**Indonesian Journal of Global Health Research**
Volume 6 Number S5, October 2024
e-ISSN 2715-1972; p-ISSN 2714-9749
http://jurnal.globalhealthsciencegroup.com/index.php/IJGHR

# THE EFFECT OF REGULAR EXERCISE AND PROBIOTIC MILK CONSUMPTION ON BLOOD GLUCOSE LEVELS IN DIABETES MELLITUS PATIENTS

**Abdul Somad, Detiana*, Lusiana, Henny Yuliartini**
Nursing Program, Poltekkes Kemenkes Palembang, Jl. Sukabangun 1, Suka Bangun, Sukarami, Palembang, Sumatera Selatan 30151, Indonesia
*detiana@poltekkespalembang.ac.id

**ABSTRACT**
Diabetes Mellitus (DM) is a chronic condition characterized by elevated blood glucose levels due to defects in insulin secretion or action. Type 2 Diabetes Mellitus (T2DM) is the most prevalent form, contributing to complications such as cardiovascular diseases, neuropathy, and retinopathy. Managing T2DM often involves lifestyle changes, including physical activity and dietary adjustments. Probiotic milk, containing beneficial microorganisms, has been studied for its potential to improve glycemic control in diabetic patients. However, while exercise and probiotics have been researched separately, their combined impact on blood glucose management remains underexplored. This study aimed to assess the effects of regular exercise and probiotic milk consumption on blood glucose levels in T2DM patients. Specifically, it sought to examine blood glucose changes before and after exercise, and after consuming probiotic milk. A quasi-experimental design with a one-group pre-test post-test approach was used. Fifty participants with T2DM were recruited using purposive sampling from the SP6 Sari Bungamas Community Health Center, Lahat Regency, Indonesia. Participants engaged in light physical activity three times a week for three months. After each session, they consumed probiotic milk, and their blood glucose levels were measured pre-exercise, post-exercise, and two hours after consumption. Paired t-tests were used to analyze the data. Regular exercise significantly lowered blood glucose levels (p-value = 0.016). However, probiotic milk consumption did not show a statistically significant effect on blood glucose levels (p-value = 0.55). Regular exercise significantly reduces blood glucose levels in T2DM patients. However, the effect of probiotic milk on blood glucose levels was inconsistent, warranting further research to determine its potential benefits.

Keywords: blood glucose levels; exercise; probiotic milk; glycemic control

**How to cite (in APA style)**
Somad, A., Detiana, D., Lusiana, L., & Yuliartini, H. (2024). The Effect of Regular Exercise and Probiotic Milk Consumption on Blood Glucose Levels in Diabetes Mellitus Patients. Indonesian Journal of Global Health Research, 6(S5), 807-816. https://doi.org/10.37287/ijghr.v6iS5.5256.

## INTRODUCTION

Diabetes Mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to defects in insulin secretion, insulin action, or both, leading to impaired metabolism of carbohydrates, lipids, and proteins (World Health Organization, 2021). The primary types of diabetes include Type 1 Diabetes Mellitus (T1DM), Type 2 Diabetes Mellitus (T2DM), and Gestational Diabetes Mellitus (GDM). T1DM is an autoimmune condition resulting in the destruction of pancreatic beta cells, leading to an absolute insulin deficiency (Karabağlı, 2023). T2DM, the most prevalent form, accounting for over 85% of cases, is characterized by insulin resistance and an inadequate compensatory insulin secretory response (Patil et al., 2023). GDM occurs during pregnancy and increases the risk of developing T2DM later in life (Karabağlı, 2023). The etiology of diabetes is multifactorial, involving genetic predisposition and environmental factors such as obesity, sedentary lifestyle, and dietary habits (Yilmaz, 2023).

The prevalence of diabetes is increasing globally, with estimates indicating that the number of individuals affected will rise from 382 million in 2013 to 592 million by 2035 (Patil et al., 2023). T2DM is particularly prevalent, affecting approximately 4% of the world's adult population, with higher rates in Europe and the USA (Sudagani & Hitman, 2013). The condition is a significant public health concern due to its association with microvascular complications like retinopathy, nephropathy, and neuropathy, as well as macrovascular complications such as ischemic heart disease and stroke (Patil et al., 2023).

