

The Effect of Range of Motion (ROM) Ankle Exercises on Ankle Brachial Index (ABI) In Patients with Type 2 Diabetes Mellitus (T2DM)

¹Imam Budi Pratomo*, ²Zenni Puspitarini, ²Ihsan Taufiq

¹Universitas Muhammadiyah Pringsewu, Lampung, Indonesia

²Poltekkes Kemenkes Tanjungkarang, Lampung, Indonesia

*Email: imambudi108@gmail.com

ABSTRACT

Type 2 diabetes mellitus (T2DM) is a chronic disease with frequent vascular complications, including decreased peripheral perfusion, which can be identified through the Ankle Brachial Index (ABI) examination. Simple interventions such as Range of Motion (ROM) ankle exercises have the potential to improve lower extremity perfusion, but empirical evidence in primary care is still limited. This study aimed to determine the effect of ankle ROM exercises on ABI values in patients T2DM at Puskesmas Kotabumi II. This study used a quasi-experimental design with a pre-posttest approach without a control group on 52 respondents selected through consecutive sampling. The intervention consisted of active ankle ROM exercises performed three times daily for 14 days. ABI values were measured before and after the intervention using a sphygmomanometer and vascular Doppler. Data analysis using paired t-test. The mean ABI value increased from 0.71 (SD=0.16) before the intervention to 0.94 (SD=0.12) after the intervention. A paired t-test showed a significant difference between the ABI values before and after ankle ROM exercises ($p=0.000$). Ankle ROM exercises have been shown to be effective in increasing ABI values in patients T2DM, so it can be recommended as a simple non-pharmacological intervention in primary care facilities to support the prevention of diabetic foot complications.

Keywords: Type 2 diabetes mellitus, ankle brachial index, range of motion.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a non-communicable disease resulting from the interaction of various genetic, physiological, environmental, and behavioral factors. It represents an increasingly significant health issue due to the potential for various vascular complications (Abiodun et al., 2021). A common complication associated with T2DM is Peripheral Arterial Disease (PAD), a condition that impairs blood flow to the lower extremities and, in advanced stages, increases the risk of diabetic foot complications, including ulcers and amputation (Zemaitis et al., 2026). Impaired peripheral perfusion in T2DM patients warrants attention, as the condition can progress over time and often lacks characteristic symptoms during the early stages (McDermott et al., 2023; Rany et al., 2024). The Ankle-Brachial Index (ABI) is a simple assessment tool used to evaluate peripheral perfusion. Low ABI values are associated with an increased risk of cardiovascular events and diabetic foot complications such as ulcers and amputation; consequently, the ABI serves as both a screening tool and a prognostic indicator for T2DM patients (Alves-Cabratosa et al., 2019; Anisah et al., 2024). These findings highlight the importance of nursing interventions aimed at maintaining or improving lower-extremity perfusion—along sides level management—as a strategy to prevent vascular complications in patients of T2DM (Đermanović Dobrota et al., 2024),.

Globally, diabetes is a major health issue affecting a vast number of people. The International Diabetes Federation (IDF) reports that approximately 589 million adults aged 20–79 years are living with diabetes worldwide—roughly one in nine adults—and the disease was responsible for approximately 1.2 million deaths in 2024. Indonesia ranks fifth globally in terms of the number of diabetes patients, following China, India, Pakistan, and United States (Perkeni, 2021; Sun et al., 2022; Yu et al., 2025). At the national level, results from the Survei Kesehatan Indonesia (SKI) 2023, indicate an increase in diabetes prevalence compared to the Riset Kesehatan Dasar (Riskesdas) 2018—rising from 10.9% to 11.7%—while the prevalence of diabetes mellitus (DM) based on physician diagnosis increased from 1.0% in 2018 to 1.2% in 2023 (BKPK, 2024). This issue is also evident at the local level; data from the North Lampung Regency Health Office show that the number of new T2DM cases rose from 501 in 2018 to 561 in 2019 and 649 in 2020 (Dinkes Kabupaten Lampung Utara, 2021). The substantial burden of managing diabetes has implications for healthcare services, including primary care nursing, as the rising number of T2DM patients potentially drives an increased need for screening, complication monitoring, patient education, and non-pharmacological interventions aimed at maintaining lower-extremity function and perfusion (Perkeni, 2021; Rany et al., 2024; Syeda et al., 2023).

