



Effects of Foot Exercises on The Ankle-Brachial Index in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Type 2 diabetes mellitus is a chronic metabolic disorder that frequently leads to vascular complications, including reduced peripheral perfusion, which can be assessed using the Ankle-Brachial Index (ABI). Patients with type 2 diabetes mellitus are non-insulin-dependent, allowing for the implementation of specific therapeutic interventions to manage the condition. This study aimed to analyze the effect of foot exercises on ABI values in patients with type 2 diabetes mellitus at the Gambiran Community Health Center in Mojoagung, Jombang. A quasi-experimental design was employed, utilizing a pre-test and post-test approach with a control group. The study sample consisted of 56 patients with type 2 diabetes mellitus, randomly assigned to either the control group or the intervention group. The intervention group performed foot exercises three times a week for two weeks, with each session lasting 30 minutes. ABI measurements were taken before and after the intervention using Doppler ultrasonography. Baseline results showed that nearly half of the experimental group fell into the mild impairment category (42.9%), while nearly half of the control group fell into the moderate impairment category (46.4%). Following the foot exercise intervention, the majority of the experimental group showed ABI values in the normal range (64.3%), whereas the control group remained predominantly in the mild impairment category (46.4%). Foot exercises significantly influenced ABI values in patients with type 2 diabetes mellitus, indicating an improvement in peripheral perfusion. This intervention can be recommended as a non-pharmacological therapy to prevent vascular complications in diabetic patients.

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INTRODUCTION

Type 2 diabetes mellitus, if not managed properly, can cause various complications with the risk of developing these complications increasing with the duration of the disease (Simamora et al., 2020). The complications that can occur in patients with diabetes mellitus involve hypoglycaemia, hyperglycemia, macrovascular disease of large vessels, coronary heart disease, microvascular disease of small vessels, neuropathy, retinopathy, nephropathy, sensory neuropathy, and lower extremity problems (Hati et al., 2020). Effective management will reduce the level of complications so that further complications that are detrimental to diabetes mellitus sufferers do not occur. Actions taken by the medical and health team include pharmacological management, which includes the administration of medications, and non-pharmacological management, such as regular metabolic control, vascular monitoring, ulcer evaluation, and foot care (Basri et al., 2021). Type 2 diabetes mellitus patients are not dependent on insulin, so they can be given therapy methods to treat type 2 diabetes mellitus (Purwaningsih et al., 2024).

According to the 2021 IDF Diabetes Atlas, the number of people worldwide suffering from diabetes is quite high. An estimated 425 million people worldwide suffer from diabetes. If the age range increases, the number of people with diabetes is expected to increase between 18 and 99 years. If this trend continues, it is predicted that by 2045, there will be 629 million people aged 20-79 with diabetes and around 693 million people aged 18-99 with diabetes mellitus (Yunir et al., 2023). The number of people with diabetes mellitus is predicted to increase to around 578 million by 2030. Diabetes mellitus is most prevalent in people aged 45-54, mostly women (Elkhalifa et al., 2024). In 2021, Indonesia ranked fifth globally in terms of the number of people living with diabetes mellitus, with an estimated 19.5 million cases (Magliano et al., 2021). In 2020, a total of 844,018 people with diabetes mellitus were reported in East Java Province, Indonesia (Kemenkes, 2023). According to the Jombang Regency Health Office, 35,735 people were living with diabetes mellitus in Jombang Regency, while 63 patients with type 2 diabetes mellitus were recorded in the Gambiran area of Mojoagung from January to July 2024.

The high rate of diabetes mellitus is caused by several factors, including genetic disorders, age, lifestyle and diet, obesity, stressful lifestyles, pancreatic diseases and infections, and medications that can damage the pancreas. In general, diabetes mellitus occurs due to an unhealthy lifestyle that causes blood sugar levels to accumulate above normal limits, which is chronic and long-term. Furthermore, if left untreated, diabetes mellitus can lead to serious complications that may result in disability, including stroke, heart attack, foot infections (gangrene), and narrowing of the arteries (Sari & Sari, 2022).