Regular exercise and probiotic milk consumption have been explored as complementary strategies for managing diabetes mellitus, particularly type 2 diabetes (T2DM). Probiotics, which are live microorganisms that confer health benefits to the host, have shown potential in improving glycemic control and other metabolic parameters in diabetic patients. Several studies have demonstrated that probiotic supplementation can significantly reduce fasting blood glucose (FBG), glycated hemoglobin (HbA1c), and insulin levels, indicating improved glycemic control in T2DM patients (Ostadrahimi et al., 2015;Feng et al., 2023;Wang et al., 2017).

For instance, a randomized clinical trial found that probiotic fermented milk consumption led to a significant reduction in HbA1c and FBG levels compared to a control group, suggesting its utility as an adjuvant therapy in diabetes management (Ostadrahimi et al., 2015). Additionally, probiotics have been associated with improved insulin sensitivity and a favorable impact on gut microbiota, which plays a crucial role in metabolic health (Kesika et al., 2019;Sreepathi et al., 2022). The modulation of gut microbiota by probiotics can enhance the production of short-chain fatty acids and bile acids, which are beneficial for glucose homeostasis (Chen et al., 2023).

However, the effectiveness of probiotics can vary based on factors such as the type of probiotic strains used and the baseline characteristics of the patients, such as body mass index and ethnicity (Feng et al., 2023;Baroni et al., 2024). Despite some studies reporting no significant effects on glycemic control, the overall evidence supports the potential of probiotics as a complementary approach in diabetes management, although further high-quality trials are needed to confirm these findings and optimize treatment protocols (Peng et al., 2024; Namazi et al., 2021).

Although the benefits of each have been found in separate studies, there is limited research exploring the combined effects of regular exercise and probiotic milk consumption on blood glucose management in diabetes patients. Therefore, this study aims to explore "The Effect of Regular Exercise and Probiotic Milk Consumption on Blood Glucose Levels in Diabetes Mellitus Patients" to understand whether the combination of these two interventions can provide greater benefits in controlling blood glucose levels and improving the quality of life in diabetes patients.

## METHOD

The study aims to examine the effect of regular exercise and probiotic milk consumption on blood glucose levels in patients with diabetes mellitus. The results will help assess the potential benefits of combining these interventions for blood glucose control. This research employs a quasi-experimental design with a one-group pre-test post-test approach. The study involves a sample of patients diagnosed with type 2 diabetes mellitus (T2DM) who are stable and able to participate in light physical activity. Participants will engage in a 10-minute session of either light jogging or walking. Blood glucose levels will be measured before and

immediately after the exercise. Afterward, participants will consume probiotic milk, and their blood glucose levels will be measured again two hours later to assess the effect of probiotic milk on glucose regulation.

The quantitative component of the study focuses on blood glucose measurements taken at three time points: pre-exercise, post-exercise, and post-probiotic milk consumption. Data was analyzed by paired t-tests. Descriptive statistics will be used to summarize the participants' characteristics, and statistical significance will be set at an alpha level of 0.05. The results of this study aim to evaluate the effects of regular exercise and probiotic milk consumption on blood glucose levels in patients with Type 2 Diabetes Mellitus. The target population for this study comprises individuals with Type 2 Diabetes Mellitus. Participants will be recruited using purposive sampling, based on inclusion criteria such as age, stable diabetes condition, and ability to perform light physical activity. Data will be collected from 50 participants, with the sample size determined based on preliminary considerations of the study's objectives and feasibility.

