Effect of Probiotic Dairy Consumption on Obesity and Overweight: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: This systematic review and meta-analysis aim to comprehensively evaluate the effect of probiotic dairy consumption on obesity and overweight individuals.
Methods: A systematic search was conducted across electronic databases to identify relevant clinical trials published between 2000 and 2021. A total of 35 studies met the inclusion criteria, comprising randomized controlled trials assessing the impact of probiotic-containing dairy products on body mass index (BMI), weight, and waist circumference. Random-effects meta-analysis was employed to calculate the Standardized Mean Difference (SMD) and 95% Confidence Intervals (CI) for each outcome.
Results: The pooled analysis of all studies indicated a significant positive association between the consumption of probiotic-containing dairy products and BMI (SMD: 0.30, 95% CI: 0.11-0.50, P<0.001). Subsequent sensitivity analyses confirmed the consistent relationship after excluding heterogeneous studies. Probiotic dairy consumption also exhibited a significant effect on weight (SMD: 0.10, 95% CI: 0.00-0.20, P<0.001) and waist circumference (SMD: 0.44, 95% CI: 0.17-0.71, P<0.001).
Conclusion: This comprehensive meta-analysis provides robust evidence supporting the potential beneficial impact of probiotic-containing dairy products on BMI, weight, and waist circumference in individuals with obesity and overweight. These findings underscore the value of incorporating probiotics into dietary interventions aimed at addressing these challenging public health issues. Further research is warranted to elucidate the mechanisms underpinning these effects and to optimize the implementation of probiotics in clinical practice.

Keywords: Probiotic; Dairy; Body Mass Index (BMI); Obesity; Overweight; Systematic Review; Meta-Analysis.

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تأثیر مصرف لبنیات پروبیوتیک بر چاقی و اضافه وزن: یک مطالعه مروری سیستماتیک و متاآنالیز

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چکیده

زمینه و هدف: این مرور سیستماتیک و متاآنالیز با هدف ارزیابی جامع اثر مصرف لبنیات پروبیوتیک بر افراد چاق و دارای اضافه وزن انجام شده است.

روش‌ها: یک جستجوی سیستماتیک در میان پایگاه‌های داده الکترونیکی برای شناسایی کارآزمایی‌های بالینی مرتبط منتشر شده بین سال‌های ۲۰۰۰ و ۲۰۲۱ انجام شد. در مجموع ۳۵ مطالعه، معیارهای ورود را داشتند که شامل کارآزمایی‌های تصادفی‌سازی و کنترل‌شده بود که تأثیر محصولات لبنی حاوی پروبیوتیک را بر شاخص توده بدن(BMI) ، وزن و دور کمر ارزیابی می‌کردند. از متاآنالیز اثرات تصادفی (SMD) برای محاسبه میانگین تفاوت استاندارد شده و فاصله اطمینان ۹۵٪ برای هر پیامد استفاده شد.

یافته‌ها: تجزیه و تحلیل تلفیقی، از تمامی مطالعات نشان داد که ارتباط مثبت معنی‌داری بین مصرف محصولات لبنی حاوی پروبیوتیک و BMI وجود دارد (SMD: 0.30, 95% CI: 0.11-0.50, P<0.001). تجزیه و تحلیل حساسیت متعاقب، پس از حذف مطالعات ناهمگن، رابطه قوی را تأیید کرد. همچنین مصرف لبنیات پروبیوتیک تأثیر قابل توجهی بر وزن (SMD: 0.10, 95% CI: 0.00-0.20, P<0.001) و دور کمر (SMD: 0.44, 95% CI: 0.17-0.71, P<0.001) نشان داد.

نتیجه‌گیری: این متاآنالیز جامع، شواهد محکمی از تأثیر بالقوه سودمند محصولات لبنی حاوی پروبیوتیک بر BMI، وزن و دور کمر در افراد چاق و اضافه وزن ارایه می‌کند. این یافته‌ها بر ارزش ترکیب پروبیوتیک‌ها در مداخلات غذایی با هدف پرداختن به این مسایل چالش‌برانگیز سلامت عمومی تاکید می‌کند. تحقیقات بیشتر برای روشن کردن مکانیسم‌های زیربنایی این اثرات و بهینه‌سازی بکارگیری پروبیوتیک‌ها در موارد بالینی ضروری است

کلید واژه‌ها: پروبیوتیک؛ لبنیات؛ شاخص توده بدنی؛ چاقی؛ اضافه وزن؛ بررسی سیستماتیک؛ متاآنالیز.