Foot exercises have a significant effect on improving blood perfusion in the legs, especially in patients with circulatory disorders such as diabetes mellitus. Regularly performing foot exercises can improve blood flow in the lower extremities by stimulating the leg muscles, which act as pumps to increase blood circulation back to the heart. These exercises can also help reduce the risk of peripheral neuropathy, a common complication in diabetes patients due to poor perfusion. As a result, patients who perform foot exercises experience increased oxygen saturation (SpO₂) and sensitivity in the feet, as well as faster capillary refill time. Furthermore, increased perfusion through foot exercises can help reduce the risk of diabetic ulcers, which often occur due to suboptimal circulation. By performing foot exercises, blood flow to the skin tissue of the feet improves, thereby reducing the likelihood of wounds and serious complications such as amputation. Therefore, foot exercise is a therapy that can be given to treat type 2 diabetes (Simamora et al., 2020) and becomes an important non-

pharmacological strategy in the treatment and prevention of diabetes complications (Rahayu, 2018).

Arterial or peripheral narrowing can be measured through non-invasive examinations, one of which is the Ankle Brachial Index (ABI) examination which functions to detect clinical signs and symptoms of decreased peripheral perfusion that can lead to diabetic angiopathy and neuropathy (Sari & Sari, 2022). The purpose of this study was to analyse the effect of foot exercises on the Ankle Brachial Index (ABI) in patients with type 2 diabetes mellitus at the Gambiran Mojoagung Community Health Center.

METHODS

This study employed a quasi-experimental design with a pre-test and post-test approach with a control group (Nursalam, 2020). The researchers aimed to analyse the effect of foot exercises on ABI in patients with type 2 diabetes mellitus at the Gambiran Community Health Center, Mojoagung, Jombang, from August to September 2024. This study has been declared ethically sound by the Research Ethics Committee Team of the Insan Cendekia Medika Health Center (ITSKes) Jombang, with Decree No. 210/KEPK/ITSKES-ICME/X/2024.

Participants

The population of this study was all 63 patients with type 2 diabetes mellitus at Gambiran Community Health Centre. The samples in this study were selected from a subset of patients with type 2 diabetes mellitus at Gambiran Community Health Center, using the Slovin formula (Nursalam, 2020).

Sampling Procedures

The sampling technique used in this study was simple random sampling, in which every member of the population has an equal chance of being selected, regardless of strata or other characteristics. The inclusion criterion for the sample is all patients with type 2 diabetes mellitus. This technique was used to obtain a representative sample by random means (Sugiyono, 2007).

Materials and Procedures

This study has two variables, namely foot exercises and the Ankle-Brachial Index (ABI) in patients with type 2 diabetes. The independent variable, foot exercise, refers to a routine activity involving specific methods and movements adapted to an individual condition during the two-week training period, consisting of six sessions lasting 30 minutes each. The measuring instrument used was the SOP for foot exercises, including warm-up, core activity, and cool-down (Widiawati et al., 2020). The dependent variable, the Ankle-Brachial Index (ABI), is a measurement of blood flow to the lower extremities which reflects the ability of the leg tissue to receive oxygen and nutrients through blood circulation. The tools used in this study included a sphygmomanometer, a Doppler, jelly, a handscoon, and a mat or bed. The Ankle-Brachial Index (ABI) was calculated by measuring the systolic blood pressure in both brachial arteries and both dorsalis pedis arteries, then using the higher systolic pressure from each limb for the calculation. The calculation of the ABI value was administered by dividing the highest systolic blood pressure from the dorsalis pedis or posterior tibia by the highest brachial dystolic blood pressure (Rahayu, 2018).

Design or Data Analysis

This study used univariate and bivariate analyses to obtain data on patient characteristics, including age, gender, education level, occupation, dietary patterns, exercise activity, family history of diabetes, and duration of diabetes.

Bivariate analysis was conducted to determine the effect of foot exercises on the Ankle-Brachial Index (ABI) using the Wilcoxon Signed Rank Test. Comparisons between the control and intervention groups were made using the Mann-Whitney test with an alpha level of 0.05 (Sugiyono, 2007).

RESULTS

The results of the univariate analysis were used to determine the characteristics of type 2 DM patients. The data obtained are attached in Table 1.

Table 1. Frequency Distribution of Respondent Characteristics

Respondent Characteristics	Intervention group		Control group	
	Frequency	Percentage	Frequency	Percentage
Gender				
Male	6	21	4	14
Female	22	79	24	86
Age				
45 – 55	12	43	15	54
56 – 65	16	57	13	46
Education Level				
Primary School	21	75	20	72
Junior High School	7	25	6	21
Senior High School	0	0	2	7
Work				
Housewife	19	68	23	82
Farmer	8	28	5	18
Entrepreneur	1	4	0	0
Diet Regulates Eating patterns				
Yes	22	79	19	68
No	6	21	9	32
Sports activities				
Routine	17	61	15	54
Not routine	11	39	13	46
Hereditary History of Diabetes				
Yes	18	64	19	68
No	10	36	9	32
Long Suffering from Diabetes				
< 5	12	43	14	50
≥ 5	16	57	14	50