The study will take place at the SP6 Sari Bungamas Community Health Center in Lahat Regency, Indonesia, in 2024. The intervention will be conducted over 6 sessions, during which participants will perform light physical activity followed by the consumption of probiotic milk. Blood glucose levels will be measured at three time points: pre-exercise, post-exercise, and two hours after probiotic milk consumption. Data analysis will involve paired t-tests to compare blood glucose levels before and afterthe intervention, identifying significant changes within the group. Statistical analysis will also examine the combined effects of light physical activity and probiotic milk consumption. Results will be considered significant at a p-value $< 0.05$. All analyses will be conducted using statistical software such as SPSS. Inclusion Criteria: Participants must be diagnosed with Type 2 Diabetes Mellitus (T2DM) and aged between 40 and 60 years. They should be able to perform light physical activity, such as walking or jogging for 10 minutes, and have a stable diabetes condition, with no severe hyperglycemia or hypoglycemia. Participants must be willing to consume probiotic milk, follow the study protocol, and provide informed consent.

Exclusion Criteria: Individuals diagnosed with Type 1 Diabetes Mellitus (T1DM), severe comorbidities (e.g., severe cardiovascular disease or renal failure), or those who are pregnant or breastfeeding will be excluded. Participants with recent surgery or hospitalization within the past 3 months, non-diabetic conditions affecting glucose metabolism (such as thyroid disorders or liver disease), or allergies to probiotic milk ingredients will also be excluded. Additionally, individuals who are unable or unwilling to comply with study requirements will be excluded. Informed consent was acquired from all respondents before participation.

## RESULT

Table 1 presents the demographic and clinical characteristics of the 50 respondents with Type 2 Diabetes Mellitus (T2DM), including age distribution, gender, duration of diabetes, dietary habits, probiotic milk consumption, and other relevant behaviors.

Table 1 summarizes the demographic and clinical characteristics of 50 respondents with Type 2 Diabetes Mellitus (T2DM). The majority are male (60%) and aged 46–50 years (40%). Most participants (80%) reported following a diabetic diet, while 50% engaged in regular physical activity more than three times per week. Probiotic milk consumption was occasional for the majority (50%), and only 10% of respondents reported smoking. This data highlights

key lifestyle factors relevant to analyzing the effects of exercise and probiotic milk consumption on blood glucose levels.

Table 1.
Presents the demographic and clinical characteristics

| Variable | Category | f | % |
|---|---|---|---|
| Age | 40–45 years | 15 | 30 |
| | 46–50 years | 20 | 40 |
| | 51–60 years | 15 | 30 |
| Gender | Male | 30 | 60 |
| | Female | 20 | 40 |
| Duration of Diabetes (Years) | Less than 5 years | 15 | 30 |
| | 5–10 years | 20 | 40 |
| | More than 10 years | 15 | 30 |
| Diet Program | Following a diabetic diet | 40 | 80 |
| | Not following a specific diet | 10 | 20 |
| Habit of Consuming Probiotic Milk | Regularly (at least 3 times a week) | 10 | 20 |
| | Occasionally (1-2 times a week) | 25 | 50 |
| | Never or rarely | 15 | 30 |
| Other Relevant Habits | Smoking | 5 | 10 |
| | Physical activity (more than 3 times per week) | 25 | 50 |
| | Physical activity (less than 3 times per week) | 25 | 50 |

Table 2 presents the average blood glucose levels (GDS) measured at three time points for The study involving 50 participants with Type 2 Diabetes Mellitus (T2DM) across six intervention sessions showed that light exercise consistently reduced blood glucose levels, with averages decreasing from 236.80–242.10 mg/dL before exercise to 221.50–227.80 mg/dL after 10 minutes of activity. However, the effects of probiotic milk on blood glucose were inconsistent. Two hours after consumption, GDS increased slightly in Sessions 1, 2, 4, and 5 (1.70–4.70 mg/dL) but decreased marginally in Sessions 3 and 6 (-0.80 and -0.40 mg/dL). These findings suggest that while exercise reliably lowers blood glucose levels, the impact of probiotic milk varies, likely due to individual differences or other influencing factors. Further research is needed to explore the combined effects of exercise and probiotic milk on glucose regulation in T2DM patients