Peripheral perfusion impairment in T2DM is a key concern in the management of diabetic complications; consequently, T2DM management is approached comprehensively through blood glucose monitoring, pharmacological therapy, nutritional therapy, physical activity, and education regarding complication care and prevention (Perkeni, 2021; Rafiq *et al.*, 2022; Smeltzer & Bare, 2014). However, interventions specifically aimed at improving peripheral perfusion through simple physical exercises—such as ankle mobility exercises—remain relatively uncommon (Alves-Cabratosa *et al.*, 2019; Natsuaki *et al.*, 2014). Previous research has largely focused on more complex or combined exercises, such as Buerger-Allen exercises, which utilize gravitational positional changes and the muscle pump mechanism to facilitate lower-extremity circulation (Lutfian *et al.*, 2025; Pi *et al.*, 2018; Utama & Nainggolan, 2021). A study by Pebrianti (2018), demonstrated that Buerger-Allen exercises could improve peripheral perfusion and Ankle-Brachial Index (ABI) values in patients with diabetic foot ulcers. Physiologically, ROM ankle exercises can enhance calf muscle pump efficiency, improve venous return, and stimulate distal perfusion through simple hemodynamic mechanisms (Suza *et al.*, 2020). Furthermore, joint exercises and calf muscle strengthening have the potential to increase venous blood flow and muscle pump function; theoretically, this could improve ABI or slow the progression of peripheral ischemia in T2DM patients (Anisah *et al.*, 2024). Nevertheless, empirical evidence directly linking ankle ROM protocols to changes in ABI among T2DM patients remains inconsistent due to variations in study designs, population characteristics, and healthcare settings (Anisah *et al.*, 2024; Kropp *et al.*, 2018; Mehana *et al.*, 2023).

One potential approach to addressing this need is ROM ankle exercise—a simple, easy-to-perform, non-pharmacological intervention that requires no special equipment and can be integrated into nursing care within primary healthcare facilities (Abiodun *et al.*, 2021; Miranda *et al.*, 2021; Yu *et al.*, 2025). Theoretically, this exercise can optimize the lower-extremity muscle pump and support peripheral circulation, consequently, changes in ABI values can serve as an objective indicator for evaluating perfusion response following the intervention (Panou *et al.*, 2026; Pebrianti, 2018; Suza *et al.*, 2020; Utama & Nainggolan, 2021).

METHODS

Study Design

This study employed a quasi-experimental design with a pre- and post-test approach—without a control group—to evaluate the effect of ankle ROM exercises on the ABI of patients with T2DM in Puskesmas Kotabumi II.

Population, Sample, and Sampling Technique

The study population consisted of all patients with Type 2 Diabetes Mellitus (T2DM) undergoing treatment and routine follow-up. A sample of 52 respondents was selected using consecutive sampling based on the following inclusion criteria: (a) willingness to participate by signing an informed consent form, (b) a diagnosis of T2DM, (c) use of oral hypoglycemic medication, and (d) a T2DM duration of five years or less.

Instruments

ABI measurements were performed using a sphygmomanometer and a vascular Doppler according to standard procedures. The intervention consisted of ROM ankle exercises administered via a structured protocol; this involved active dorsiflexion and plantarflexion of both the left and right ankles, performed three times daily with ten repetitions of each movement over a 14-day period. The study procedure began with a pre-intervention ABI measurement, followed by the administration of the ankle ROM exercises according to the protocol over the specified timeframe, and concluded with a post-intervention ABI measurement.