Table 1 shows that almost all (78.75%) of the experimental group respondents were female, totalling 22 respondents. In the control group, almost all (85.71%) of the respondents were female, totalling 24 respondents. In the experimental group, the majority (57.14%) of respondents were aged 56-65 years (16 respondents), while in the control group, the majority (53.57%) of respondents were aged 45-55 years (15 respondents). In the experimental group, almost all (75%) of the respondents had elementary school education (21 respondents), while in the control group, the majority (71%) of the respondents had elementary school education, (20 respondents). In addition, in both experimental and control groups, the majority of respondents worked as housewives, totalling 68% (19 respondents) for the experimental group and 82% (23 respondents) for the control group.

In the experimental group, almost all (79%) of the respondents regulated their diet, amounting to 22 respondents, while in the control group, the majority (68%) of respondents regulated their diet, amounting to 15 respondents. In both experimental group and control groups, the majority exercised regularly, totalling 61% (17 respondents) for the experimental group and 54% (15 respondents) for the control group. In addition, the majority of participants in experimental and control groups had a hereditary history of diabetes, namely 64% (18 respondents) for the experimental group and 68% (19 respondents) for the control group. Furthermore, in the experimental group, the majority (57%) had suffered from diabetes for more than 5 years (16 respondents), while in the control group, half (50%) of them had suffered from diabetes for less than 5 years and more than 5 years (14 respondents each).

Ankle Brachial Index in Type 2 Diabetes Mellitus Patients Before Foot Exercises

Table 2 shows that, before being given leg exercises, almost half (42.9%) of participants in the experimental group had an ABI value in the mild category (12 respondents). In addition, in the control group, almost half (46.4%) of the participants had an ankle brachial index (ABI) value in the moderate category (13 respondents) before being given leg exercises.

Table 2. Frequency Distribution of Ankle Brachial Index (ABI) Before Foot Exercise Intervention

Ankle Brachial Index	Intervention Group		Control Group	
	Frequency	Percentage	Frequency	Percentage
Normal	5		2	
Mild	12		11	
Moderate	7		13	
Severe	4		2	

Ankle Brachial Index in Type 2 Diabetes Mellitus Patients After Foot Exercises

Based on Table 3, after the leg exercise intervention, the majority of participants in the experimental group (64.3%) had an ABI value in the normal category (18 respondents). Meanwhile, in the control group, almost half (46.4%) of respondents had an ABI value in the mild category (13 respondents) after being given education.

Table 3. Frequency Distribution of Ankle Brachial Index (ABI) After Foot Exercise Intervention

Ankle Brachial Index	Intervention Group		Control Group	
	Frequency	Percentage	Frequency	Percentage
Normal	18		3	
Mild	2		13	
Moderate	6		11	
Severe	2		1	

Effects of Foot Exercise on The Ankle Brachial Index in Patients with Type 2 Diabetes Mellitus

Table 4 shows that before the foot exercise intervention, 39.3% of respondents had ABI values in the mild category. Following the intervention, 11 respondents had ABI values within the normal category. From the Wilcoxon statistical test, the probability value was obtained = $0.000 < \alpha (0.05)$, thus H_0 was rejected and H_1 was accepted. It indicated that there was an effect of foot exercises on the ankle brachial index (ABI) in patients with type 2 diabetes mellitus.

Table 4. Cross-Tabulation of The Effect of Foot Exercise on The Ankle-Brachial Index (ABI) in Patients with Type 2 Diabetes Mellitus

Ankle Brachial Index (ABI) Pre	Ankle Brachial Index (ABI) Post								Total	
	Normal		Mild		Moderate		Severe		f	%
	f	%	f	%	f	%	f	%		
Normal	5		0		0		0		5	
Mild	11		1		0		0		12	
Moderate	2		1		4		0		7	
Severe	0		0		2		2		4	
Total	18		2		6		2		28	

Wilcoxon Signed Rank Test p-value 0,000

Ankle Brachial Index Differences Between Experimental and Control Groups in Type 2 Diabetes Patients

Table 5 shows that there is a difference between the intervention group and the control group based on the results of the Mann-Whitney statistical test, which obtained a probability value of $0.000 < \alpha (0.05)$, meaning that there is a difference between the intervention group and the control group.