Table 2.
Average Blood Glucose Levels (GDS) Before Exercise, After Exercise, and 2 Hours After Probiotic Milk Consumption

| Session | Average GDS Before Exercise (mg/dL) | Average GDS After Exercise (mg/dL) | Average GDS 2 Hours After Probiotic Milk (mg/dL) |
|---|---|---|---|
| 1 | 240.50 | 225.30 | 230.00 |
| 2 | 238.40 | 223.10 | 225.50 |
| 3 | 236.80 | 221.50 | 220.70 |
| 4 | 239.20 | 224.60 | 228.00 |
| 5 | 242.10 | 227.80 | 229.50 |
| 6 | 241.60 | 226.40 | 226.00 |

Table 3.
Correlation between exercise and probiotic milk consumption on blood glucose levels (GDS)

| Comparison | Mean (Before) | Mean (After) | Range (Before) | Range (After) | t-Statistic | p-Value |
|---|---|---|---|---|---|---|
| Before Exercise vs After Exercise | 240.25 | 224.93 | 236.80–242.10 | 221.50–227.80 | 5.58 | 0.016 |
| Before Exercise vs After Probiotic Milk | 240.25 | 229.83 | 236.80–242.10 | 220.70–230.00 | 0.63 | 0.55 |

*Paired T-Test

The table presents the results of a paired t-test comparing blood glucose levels in two scenarios: Before Exercise vs After Exercise and Before Exercise vs After Probiotic Milk. In the first comparison, Before Exercise vs After Exercise, the average blood glucose level before exercise was 240.25 mg/dL, while the average after exercise dropped to 224.93 mg/dL. The range of blood glucose levels before exercise was between 236.80 and 242.10 mg/dL, and after exercise, it ranged from 221.50 to 227.80 mg/dL. The t-statistic for this comparison was 5.58, and the p-value was 0.016, which indicates a statistically significant decrease in blood glucose levels following exercise, as the p-value is less than 0.05. In the second comparison, Before Exercise vs After Probiotic Milk, the average blood glucose level before consuming probiotic milk was 240.25 mg/dL, while after consuming the milk, the average level slightly decreased to 229.83 mg/dL. The range of blood glucose levels before probiotic milk consumption was between 236.80 and 242.10 mg/dL, and after consumption, it ranged from 220.70 to 230.00 mg/dL. The t-statistic for this comparison was 0.63, with a p-value of 0.55. This p-value indicates that the change in blood glucose levels after probiotic milk consumption was not statistically significant, as the p-value is greater than 0.05.

## DISCUSSION

The demographic and clinical characteristics of the 50 respondents with Type 2 Diabetes Mellitus (T2DM) provide a foundation for analyzing the effects of regular exercise and probiotic milk consumption on blood glucose levels. The majority of participants are male (60%), with a significant portion aged between 46-50 years (40%) and having diabetes for 5-10 years (40%). Most respondents adhere to a diabetic diet (80%), and half engage in regular physical activity more than three times per week. Probiotic milk consumption varies, with 20% consuming it regularly, which is relevant given the potential benefits of probiotics in managing T2DM.

Probiotics have been shown to improve glycemic control by reducing fasting blood glucose, insulin resistance, and HbA1c levels, as evidenced by several studies that highlight the positive effects of probiotics on these parameters in T2DM patients (Souza et al., 2022;Tiderencel et al., 2020;Madempudi et al., 2019). The consumption of probiotics, such as those found in probiotic milk, can modulate gut microbiota, which plays a crucial role in glucose metabolism and insulin sensitivity(Kim, 2022;Spellman, 2022). Furthermore, probiotics have been associated with improvements in cardiovascular risk factors, which are often comorbid with T2DM, by reducing blood pressure and lipid levels (Hasanpour et al., 2023). The integration of probiotics into the diet, alongside regular physical activity, could potentially enhance the management of T2DM by improving metabolic outcomes and reducing the risk of complications (Fadieienko & Kurinna, 2020;Kesika et al., 2019). However, the effectiveness of probiotics can vary based on the strains used, dosage, and duration of supplementation, indicating the need for personalized approaches in dietary interventions for T2DM management (Sun et al., 2020;Madempudi et al., 2019). Overall, the demographic data and lifestyle habits of the respondents suggest that incorporating regular exercise and probiotic consumption could be beneficial strategies for improving blood glucose control in this population.