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1. Introduction

Obesity and overweight have emerged as significant global health concerns, with a rising prevalence across various age groups and geographical regions. These conditions are associated with a multitude of health complications, including cardiovascular diseases, type 2 diabetes, and metabolic syndrome. Addressing the complex factors contributing to obesity and overweight requires a comprehensive approach that encompasses dietary habits, lifestyle modifications, and novel interventions (1). Probiotics, defined as live microorganisms that confer health benefits when administered in adequate amounts, have gained substantial attention for their potential role in modulating gut microbiota composition and function. Emerging research has highlighted the potential of probiotic-containing dairy products as a promising intervention to combat obesity and overweight. Dairy products, known for their nutritional richness and probiotic content, offer a unique platform for delivering these beneficial microorganisms to consumers (2-8). Despite a growing body of individual studies exploring the relationship between probiotic dairy consumption and its effects on body weight and composition, there remains a need for a comprehensive synthesis of available evidence. A systematic review and meta-analysis provide a robust methodology to aggregate and evaluate existing research findings, allowing for a more comprehensive understanding of the overall effect size and potential clinical implications (9-12). In this context, the present study aims to systematically review and conduct a meta-analysis of the available literature to assess the effect of probiotic-containing dairy products on obesity and overweight (13). By synthesizing the collective evidence from clinical trials, this paper aims to elucidate whether there is a significant relationship between the consumption of probiotic dairy products and improvements in body mass index (BMI) and waist circumference (14-16). The outcomes of this study hold the potential to inform dietary recommendations and public health interventions aimed at tackling the growing burden of obesity and overweight. By critically evaluating and summarizing the existing research landscape, this paper contributes to the broader understanding of the role of probiotic dairy consumption in promoting healthy body weight and composition (17-22). In the following sections, we present the methodology employed for the systematic review and meta-analysis, followed by a comprehensive presentation and discussion of the results obtained. Through this analysis, we aim to provide a comprehensive overview of the current state of knowledge in this area and offer insights into potential avenues for future research and clinical applications.

2. Methods:

2.1 Guidelines

This study's methodology adheres to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA), ensuring a systematic and transparent approach to data collection and analysis (23, 24).

2.2 Search Strategy

Four databases, including PubMed/Medline, ISI Web of Science, Cochrane, and SCOPUS, were thoroughly searched. The goal was to find pertinent research that looked at how probiotic dairy consumption can affect obesity and overweight. It had been published between the years 2000 and 2022. ("weight control" AND "dairy" AND "probiotics") OR ("weight loss" AND "dairy" AND "probiotics") OR ("overweight" AND "dairy" AND "probiotics") OR ("obesity" AND "dairy" AND "probiotics")

2.3 Study Screening

Inclusion criteria were meticulously applied to the retrieved articles, narrowing the scope to studies published in English after the year 2000. Additionally, a comprehensive review of the references of retrieved studies was performed to ensure the inclusion of any relevant articles. Independent screening of articles was conducted by two researchers to identify studies meeting the defined criteria.

2.4 Inclusion and Exclusion Criteria

Eligibility criteria for inclusion were stringent, encompassing various study designs, including observational and intervention studies such as clinical trials, cohorts, case-control, and cross-sectional analyses. Conversely, exclusion criteria covered letters, opinions, editorials, reviews, meta-analyses, animal studies, investigations involving children below 18 years, in vitro studies, and studies not available in the English language.

2.5 Data Extraction

A standardized data collection form was used to ensure consistency and accuracy during the data extraction process. The extracted data were organized and entered into Microsoft Excel 2016 for subsequent analysis.

2.6 Quality Assessment

The quality of case-control, cohort, and cross-sectional studies was assessed using the Newcastle-Ottawa scale (NOS). Studies with NOS scores of 7 or higher were deemed to have "high" quality.

2.7 Statistical Analysis

Data analysis was conducted using the STATA version 14 software. Statistical significance was set at $P \leq 0.05$. Effect sizes, represented as Odds Ratios (OR) or Relative Risks (RR) along with their corresponding 95% Confidence Intervals (CIs), were pooled using a random-effects model.

2.8 Heterogeneity and Subgroup Analysis

Heterogeneity was assessed using Cochran's Q test and the I2 statistic. Subgroup analyses were performed to explore potential sources of heterogeneity based on different dairy types, probiotic strains, and participant populations.

2.9 Publication Bias Assessment

Egger's test was utilized to examine potential publication bias, providing insights into the selective reporting of studies.

