

EFFECTS OF BIFIDOBACTERIUM BREVE ON LIPID AND BMI IN METABOLIC SYNDROME: DOUBLE-BLIND, PLACEBO-CONTROLLED CLINICAL TRIAL

Dorn Numnark^{1,*} and Penpitcha Panprame

Received: July 31, 2025; Revised: October 10, 2025; Accepted: October 21, 2025

Abstract

Metabolic Syndrome (MetS) comprises a number of conditions arising due to particular malfunctions in the body's metabolic system. The symptoms consist of abnormal glucose tolerance (glucose intolerance) and a high lipid profile. In Thailand, MetS has been found to be a major medical issue that is linked to other diseases such as cardiovascular diseases (CVDs), arteriosclerosis, and diabetes mellitus. There are 95,064 deaths per year across the country, equivalent to a death rate of 151.94 per 100,000 populations. Therefore, metabolic syndrome may be considered a major problem in Thailand. Objective: to study the effectiveness of using probiotics and food diet for 6 months to control BMI and biochemical measurements in people with MetS. The current research involved a randomized, case-control clinical trial using forty participants with MetS. The probiotic strains in this study included microencapsulated *Bifidobacterium breve* BRO3 and B632. Initially, measurements were taken for BMI and biochemical parameters, from the first month (M0) to 6 months (M6). The body composition measurements included BMI and blood pressure. The biochemical measurements included HbA1c, FBS, cholesterol, low-density lipoprotein cholesterol, triacylglycerols, and high-density lipoprotein cholesterol. Overall, forty cases with MetS revealed differences for the treatment group, with a significant decrease in BMI ($P = 0.019$), HbA1c ($P = 0.004$), FBS ($P = 0.006$), TC ($P = 0.004$), TGs ($P = 0.002$), LDL-C ($P = 0.003$) and HDL-C ($P = 0.014$) which could be considered significant at $P < 0.05$.

Keywords: Bifidobacterium Breve; Dyslipidemia; Metabolic Syndrome; Probiotics

College of Health and Wellness, Faculty of science, Dhurakij Pundit University, Bangkok, Thailand. E-mail. Dorn.num@dpu.ac.th*,
ORCID: 0009-0008-8936-1633; Penpitcha.pan@dpu.ac.th, ORCID: 0009-0009-8228-7917

* Corresponding author

DOI: <https://doi.org/10.55766/sujst10940>

Suranaree J. Sci. Technol. 33(2):070104(1-8)

Introduction

Metabolic syndrome (MetS) arises as a consequence of abnormal bodily metabolic processes characterized by a cluster of symptoms including insulin resistance, glucose intolerance (Eberly *et al.*, 2006), hypertriglyceridemia, low high-density lipoprotein (HDL) cholesterol (Sattar *et al.*, 2003), and hypertension (blood pressure higher than 130/85 mmHg) (Hoyas and León-Sanz, 2019). Individuals with MetS face 3-5 times the risk of diagnosis with diabetes in comparison to individuals without the syndrome, as well as 2-3 times the risk of death from heart conditions (Malik *et al.*, 2004).

In Thailand, cardiovascular diseases are a significant concern, with an annual death toll of 95,064 translating to a mortality rate of 151.94 per 100,000 population, standardized by age. Thus, metabolic syndrome could represent a significant health concern in Thailand.

Diagnostic criteria for metabolic syndrome according to the National Cholesterol Education Program or NCEP ATP III 2007 (Grundy *et al.*, 2005), International Diabetes Federation, 2023; Alberti *et al.*, 2006), and the World Health Organization (WHO) require the existence of no fewer than three of the five criteria listed as follows, comprising 1) Measurement around the waist exceeding standard measurements: >90 cm (36 inches) for men and >80 cm (32 inch) for women. Alternatively, body mass index (BMI) may be considered when the value exceeds 25 kg/m² (for Asians), 2) High blood pressure defined as >130/85 mmHg or the need for medication to treat hypertension, 3) High triglyceride levels (TG) greater than 150 mg/dL or use of medication for triglycerides, 4) Low levels of HDL-C <50 mg/dL in females and 40 mg/dL in males, and 5) Elevated levels of glucose in the blood, with fasting glucose exceeding 100 mg/dL or a diagnosis of diabetes.

In addition, behavioral changes in dietary habits are crucial for managing Metabolic Syndrome. This includes controlling energy and nutrient intake by consuming complex carbohydrates (e.g., corn, brown rice, whole wheat bread, and other whole grains) low-fat proteins (e.g., fish, skinless chicken breast, lean pork, tofu), and foods rich in dietary fiber (e.g., vegetables, low-sugar fruits, beans, and other legumes). It is important to avoid foods high in sugar and fat such as sweetened beverages, soda, candies, and processed foods like sausages, ham, and canned foods. Such dietary changes help control blood sugar, lipid levels, and blood pressure, potentially leading to weight loss.

Additionally, healthy diet habits promote bacterial growth within the gut which can be

advantageous in ensuring a suitable intestinal balance and contribute to long-term weight reduction.