Table 5. Frequency Distribution of Ankle Brachial Index in Type 2 Diabetes Mellitus Patients in The Experimental Group and Control Group

Ankle Brachial Index	Experimental Group	Control Group	Mann-Whitney
Normal	18	3	p-value 0,000
Mild	2	13	
Moderate	6	11	
Severe	2	1	
Total	28	28	

DISCUSSION

The results of the study showed that, before the leg exercises, most respondents in the experimental group were categorized as having mild ABI. Meanwhile, most of participants in the control group had moderate ABI. Gender and age were among the influencing factors.

Type 2 diabetes mellitus (DM) is more common in women due to biological risk factors, such as gestational diabetes and hormonal changes during pregnancy, menstruation, and menopause, which affect insulin sensitivity. Polycystic ovary syndrome (PCOS) also contributes to insulin resistance. Furthermore, social pressures and household responsibilities make it more difficult for women to maintain a healthy diet and engage in regular physical activity. Poor access to health services in some countries also hinders the prevention and management of DM in women.

The number of people worldwide suffering from diabetes is quite high. An estimated 425 million people worldwide suffer from diabetes. If the age range is extended, the number of diabetes mellitus patients is expected to increase between 18 and 99 years. If this continues, it is predicted that there will be 629 million diabetes patients aged 20-79 and around 693 million people aged 18-99 will suffer from diabetes mellitus by 2045 (Yunir et al., 2023). The number of diabetes mellitus cases is predicted to increase to around 578 million by 2030. Diabetes mellitus is most common in people aged 45-54 years, mostly women (Elkhalifa et al., 2024).

Before the foot exercises, most respondents had mild ABI values, indicating poor blood flow to the lower extremities due to peripheral vascular disease (PAD). Prior to the foot exercises, patients complained of tingling and heaviness in the feet, a common symptom in type 2 diabetes mellitus patients caused by peripheral neuropathy resulting from nerve damage and impaired blood flow due to high blood sugar levels. Blood vessel narrowing reduces the supply of oxygen and nutrients, while reduced muscle activity impairs circulation. Fluid accumulation in the lower extremities can further exacerbate symptoms, particularly at night. Foot exercises are important because they can stimulate blood circulation, strengthen muscles, and reduce nerve tension, thus alleviating symptoms such as tingling and heaviness. Furthermore, foot exercises also help prevent serious complications such as diabetic ulcers and infections.

Based on the results of the study in the experimental group, almost all of the participants had ABI values in the normal category after being given leg exercises. This is because the intervention group was given non-pharmacological treatment using leg exercises, which showed that blood flow to the lower extremities returned to normal and there were no significant obstructions in the arteries. This improvement occurred because leg exercises stimulate leg muscle activity, which in turn increases blood flow and elasticity of peripheral blood vessels. Leg exercises help improve blood circulation through the mechanism of vasodilation due to muscle contraction and increased activity of the calf muscle pump. This reduces vascular resistance and increases tissue perfusion in the lower extremities. In addition, leg exercises also reduce the risk of blood clots and increase the ability of arteries to accommodate better blood flow. When done regularly, leg exercises can be an effective non-pharmacological therapy to maintain and improve ABI values, especially in individuals at risk for peripheral artery disease (Yulianti & Januari, 2021).

The control group almost entirely had moderate ABI values. This is because the education provided to the control group reflects success in increasing individual awareness regarding

managing risk factors that affect blood vessel health. Education can include understanding the importance of a healthy diet, physical activity, smoking cessation, and controlling chronic diseases such as hypertension and diabetes. After education, normal ABI values can be achieved because individuals make lifestyle changes that support vascular health. For example, reducing saturated fat and sugar consumption can prevent the formation of atherosclerotic plaque, while the light physical activity recommended during education helps improve blood flow, although not as intensive as leg exercises. This suggests that good education can have a positive impact on vascular health (Widiastuti, 2020).

Based on the results of the research, foot exercise intervention could significantly impact patients with diabetes mellitus because they directly improve vascular function and blood flow to the lower extremities. Increased ABI reflects improved blood flow due to reduced vascular resistance and increased arterial elasticity. Foot exercises work through physiological mechanisms such as increased calf muscle contractions, which act as a blood pump, pushing blood back to the heart and reducing the risk of blood stagnation in the legs. Furthermore, foot exercises also reduce chronic inflammation often associated with atherosclerosis, thereby increasing blood vessel elasticity. Therefore, foot exercises are more effective than education in improving ABI in patients with peripheral blood flow disorders (Kurnia & Ika, 2024).