Data Analysis

Data normality testing was conducted using the Kolmogorov-Smirnov test. The results indicated that ABI values were normally distributed. Data analysis was performed using a paired t-test to compare ABI values before and after the intervention.

Ethical Considerations

This study received ethical approval from the Health Research Ethics Committee of the Faculty of Health Sciences, Universitas Muhammadiyah Pringsewu (registration number 0452/KEPK/FKES/2025). Ethical principles were strictly adhered to throughout the study. Each respondent received a comprehensive explanation regarding the study's objectives, procedures, benefits, potential risks, and data confidentiality rights prior to signing the informed consent form. Respondent identities were protected using anonymous codes on research instruments and data storage documents. Participants also retained the right to withdraw from the study at any time without penalty or impact on their access to local healthcare services.

RESULT

This section presents data on the effect of ankle ROM exercises on the ABI of patients with T2DM, as follows:

Table 1. Respondent Characteristics

Characteristics	n	%
Sex		
Male	25	48,1
Female	27	51,9
Age		
Average	58,4 years	-
Minimum	42 years	
Maximum	74 years	
Duration of T2DM		
Average	2,6 years	
Minimum	1 years	-
Maximum	5 years	

Based on Table 1, most respondents were female (51.9%) the mean age was 58.4 years, ranging from a minimum of 42 years to a maximum of 74 years; and the mean duration of T2DM was 2.60 years, with the shortest duration being 1 year and the longest 5 years.

Tabl2 2. Distribution of ABI Before and After Intervention

Variable	Mean	SD	Min. – Max.
ABI before	0,71	0,16	0,4 - 1.0
ABI after	0,94	0,12	0,7 – 1,2

Table 2 shows that the mean ABI before ankle ROM training is 0.71 (SD = 0.16). The lowest ABI is 0.4 and the highest is 1.0. The mean ABI after ankle ROM training was 0.94 (SD = 0.12). The lowest ABI is 0.7 and the highest is 1.2.

Table 3. Differences in ABI Before and After Intervention

Variabel	n	Mean	SD	p-value
ABI before	52	0,71	0,16	0,000
ABI after		0,94	0,12	

Based on Table 3, the mean ABI before ankle ROM exercises was 0.71 (SD = 0.16), whereas the mean ABI after exercises was 0.94 (SD = 0.12). There was a difference in the mean values between the before and after intervention measurements, with a p-value of 0.000 ($p < \alpha$).

DISCUSSION

The following is a discussion regarding the effect of ankle ROM exercises on ABI in patients with T2DM:

Respondent Characteristics

The study results indicate that out of a total of 52 respondents, the majority were female, comprising 27 respondents (51.9%). According to Gado (2024), differences in body fat distribution and muscle mass between male and female are important factors influencing insulin sensitivity, as women tend to exhibit subcutaneous fat accumulation that can impact glucose and insulin metabolism.

Among the 52 respondents, the mean age was 58.40 years, ranging from a minimum of 42 years to a maximum of 74 years. In patients with T2DM classified as late-stage elderly (56–65 years), blood vessels tend to exhibit stiffness; therefore, monitoring is required to anticipate the development of PAD (Perkeni, 2021).

The average duration of T2DM was 2.60 years. The longest duration of T2DM was 1 year, and the longest was 5 years. According to Smeltzer & Bare (2014), long-standing disease processes and aging cause changes in blood vessel walls, thereby affecting the transport of oxygen and nutrients to tissues. The intima thickens due to cellular proliferation and fibrosis. Fibers in the media undergo calcification, thinning, and fragmentation, while collagen accumulates in both the intima and the media. These changes lead to vascular stiffness, resulting in increased peripheral vascular pressure, impaired blood flow, and increased left ventricular workload (Boulton et al., 2020; Ming et al., 2019). Similarly, the duration of T2DM can exacerbate the risk of diabetic complications, one of which is diabetic foot. (Rany et al., 2024).