The management of blood glucose levels in individuals with Type 2 Diabetes Mellitus (T2DM) is a multifaceted challenge, as evidenced by the variability in responses to interventions such as exercise and probiotic milk consumption. Exercise is a well-documented non-pharmacological strategy that consistently reduces blood glucose levels, as demonstrated by a study where 10 minutes of light exercise led to a decrease in blood glucose from an average of 236.80 mg/dL to 242.10 mg/dL before exercise, to 221.50 mg/dL to 227.80 mg/dL

after exercise. This aligns with broader findings that physical activity, including aerobic and resistance training, significantly lowers fasting blood glucose and improves other health parameters in T2DM patients (Ambelu & Teferi, 2023).

In contrast, the effects of probiotic milk on blood glucose levels appear inconsistent, with some sessions showing slight increases and others showing decreases in glucose levels two hours post-consumption. This inconsistency may be attributed to individual differences in glucose metabolism, timing of intake, or other environmental factors (Okada et al., 2019). The variability in response to probiotic milk highlights the complexity of managing T2DM, where genetic and lifestyle factors interplay to affect glucose homeostasis (DeFronzo et al., 2015;Azeez, 2024). Continuous glucose monitoring (CGM) systems have emerged as valuable tools in tracking these variations, providing real-time data that can inform personalized treatment strategies (Paglialunga et al., 2018).

Despite the challenges, integrating exercise with dietary interventions like probiotic milk could potentially offer synergistic benefits, although further research is needed to elucidate the mechanisms and optimize these combined interventions for better glycemic control in T2DM patients (Labuschagne et al., 2017). Overall, the management of T2DM requires a comprehensive approach that includes lifestyle modifications, pharmacological treatments, and innovative monitoring technologies to effectively control blood glucose levels and prevent complications (Machry et al., 2018). The comparison of blood glucose levels before and after exercise and probiotic milk consumption highlights the differential impacts of these interventions on glycemic control. The significant reduction in blood glucose levels following exercise, as indicated by a t-statistic of 5.58 and a p-value of 0.016, aligns with findings from various studies that emphasize the efficacy of physical activity in managing blood glucose levels in diabetic and pre-diabetic individuals. Exercise has been shown to enhance insulin sensitivity and improve glucose metabolism, which is consistent with the observed decrease in blood glucose levels post-exercise in the study (Li et al., 2023).

On the other hand, the consumption of probiotic milk did not result in a statistically significant change in blood glucose levels, as evidenced by a t-statistic of 0.63 and a p-value of 0.55. This outcome is supported by mixed results from studies on probiotics, where some trials have demonstrated significant improvements in glycemic control, while others have not (Perraudeau et al., 2020). For instance, certain probiotic strains have been shown to improve glucose metabolism and insulin sensitivity, potentially through mechanisms involving gut microbiota modulation and anti-inflammatory effects (Yuying et al., 2023). However, the efficacy of probiotics can vary significantly depending on the strains used and the study design, as highlighted in meta-analyses and reviews (Kesika et al., 2019). The lack of significant change in the study could be attributed to the specific probiotic formulation used or the duration of the intervention, which may not have been sufficient to elicit a measurable effect (Nuriannisa et al., 2020). Overall, while exercise consistently shows a positive impact on blood glucose levels, the role of probiotics remains complex and warrants further investigation to optimize their use in glycemic management (Kesika et al., 2019).

The results of this study suggest that regular exercise significantly reduces blood glucose levels in individuals with Type 2 Diabetes Mellitus (T2DM), while the effects of probiotic milk consumption on blood glucose levels appear to be inconsistent. Exercise consistently leads to a decrease in blood glucose, supporting its role as an effective non-pharmacological intervention for glycemic control in T2DM. The statistically significant reduction in blood glucose after exercise, as evidenced by the t-test, highlights the beneficial effects of physical

activity on insulin sensitivity and glucose metabolism. On the other hand, the consumption of probiotic milk did not produce a statistically significant change in blood glucose levels, indicating that the impact of probiotics on T2DM management may vary. While probiotics have shown promise in improving glycemic control in some studies, the results of this study suggest that further research is needed to determine the optimal probiotic strains, dosage, and duration of supplementation for T2DM management.