4. Results

4.1 Search Results

Following a systematic search based on the search strategy outlined in the previous section, a total of 1266 articles were imported into the EndNote software. Additionally, to ensure comprehensive coverage, a systematic search of articles on Google Scholar was conducted, resulting in 20 additional articles. After removing duplicates using EndNote, 833 articles remained for further examination. A further 84 duplicate articles were manually excluded. In total, 749 article titles underwent review. Upon title review, 91 articles were selected for abstract screening. Ultimately, 35 articles were included in the meta-analysis. Figure 1 illustrates the flow diagram of the search process according to the PRISMA guidelines.
Figure 1. PRISMA Flow Diagram of the Search Process

4.2 Characteristics of Included Studies

This systematic review encompassed 35 clinical trials. The studies were published between 2000 and 2021. All studies encompassed both genders. Among these, 30 articles specifically assessed the relationship between the consumption of specific probiotic-containing dairy products and obesity (1 article on yogurt, 14 on yogurt, 13 on enriched milk and kefir, 1 on soy milk, and 1 on cheese). Four studies evaluated this association in diabetic patients, 15 in overweight and obese individuals, 4 in patients with metabolic syndrome, 3 in patients with hypercholesterolemia, 1 in patients with Alzheimer's disease, 1 in patients with fatty liver, and 7 studies investigated healthy individuals.
In 16 studies, the added probiotic contained Lactobacillus acidophilus, in 5 studies it contained Lactobacillus casei, in 4 studies it contained Lactobacillus plantarum, and finally, in 8 studies, Streptococcus thermophilus was used as the added probiotic to dairy products. In all articles, a BMI above 25 was classified as overweight and a BMI above 30 was classified as obesity. Table 2 provides a summary of information for each of the included studies.

Table 2. summary of information for each of the included studies

Row		Author/ Publication Year	Country	Sample Size (Number of	Study Population	Average Age (Years)	Duration (Weeks)	Dairy Type	Probiotic Type	Result	
1		Akbari 2016	Iran	60 (48)	Alzheimer's	79.8	12	Kefir	L. acidophilus, L. casei	BMI	-1.38
2		Ali Hosseini 2017	Iran	60 (26)	Type 2 Diabetes	35-65	8	Kefir	L. casei, L. acidophilus	BMI	0.12
3		Bellikci-koyu 2019	Turkey	22 (16)	Metabolic Syndrome	52.5	12	Kefir	Actinobacteria	BMI	-0.06
4		Bernini 2016	Brazil	51 (na)	Metabolic Syndrome	39	6	Kefir	Bifidobacterium Lactis	BMI	0.11
5		Chang 2011	South Korea	101 (70)	Metabolic Syndrome	36.8	8	Yogurt	L. acidophilus, S. thermophilus	BMI	0.63

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0.8	0.9	1.09	0.66	0.62	0.02	0.02	0.03	0	-0.32	0.2	0.32
BMI	WC	BMI	WC	BMI	BMI	BW	WC	BMI	BW	BMI	BW
L. gasseri		L. gasseri		L. acidophilus, S. thermophilus, L.	L. acidophilus, S. thermophilus			B. breve		L. bulgaricus, Bifidobacterium lactis	
Kefir		Kefir		Kefir	Yogurt			Capsule		Yogurt	
12		12		8	12			12		10	
47.1		47.4		19-65	27.4			59.5		45.5	
Healthy		Healthy		Overweight	Overweight			Overweight		Metabolic Syndrome	
210 (105)		100 (50)		36 (36)	89 (89)			44 (27)		87 (53)	
Japan		Japan		South Korea	Iran			Japan		Iran	
Kadooka 2013		Kadooka 2013		Lee 2013	Majd 2016			Minami 2015		Mohammadi 2018	
13		14		15	16			17		18	

1.63	1.49	0	0	-0.09	0.07	0.06	0.26	0.24	1.02	1.14	1.38
BMI	BMI	BMI	BW	WC	BMI	BW	BMI	BW	BMI	BW	WC
N/A	N/A	L. helveticus			L. casei		L. reuteri		L. gasseri		
Kefir	Milk	Yogurt			Kefir		Yogurt		Kefir		
8	8	12			1		6		12		
35.2	25-45	59.5			24.5		50.3		48.9		
Overweight and Obesity	Overweight and Obesity	Type 2 Diabetes			Healthy		Healthy		Healthy		
58 (na)	75 (75)	41 (0)			17 (3)		120 (61)		87 (28)		
Iran	Iran	Denmark			UK		Czech Rep.		Japan		
Fathi (A) 2016	Fathi (B) 2016	Hove 2015			Hulston 2015		Jones 2012		Kadooka 2010		
6	7	9			10		11		12		

