

Temporary reduction of sugar levels in diabetes mellitus sufferers on the effect of diabetes mellitus exercises at Salewangan Maros Hospital, Maros Regency

Cici Yusnayani^{1*}, Andi Ernawati Manuntungi², Suningsih Suabey³, Sethiana Dewi Ruben⁴, Lumastari Ajeng Wijayanti⁵, Marwan Ahmad Ganoko⁶, Rezqiqah Aulia Rahmat⁷

¹Undergraduate Nursing and Professional Nurse Study Program, University Waluya Mandala, Kendari, Indonesia

² Program Studies Nursing, St Fatimah Mamuju Institute of Health and Business, Mamuju, Indonesia

^{3,4} Study program DIII Nursing Wamena, Jayapura Ministry of Health Polytechnic, Jayapura, Indonesia

⁵ Programs Studies Bachelor of Applied Midwifery Kediri, Malang Ministry of Health Polytechnic, Malang Indonesia

^{6,7} Programs Studies Medical science, University Bososwa, Makassar, Indonesia

ARTICLE INFO

ABSTRACT

Article history:

Received Jun 5, 2024

Revised Jun 27, 2024

Accepted Jun 30, 2024

Keywords:

Decrease;
Diabetes mellitus;
Hospital Exercises;
Patients;
Temporary Sugar Levels.

One of the causes of Diabetes Mellitus is a lack of exercise or physical activity. Glycogen or fat reserves will accumulate enough in the body if a person does not do physical activity or exercise. The aim of this research is to determine the effect of diabetes mellitus exercise on reducing sugar levels over time in diabetes mellitus sufferers. This research method is pre-experimental with a one group pre-post test design approach. The sampling technique used was total sampling with data analysis using the data normality test. The results of this study showed differences in blood sugar levels before and after doing diabetes exercises. After doing diabetes exercises, blood sugar levels drop. The decrease in blood sugar levels varied from one respondent to another. This indicates that exercise has a significant influence on reducing blood sugar levels in Diabetes Mellitus sufferers.

This is an open access article under the CC BY-NC license.



Corresponding Author:

Cici Yusnayani,
Undergraduate Nursing and Nursing Profession Study Program,
Mandala Waluya University,
Jl. Jend. AH. Nasution, Kambu, Kec. Kambu, Kota Kendari, Sulawesi Tenggara 93561, Indonesia
E-mail : cicistikesmw@gmail.com

INTRODUCTION

Hyperglycemia resulting from abnormalities in insulin secretion, insulin action, or both is characteristic of a group of metabolic diseases known as diabetes mellitus (Beyatli, 2024; Holst et al., 2011). General signs of diabetes mellitus, such as polyuria, polydipsia, and polyphagia, can appear together with immediate blood sugar levels of 200 mg/dl and fasting blood sugar of 126 mg/dl. (Balaji et al., 2019; Dewi, 2013; Hajam et al., 2022).

Diabetes mellitus, a series of chronic metabolic diseases, is characterized by hyperglycemia caused by defects in insulin synthesis, insulin action, or both (Haas et al., 2016; Kelly, 2014; Wiedensohler et al., 2012). Lack of insulin causes type 2 diabetes mellitus, also

known as Non-Insulin-Dependent Diabetes Mellitus, which causes hyperglycemia. This type accounts for 90–95 percent of diabetes cases when compared to other types (Kelly, 2014).

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia caused by abnormalities in insulin production, insulin action, or both (Indonesia, 2015). DM sufferers whose blood sugar levels are not controlled are at risk of experiencing complications of hyperglycemia, which is always followed by difficulty narrowing the blood vessels and resulting in damage and failure of the brain, eyes, heart and kidneys (Avillion, n.d.; Chowdhury, 2017; Kakadiya, n.d.).

In people with type 2 diabetes, exercise helps regulate blood sugar levels. The fundamental problem in type 2 diabetes is insulin resistance, which inhibits glucose from entering cells. Muscle contraction has an insulin-like effect in causing an increase in membrane glucose permeability. As a result, when doing physical activity such as exercise, insulin resistance decreases. Exercise helps people with type 2 diabetes mellitus control blood sugar levels and lose weight (James et al., 2021; Jorquera et al., 2021; Sylow et al., 2021)

The World Health Organization estimates that by 2030, diabetes mellitus will be ranked the sixth cause of death worldwide. The death rate due to DM is expected to increase by more than 50% in the next ten years. A health problem that often occurs in society is DM. According to international research data, there were 387 million diabetes sufferers worldwide in 2014, and by 2035, this number is expected to increase to 592 million (Liu et al., 2017; Montresor et al., 2020).