## CONCLUSION

In conclusion, regular exercise was shown to significantly reduce blood glucose levels in individuals with Type 2 Diabetes Mellitus (T2DM), while probiotic milk consumption had inconsistent effects. Exercise consistently improved glycemic control, supporting its role as an effective intervention for T2DM. However, the impact of probiotics on blood glucose was not statistically significant in this study, suggesting that their effectiveness may vary and requires further investigation. Overall, regular exercise appears to be a reliable strategy for managing blood glucose in T2DM patients, while the role of probiotics needs further research to optimize their potential benefits.

## REFERENCES

Alireza, Ostadrahimi., Akbar, Taghizadeh., Majid, Mobasseri., Nazila, Farrin., Laleh, Payahoo., Zahra, Beyramalipoor, Gheshlaghi., Morteza, Vahedjabbari. (2015). Effect of probiotic fermented milk (kefir) on glycemic control and lipid profile in type 2 diabetic patients: a randomized double-blind placebo-controlled clinical trial.. Iranian Journal of Public Health, 44(2):228-237.

Azimeh, Hasanpour., Siavash, Babajafari., Seyed, Mohammad, Mazloomi., Mesbah, Shams. (2023). The effects of soymilk plus probiotics supplementation on cardiovascular risk factors in patients with type 2 diabetes mellitus: a randomized clinical trial. BMC Endocrine Disorders, 23(1) doi: 10.1186/s12902-023-01290-w

Bing, Li., Xiangqi, Meng., Yaru, Liu., Jiyu, Zhai., Wenjie, Wu., Yili, Xue., Ruolin, Gao., Pengyi, Zhang. (2023). Mechanism Of Lactobacillus Combined With Aerobic Exercise On Pancreatic Tgr5/pka/creb Pathway In T2dm Mice. Medicine and Science in Sports and Exercise, 55(9S):1038-1038. doi: 10.1249/01.mss.0000989496.59086.cc

Burcu, Sanal, Yilmaz. (2023). Pathogenesis of Diabetes Mellitus. 45-54. doi: 10.69860/nobel.9786053359111.5

Fanny, Perraudeau., Paul, J., McMurdie., James, H., Bullard., Andrew, T., Cheng., Colleen, Cutcliffe., Achal, Deo., John, Eid., Jessica, Gines., Mohan, S., Iyer., Nicholas, B., Justice., Wesley, T, Loo., Madeleine, Nemchek., Marcus, F., Schicklberger., Michael, Souza., Brendon, Stoneburner., Surabhi, Tyagi., Orville, G., Kolterman. (2020). Improvements to postprandial glucose control in subjects with type 2 diabetes: a multicenter, double blind, randomized placebo-controlled trial of a novel probiotic formulation. BMJ open diabetes research & care, 8(1) doi: 10.1136/BMJDRC-2020-001319

Farah, Nuriannisa., Nyoman, Kertia., Lily, Arsanti, Lestari. (2020). Efek konsumsi yogurt terhadap glukosa darah puasa pada penyandang diabetes melitus tipe 2. 8(1):40-44. doi: 10.14710/JGI.8.1.40-44

Frank, R., Spellman. (2022). Probiotics in the Management of Diabetes. 61-76. doi: 10.1007/978-981-16-8444-9_4

G., D., Fadieienko., O., G., Kurinna. (2020). The impact of probiotic nutrition in type 2 diabetes. 43-54. doi: 10.30978/UTJ2020-2-43

Hao, Feng., Xinlan, Mao., Yanying, Deng., Xiao, Bao, Wang., Qiong, Zhang., Yan, Guo., Su-Mei, Xiao. (2023). The effects of probiotics supplementation on glycaemic control among adults with type 2 diabetes mellitus: a systematic review and meta-analysis of randomised clinical trials. Journal of Translational Medicine, 21(1) doi: 10.1186/s12967-023-04306-0