ABI Before Ankle ROM Exercise

Based on the research results, it shows that the average ABI value before ankle ROM exercise was 0.71 (SD = 0.16) with the lowest ABI value being 0.4 and the highest being 1.0. According to Alves-Cabrata et al. (2019) patients with T2DM exhibit a decrease in ABI values, serving as an indicator of the development of microvascular and macrovascular complications.

Many factors influence ABI values, such as diabetes, smoking, obesity, and high blood triglyceride levels (Đermanović Dobrota et al., 2024). Patients with T2DM and an ABI value of 0.6–0.8—interpreted as borderline perfusion—are at two to three times the risk of developing peripheral vascular obstruction (specifically PAD) compared to non-diabetic patients. (Natsuaki et al., 2014). In states of borderline perfusion, primary symptoms of PAD—specifically pain in the buttocks or calves during walking (intermittent claudication)—begin to manifest (Potter et al., 2020; Smeltzer & Bare, 2014). Pain arises due to blood vessel occlusion,

which prevents blood flow from meeting nutritional demands—particularly in the lower extremities—during periods of increased metabolic activity (Kim, 2023; Zemaitis et al., 2026).

ABI After Ankle ROM Exercise

Based on the research results, it shows that after ankle ROM exercises, the average ABI value of respondents was 0.94 (SD = 0.12) with the lowest ABI value being 0.7 and the highest being 1.2. This is in line with Abiodun et al., (2021) it is stated that a normal ABI interpretation (>0.9–1.3) indicates proper blood circulation without significant peripheral vascular obstruction, thereby ensuring that the nutritional and oxygen requirements of the lower extremities are adequately met. Ankle ROM exercise is a form of physical activity for patients with T2DM. The effects of this exercise include lowering blood glucose levels, improving blood circulation, enhancing muscle glucose uptake, and improving insulin utilization. (Gado et al., 2024; Utama & Nainggolan, 2021).

Difference in ABI Before and After Ankle ROM Exercises.

The results of the study showed a significant difference between the mean ABI values before and after ankle ROM exercises (p-value = 0.000). This means that ankle ROM influences ABI values. This is in line with the results of Utama & Nainggolan (2021), that patients with T2DM experienced an increase in ABI after receiving an intervention in the form of ankle ROM exercises. Physical exercises involving ankle ROM—specifically dorsiflexion and plantarflexion—can enhance calf muscle pumping, a process crucial for venous return and the improvement of venous circulation. Performing ankle ROM exercises stimulates muscle activity, a phenomenon consistent with the acute metabolic theory regarding local blood flow known as active hyperemia. Active hyperemia involves an increase in local metabolism, enabling cells to rapidly obtain nutrients from the bloodstream while simultaneously releasing vasodilating substances (Syeda et al., 2023; Yu et al., 2025; Zemaitis et al., 2026). Consequently, vasodilation occurs in the blood vessels surrounding the foot, leading to increased local blood flow (Alves-Cabratosa et al., 2019; Kropp et al., 2018; Natsuaki et al., 2014; Pi et al., 2018).

This is in line with several previous studies showing that ankle ROM exercises in people with T2DM can improve ABI values (Natsuaki et al., 2014; Pi et al., 2018; Suza et al., 2020). The isotonic exercises, such as active ROM exercises, can improve muscle tone, mass, and strength, while also maintaining joint flexibility and circulation. During isotonic exercise, heart rate and cardiac output increase, thereby enhancing blood flow throughout the body (Potter et al., 2020). Exercise combined with dietary management serves as the first-line therapy for patients with diabetes mellitus. According to this view, exercise helps control blood glucose

levels, thereby preventing other conditions caused by elevated blood glucose (Abiodun et al., 2021; Syeda et al., 2023).

Simple physical exercises—specifically ankle ROM exercises—performed routinely and consistently by patients with T2DM can prevent future complications and help maintain normal ABI values (Bus et al., 2020; Miranda et al., 2021). These exercises are part of a secondary prevention program targeting risk factors for diabetic complications, particularly diabetic foot issues and amputation (Kropp et al., 2018; Pebrianti, 2018; Suza et al., 2020; Utama & Nainggolan, 2021).