-0.03	0.04	0.09	0.63	0	0.54	0.54	0.56	0.21	-0.02	0.04	0.02
BW	BMI	BW	BMI	BW	WC	BMI	BW	BMI	BW	BMI	BW
	L. plantarum		L. acidophilus, B. lactis			L. plantarum		L. acidophilus, Bifidobacterium lactis		L. acidophilus, L. casei	
	Capsule		Kashk			Capsule		Yogurt		Yogurt	
	8		8			13		6		8	
	53.68		20-60			44.37		35.1		36	
	Overweight		Overweight			Overweight		Healthy		Overweight	
	25 (17)		70 (70)			60 (36)		60 (60)		50 (؟)	
	Italy		Iran			Indonesia		Iran		Iran	
	Rondanelli 2021		Razmpoosh 2019			Rahayu 2021		Sadrzadeh 2010		Zarrati 2014	
	25		26			27		28		29	

0.75	0.22	0.15	0.35	0.28	0.1	0.08	0.01	0.02	-0.05	-0.04	-0.03
WC	BMI	BW	BMI	BW	BMI	BW	BMI	BW	BMI	BW	BMI
	L. acidophilus		S. thermophilus		L. acidophilus, Bifidobacterium lactis		L. casei		L. gasseri		L. acidophilus
	Cheese		Yogurt		Yogurt		Kefir		Kefir		Capsule
	8		8		8		8		2		12
	39.4		37.7		43.4		47		41.3		34.3
	Hypercholesterolemia		Hypercholesterolemia		Fatty Liver		Overweight		Healthy		Hypercholesterolemia
	112		111		74 (39)		98 (0)		30 (18)		32 (14)
	Iran		Iran		Iran		Japan		Japan		Malaysia
	Mohammad Moradi 2015		Mohammad Moradi 2015		Nabavi 2014		Naito 2018		Ogawa 2015		Ooi 2011
	19		20		21		22		23		24

30		Larsen (a) 2000	Denmark	30 (14)	Overweight	38.7	8	Yogurt	L. acidophilus, S. thermophilus	BW	0.09
31		Larsen (b) 2000	Denmark	28 (14)	Overweight	38.7	8	Yogurt	L. acidophilus, S. thermophilus	BW	-0.12
32		Larsen (c) 2000	Denmark	30 (14)	Overweight	38.7	8	Yogurt	L. acidophilus, S. thermophilus	BW	1.07
33		Larsen (d) 2000	Denmark	30 (16)	Overweight	38.7	8	Yogurt	L. acidophilus, S. thermophilus	BW	1.94
34		Onar 2012	Canada	28 (18)	Overweight	46.3	6	Yogurt	L. amylovorus, L. fermentum	BW	0.15
35		Estad Rahimi 2015	Iran	60 (26)	Type 2 Diabetes	65-35	8	Kefir	L. acidophilus	BW	0.01
										WC	-0.02

4.3. Meta-analysis:

To standardize the reported effect sizes in the articles, the effect sizes were combined to obtain the overall effect size for each article. The random-effects method was used to merge the data, and SMD was calculated for each analysis. The overall analysis of all available effect sizes showed a significant relationship between the consumption of probiotic-containing dairy products and the body mass index (BMI) (SMD: 0.30, 95% CI: 0.11-0.50, P< 0.001) (Figure 2).

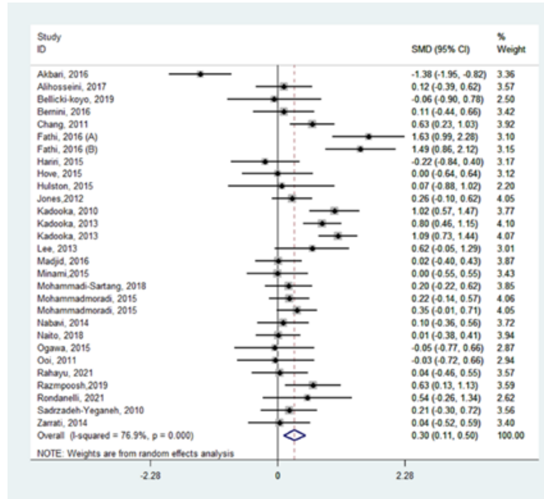

Figure 2. Forest plot depicting the effect of probiotic dairy on BMI before excluding heterogeneous articles.

Heterogeneous studies were identified and excluded based on the Galbraith plot. As shown in Figure 3, five studies were excluded due to overestimation and one study due to underestimation.

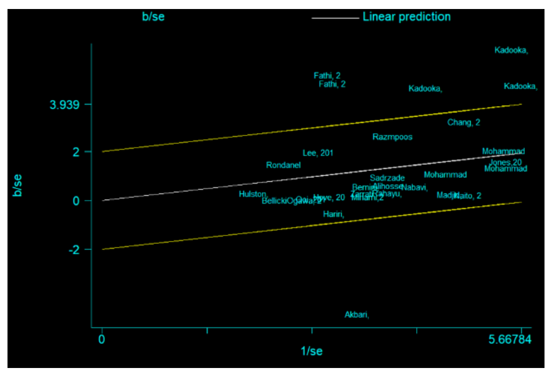

Figure 3. Galbraith plot for identifying heterogeneous studies in the analysis of body mass index.