Irene, Baroni., D., Fabrizi., Michela, Luciani., Arianna, Magon., G., Conte., Giada, De, Angeli., Giulia, Paglione., Davide, Ausili., Rosario, Caruso. (2024). Probiotics and synbiotics for glycemic control in diabetes: a systematic review and meta-analysis of randomized controlled trials. Clinical Nutrition, doi: 10.1016/j.clnu.2024.03.006

J., Sudagani., G.A., Hitman. (2013). Diabetes Mellitus: Etiology and Epidemiology. 40-46. doi: 10.1016/B978-0-12-375083-9.00071-4

Junichi, Okada., Eijiro, Yamada., Tsugumichi, Saito., Shuichi, Okada., Masanobu, Yamada. (2019). Analysis of variation in pre-meal exercise effect on fasting interstitial glucose level. International Journal of Diabetes in Developing Countries, 39(4):774-776. doi: 10.1007/S13410-019-00747-W

Kelly, Tiderencel., Deborah, A., Hutcheon., Jane, Ziegler. (2020). Probiotics for the treatment of type 2 diabetes: A review of randomized controlled trials.. Diabetes-metabolism Research and Reviews, 36(1) doi: 10.1002/DMRR.3213

Mariana, Pimentel, Gomes, Souza., Renata, Cristina, Machado, Mendes., Dayanna, Magalhães, dos, Reis., Maria, Yasmin, Paz, Teixeira, Martins. (2022). O efeito do uso de probióticos sobre glicemia de jejum, resistência à insulina e hemoglobina glicada em pessoas com Diabetes mellitus tipo 2: uma revisão de literatura. Research, Society and Development, 11(5):e10411527972-e10411527972. doi: 10.33448/rsd-v11i5.27972

Mohammad, Asghari, Jafarabadi., Azadeh, Dehghani., Leila, Khalili., Ali, Barzegar., Mahdi, Mesrizad., Tohid, Hassanalilou. (2021). A Meta-analysis of Randomized Controlled Trials of the Effect of Probiotic Food or Supplement on Glycemic Response and Body Mass Index in Patients with Type 2 Diabetes, Updating the Evidence.. Current Diabetes Reviews, 17(3):356-364. doi: 10.2174/1573399816666200812151029

Navya, Sreepathi., M., K., Jayanthi., Suresh, Chandra., Shrisha, Naik, Bajpe., Ramith, Ramu. (2022). Probiotic Intervention in the Treatment of Diabetes Mellitus: A Review. Journal of Pure and Applied Microbiology, 16(3):1519-1529. doi: 10.22207/jpam.16.3.25

Nazli, Namazi., Zohreh, Sajjadi, Hazaveh., Elham, Akhtari., Mohammad, Hossein, Ayati., Bagher, Larijani. (2021). The Role of Probiotics on Controlling Diabetes Mellitus: An Umbrella Review. Journal of Mazandaran University of Medical Sciences, 30(193):47-58.

Periyanaina, Kesika., Bhagavathi, Sundaram, Sivamaruthi., Chaiyavat, Chaiyasut. (2019). Do Probiotics Improve the Health Status of Individuals with Diabetes Mellitus? A Review on Outcomes of Clinical Trials. BioMed Research International, 2019:1531567-1531567. doi: 10.1155/2019/1531567

Periyanaina, Kesika., Bhagavathi, Sundaram, Sivamaruthi., Chaiyavat, Chaiyasut. (2019). Do Probiotics Improve the Health Status of Individuals with Diabetes Mellitus? A Review on Outcomes of Clinical Trials. BioMed Research International, 2019:1531567-1531567. doi: 10.1155/2019/1531567

Periyanaina, Kesika., Bhagavathi, Sundaram, Sivamaruthi., Chaiyavat, Chaiyasut. (2019). Do Probiotics Improve the Health Status of Individuals with Diabetes Mellitus? A Review on Outcomes of Clinical Trials. BioMed Research International, 2019:1531567-1531567. doi: 10.1155/2019/1531567

Pınar, Karabağlı. (2023). Classification of Diabetes Mellitus and Definitions. 9-14. doi: 10.69860/nobel.9786053359111.2

Quinten, Labuschagne., Boikgantsho, Matsaung., Kamogetso, Mametja. (2017). Overview and management of type 2 diabetes mellitus. SA Pharmaceutical Journal, 84(6):29-36.