Research Objectives

- To investigate the effectiveness of using the probiotic strains *Bifidobacterium breve* BR03 and B632 in weight management among individuals with metabolic syndrome at Dhurakij Pundit University over a period of 6 months
- To investigate the effectiveness of probiotic strains in controlling blood sugar and lipid levels (FBS, HbA1c, TG, CH, LDL, HDL) among individuals with metabolic syndrome at Dhurakij Pundit University over a period of 6 months

Materials and Methods

The current research involved a prospective randomized clinical trial using a control group and placebo group (Therapeutic research, treatment, and placebo). The study was conducted among individuals with MetS at Dhurakij Pundit University. A total of 40 participants were segregated so that 20 participants were allocated to the treatment group and 20 were assigned to the placebo group. Each participant was given a unique code in order to maintain allocation secrecy. To maintain the integrity of the trial, investigators, participants, and personnel who administered the product were blinded to group assignment. The dropout rate is calculated at 20% per group. The study adhered to the inclusion criteria aligned with the National Cholesterol Education Program or NCEP ATP III 2007 (Grundy *et al.*, 2005; Alberti *et al.*, 2006; IDF, 2023) and the World Health Organization (WHO). Participants assigned to the treatment group received probiotics of the *Bifidobacterium breve* strains BR03 and B638 in a 1.6-gram sachet containing approximately 2×10^9 cells of these probiotic strains in 1.6 g. The placebo group received 1.6 g of microcrystalline cellulose (MCC) in a sachet. Both the treatment and placebo sachets were identical in appearance, as was the powder used for consumption. Data were collected over 6 months, including clinical data and health-related questionnaires. Physical measurements such as height, weight, waist circumference, pulse, blood pressure, and body mass index (BMI) were taken. Subsequently, biochemical blood tests including HbA1c, FBS, triglycerides, cholesterol, LDL, and HDL were also conducted. Additionally, data were collected on exercise habits and dietary behaviors with participants advised to consume

1,600-1,800 kcal/day, supported by detailed daily meal plans, food intake records and weekly follow-up calls to ensure compliance. Recommended foods included complex carbohydrates (e.g. brown rice or rice berry 1-2 ladle/meal), vegetables (2 ladle/meal), low-sugar fruits (e.g., apple, orange 1 piece/meal or half a guava, dragon fruit or 6-8 pieces of papaya, pineapple), and low-fat proteins (e.g., lean pork, chicken breast, fish 4-6 tablespoons/meal).

Inclusion Criteria

- Consent to participate in the research project
- Age between 25-50 years
- Waist circumference above average standards:
 - Males: Waist circumference >90 cm (36 inch)
 - Females: Waist circumference >80 cm (32 inch) or BMI greater than 25 kg/m²
- Hypertension: Blood pressure >130/85 mmHg
- Triglyceride (TG) level: > to 150 mg/dL
- HDL-C level:
 - Males: <50 mg/dL
 - Females: <40 mg/dL
- Elevated blood sugar level: Blood sugar levels >100 mg/dL or diabetes mellitus diagnosis
- During participation in the study, supplementation of “probiotics and weight management supplements” should be avoided.

The criteria are aligned with the National Cholesterol Education Program: NCEP ATP III, 2007 in conjunction with the International Diabetes Federation (IDF) and the World Health Organization (WHO).

Exclusion Criteria

- Pregnancy
- Individuals with a history of allergic reactions to probiotics
- Volunteers who wish to withdraw from the research project
- Volunteers using other probiotic products
- Antihypertensive drugs. Major classes include ACE inhibitors (lisinopril), ARBs (losartan), calcium channel blockers (amlodipine), diuretics (hydrochlorothiazide), and beta-blockers (atenolol).
- Antihyperglycemic drugs for example insulin secretion (sulfonylureas), improving insulin sensitivity (metformin).
- Antidepressants (TCA (Tricyclic Antidepressants), MAOI (Monoamine Oxidase Inhibitors) and SSRI (Selective Serotonin Reuptake Inhibitors).
- Individuals using steroids, NSAIDs, or antibiotics

Research Instruments

- Questionnaire for Personal Information, which includes questions about gender, age, medical history, family medical history, medication use, and smoking habits
- Health Behavior Questionnaire, which includes questions about physical activity and dietary behaviors

Physical data includes measurements for height, weight, blood pressure, and BMI using the EIKON HD200M and TANITA RD-953 inner scan Dual devices.

- Blood Chemical Testing, which includes tests for blood lipid levels such as HbA1c, Fasting Blood Sugar (FBS), Cholesterol, LDL-Cholesterol, HDL-Cholesterol, and Triglycerides.
- Probiotic Microorganisms, including probiotic *Bifidobacterium breve* strains BR03 and B632 provided in a 1.6 g sachet containing approximately 2×10^9 cells/1.6 g.
- Placebo consisting of Microcrystalline Cellulose (MCC) packaged in a 1.6 g sachet.