After excluding heterogeneous studies, the data was aggregated again, and SMD was calculated for each analysis. The overall analysis of all available effect sizes showed that even after removing outlier articles, a significant relationship between the consumption of probiotic-containing dairy products and patients' weight still existed (SMD: 0.19, 95% CI: 0.09-0.30, P < 0.001) (Figure 4).

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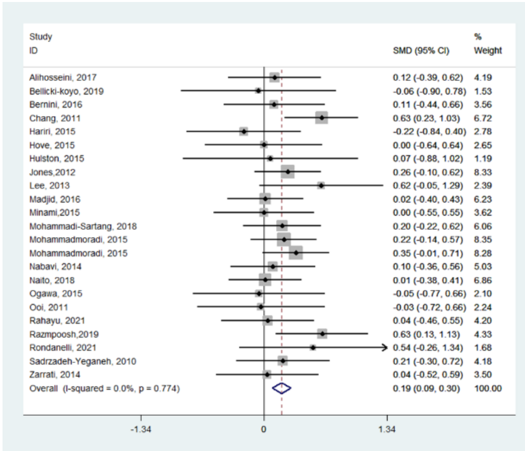

Figure 4. Forest plot depicting the effect of probiotic dairy on weight after excluding heterogeneous articles.

For waist circumference, the effect of these products on waist circumference is presented in Figure 5. The random-effects method was used to combine the data, and SMD was calculated for each analysis. The overall analysis of all effect sizes available indicated a significant relationship between the consumption of probiotic-containing dairy products and patients' weight (SMD: 0.26, 95% CI: 0.17-0.46, P< 0.001).

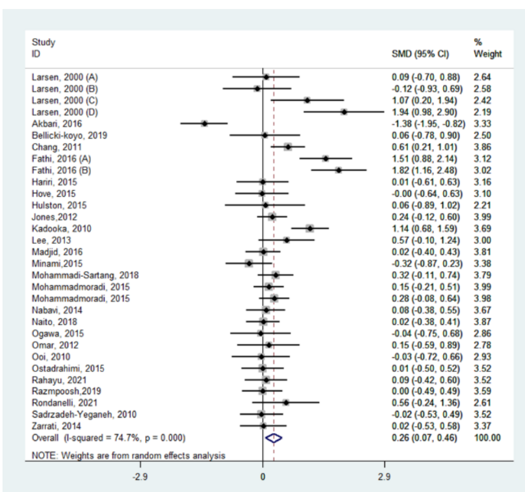

Figure 5. Forest plot depicting the effect of probiotic dairy on waist circumference before excluding heterogeneous articles.

Outlier studies were again removed using the Galbraith plot (Figure 6), and the results were reanalyzed using the Random Effect method. The results are presented in Figure 7 (SMD: 0.10, 95% CI: 0.00-0.20, P<0.001).

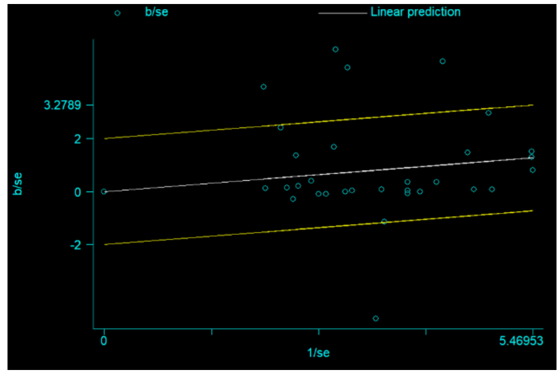

Figure 6. Galbraith plot for identifying heterogeneous studies in the analysis of patient weight.

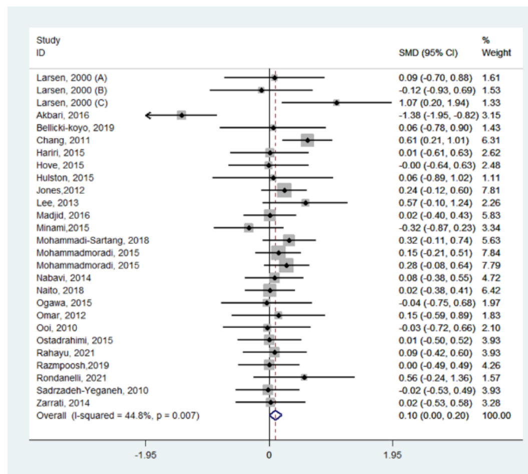

Figure 7. Forest plot depicting the effect of probiotic dairy on weight after excluding heterogeneous articles.