One of the causes of Diabetes Mellitus is a lack of exercise or physical activity. Glycogen or fat reserves will accumulate in the body if a person does not do enough physical activity or exercise, according to a study conducted in China some time ago. This is what causes diabetes mellitus (Basri, 2019; Sarwan & Kasim, 2023; Sitompul et al., 2015).

Exercise for Diabetes Mellitus is very important to reduce blood glucose levels in Diabetes Mellitus sufferers. Diabetes mellitus sufferers cannot use insulin to transport glucose into their cells. because the insulin response from cell receptors is still lacking. Exercise reduces insulin resistance by increasing the permeability of muscle contractions to glucose (Bonadonna et al., 1993; Ciaraldi et al., 1995). Diabetes exercises are low-impact, rhythmic aerobic exercises that are fun for people of all ages to participate in, making them a popular choice at diabetes clubs. Diabetes exercise can improve aerobic function and physical fitness (Colberg et al., 2016; Syeda et al., 2023; Walker, 2019). Diabetes exercise is a physical activity created for certain ages and physical conditions and is used to cure diabetes mellitus (Persadia, 2006). Specialists in internal medicine, sports medicine, medical rehabilitation, nutrition, and exercise studios, among others, create diabetes workouts. Diabetes exercise is a physical activity created for certain ages and physical conditions and is used to cure diabetes mellitus. Diabetes exercises are low-impact, rhythmic aerobic exercises that are fun for people of all ages to participate in, making them a popular choice at diabetes clubs. Diabetes exercise can improve aerobic function and physical fitness (Hutapea, 2016; Maulida et al., 2022).

Specialists in internal medicine, sports medicine, medical rehabilitation, nutritionists, and gymnastics studios are among those who create diabetes exercises. Physical activity is used in diabetes exercise as a means of preventing and managing the disease. Muscle cells work harder when you exercise, which means they need more sugar to burn for energy. Diabetic exercise causes insulin to bind to the plasma membrane and insulin receptors become active, thereby reducing blood glucose levels.

The four basic pillars of DM management are medical diet therapy, counseling or education, physical activity or exercise, and medical intervention. All types of DM, including type 2 DM, can be managed using these four management pillars. These four main pillars must be followed consistently to achieve an effective DM management focus. Implementation of the 4 pillars of a therapeutic regimen is one of the keys to managing

diabetes mellitus. The presence of regular therapy by patients will help reduce the risk of complications, thereby reducing the death rate due to DM. Regular physical activity has a 40% greater impact on the success of DM management than other factors (Colberg et al., 2016; Hayes & Kriska, 2008; Kanaley et al., 2022).

Regular physical activity, such as exercise, has been proven to be able to maintain body weight, keep blood pressure normal, help improve insulin function in the body, and improve psychological well-being. This makes it important to treat diabetes mellitus in everyday life (Kelly, 2014).

The results of Nurwidya Agraini's 2017 research on the effect of diabetes exercise on changes in blood sugar levels in diabetes mellitus sufferers in the Tawangrejo Health Center working area, Madiun City, showed that there were changes in blood sugar levels where the average value was that the respondents' blood sugar levels varied after completing diabetes exercises.

After age 50, normal blood glucose levels often increase slowly but progressively, especially in inactive individuals. After eating or drinking, an increase in blood glucose levels prompts the pancreas to produce insulin, which prevents a further increase and causes blood glucose levels to gradually decrease (Gerich, 1988; Tang et al., 2020; Yu et al., 2020).