HbA1c was determined only in M0, M3, and M6 measurements because it is used to evaluate a person's level of glucose control.

The test shows an average of the blood sugar level over the previous 90 days (3 months) and represents a percentage.

The Wilcoxon matched pairs test was employed for the analysis of changes from the baseline (intragroup changes).

* Baseline group differences, Intragroup (P-value <0.05.)

[†] Change percentage from the baseline, Intergroup (P-value <0.05)

Ethical Approval

The current research was granted approval from the Dhurakij Pundit University Human Research Ethics Committees (DPUHRECs) of Dhurakij Pundit University, Bangkok, Thailand (Protocol number COA No. 007/66, Full Board Review). The subject group was recruited in Bangkok, Thailand between October 2023 and January 2024.

Statistical Analysis

Quantitative data comprised personal details such as age, BMI, height, weight, and laboratory test values. For data analysis, descriptive statistics such as mean, standard deviation, percentage, and frequency distribution were employed. These data

were analyzed using the exact probability test, with two-sided P-values considered significant at <0.05 . The Mann-Whitney U test served to draw comparisons between baseline parameters, and between different treatment groups. The percentage of change from baseline was also calculated, using a statistical significance level of $P<0.05$.

Results

Forty individuals diagnosed with metabolic syndrome (MetS) consented to participate in this study. Twenty subjects were allocated on a random basis to both the placebo group and the probiotic diet group (treatment group). General characteristics and

Table 1. Participant characteristics at the baseline (n = 40)

Data	Placebo Group Mean (Min, Max) (N = 20)	Treatment Group Mean (Min, Max) (N = 20)
Age (Years)	41.42 (range: 22.00-43.00)	43.59 (range: 24.00-49.00)
Gender		
Male	8 (40.00), n (%)	7 (35.00), n (%)
Female	12 (60.00), n (%)	13 (65.00), n (%)
BMI(Kg/m ²)	37.02 (range: 21.80-45)	36.09 (range: 22.22-50.65)
HbA1c (%)	5.45 (range: 4.50-13.10)	5.91 (range: 5.50-11.22)
FBS (mg/dL)	115.02 (range: 80.00-306.00)	118.35 (range: 92.00-402.00)
TC (mg/dL)	250.26 (range: 166.00-350.00)	255.69 (range: 178.00-319.00)
TGs (mg/dL)	220.50 (range: 180.00-682.00)	219.60 (range: 165.00-542.00)
LDL-C (mg/dL)	165.65 (range: 122.00-240.00)	168.90 (range: 135.00-280.00)
HDL-C (mg/dL)	52.36 (range: 35.00-70.00)	54.21 (range: 23.00-65.00)

Table 2. Summary of correlation data from participants (Control group vs. Treatment group)

Parameters	Group	M0	M1	M2	M3	M4	M5	M6	P1	P2
(Mean±SD)										(p-value <0.05)
BMI (kg/m²)	Placebo G.	37.02±	37.08±	39.05±	41.01±	42.00±	41.56±	41.89±	0.042*	0.019*t
		10.22	12.23	11.98	14.01	13.56	11.22	12.17		
	Treatment G.	36.09±	36.55±	35.02±	34.11±	33.71±	32.68±	31.22±	0.035*	
SBP (mmHg)	Placebo G.	145.25±	149.16±	142.59±	158.23±	152.31±	157.21±	150.26±	0.022*	0.19
		91.00	89.05	97.00	96.23	92.31	89.23	91.45		
	Treatment G.	149.50±	145.26±	139.22±	141.27±	152.31±	157.21±	150.26±	0.12	
DBP (mmHg)	Placebo G.	85.22±	89.26±	92.22±	108.00±	95.23±	101.02±	110.90±	0.037*	0.15
		75.00	90.00	92.11	96.04	91.00	92.00	95.38		
	Treatment G.	90.51±	92.89±	96.56±	89.07±	92.54±	91.21±	99.66±	0.22	
HbA1c (%)*	Placebo G.	5.45±	-	-	6.22±	-	-	7.79±	0.014*	0.004*t
		13.66			15.14			10.40		
	Treatment G.	5.91±	-	-	4.87±	-	-	4.12±	0.008*	
FBS (mg/dL)	Placebo G.	115.02±	120.24±	122.21±	121.25±	120.65±	125.59±	124.23±	0.029*	0.006*t
		75.00	90.00	85.00	89.26	82.15	84.28	87.23		
	Treatment G.	118.35±	119.5±	116.37±	112.98±	109.64±	108.25±	102.36±	0.003*	
TC (mg/dL) *	Placebo G.	250.06±	265.39±	261.38±	259.38±	267.88±	275.31±	268.90±	0.012*	0.004*t
		165.00	175.00	182.00	195.00	187.26	191.20	193.91		
	Treatment G.	255.69±	259.17±	250.61±	249.36±	247.63±	240.30±	231.51±	0.001*	
TGs (mg/dL)	Placebo G.	220.50±	224.11±	224.89±	223.68±	222.41±	221.51±	223.46±	0.003*	0.002*t
		55.00	75.00	89.00	90.00	72.01	78.59	85.02		
	Treatment G.	219.60±	221.35±	219.85±	218.84±	216.53±	212.37±	199.7±	0.001*	
LDL-C (mg/dL)*	Placebo G.	165.65±	166.3±	167.93±	169.80±	164.50±	166.80±	167.23±	0.005*	0.003*t
		75.00	85.00	87.09	89.00	82.10	84.07	89.12		
	Treatment G.	168.90±	167.80±	168.50±	162.32±	160.81±	154.32±	145.21±	0.001*	
HDL-C (mg/dL)*	Placebo G.	52.36±	53.66±	54.21±	53.74±	52.31±	53.98±	52.66±	0.038*	0.014*t
		28.74	27.00	27.04	28.45	27.22	27.45	28.98		
	Treatment G.	54.21±	54.98±	55.62±	56.32±	55.41±	55.98±	56.42±	0.030*	