For waist circumference, as shown in Figure 8, the results of studies investigating the effect of probiotic-containing dairy products on waist circumference are displayed. The random-effects method was used to assess these studies. The results indicated a significant effect with SMD: 0.44, CI: 0.17-0.71 (I^2: 76.4, P<0.001).

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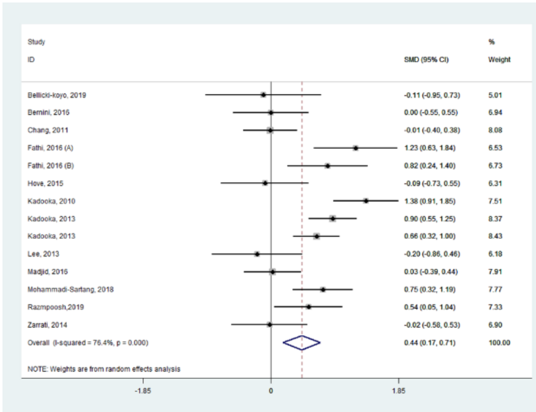

Figure 8. Forest plot depicting the effect of probiotic dairy on waist circumference.

4-4. Study Quality:

According to the NOS scale, all articles obtained an acceptable score (NOS score of 7 or higher). The lost scores in most studies were primarily related to the selection criteria.

4-5. Publication Bias:

Publication bias was assessed using the Egger's test. A funnel plot was also constructed. Both tests indicated that the estimates are symmetric, and there is no publication bias for any variable. Figure 9 illustrates the funnel plot for assessing publication bias.

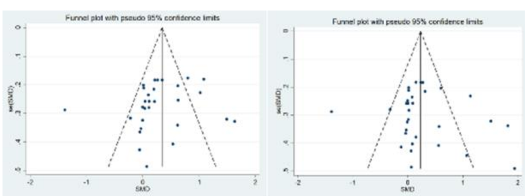

Figure 9. Funnel plot for assessing publication bias regarding weight (A) and body mass index (B).

Discussion

The present study conducted a systematic review and meta-analysis to examine the effect of probiotic-containing dairy product consumption on obesity and overweight. The results of our analysis suggest a significant relationship between such dietary interventions and body weight metrics. The analysis of standardized mean differences (SMDs) for body mass index (BMI) revealed a substantial effect in favor of probiotic dairy consumption. The overall SMD of 0.30 (95% CI: 0.11-0.50) indicates a notable reduction in BMI among individuals who regularly consumed probiotic dairy products. This finding aligns with the notion that probiotics, as live microorganisms with potential health benefits, may influence metabolic processes, thereby contributing to weight management (25-31). Heterogeneity is an important consideration in meta-analyses. The identification and exclusion of heterogeneous studies aided in enhancing the robustness of our results. After removing outlier studies, the consistent association between probiotic dairy consumption and weight reduction persisted, as evidenced by an SMD of 0.19 (95% CI: 0.09-0.30). This finding underscores the potential of probiotic-containing dairy products to contribute positively to weight control efforts (4-7). In addition to BMI, waist circumference is a crucial anthropometric indicator of obesity-related health risks. Our analysis of waist circumference revealed a significant effect associated with the consumption of probiotic dairy products. The initial SMD of 0.26 (95% CI: 0.17-0.46) indicated a positive influence on waist circumference reduction. Despite the heterogeneity observed in the studies, the exclusion of outliers led to the affirmation of this relationship, with an SMD of 0.10 (95% CI: 0.00-0.20)(3).

The consistency of the observed effects across BMI and waist circumference metrics, even after addressing heterogeneity, adds strength to the validity of our findings. However, it is important to note that while our results are promising, the mechanisms underlying the observed effects require further exploration. The influence of probiotics on gut microbiota composition, modulation of inflammation, and potential impacts on energy metabolism warrants in-depth investigation (3-8). Several limitations of this study should be acknowledged. The diversity in study designs, populations, and interventions among the included studies may have contributed to heterogeneity. Additionally, publication bias and the lack of long-term follow-up in some studies are potential sources of bias. Further research with well-designed, controlled trials and standardized interventions is needed to confirm and elucidate the observed relationships.

In conclusion, this systematic review and meta-analysis provides evidence suggesting a significant association between probiotic-containing dairy product consumption and beneficial effects on BMI and waist circumference. Our findings underscore the potential role of probiotics as a complementary strategy for obesity and overweight management. Future research should focus on unraveling the underlying mechanisms and establishing specific recommendations for the incorporation of

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probiotic dairy products into dietary strategies for weight control.

Conflict of Interest Statement:

The authors declare no conflicts of interest.