RESEARCH METHOD

One-shot case study methodology, also known as pre-experimental experimental research with a post-test only approach, was used in this research to conduct research on the intervention group only without the participation of the control group (Siregar et al., 2022). Medical staff at Salewangan Maros District Hospital, Maros Regency, offered diabetes exercises as a treatment in this study. The research design is described as follows:

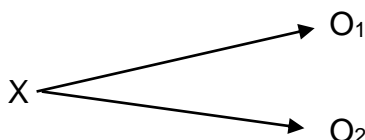


Figure 1. Research Design

Note: X = Given diabetes exercises by health workers, O₁ = GDS data before exercise (taken from health worker records), O₂ = GDS data after exercise was measured by the researcher

Participants in this study were all elderly people with diabetes mellitus who exercised to manage their condition. 22 people. Data collection was carried out on diabetes mellitus sufferers who had participated in diabetes exercise at least once and were screened and collected as research samples:

- a) Researchers took GDS data before exercise from health workers' records
- b) Researchers were present at diabetes exercise activities
- c) Health workers at Salewangan Maros District Hospital, Maros Regency, lead activities that include warming up, core training, cooling down and stretching.
- d) After the exercise, the scientists checked the blood levels of people with diabetes mellitus.

RESULTS AND DISCUSSIONS

Results

Univariate analysis

Respondent characteristics

Table 2. Descriptive statistics of the characteristics of DM sufferers

Characteristics	n	%
Age group		
Adult (25-44 years)	9	28.1
Middle age (45-60 years)	12	68.8
Elderly (>60 years)	1	3.1
Gender		
Man	5	15.6
Woman	17	84.4
Level of education		
Junior High School	3	9.4
Senior High School	13	71.8
Diploma/Bachelor	6	18.8
Work		
Housewife (IRT)	7	54
Casual Daily Workforce (THL)	3	9.4
Private sector employee	6	18.8
Civil Servants (PNS)	6	18.8
Suffering from DM for a long time		
1-2 years	12	58.7
3 years and above	10	31.3
Number of people taking part in gymnastics		
1 time a month	3	9.4
2 times a month	3	9.4
3 times a month	5	31.2
4 times a month	11	50.0
Length of exercise		
30 minutes	22	100.0

Source: Primary Data 2023

Age, education, occupation, and duration of suffering from DM are used to calculate the frequency distribution of characteristics of DM sufferers, the number of diabetes exercise participants, and duration of exercise are presented in Table 2. According to WHO age criteria (2015), the majority of diabetes mellitus (DM) sufferers are in the range middle age (45–60 years), namely 68.8% of all cases. The majority of respondents (84.4%) were women, while the highest level of education was high school (71.8%). Most DM sufferers are housewives (53%). More respondents (58.7%) reported suffering from DM for 1-2 years. Half of the respondents (50%) exercise four times every month for a total of 30 minutes of exercise.

Characteristics of research variables

Table 3. Descriptive statistics of GDS of DM sufferers

Descriptive	GDS before exercise	GDS after exercise	Difference before & after exercise
Mean	285 mg/dl	180.38 mg/dl	104.63 mg/dl
Median	280 mg/dl	178.50 mg/dl	97 mg/dl
Standard deviation	52.15	30.29	56.05
Minimum	200 mg/dl	130 mg/dl	17 mg/dl
Maximum	380 mg/dl	280 mg/dl	200 mg/dl
Range	180 mg/dl	150 mg/dl	183 mg/dl

Source: Primary Data 2023

The percentage of GDS before and after exercise is presented in Table 3. When comparing the average GDS, before activity it is higher than after exercise, with a decrease difference of 104.63 mg/dl. The lowest and highest GDS levels of previous activity were 200 mg/dl and 380 mg/dl, respectively. After exercise, GDS levels range from 130 mg/dl to 280 mg/dl.

Bivariate analysis

Table 4. The effect of exercise on GDS levels in DM sufferers

Variable	Change	f (%)	p-value*
Before and after exercise	Decrease	32 (100%)	<0.001
	Increase	0 (0%)	
	Stay	0 (0%)	

Source: 2023 Wilcoxon test

Considering that GDS data is not distributed regularly, the results of the Wilcoxon statistical test are presented in Table 4. Based on the test results, all DM patients (100%) experienced a decrease in GDS from before to after exercise, with a value of 0.05 p. This suggests that exercise substantially reduces the level of GDS . diabetes sufferers was 104.63 mg/dl, rejecting the null hypothesis (H0).

Discussion

Blood Sugar Levels Before Diabetes Mellitus Exercise

It displays the percentage of GDS before and after exercise based on table 1. If examined more closely, the average GDS is higher before activity than after exercise. where the average value before exercise is 285mg/dl, the minimum value before exercise is 200mg/dl, and the maximum GDS value before exercise is 380mg/dl.