biochemical measurements included age, gender, BMI (kg/m^2), blood pressure (mmHg), HbA1c (%), fasting blood sugar (FBS) (mg/dL), total cholesterol (TC) (mg/dL), triglycerides (TGs) (mg/dL), high-density lipoprotein cholesterol (HDL-C) (mg/dL), and low-density lipoprotein cholesterol (LDL-C) (mg/dL) (Table 1).

After completing the 6-month treatment plan, a comparison of most parameters in the placebo group (intra-group) showed significant increases ($P < 0.05$), including BMI ($P = 0.042$) and blood pressure (SBP $P < 0.022$; DBP $P < 0.037$). In contrast, the parameters in the treatment group (intra-group) showed significant decreases, including BMI ($P < 0.035$), while blood pressure values were not significant (SBP $P = 0.12$; DBP $P = 0.22$). When comparing the two groups from M0 to M6, the treatment group exhibited significant reductions in comparison to the group which received the

placebo in terms of BMI ($P = 0.019$) (Figure 1(a)). Blood pressure values did not differ significantly between groups (SBP $P = 0.19$; DBP $P = 0.15$) (Table 2).

Biochemical parameters in the placebo group (intra-group) increased significantly from baseline to after 6 months (HbA1c (%): $P = 0.014$; FBS (mg/dL): $P = 0.029$; TC (mg/dL): $P = 0.012$; TGs (mg/dL): $P = 0.003$; LDL-C (mg/dL): $P = 0.005$; HDL-C (mg/dL): $P = 0.038$). In contrast, the treatment group showed significant decreases from baseline to after 6 months (M0-M6) in the following parameters: HbA1c (%): $P = 0.008$; FBS (mg/dL): $P = 0.003$; TC (mg/dL): $P = 0.001$; TGs (mg/dL): $P = 0.001$; LDL-C (mg/dL): $P = 0.001$; HDL-C (mg/dL): $P = 0.030$) (Table 2). When comparing the subjects receiving the placebo to those receiving the treatment from M0 to M6, significant differences were observed for HbA1c (%),