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Ethical Considerations:

Ethical approval was not required for this systematic review and meta-analysis, as it involved the analysis of previously published data.

References

1. Sivamaruthi BS, Kesika P, Suganthy N, Chaiyasut C. A review on role of microbiome in obesity and antiobesity properties of probiotic supplements. BioMed Research International. 2019;2019.
2. Mekkes M, Weenen T, Brummer RJ, Claassen E. The development of probiotic treatment in obesity: a review. Beneficial microbes. 2014;5(1):19-28.
3. Barrett HL, Gomez-Arango LF, Wilkinson SA, McIntyre HD, Callaway LK, Morrison M, et al. A Vegetarian Diet Is a Major Determinant of Gut Microbiota Composition in Early Pregnancy. Nutrients. 2018;10(7).
4. Gomes AC, Hoffmann C, Mota JF. Gut microbiota is associated with adiposity markers and probiotics may impact specific genera. Eur J Nutr. 2020;59(4):1751-62.
5. Łagowska K, Drzymała-Czyż S. A low glycemic index, energy-restricted diet but not Lactobacillus rhamnosus supplementation changes fecal short-chain fatty acid and serum lipid concentrations in women with overweight or obesity and polycystic ovary syndrome. Eur Rev Med Pharmacol Sci. 2022;26(3):917-26.
6. Pellonperä O, Mokkala K, Houttu N, Vahlberg T, Koivuniemi E, Tertti K, et al. Efficacy of Fish Oil and/or Probiotic Intervention on the Incidence of Gestational Diabetes Mellitus in an At-Risk Group of Overweight and Obese Women: A Randomized, Placebo-Controlled, Double-Blind Clinical Trial. Diabetes Care. 2019;42(6):1009-17.
7. Sanchez M, Darimont C, Drapeau V, Emady-Azar S, Lepage M, Rezzonico E, et al. Effect of Lactobacillus rhamnosus CGMCC1.3724 supplementation on weight loss and maintenance in obese men and women. Br J Nutr. 2014;111(8):1507-19.
8. Sanchez M, Darimont C, Panahi S, Drapeau V, Marette A, Taylor VH, et al. Effects of a Diet-Based Weight-Reducing Program with Probiotic Supplementation on Satiety Efficiency, Eating Behaviour Traits, and Psychosocial Behaviours in Obese Individuals. Nutrients. 2017;9(3).
9. Hibberd AA, Yde CC, Ziegler ML, Honoré AH, Saarinen MT, Lahtinen S, et al. Probiotic or synbiotic alters the gut microbiota and metabolism in a randomised controlled trial of weight management in overweight adults. Benef Microbes. 2019;10(2):121-35.
10. Krumbeck JA, Rasmussen HE, Hutkins RW, Clarke J, Shawron K, Keshavarzian A, et al. Probiotic Bifidobacterium strains and galactooligosaccharides improve intestinal barrier function in obese adults but show no synergism when used together as synbiotics. Microbiome. 2018;6(1):121.
11. Rahayu ES, Mariyatun M, Putri Manurung NE, Hasan PN, Therdtatha P, Mishima R, et al. Effect of probiotic Lactobacillus plantarum Dad-13 powder consumption on the gut microbiota and intestinal health of overweight adults. World J Gastroenterol. 2021;27(1):107-28.
12. Sergeev IN, Aljutaily T, Walton G, Huarte E. Effects of Synbiotic Supplement on Human Gut Microbiota, Body Composition and Weight Loss in Obesity. Nutrients. 2020;12(1).
13. Asgharian H, Homayouni-Rad A, Mirghafourvand M, Mohammad-Alizadeh-Charandabi S. Effect of probiotic yoghurt on plasma glucose in overweight and obese pregnant women: a randomized controlled clinical trial. Eur J Nutr. 2020;59(1):205-15.
14. Palacios T, Vitetta L, Coulson S, Madigan CD, Denyer GS, Caterson ID. The effect of a novel probiotic on metabolic biomarkers in adults with prediabetes and recently diagnosed type 2 diabetes mellitus: study protocol for a randomized controlled trial. Trials. 2017;18(1):7.
15. Pedret A, Valls RM, Calderón-Pérez L, Llauradó E, Companys J, Pla-Pagà L, et al. Effects of daily consumption of the probiotic Bifidobacterium animalis subsp. lactis CECT 8145 on anthropometric adiposity biomarkers in abdominally obese subjects: a randomized controlled trial. Int J Obes (Lond). 2019;43(9):1863-8.
16. Stenman LK, Lehtinen MJ, Meland N, Christensen JE, Yeung N, Saarinen MT, et al. Probiotic With or Without Fiber Controls Body