Insulin resistance, or lack of response to insulin, is thought to be the main cause of diabetes mellitus because it inhibits glucose from entering cells. Research findings showed that 5 respondents had moderate glucose levels before exercise, indicating that various variables, including aging, can contribute to high blood sugar levels in the body. Evidence shows that as people age , a person's chances of developing diabetes increase and their basic body abilities decrease.

As we age , pancreatic beta cells work less efficiently (Campbell & Newgard, 2021). After the age of 40, humans often begin to experience more rapid physiological decline. Fellingner, Paul (2019) stated that DM is more common in elderly people who are overweight or obese. Age and prevalence of type 2 diabetes are correlated, with a 72% reduction in risk in people under 45 years compared with people over 45 years, according to Sattar, Naveed (2019).

Table 2, shows that 17 respondents (84.4 %) or the majority of respondents were women. According to research, the chance of developing diabetes mellitus in men and women is the same . This is caused by a lack of movement or light activity, thereby reducing energy consumption. As a result, more energy is stored in the form of fat, which, if left for a long period of time, can cause overweight (obesity). Obesity has been linked to the development of insulin-insensitive (insulin-resistant cells), according to Petersen, Max C (2018). More adipose tissue makes the body more resistant to the effects of insulin, especially if it accumulates in the middle of the body or stomach (central obesity). Hyperglycemia and hyperlipidemia are two symptoms of a systemic, chronic and multifactorial disease known as diabetes mellitus. Symptoms appear because not enough insulin is released or because enough insulin is available but is not effective. Based on the research findings of Okamura, Takuro (2019) which

examined the relationship between diabetes mellitus and obesity, it was found that obesity increases the risk of developing diabetes mellitus by 2.26 times compared to not being obese.

Blood Sugar Levels After Diabetes Mellitus Exercise

This displays the percentage of GDS before and after exercise based on table 3. When comparing the average GDS, before activity it is higher than after exercise, with a decrease difference of 104.63 mg /dl. The lowest and highest GDS levels of previous activity were 200 mg/dl and 380 mg/dl, respectively. After exercise, GDS levels range from 130 mg/dl to 280 mg/dl. Many factors, including food consumption, activity, and food and activity, contribute to glucose decline.

Physical activity, in addition to keeping individuals healthy, can aid weight loss and improve insulin sensitivity, which can help regulate blood sugar. Examples of recommended aerobic exercise include walking, cycling, jogging and swimming. When choosing an exercise program, age and physical fitness level should be taken into account. Don't live a sedentary or slow life. These results indicate that after exercise, blood glucose levels change; This is because cells use insulin as a catalyst to burn energy from blood glucose into energy. A person who does physical activity will have a catalytic effect on insulin, allowing cells to burn blood glucose more quickly in the body. In contrast to those who have high levels of insulin resistance, glucose in the body is excreted from the body in the form of urine, not stored as fat.

In people with diabetes mellitus (DM), physical activity can increase the use of blood glucose by active muscles, according to sources from the Ministry of Health (2013). As a result, exercise can directly reduce body fat percentage, control blood sugar levels, increase insulin sensitivity, and reduce stress. Type II diabetes mellitus can also arise due to inactivity or lack of exercise. Based on research findings, four respondents (or 40%) had been exercising for diabetes mellitus for at least two years. This shows how respondents' lifestyle and blood sugar levels can be changed by their enjoyment of exercise or other hobbies. A person's body will accumulate glycogen or fat reserves if they do not exercise frequently throughout their life, which can trigger a number of degenerative diseases, including type II diabetes mellitus, according to research conducted in China some time ago (Anggraeni et al., 2023).

The Relationship between the Effect of Diabetes Mellitus Exercise on Blood Sugar Levels in Diabetes Mellitus Sufferers at Salewangan Maros Regional Hospital, Maros Regency.

Research findings, shows that six respondents (or 60%) out of 10 respondents with diabetes mellitus reported experiencing a decrease in blood sugar levels after exercising.

The Wilcoxon Signed Ranks Test was used in statistical analysis, and the results showed that a p value of 0.05, or $p = 0.001$, was obtained. Based on the examination results, all DM patients (100%) experienced a decrease in GDS from before to after exercise. This shows that exercise significantly reduces GDS levels in diabetes sufferers by 104.63 mg /dl.