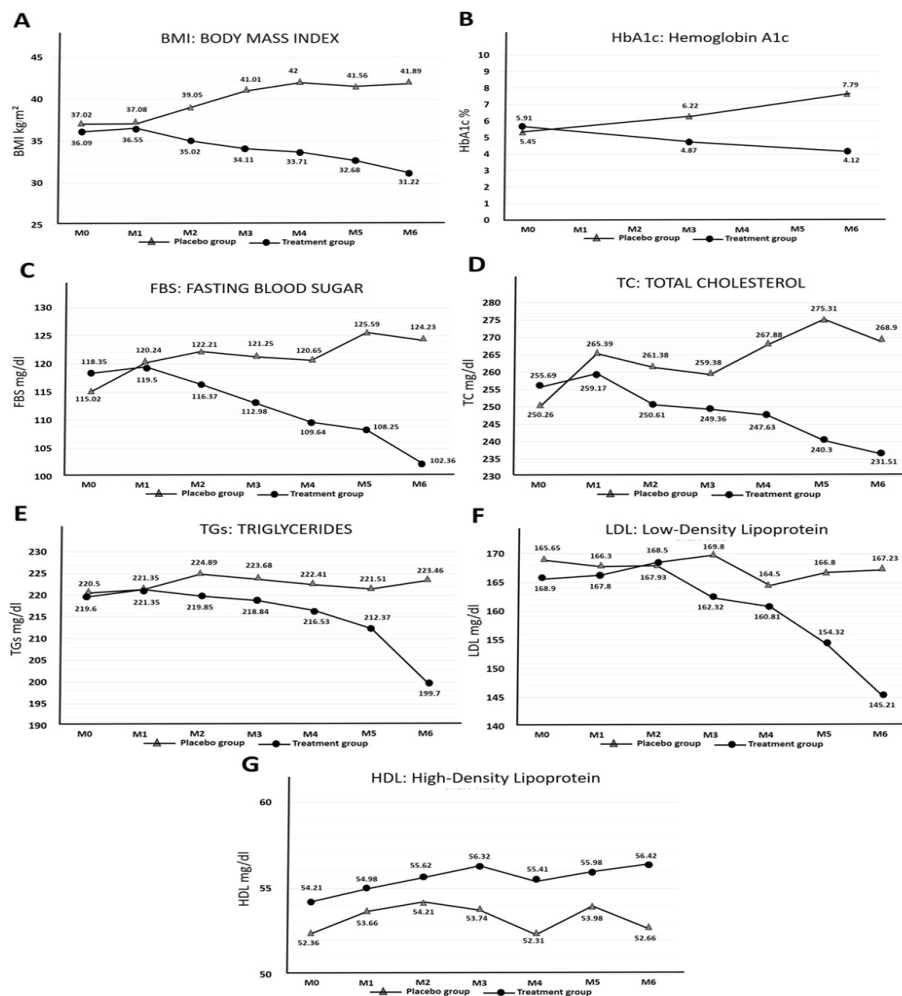


Figure 1. Graph of Biochemistry Parameters from Baseline to 6 Months, Comparing Treatment and Placebo

as in Figure 1(b) ($P = 0.004$), FBS (mg/dL), as in Figure 1(c) ($P = 0.006$), TC (mg/dL), as in Figure 1(d) ($P = 0.004$), TGs (mg/dL), as in Figure 1(e) ($P = 0.002$), LDL-C (mg/dL), as in Figure 1(f) ($P = 0.003$), and HDL-C (mg/dL), as in Figure 1(g) ($P = 0.014$) (Table 2).

Discussion

This research sought to examine the beneficial effects of *Bifidobacterium breve* BR03 and *Bifidobacterium breve* B632 upon BMI, systolic and diastolic blood pressure (SBP, DBP), and pulse pressure (PP), as well as hemoglobin A1c (HbA1c), fasting blood sugar (FBS), total cholesterol (TC), triglycerides (TGs), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) in individuals diagnosed with metabolic syndrome (MetS). The findings demonstrated that *Bifidobacterium breve* BR03 and *Bifidobacterium breve* B632 decreased BMI, HbA1c, FBS, TC, TGs, and LDL-C significantly, and raised HDL-C. However, there were no significant differences in blood pressure (SBP, DBP). Short-chain fatty acids (SCFAs) are group of two to six carbon atoms that are mainly produced by gut microbiome fermentation of dietary fiber. Propionate, acetate, and butyrate are the three major SCFAs, and they offer a number of advantageous biological properties for human health, including such as immunoregulatory, anti-inflammatory, anti-diabetes, anti-obesity, anticancer, and neuroprotective activities, in addition to offering cardiovascular protection (Xiong *et al.*, 2022). The study in patients with T2DM using a mixture comprising mixed-strain probiotics (*B. breve* UBBR 01, *Bacillus coagulans* Unique- IS2, *L. salivarius* UBLS22, *L. plantarum* UBLP40, *L. casei* UBLC42 and *L. Acidophilus*. UBLA34 and prebiotics such as fructo-oligosaccharide for a treatment duration of 12 weeks revealed that the influence declined with HbA1c ($P = 0.0023$) and weight ($P < 0.001$) in comparison to the use of a placebo (Madempudi *et al.*, 2019). The study of mixed-strain probiotics (*L. Salivarius* UBLS-22, *L. Casei* UBLC-42, *L. plantarum*, UBLP-40, *L. Acidophilus* UBLA-34, *B. Breve* UBBR- 01, *B. Coagulans* Unique IS2 and prebiotics such as fructo-oligosaccharide as a mixture for 12 weeks of treatment showed effects of probiotic groups decreased from the baseline with BMI ($P = 0.0001$), weight ($P < 0.0001$), and waist-hip ratio, WHR ($P = 0.007$) in comparisons to the group taking the placebo (Sudha *et al.*, 2019). Several previous studies have explained the role of *Bifidobacterium breve* BR03 and B632 strains in regulating sensitivity to insulin as well as tolerance

of glucose. The mechanism of reducing glucose serves to produce SCFAs which are able to reverse the effects of tolerance to glucose and fasting glucose in T2DM (Zhang *et al.*, 2021). It has been shown that the use of probiotic supplements might serve to lower the risk of developing metabolic disorders for pre-diabetic people (Kassanian *et al.*, 2018). A study showed *B. breve* B632 and BR03 strains may increase sensitivity to insulin among obese teenagers and younger children in the trial (Sung *et al.*, 2023). A study on the use of *Bifidobacterium breve* B-3 (BB-3) to lower body fat over 12 weeks revealed substantial falls in weight as well as hip and waist measurements (Miglioranza Scavuzzi *et al.*, 2015). A study on *Bifidobacterium breve* supplementation involved 40 subjects diagnosed with T2DM. Significant changes were observed within the placebo group, with increased HbA1c and HDL levels in comparison to values at the baseline. In contrast, the treatment group showed significant improvements after 12 weeks, with decreased fasting blood sugar (FBS), HbA1c, total cholesterol (TC), and LDL amounts, and a rise in HDL levels compared to baseline values (Chaiyasut *et al.*, 2021).