The results of the statistical analysis showed that the intervention group had a p-value of less than 0.05, indicating a statistically significant effect of foot exercises on the Ankle-Brachial Index (ABI) in patients with type 2 diabetes mellitus. Therefore, the alternative hypothesis (H1) was accepted. According to Rahayu (2018), foot exercise therapy has been shown to be effective in increasing the ankle brachial index (ABI) through several mechanisms, such as stimulating contractions of the gastrocnemius and soleus muscles, which function as muscle pumps to improve venous and arterial blood circulation, increasing blood vessel elasticity through the release of nitric oxide, which facilitates vasodilation, and reducing resistance to blood flow in the lower extremities. Research shows that in patients with diabetes mellitus and peripheral arterial disease (PAD), regular foot exercise for 8-12 weeks can significantly improve ABI. This effectiveness is optimal with moderate intensity and a frequency of 3-5 times per week, involving movements such as dorsiflexion, plantarflexion, eversion, and inversion to ensure maximum blood flow distribution.

Foot exercises are highly effective in improving vascular function and blood flow to the lower extremities. Regular foot exercise interventions provide various benefits for patients with type 2 diabetes mellitus, including feeling lighter and less fatigued. Foot exercises improve blood circulation, allowing oxygen and nutrients to reach tissues more easily, reducing feelings of heaviness and fatigue caused by poor perfusion. These exercises also strengthen the small muscles in the feet, calves, and thighs, which function as muscle pumps to improve blood flow. Furthermore, foot exercises increase joint flexibility, prevent stiffness, and relieve nerve tension that causes discomfort, such as tingling. These activities also prevent fluid buildup in the lower extremities, reducing the risk of swelling and heaviness. Overall, foot exercises help improve patient comfort and ability to carry out daily activities and reduce chronic inflammation often associated with atherosclerosis, thereby improving blood vessel elasticity. Based on these research results, the implementation of foot exercises for patients with type 2 diabetes mellitus must be balanced with changes in exercise activity. Therefore, it can be said to be effective in improving ABI (Hati et al., 2020).

The results showed a statistically significant difference in Ankle-Brachial Index (ABI) values ($p < 0.05$) between the intervention group, which received foot exercises, and the control group, which received educational therapy. Rahayu (2018) study involved 16 patients with

type 2 diabetes mellitus, who were divided into an intervention group and a control group. The intervention group was given foot exercises three times a week for 21 days and the control group was given education about diabetes mellitus. The results showed that 88% of participants in the intervention group experienced changes in ABI values, whereas 56% of participants in the control group receiving education experienced a decrease in ABI values. Diabetic foot exercises may help improve blood circulation in the lower extremities. Furthermore, Lariwu & David (2022) study explained that the average ABI measurement results in the experimental group were at a mild score, while the average ABI measurement results in the control group were at a moderate score. There was an effect of foot exercises on ABI values in type 2 diabetes patients with a $p\text{-value} = 0.000$, meaning that there was a difference between the control group and the intervention group.

Based on the research results, the differences in interventions provided between the two groups led to the differences in outcomes. The experimental group received leg exercise therapy, which can improve ABI values, while the control group received only information. Therefore, the experimental group gained a more significant and accurate improvement in ABI because they received direct leg exercises, while the control group received only information without any direct exercises.

The nursing implication of this study is that foot exercises can serve as an easy, simple, and self-administered non-pharmacological nursing intervention for patients with type 2 diabetes mellitus to help improve peripheral circulation. Regular practice of foot exercises is expected to increase the Ankle-Brachial Index (ABI) and act as a preventive measure to reduce the risk of diabetic foot complications. Nurses play a crucial role as educators and facilitators in teaching foot exercise techniques, monitoring patient adherence, and evaluating peripheral circulation status through ABI measurements.

CONCLUSION

Research indicates that pre-exercise Ankle-Brachial Index (ABI) values fell predominantly into the mild impairment category, whereas post-exercise values were almost entirely within the normal range. Foot exercises were found to influence ABI values in patients with type 2 diabetes mellitus at the Gambiran Community Health Center. A difference in outcomes was observed between the intervention and control groups. Patients with type 2 diabetes mellitus are advised to perform foot exercises routinely, 3-5 times a week for 15-30 minutes, to improve blood circulation in the feet. Patients are also encouraged to adopt a healthy lifestyle by controlling blood sugar levels, maintaining a proper diet, exercising regularly, and adhering to prescribed medication regimens to achieve optimal results in improving ABI values.