This study has several strengths, particularly the practical nature of ankle ROM exercises, which are simple, relatively inexpensive, and potentially easy to implement in community healthcare settings as part of routine care for patients with T2DM. In addition, the use of the ABI as an objective outcome measure provides a quantitative assessment of peripheral arterial status, allowing changes following the intervention to be evaluated. However, a key limitation is the need for a control group as a standard comparator to determine whether the observed changes in ABI can be attributed to the ankle ROM intervention rather than to other factors. Without an appropriate control group, the causal relationship between the intervention and the observed outcomes cannot be established with confidence, and the findings should therefore be interpreted cautiously. Future studies incorporating a control group and adequate control of potential confounding factors are needed to provide stronger evidence regarding the effectiveness of ankle ROM exercises in patients with T2DM.

CONCLUSION

The study results indicate that ankle ROM exercises can increase ABI values in patients with T2DM at community health centers, signifying an improvement in peripheral blood flow following the intervention. These findings reinforce the potential of ankle ROM exercises as a simple, safe, and easily implementable non-pharmacological intervention within primary healthcare settings to help prevent diabetic foot complications. Results should be interpreted with caution, however, as the study lacked a control group and involved a relatively small sample size. To more robustly confirm the effectiveness of ankle ROM exercises, further research employing a more rigorous experimental design and a longer intervention duration is required.

ACKNOWLEDGEMENTS

The author extends gratitude to all respondents who participated. Appreciation is also expressed to the leadership and staff of Puskesmas Kotabumi II for granting permission and support for this research. The author also acknowledges the Ethics Committee of Universitas Muhammadiyah Pringsewu for granting ethical approval. Finally, thanks are due to the entire research team and all those who contributed to the preparation of this manuscript but could not be named individually.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to the publication of this manuscript. Artificial intelligence (AI)-assisted tools were used to support language editing and improve the clarity and readability of the manuscript. AI tools were not used to generate research data, conduct statistical analyses, or determine the interpretation of the findings. The authors reviewed and verified the manuscript content and took full responsibility for the accuracy, integrity, and originality of the work.

REFERENCES

- Abiodun, O. O., Ikem, R. T., Kolawole, B. A., Akintomide, A. O., & Soyoye, D. O. (2021). Diabetes and peripheral artery disease: A review. *World Journal of Diabetes*, 12(6), 827–838. <https://doi.org/10.4239/wjd.v12.i6.827>
- Alves-Cabrata, L., Garcia-Gil, M., Comas-Cufí, M., Blanch, J., Ponjoan, A., Martí-Lluch, R., Elosua-Bayes, M., Parramon, D., Camós, L., & Ramos, R. (2019). Role of Low Ankle–Brachial Index in Cardiovascular and Mortality Risk Compared with Major Risk Conditions. In *Journal of Clinical Medicine* (Vol. 8, Number 6, p. 870). <https://doi.org/10.3390/jcm8060870>
- Anisah, H., Limanto, D. H., Suryantoro, S. D., Utomo, B., Bagus, P., & Permana, D. (2024). Type 2 Diabetes Mellitus Status with Ankle-Brachial Index among Patients with Diabetic Foot Ulcer at Universitas Airlangga Hospital. *Jurnal Ilmiah Mahasiswa Kedokteran Universitas Airlangga*, (01), 51–56. <https://doi.org/10.20473/juxta.V15I12024.51-56>
- BKPK. (2024). *Survei Kesehatan Indonesia 2023*. Badan Kebijakan Pembangunan Kesehatan.
- Boulton, A. J. M., Armstrong, D. G., Hardman, M. J., Malone, M., Embil, J. M., Attinger, C. E., Lipsky, B. A., Aragón-Sánchez, J., Li, H. K., Schultz, G., & Kirsner, R. S. (2020). *Diagnosis and Management of Diabetic Foot Infections*. American Diabetes