Probiotics can be an alternative approach to therapy for obesity and metabolic syndrome. Among *Bifidobacteria spp.*, the species *Bifidobacterium breve* is a dominant strain found within the gut of babies fed on breast milk, which in addition can be isolated from samples of human milk (Miglioranza Scavuzzi *et al.*, 2015). *Bifidobacterium breve* offers antimicrobial activity to protect against bacteria affecting human health. Additionally, it is not able to transmit genes offering resistance to antibiotics. It exhibits no cytotoxicity, and is able to stimulate the immune system (Bernini *et al.*, 2016). This study focuses upon the practical uses of *B. breve* varieties, especially in preventing and treating diseases affecting children. The results of the study showing reductions in fasting blood sugar (FBS), HbA1c, total cholesterol (TC), triglycerides (TGs), and LDL-C, corroborate findings from other reports (Greany *et al.*, 2008; Guo *et al.*, 2011). One meta-analysis investigating the results of randomized controlled trials estimated the influence of probiotics upon decreasing LDL-C and cholesterol levels in study groups exhibiting high or near-high TC levels (Greany *et al.*, 2008). The effects of probiotics involve a mechanism whereby cholesterol is able to bind to the probiotic cell wall surface, which blocks cholesterol absorption into the blood from the small intestine (Zhang *et al.*, 2021). Moreover, probiotic bacteria can produce hydrolases that de-conjugate bile acids. Probiotics are also associated with increased levels of short-chain fatty acids (SCFAs). SCFAs consist of propionate, acetate, and butyrate

are primarily produced by the gut microbiome fermentation of dietary fiber. These SCFAs can enhance lipid metabolism through direct action upon the liver and through the inhibition of hydroxymethylglutaryl coenzyme-A reductase, a key enzyme in the cholesterol synthesis pathway (Zhang *et al.*, 2021). The regulation of food diet is also crucial for weight reduction and the control of metabolic syndrome symptoms. Diets such as the Mediterranean or DASH diets, low-carbohydrate diets, and low fat diets have been shown to improve key health indicators including blood pressure, blood sugar levels, and cholesterol levels. Furthermore, these dietary approaches can help reduce the risk of heart disease and diabetes (Di Daniele *et al.*, 2017; Hoyas and León-Sanz 2019; Vasei *et al.*, 2022). Studies on appropriate dietary control such as reducing fat intake and increasing the consumption of protein and fiber have shown that these dietary changes help improve several variables of metabolic syndrome includes elevated blood lipid, blood pressure, and blood sugar levels (Te Morenga *et al.*, 2011).

Consuming low glycemic index (low GI) foods including whole-wheat bread and brown rice or unrefined pasta helps control blood sugar levels more effectively than carbohydrates that have a high glycemic index. This can lower the chance of getting type-2 diabetes, a primary cause of metabolic syndrome (Brand-Miller *et al.*, 2003). Researchers have studied the influence of low GI foods in individuals exhibiting metabolic syndrome, and studies have revealed that low-GI foods can help control blood sugar levels as well as enhancing insulin responsiveness among individuals exhibiting metabolic syndrome (Radulian *et al.*, 2009). Additionally, consuming foods high in unsaturated fats such as olive oil, rice bran oil, and various nuts has been found to help reduce metabolic syndrome. By raising HDL cholesterol and decreasing LDL cholesterol, these foods help minimize the risk of cardiovascular illnesses (Xia *et al.*, 2022). The fiber found in vegetables, fruits, and unrefined grains control cholesterol levels and sugar levels, which are key factors in managing the symptoms of metabolic syndrome (Chen *et al.*, 2018; Bulsiewicz, 2023). Furthermore, the likelihood of high blood pressure can be reduced by limiting sodium intake by avoiding foods containing high levels of sodium, such as processed foods or salt, since high blood pressure is one of the symptoms of metabolic syndrome. This also helps to lower the potential for the onset of cardiovascular disease (Aronow, 2017; Grillo *et al.*, 2019). Therefore, modifying dietary behaviors is an essential factor in mitigating MetS and lowering

the probability of getting several chronic, non-communicable diseases.

A number of researchers have discussed the influence of probiotic supplements with MetS subjects, though the results have been inconsistent. The use of just one probiotic strain in this study, along with the limited number of participants, present significant limitations. Furthermore, this research lacked data concerning physical activity as well as ethnicity. Accordingly, it may be necessary to validate the findings from this study in the future through conducting additional work with a larger and more diverse experimental group.