According to researchers, the system of burning blood glucose in cells through the action of insulin is closely related to how glucose levels affect exercise activity. This is caused by inactivity or light exercise which causes an imbalance between the energy used and the energy consumed. The more fat reserves a person has, the bigger his body will be due to excess energy. Exercise participation and insulin sensitivity are closely related; those who exercise will have stable blood sugar levels due to insulin's efficiency in converting glucose into energy.

Regular physical exercise by 40% has the greatest impact on the success of controlling DM, according to Yoga (2011). Regular physical activity, such as exercise, is very important in managing diabetes mellitus in everyday life because it has been proven to be able to maintain body weight, maintain normal blood pressure, help improve insulin function in the body, and improve psychological well-being (Kelly, 2014).

All body movements are considered “exercise” because they increase energy consumption. Exercise can help you regulate blood sugar. Glucose will be converted into energy during activity. Exercise lowers blood sugar levels, which increases insulin. People who do not exercise do not burn the components of the food they consume; instead, they store it as sugar and fat. If there is insufficient insulin to convert glucose into energy, DM will develop.

CONCLUSION

This study demonstrates the significant impact of regular physical exercise on reducing blood glucose levels in individuals with diabetes mellitus (DM). The findings reveal that exercise contributes to a substantial decrease in glucose levels, with a mean reduction of 104.63 mg/dl, highlighting its effectiveness in managing blood sugar. Notably, 100% of the participants experienced a decrease in glucose levels after engaging in exercise, confirming the critical role of physical activity in enhancing insulin sensitivity and glucose metabolism. These results underscore the importance of incorporating regular exercise into the management plan for DM patients, particularly in mitigating the effects of insulin resistance and improving overall metabolic health. Given the compelling evidence on the benefits of exercise for DM management, healthcare practitioners should prioritize the integration of structured physical activity programs into the treatment protocols for DM patients. Tailored exercise regimens that consider individual patient capabilities and preferences can optimize adherence and efficacy. Additionally, future research should explore the long-term effects of different types and intensities of exercise on blood glucose regulation, as well as the potential psychological benefits associated with improved metabolic control. Promoting education and awareness about the importance of physical activity among DM patients can further enhance disease management and improve quality of life.

References

- Anggraeni, D. E., Darmayanti, R., Saputra, A., Khasanah, U., & Hardiyanti, A. (2023). HUBUNGAN PENGETAHUAN DENGAN KEPATUHAN DIET PADA PASIEN DIABETES MELLITUS TIPE II DI RSUD KOTA BANDUNG. *Jurnal Keperawatan BSI*, 11(2), 154-159.
- Avillion, A. E. (n.d.). *Chapter: Diabetes: A Comprehensive Overview*.
- Balaji, R., Duraisamy, R., & Kumar, M. P. (2019). Complications of diabetes mellitus: A review. *Drug Invention Today*, 12(1).
- Basri, M. H. (2019). Pengalaman Pasien DM TIPE 2 dalam Melakukan Perawatan Ulkusdiabetik Secara Mandiri. *Jurnal Endurance*, 4(1), 58-69.
- Beyatli, A. (2024). In Vitro α -Glucosidase, α -Amylase Inhibitory and Antioxidant Activities of Root Crude Extract and Solvent Fractions of *Arbutus unedo* L. (Ericaceae) TT - *Arbutus unedo* L. (Ericaceae) Kök Ham Ekstresinin ve Çözücü Fraksiyonlarının İn Vitro α -Glikosidaz, α -Amilaz İnhibitör ve Antioksidan Aktiviteleri. *Yüzüncü Yıl Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 29(1), 53-61. <https://doi.org/10.53433/yyufbed.1365174>
- Bonadonna, R. C., Del Prato, S., Saccomani, M. P., Bonora, E., Gulli, G., Ferrannini, E., Bier, D., Cobelli, C., & DeFronzo, R. A. (1993). Transmembrane glucose transport in skeletal muscle of patients with non-insulin-dependent diabetes. *The Journal of Clinical Investigation*, 92(1), 486-494.
- Campbell, J. E., & Newgard, C. B. (2021). Mechanisms controlling pancreatic islet cell function in insulin secretion. *Nature Reviews Molecular Cell Biology*, 22(2), 142-158.
- Chowdhury, I. A. (2017). *Prevalence of epidemiological influence, risk factors of type-2 Diabetes Mellitus and analysis of hypertension as a complication among the relatively newly diagnosed patients from BIRDEM hospital*. BRAC University.
- Ciaraldi, T. P., Abrams, L., Nikoulina, S., Mudaliar, S., & Henry, R. R. (1995). Glucose transport in cultured human skeletal muscle cells. Regulation by insulin and glucose in nondiabetic and non-insulin-dependent diabetes mellitus subjects. *The Journal of Clinical Investigation*, 96(6), 2820-2827.
- Colberg, S. R., Sigal, R. J., Yardley, J. E., Riddell, M. C., Dunstan, D. W., Dempsey, P. C., Horton, E. S., Castorino, K., & Tate, D. F. (2016). Physical activity/exercise and diabetes: a position statement of the