- Association. <https://doi.org/10.2337/db2020-01>
- Bus, S. A., Lavery, L. A., Monteiro-Soares, M., Rasmussen, A., Raspovic, A., Sacco, I. C. N., van Netten, J. J., & Foot, on behalf of the I. W. G. on the D. (2020). Guidelines on the prevention of foot ulcers in persons with diabetes (IWGDF 2019 update). *Diabetes/Metabolism Research and Reviews*, 36(S1), e3269. <https://doi.org/https://doi.org/10.1002/dmrr.3269>
- Đermanović Dobrota, V., Brkljačić, N., Tičinović Ivančić, A., Čavlović, M., Bulum, T., & Tomić, M. (2024). Risk Factors for Ankle Brachial Index and Carotid Artery Stenosis in Patients with Type 2 Diabetes. In *Metabolites* (Vol. 14, Number 1, p. 59). <https://doi.org/10.3390/metabo14010059>
- Dinkes Kabupaten Lampung Utara. (2021). *Profil Kesehatan Kabupaten Lampung Utara Tahun 2020*. Dinkes Kabupaten Lampung Utara.
- Gado, M., Tsaousidou, E., Bornstein, S. R., & Perakakis, N. (2024). Sex-based differences in insulin resistance. *Journal of Endocrinology*, 261(1), e230245. <https://doi.org/10.1530/JOE-23-0245>
- Kim, A. (2023). Daily Life Management Guidelines for Diabetic Foot Patients. *J Korean Diabetes*, 24(4), 214–220. <https://doi.org/10.4093/jkd.2023.24.4.214>
- Kropp, A. T., Meiss, A. L., Guthoff, A. E., Vettorazzi, E., Guth, S., & Bamberger, C. M. (2018). The efficacy of forceful ankle and toe exercises to increase venous return: A comprehensive Doppler ultrasound study. *Phlebology*, 33(5), 330–337. <https://doi.org/10.1177/0268355517706042>
- Lutfian, L., Wardika, I. J., Azizah, A., Wildana, F., Taplo, Y. M., & Wartakusumah, R. (2025). Community-Based Intervention for Type 2 Diabetes Management in Developing Countries: A Systematic Review. *Jurnal Keperawatan Indonesia*, 28(2 SE-Articles), 68–83. <https://doi.org/10.7454/jki.v28i2.1494>
- McDermott, K., Fang, M., Boulton, A. J. M., Selvin, E., & Hicks, C. W. (2023). Etiology, Epidemiology, and Disparities in the Burden of Diabetic Foot Ulcers. *Diabetes Care*, 46(1), 209–221. <https://doi.org/10.2337/dci22-0043>
- Mehana, A. M., Selim, A., & Saied, S. M. (2023). Foot self-care : Awareness and practices among diabetic patients at Tanta University hospitals. *International Journal of Advanced Community Medicine*, 6(4), 27–32.
- Ming, A., Walter, I., Alhajjar, A., Leuckert, M., & Mertens, P. R. (2019). Study protocol for a randomized controlled trial to test for preventive effects of diabetic foot ulceration by telemedicine that includes sensor-equipped insoles combined with photo