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AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

REFERENCES

- Basri, M., Baharuddin, K., & Rahmatia, S. (2021). Pengaruh Senam Kaki Terhadap Nilai Respon Neuropati Pada Penderita Diabetes Mellitus Type 2 Di Puskesmas Tamalanrea Makassar. *Diagnosis Jurnal Ilmiah Kesehatan*, 16(1), 40-46.
- Elkhalifa, A. M., Nazar, M., Ali, S. I., Khursheed, I., Taifa, S., Ahmad Mir, M., ... & Nabi, S. U. (2024). Novel therapeutic agents for management of diabetes mellitus: a hope for drug designing against diabetes mellitus. *Life*, 14(1), 99.
- Hati, Y., & Sharfina, D. (2020). Pengaruh Senam Kaki Diabetik Terhadap Penurunan Risiko Ulkus Diabetikum Pada Pasien Diabetes Mellitus Tipe 2 Di Puskesmas Taupah Barat Kecamatan Taupah Barat Kabupaten Simeule Tahun 2020. *Jurnal Ilmiah Kebidanan Imelda*, 6(1), 50-56.
- Kemenkes. (2023). Waspada diabetes militus pada usia muda, kenali gejala dan faktor risikonya. Kemenkes RI.
- Kurnia, J., & Ika, S. (2024). Penerapan Senam Kaki Diabetik terhadap Tingkat Resiko Terjadinya Ulkus Diabetik pada Penderita Diabetes Mellitus Di Wilayah Kerja Puskesmas Sukoharjo. *Jurnal Ilmu Kesehatan dan Gizi*, 2(4), 79-88.
- Lariwu, C. K., & David, B. (2022). Pengaruh Senam Kaki Terhadap Nilai Abi Pada Pasien Dmt2. *Watson Journal Of Nursing*, 1(1), 30-34.
- Magliano, D. J., Boyko, E. J., & Atlas, I. D. (2021). Global picture. In *IDF DIABETES ATLAS* [Internet]. 10th edition. International Diabetes Federation.
- Nursalam. (2020). *Metodologi Penelitian Untuk Keperawatan*. Salemba Medika.
- Purwaningsih, E., Wiratmoko, H., & Suwanto, A. W. (2024). Senam Kaki Menurunkan Risiko Ulkus Diabetikum. In *Eureka Media Aksara* (p. 45).
- Rahayu, K. I. N. (2018). Pengaruh senam kaki terhadap perfusi kaki pada pasien diabetes mellitus di wilayah kerja Puskesmas Ngadiluwih Kabupaten Kediri. *Jurnal Ilmu Kesehatan*, 6(2), 118-124.
- Sari, M., & Sari, N. P. (2022). Perawatan kaki (foot care) pada perfusi perifer tidak efektif diabetes melitus. *Jurnal Ilmu Keperawatan Indonesia (JIKPI)*, 3(1), 13-20.
- Simamora, F. A., Siregar, H. R., & Hidayah, A. (2020). Pengaruh Senam Kaki Diabetik terhadap penurunan neuropati pada penderita diabetes melitus tipe 2. *Jurnal Education and development*, 8(4), 431-431.
- Sugiyono. (2007). *Statistika Untuk Penelitian*. Alfabeta Bandung.
- Widiastuti, L. (2020). Acupressure dan Senam Kaki terhadap Tingkat Peripheral Arterial Disease pada Klien DM Tipe 2. *Jurnal Keperawatan Silampari*, 3(2), 694–706.
- Widiawati, S., Maulani, M., & Kalpataria, W. (2020). Implementasi Senam Kaki Diabetes Pada Penderita Diabetes Melitus di RSUD Raden Mattaher Jambi. *Jurnal Pengabdian Harapan Ibu (JPHI)*, 2(1), 6-14.
- Yulianti, Y., & Januari, R. S. (2021). Pengaruh senam kaki diabetes mellitus terhadap kadar gula darah penderita DM Tipe 2 di wilayah kerja puskesmas ciemas. *Lentera: Jurnal Ilmiah Kesehatan dan Keperawatan*, 4(2), 87-94.
- Yunir, E., Nugraha, A. R., Rosana, M., Kurniawan, J., Iswati, E., Sarumpaet, A., ... & Tahapary, D. L. (2023). Risk factors of severe hypoglycemia among patients with type 2 diabetes mellitus in outpatient clinic of tertiary hospital in Indonesia. *Scientific reports*, 13(1), 16259.