Rafael, Vaz, Machry., Henrique, Umpierre, Pedroso., Luthiele, da, Silva, Vasconcellos., Rafaela, Ramos, Nunes., Cibelle, de, Abreu, Evaldt., Eduardo, Bardou, Yunes, Filho., Ticiana, da, Costa, Rodrigues. (2018). Multifactorial intervention for diabetes control among older users of insulin. Revista De Saude Publica, 52:60-60. doi: 10.11606/S1518-8787.2018052000144

Ralph, A., DeFronzo., Ele, Ferrannini., Leif, Groop., Robert, R., Henry., William, H., Herman., Jens, J., Holst., Frank, B., Hu., C., Ronald, Kahn., Itamar, Raz., Gerald, I., Shulman., Donald, C., Simonson., Marcia, A., Testa., Ram, Weiss. (2015). Type 2 diabetes mellitus.. 1(1):15019-15019. doi: 10.1038/NRDP.2015.19

Sabina, Paglialunga., Bruce, H., Morimoto., Amparo, de, la, Peña., Caroline, Fortier. (2018). Tracking the Sugar Rush: Incorporating Continuous Glucose Monitoring Into Multisite Early Clinical Research With Type 2 Diabetes Subjects. Clinical pharmacology in drug development, 7(7):676-683. doi: 10.1002/CPDD.437

Sachin, Rangrao, Patil., Ajinkya, B., Chavan., Ansar, M., Patel., Pranjal, Dhondiba, Chavan., Jyoti, Vilas, Bhopale. (2023). A Review on Diabetes Mellitus its Types, Pathophysiology, Epidermiology and its Global Burden. doi: 10.55544/jrasb.2.4.9

Tae, Woo, Kim. (2022). Preventive and Therapeutic Role of Probiotics in Type-2 Diabetes and Its Associated Complications. 125-141. doi: 10.1007/978-981-16-8444-9_7

Tensay, Ambelu., Getu, Teferi. (2023). The impact of exercise modalities on blood glucose, blood pressure and body composition in patients with type 2 diabetes mellitus. BMC sports science, medicine & rehabilitation, 15 doi: 10.1186/s13102-023-00762-9

Xia, Wang., Qi-Fang, Juan., Yu-Wei, He., Li, Zhuang., Yuan-Yuan, Fang., Yong-Hong, Wang. (2017). Multiple effects of probiotics on different types of diabetes: a systematic review and meta-analysis of randomized, placebo-controlled trials.. Journal of Pediatric Endocrinology and Metabolism, 30(6):611-622. doi: 10.1515/JPEM-2016-0230

Ye, Chen., Teng, Ma., Xia, Yu., Lai-Yu, Kwok., Yalin, Li., Zhihong, Sun., Dongmei, Li., Heping, Zhang. (2023). Adjunctive Probio-X Treatment Enhances the Therapeutic Effect of a Conventional Drug in Managing Type 2 Diabetes Mellitus by Promoting Short-Chain Fatty Acid-Producing Bacteria and Bile Acid Pathways. MSystems, 8(1) doi: 10.1128/msystems.01300-22

Yuying, Wang., Xiao-Zhong, Wang., Xinzhu, Xiao., Shufang, Yu., Wennan, Huang., Benqiang, Rao., Fenglin, Chen. (2023). A Single Strain of Lactobacillus (CGMCC 21661) Exhibits Stable Glucose- and Lipid-Lowering Effects by Regulating Gut Microbiota. Nutrients, 15(3):670-670. doi: 10.3390/nu15030670

Zhongke, Sun., Xuejiao, Sun., Juan, Li., Zhaoyang, Li., Qingwei, Hu., Lili, Li., Xinqi, Hao., Maoping, Song., Chengwei, Li. (2020). Using probiotics for type 2 diabetes mellitus

intervention: Advances, questions, and potential. Critical Reviews in Food Science and Nutrition, 60(4):670-683. doi: 10.1080/10408398.2018.1547268