Conclusions

Six months of treatment with *Bifidobacterium breve* BR03 and *Bifidobacterium breve* B632 had beneficial effects on BMI, HbA1c, FBS, TC, TGs, and LDL-C, increasing HDL-C in MetS. The mechanisms of probiotic effects stopped cholesterol from being absorbed into the blood from the intestinal tract. SCFAs directly influence sensitivity to insulin and the glucose metabolism. Regulating food intake is crucial for weight reduction and the management of BMI for those with symptoms of metabolic syndrome. Long-term studies to confirm and enrich the findings of this study are justified.

References

- Aronow, W. S. (2017). Reduction in dietary sodium improves blood pressure and reduces cardiovascular events and mortality. *Annals of Translational Medicine*, 5(20), 405. <https://doi.org/10.21037/atm.2017.08.06>
- Alberti, G., Zimmet, P., Shaw, J., & Grundy, S. M. (2006). The IDF consensus worldwide definition of the metabolic syndrome. Consensus statement. Brussels, Belgium: *International Diabetes Federation*.
- Bernini, L. J., Simão, A. N. C., Alfieri, D. F., Lozovoy, M. A. B., Mari, N. L., de Souza, C. H. B., Dichi, I., & Costa, G. N. (2016). Beneficial effects of *Bifidobacterium lactis* on lipid profile and cytokines in patients with metabolic syndrome: A randomized trial. *Nutrition*, 32(6), 716–719. <https://doi.org/10.1016/j.nut.2015.11.001>
- Brand-Miller, J., Hayne, S., Petocz, P., & Colagiuri, S. (2003). Low-glycemic index diets in the management of diabetes: A meta-analysis of randomized controlled trials. *Diabetes Care*, 26(8), 2261–2267. <https://doi.org/10.2337/diacare.26.8.2261>
- Bulsiewicz, W. J. (2023). The importance of dietary fiber for metabolic health. *American Journal of Lifestyle Medicine*, 17(5), 639–648. <https://doi.org/10.1177/15598276231167778>
- Chaiyasut, C., Sivamaruthi, B. S., Kesika, P., Khongtan, S., & Sirilun, S. (2021). Synbiotic supplementation improves obesity index and metabolic biomarkers in Thai obese adults: A randomized clinical trial. *Foods*, 10(7), Article 1580. <https://doi.org/10.3390/foods10071580>
- Chen, J.-P., Chen, G.-C., Wang, X.-P., Qin, L., & Bai, Y. (2018). Dietary fiber and metabolic syndrome: A meta-analysis