[DOI: 10.61186/sjrm.7.4.259]

Fat Mass, Associated With Serum Zonulin, in Overweight and Obese Adults-Randomized Controlled Trial. EBioMedicine. 2016;13:190-200.
17. Dawe JP, McCowan LME, Wilson J, Okesene-Gafa KAM, Serlachius AS. Probiotics and Maternal Mental Health: A Randomised Controlled Trial among Pregnant Women with Obesity. Sci Rep. 2020;10(1):1291.
18. Marcelo TLP, Pellicciari CR, Artioli TO, Leiderman DBD, Gradinar ALT, Mimica M, et al. Probiotic therapy outcomes in body composition of children and adolescent with obesity, a nonrandomized controlled trial. Arch Endocrinol Metab. 2022;66(6):815-22.
19. Razmpoosh E, Javadi A, Ejtahed HS, Mirmiran P, Javadi M, Yousefinejad A. The effect of probiotic supplementation on glycemic control and lipid profile in patients with type 2 diabetes: A randomized placebo controlled trial. Diabetes Metab Syndr. 2019;13(1):175-82.
20. Schei K, Avershina E, Øien T, Rudi K, Follestad T, Salamati S, et al. Early gut mycobiota and mother-offspring transfer. Microbiome. 2017;5(1):107.
21. Xue L, Deng Z, Luo W, He X, Chen Y. Effect of Fecal Microbiota Transplantation on Non-Alcoholic Fatty Liver Disease: A Randomized Clinical Trial. Front Cell Infect Microbiol. 2022;12:759306.
22. Ziegler MC, Garbim Junior EE, Jahnke VS, Lisbôa Moura JG, Brasil CS, Schimitt da Cunha PH, et al. Impact of probiotic supplementation in a patient with type 2 diabetes on glycemic and lipid profile. Clin Nutr ESPEN. 2022;49:264-9.
23. Mahdavi FS, Mardi P, Mahdavi SS, Kamalinejad M, Hashemi SA, Khodaii Z, et al. Therapeutic and Preventive Effects of Olea europaea Extract on Indomethacin-Induced Small Intestinal Injury Model in Rats. Evid Based Complement Alternat Med. 2020;2020:6669813.
24. Mardi P. Opium abuse and stroke in Iran: A systematic review and meta-analysis. Front Neurol. 2022;13:855578.
25. Ben Othman R, Ben Amor N, Mahjoub F, Berriche O, El Ghali C, Gamoudi A, et al. A clinical trial about effects of prebiotic and probiotic supplementation on weight loss, psychological profile and metabolic parameters in obese subjects. Endocrinol Diabetes Metab. 2023;6(2):e402.
26. Callaway LK, McIntyre HD, Barrett HL, Foxcroft K, Tremellen A, Lingwood BE, et al. Probiotics for the Prevention of Gestational Diabetes Mellitus in Overweight and Obese Women: Findings From the SPRING Double-Blind Randomized Controlled Trial. Diabetes Care. 2019;42(3):364-71.
27. Jones RB, Alderete TL, Martin AA, Geary BA, Hwang DH, Palmer SL, et al. Probiotic supplementation increases obesity with no detectable effects on liver fat or gut microbiota in obese Hispanic adolescents: a 16-week, randomized, placebo-controlled trial. Pediatr Obes. 2018;13(11):705-14.
28. Kaczmarczyk M, Szulińska M, Łoniewski I, Kręgielska-Narożna M, Skonieczna-Żydecka K, Kosciolek T, et al. Treatment With Multi-Species Probiotics Changes the Functions, Not the Composition of Gut Microbiota in Postmenopausal Women With Obesity: A Randomized, Double-Blind, Placebo-Controlled Study. Front Cell Infect Microbiol. 2022;12:815798.
29. Kanazawa A, Aida M, Yoshida Y, Kaga H, Katahira T, Suzuki L, et al. Effects of Synbiotic Supplementation on Chronic Inflammation and the Gut Microbiota in Obese Patients with Type 2 Diabetes Mellitus: A Randomized Controlled Study. Nutrients. 2021;13(2).
30. Kim J, Yun JM, Kim MK, Kwon O, Cho B. Lactobacillus gasseri BNR17 Supplementation Reduces the Visceral Fat Accumulation and Waist Circumference in Obese Adults: A Randomized, Double-Blind, Placebo-Controlled Trial. J Med Food. 2018;21(5):454-61.
31. Vähämiko S, Laiho A, Lund R, Isolauri E, Salminen S, Laitinen K. The impact of probiotic supplementation during pregnancy on DNA methylation of obesity-related genes in mothers and their children. Eur J Nutr. 2019;58(1):367-77.

[DOI: 10.61186/sjrm.7.4.259]