 diabetes, irritable bowel syndrome, and colon cancer by affecting your immune system. A proper diet is necessary to create this equilibrium, but probiotics and prebiotics can also help the gut bacteria. These strains and substances frequently have anti-obesity properties and impact the host's energy intake. Increased counts of beneficial gut microorganisms, higher levels of short-chain fatty acids, and several other benefits of probiotic and prebiotic supplementation were highlighted in this review, including reductions in BMI, total body fat, metabolic disorders' markers, increased counts of beneficial gut microorganisms, and several others. However, there is still a significant need to be filled, given the low quantity and quality of studies available. During most studies, the number of people who are tested is kept to a minimum. This, combined with the participants lack of monitoring, produces a significant risk of mistakes. There's a good chance that many links between distinct gut microbiota compositions and the host's health are yet unknown, but worth exploring. As a result, more research is needed to expand our understanding of microbiota and its relationship to human health.

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Conflict of interests

The authors declare that there are no competing interests.

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