- and review of related mechanisms. *Nutrients*, 10(1), Article 24. <https://doi.org/10.3390/nu10010024>
- Di Daniele, N., Noce, A., Vidiri, M. F., Moriconi, E., Marrone, G., Annicchiarico-Petruzzelli, M., D'Urso, G., Tesaro, M., Rovella, V., & De Lorenzo, A. (2017). Impact of Mediterranean diet on metabolic syndrome, cancer and longevity. *Oncotarget*, 8(5), 8947–8979. <https://doi.org/10.18632/oncotarget.13553>
- Eberly, L. E., Prineas, R., Cohen, J. D., Vazquez, G., Zhi, X., Neaton, J. D., & Kuller, L. H. (2006). Metabolic syndrome, risk factor distribution, and 18-year mortality in the Multiple Risk Factor Intervention Trial. *Diabetes Care*, 29(1), 123–130. <https://doi.org/10.2337/diacare.29.01.06.dc05-1320>
- Greany, K. A., Bonorden, M. J. L., Hamilton-Reeves, J. M., McMullen, M. H., Wangen, K. E., Phipps, W. R., Feirtag, J., Thomas, W., & Kurzer, M. S. (2008). Probiotic capsules do not lower plasma lipids in young women and men. *European Journal of Clinical Nutrition*, 62(2), 232–237. <https://doi.org/10.1038/sj.ejcn.1602719>
- Grillo, A., Salvi, L., Coruzzi, P., Salvi, P., & Parati, G. (2019). Sodium intake and hypertension. *Nutrients*, 11(9), Article 1970. <https://doi.org/10.3390/nu11091970>
- Grundy, S. M., Cleeman, J. I., Daniels, S. R., Donato, K. A., Eckel, R. H., Franklin, B. A., Gordon, D. J., Krauss, R. M., Savage, P. J., Smith, S. C., Spertus, J. A., & Costa, F. (2005). Diagnosis and management of the metabolic syndrome: An American Heart Association/National Heart, Lung, and Blood Institute scientific statement. *Circulation*, 112(17), 2735–2752. <https://doi.org/10.1161/CIRCULATIONAHA.105.169404>
- Guo, Z., Liu, X. M., Zhang, Q. X., Shen, Z., Tian, F. W., Zhang, H., Sun, Z. H., Zhang, H. P., & Chen, W. (2011). Influence of consumption of probiotics on the plasma lipid profile: A meta-analysis of randomized controlled trials. *Nutrition, Metabolism and Cardiovascular Diseases*, 21(11), 844–850. <https://doi.org/10.1016/j.numecd.2011.04.008>
- Hoyas, I., & León-Sanz, M. (2019). Nutritional challenges in metabolic syndrome. *Journal of Clinical Medicine*, 8(9), Article 1301. <https://doi.org/10.3390/jcm8091301>
- International Diabetes Federation. (2023). IDF diabetes atlas (11th ed.). International Diabetes Federation.
- Kassanian, N., Feizi, A., Aminoroaya, A., Jafari, P., Ebrahimi, M. T., & Amini, M. (2018). The effects of probiotics and synbiotic supplementation on glucose and insulin metabolism in adults with prediabetes: A double-blind randomized clinical trial. *Acta Diabetologica*, 55(10), 1019–1028. <https://doi.org/10.1007/s00592-018-1175-2>
- Madempudi, R. S., Ahire, J. J., Neelamraju, J., Tripathi, A., & Nanal, S. (2019). Efficacy of UB0316, a multi-strain probiotic formulation in patients with type 2 diabetes mellitus: A double-blind, randomized, placebo-controlled study. *PLOS ONE*, 14(11), Article e0225168. <https://doi.org/10.1371/journal.pone.0225168>
- Malik, S., Wong, N. D., Franklin, S. S., Kamath, T. V., L'Italien, G. J., Pio, J. R., & Williams, G. R. (2004). Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. *Circulation*, 110(10), 1245–1250. <https://doi.org/10.1161/01.CIR.0000140677.20606.0E>
- Scavuzzi, B. M., Miglioranza, L. H. S., Henrique, F. C., Paroschi, T. P., Lozovoy, M. A. B., Simão, A. N. C., & Dichi, I. (2015). The role of probiotics on each component of the metabolic syndrome and other cardiovascular risks. *Expert Opinion on Therapeutic Targets*, 19(8), 1127–1138. <https://doi.org/10.1517/14728222.2015.1028361>
- Radulian, G., Rusu, E., Dragomir, A., & Posea, M. (2009). Metabolic effects of low glycaemic index diets. *Nutrition Journal*, 8, Article 5. <https://doi.org/10.1186/1475-2891-8-5>
- Sattar, N., Gaw, A., Scherbakova, O., Ford, I., O'Reilly, D. S. J., Haffner, S. M., Isles, C., Macfarlane, P. W., Packard, C. J., Cobbe, S. M., & Shepherd, J. (2003). Metabolic syndrome with and without C-reactive protein as a predictor of coronary heart disease and diabetes in the West of Scotland Coronary Prevention Study. *Circulation*, 108(4), 414–419. <https://doi.org/10.1161/01.CIR.0000080897.52664.94>
- Sudha, M. R., Ahire, J. J., Jayanthi, N., Tripathi, A., & Nanal, S. (2019). Effect of multi-strain probiotic (UB0316) in weight management in overweight/obese adults: A 12-week double-blind, randomised, placebo-controlled study. *Beneficial Microbes*, 10(8), 855–866. <https://doi.org/10.3920/BM2019.0052>
- Sung, H. K., Youn, S. J., Choi, Y., Eun, S. W., & Shin, S. M. (2023). Body fat reduction effect of *Bifidobacterium breve* B-3: A randomized controlled trial. *Nutrients*, 15(1), Article 28. <https://doi.org/10.3390/nu15010028>
- Te Morenga, L. A., Levers, M. T., Williams, S. M., Brown R. C., & Mann, J. (2011). Comparison of high protein and high fiber weight-loss diets in women with risk factors for the metabolic syndrome: A randomized trial. *Nutrition Journal*, 10, Article 40. <https://doi.org/10.1186/1475-2891-10-40>
- Vasei, M. H., Aliasgharzadeh, A., Mobasser, M., & Mojtahedi, S. Y. (2022). Effect of dietary approaches to stop hypertension (DASH) diet with different sources of protein on cardiometabolic risk factors in patients with type 2 diabetes: A randomized clinical trial. *Primary Care Diabetes*, 16(5), 634–639. <https://doi.org/10.1016/j.pcd.2022.09.001>
- Xia, M., Zhong, Y., Peng, Y., & Qian, C. (2022). Olive oil consumption and risk of cardiovascular disease and all-cause mortality: A meta-analysis of prospective cohort studies. *Frontiers in Nutrition*, 9, Article 1041203. <https://doi.org/10.3389/fnut.2022.1041203>
- Xiong, R.-G., Zhou, D.-D., Wu, S.-X., Huang, S.-Y., Saimaiti, A., Yang, Z.-J., Shang, A., Zhao, C.-N., Gan, R.-Y., & Li, H.-B. (2022). Health benefits and side effects of short-chain fatty acids. *Foods*, 11(18), Article 2863. <https://doi.org/10.3390/foods11182863>
- Zhang, L., Chu, J., Hao, W., Zhang, J., Li, H., Yang, C., Yang, J., Chen, X., & Wang, H. (2021). Gut microbiota and type 2 diabetes mellitus: Association, mechanism, and translational applications. *Mediators of Inflammation*, 2021, Article 5110276. <https://doi.org/10.1155/2021/5110276>