- documentation. *Trials*, 20(1), 521. <https://doi.org/10.1186/s13063-019-3623-x>
- Miranda, C., Da Ros, R., & Marfella, R. (2021). Update on prevention of diabetic foot ulcer. *Archives of Medical Sciences. Atherosclerotic Diseases*, 6, e123–e131. <https://doi.org/10.5114/amsad.2021.107817>
- Natsuaki, C., Inoguchi, T., Maeda, Y., Yamada, T., Sasaki, S., Sonoda, N., Shimabukuro, M., Nawata, H., & Takayanagi, R. (2014). Association of borderline ankle-brachial index with mortality and the incidence of peripheral artery disease in diabetic patients. *Atherosclerosis*, 234(2), 360–365. <https://doi.org/10.1016/j.atherosclerosis.2014.03.018>
- Panou, Theodoros, Papanas, Nikolaos, Gouveri, Evanthia, Skoufi, Georgia, Constantinidis, Theodoros C, & Nena, Evangelia. (2026). Diabetic Foot and Work Outcomes: A Review. *The International Journal of Lower Extremity Wounds*, 25(2), 321–330. <https://doi.org/10.1177/15347346241239719>
- Pebrianti, S. (2018). Buerger Allen Exercise Dan Ankle Brachial Index (ABI) Pada Pasien Ulkus Kaki Diabetik di RSUD . Slamet Garut. *Journal of Nursing Sciences and Practice*, 1(1), 94–110. <https://jurnal.umj.ac.id/index.php/ijnsp/article/view/271>
- Perkeni. (2021). *Pedoman Pengelolaan dan Pencegahan Diabetes Melitus Tipe 2 Dewasa di Indonesia 2021*. PB Perkeni.
- Pi, H., Ku, H., Zhao, T., Wang, J., & Fu, Y. (2018). Influence of Ankle Active Dorsiflexion Movement Guided by Inspiration on the Venous Return From the Lower Limbs: A Prospective Study. *Journal of Nursing Research*, 26(2), 123–129. <https://doi.org/10.1097/jnr.0000000000000214>
- Potter, P. A., Perry, A. G., Stockert, P., & Hall, A. (2020). *Dasar-Dasar Keperawatan Vol. 2* (9th ed.). Elsevier.
- Rafiq, M. K., Kamran, H., Ayub, A., & Jameel, F. (2022). Diabetic Foot Ulcers: Insights into Management and Prevention. *Pakistan Journal of Medical and Health Sciences*. <https://api.semanticscholar.org/CorpusID:253505476>
- Rany, N., Harnani, Y., & Abidin, A. R. (2024). Diabetes Mellitus Tipe 2 Risk factors associated with complications of Type 2 Diabetes Mellitus. *Jurnal Kesehatan Komunitas*, 10(September), 534–545.
- Smeltzer, S. C., & Bare, B. G. (2014). *Buku Ajar Keperawatan Medikal-Bedah Brunner & Suddarth* (12th ed.). EGC.
- Sun, H., Saeedi, P., Karuranga, S., Pinkepank, M., Ogurtsova, K., Duncan, B. B., Stein, C., Basit, A., Chan, J. C. N., Mbanya, J. C., Pavkov, M. E., Ramachandaran, A., Wild, S.

- H., James, S., Herman, W. H., Zhang, P., Bommer, C., Kuo, S., Boyko, E. J., & Magliano, D. J. (2022). IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Research and Clinical Practice*, 183. <https://doi.org/10.1016/j.diabres.2021.109119>
- Suza, D. E., Hijriana, I., Ariani, Y., & Hariati, H. (2020). Effects of Lower Extremity Exercises on Ankle-Brachial Index Values among Type 2 Diabetes Mellitus Patients. *Macedonian Journal of Medical Sciences*, 8, 1–6.
- 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. <https://doi.org/https://doi.org/10.1016/j.ajmo.2023.100031>
- Utama, Y. A., & Nainggolan, S. S. (2021). Pengaruh Senam Kaki terhadap Nilai Ankle Brachial Index pada Pasien Diabetes Melitus Tipe II: sebuah Tinjauan Sistematis. *Jurnal Ilmiah Universitas Batanghari Jambi*, 21(2), 657–663. <https://doi.org/10.33087/jiubj.v21i2.1439>
- Yu, X., Kan, C., Zhang, K., Zhang, X., Ren, J., Chen, J., Wang, Y., Zhang, Y., Zhang, G., & Sun, X. (2025). Global epidemiology and burden of type 2 diabetes in adults aged 55 and older: insights from 1990 to 2021. *Sage Journals*, 14(1), 16. <https://doi.org/https://doi.org/10.1177/20420188251406531>
- Zemaitis, M. R., Boll, J. M., Kato, M., & Golla, M. S. G. (2026). *Peripheral Arterial Disease*. StatPearls Publishing.