- American Diabetes Association. *Diabetes Care*, 39(11), 2065.
- Dewi, N. (2013). *Studi Kesesuaian Terapi Diabetes Mellitus Tipe 2 dengan Pedoman Terapi PERKENI 2011*. Universitas Brawijaya.
- Fellinger, P., Fuchs, D., Wolf, P., Heinze, G., Luger, A., Krebs, M., & Winhofer, Y. (2019). Overweight and obesity in type 1 diabetes equal those of the general population. *Wiener Klinische Wochenschrift*, 131, 55–60.
- Gerich, J. E. (1988). Glucose counterregulation and its impact on diabetes mellitus. *Diabetes*, 37(12), 1608–1617.
- Haas, N. B., Manola, J., Uzzo, R. G., Flaherty, K. T., Wood, C. G., Kane, C., Jewett, M., Dutcher, J. P., Atkins, M. B., & Pins, M. (2016). Adjuvant sunitinib or sorafenib for high-risk, non-metastatic renal-cell carcinoma (ECOG-ACRIN E2805): a double-blind, placebo-controlled, randomised, phase 3 trial. *The Lancet*, 387(10032), 2008–2016.
- Hajam, Y. A., Rani, R., Malik, J. A., Pandita, A., Sharma, R., & Kumar, R. (2022). Diabetes Mellitus: Signs and Symptoms, Epidemiology, Current Prevention, Management Therapies, and Treatments. In *Antidiabetic Potential of Plants in the Era of Omics* (pp. 31–77). Apple Academic Press.
- Hayes, C., & Kriska, A. (2008). Role of physical activity in diabetes management and prevention. *Journal of the American Dietetic Association*, 108(4), S19–S23.
- Holst, J. J., Knop, F. K., Vilsbøll, T., Krarup, T., & Madsbad, S. (2011). Loss of Incretin Effect Is a Specific, Important, and Early Characteristic of Type 2 Diabetes. *Diabetes Care*, 34(Supplement_2), S251–S257. <https://doi.org/10.2337/dc11-s227>
- Hutapea, D. (2016). *Perceived Benefits, Perceived Barriers, and Treatment Adherence Among Indonesian Older Adults with Type 2 Diabetes Mellitus*. Prince of Songkla University.
- Indonesia, P. E. (2015). Pengelolaan dan pencegahan diabetes mellitus tipe 2 di Indonesia. *Pb. Perkeni*, 6.
- James, D. E., Stöckli, J., & Birnbaum, M. J. (2021). The aetiology and molecular landscape of insulin resistance. *Nature Reviews Molecular Cell Biology*, 22(11), 751–771.
- Jorquera, G., Russell, J., Monsalves-Álvarez, M., Cruz, G., Valladares-Ide, D., Basualto-Alarcón, C., Barrientos, G., Estrada, M., & Llanos, P. (2021). NLRP3 inflammasome: Potential role in obesity related low-grade inflammation and insulin resistance in skeletal muscle. *International Journal of Molecular Sciences*, 22(6), 3254.
- Kakadiya, M. J. L. (n.d.). *RUNNING PHARMACY EDUCATION SERIES: DIABETES AND ITS COMPLICATIONS–A REVIEW*.
- Kanaley, J. A., Colberg, S. R., Corcoran, M. H., Malin, S. K., Rodriguez, N. R., Crespo, C. J., Kirwan, J. P., & Zierath, J. R. (2022). Exercise/physical activity in individuals with type 2 diabetes: a consensus statement from the American College of Sports Medicine. *Medicine and Science in Sports and Exercise*, 54(2), 353.
- Kelly, L. (2014). American Diabetes Association 74th Annual Scientific Sessions (ADA 2014). *Journal of Diabetes*, 6, 491–495.
- Liu, J. X., Goryakin, Y., Maeda, A., Bruckner, T., & Scheffler, R. (2017). Global health workforce labor market projections for 2030. *Human Resources for Health*, 15, 1–12.
- Maulida, N. R., Prajitno, J. H., & Sulistiawaty, N. N. (2022). The effect of diabetes exercise on the quality of life of type 2 diabetes mellitus patients. *Jurnal Keolahragaan*, 10(1), 63–70.
- Montresor, A., Mupfasoni, D., Mikhailov, A., Mwinzi, P., Lucianez, A., Jamsheed, M., Gasimov, E., Warusavithana, S., Yajima, A., & Bisoffi, Z. (2020). The global progress of soil-transmitted helminthiasis control in 2020 and World Health Organization targets for 2030. *PLoS Neglected Tropical Diseases*, 14(8), e0008505.
- Okamura, T., Hashimoto, Y., Hamaguchi, M., Obora, A., Kojima, T., & Fukui, M. (2019). Ectopic fat obesity presents the greatest risk for incident type 2 diabetes: a population-based longitudinal study. *International Journal of Obesity*, 43(1), 139–148.
- Petersen, M. C., & Shulman, G. I. (2018). Mechanisms of insulin action and insulin resistance. *Physiological Reviews*.
- Sarwan, S., & Kasim, Z. (2023). Pengaruh Senam DM Terhadap Kadar Gula Darah Sewaktu Pada Penderita DM Tipe II Di Puskesmas Tuminting. *Jurnal Anestesi*, 1(1), 62–67.
- Sattar, N., Rawshani, A., Franzén, S., Rawshani, A., Svensson, A.-M., Rosengren, A., McGuire, D. K., Eliasson, B., & Gudbjörnsdóttir, S. (2019). Age at diagnosis of type 2 diabetes mellitus and associations with cardiovascular and mortality risks: findings from the Swedish National Diabetes Registry. *Circulation*, 139(19), 2228–2237.
- Siregar, M. H., Susanti, R., Indriawati, R., Panma, Y., Hanaruddin, D. Y., Adhiwijaya, A., Akbar, H., Nugraha,

- D. P., & Renaldi, R. (2022). *Metodologi penelitian kesehatan*. Yayasan Penerbit Muhammad Zaini.
- Sitompul, Y., Budiman, B., Soebardi, S., & Abdullah, M. (2015). Profil Pasien Kaki Diabetes yang Menjalani Reamputasi di Rumah Sakit Cipto Mangunkusumo Tahun 2008-2012. *Jurnal Penyakit Dalam Indonesia*, 2(1), 9-14.
- Syeda, U. S. A., Battillo, D., Visaria, A., & Malin, S. K. (2023). The importance of exercise for glycemic control in type 2 diabetes. *American Journal of Medicine Open*, 9, 100031.
- Sylov, L., Tokarz, V. L., Richter, E. A., & Klip, A. (2021). The many actions of insulin in skeletal muscle, the paramount tissue determining glycemia. *Cell Metabolism*, 33(4), 758-780.
- Tang, L., Chang, S. J., Chen, C.-J., & Liu, J.-T. (2020). Non-invasive blood glucose monitoring technology: a review. *Sensors*, 20(23), 6925.
- Walker, B. (2019). *Traditional Dance as an Exercise Regimen for Marshallese Patients with Type 2 Diabetes Mellitus*.
- Wiedensohler, A., Birmili, W., Nowak, A., Sonntag, A., Weinhold, K., Merkel, M., Wehner, B., Tuch, T., Pfeifer, S., & Fiebig, M. (2012). Mobility particle size spectrometers: harmonization of technical standards and data structure to facilitate high quality long-term observations of atmospheric particle number size distributions. *Atmospheric Measurement Techniques*, 5(3), 657-685.
- Yu, J., Wang, J., Zhang, Y., Chen, G., Mao, W., Ye, Y., Kahkoska, A. R., Buse, J. B., Langer, R., & Gu, Z. (2020). Glucose-responsive insulin patch for the regulation of blood glucose in mice and minipigs. *Nature Biomedical Engineering*, 4(5), 499-506.