

The Effectiveness of Education and Buerger Allen Exercise on Peripheral Neuropathy Symptoms and Fasting Blood Sugar in Type 2 Diabetes Patients at Hospital X, Bandar Lampung

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ARTICLE INFO	ABSTRACT
Keywords: dm, education, buerger allen exercise, peripheral neuropathy, fasting blood sugar	Type 2 diabetes mellitus (DM) is a prevalent metabolic disorder often accompanied by complications such as diabetic peripheral neuropathy (DPN), which impairs sensation and quality of life. Non-pharmacological interventions such as patient education and Buerger Allen Exercise (BAE) have been recommended for managing symptoms and glycemic control, but evidence on their combined effectiveness in clinical settings in Indonesia remains limited. This study evaluated the effectiveness of structured diabetes education combined with Buerger Allen Exercise (BAE) in reducing peripheral neuropathy symptoms and improving fasting blood glucose (FBG) levels among type 2 diabetes mellitus patients. A quasi-experimental one-group pretest-posttest design was employed with 120 purposively sampled patients at Hospital X in Bandar Lampung. The intervention consisted of comprehensive DM education followed by supervised BAE training, performed twice daily for 15 minutes over 14 consecutive days. Neuropathy symptoms were assessed using the Michigan Neuropathy Screening Instrument (MNSI), and FBG was measured with a digital glucometer. Results showed significant reductions in both outcome measures post-intervention ($p = 0.001$). The mean MNSI score decreased from 5.600 to 2.996, and mean FBG declined from 146.48 mg/dL to 112.59 mg/dL. The proportion of patients with normal FBG increased from 38.3% to 79.2%. Multivariate analysis (MANCOVA) confirmed the intervention's significant effect after controlling for age, gender, and diabetes duration, contributing 44.2% to neuropathy reduction and 18.8% to FBG improvement. The findings demonstrate that integrated education and BAE is an effective, non-pharmacological strategy for managing diabetic complications and glycemic control, suitable for implementation in clinical and self-care settings.

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INTRODUCTION

Diabetes mellitus is the most common metabolic disorder affecting populations across the world's geographical regions, with the number of sufferers continuing to increase daily. Complications of diabetes can affect the eyes, heart, kidneys, nerves, and even lead to leg amputation (Tandra, 2015). The World Health Organization (WHO, 2021) reports that currently, about 6% of the world's population—or more than 400 million people—suffer from type 1 or type 2 diabetes. Meanwhile, based on data from the International Diabetes Federation (2021), the world's population has reached 7.9 billion people, with the adult population (20–79 years) reaching 5.1 billion; the prevalence of diabetes is 10.5%, meaning nearly 536.6 million

adults currently have diabetes. Indonesia ranks fifth globally, with 19.5 million people diagnosed with diabetes and an estimated 14.3 million living with undiagnosed diabetes.

The 2018 Basic Health Research Report (*Riskesdas*) stated that the national prevalence of DM was 10.9%, up from 6.9% in 2013; in other words, around 29.8 million Indonesians are currently diagnosed with DM. The prevalence of DM in Bandar Lampung City among those aged over 15 years—based on doctor's diagnosis—is 2.25%, the second highest in Lampung Province after Metro City (Ministry of Health of the Republic of Indonesia, 2018). Diabetes mellitus has different types, such as type 1 diabetes mellitus, type 2 diabetes mellitus, gestational diabetes, and other types. Type 2 diabetes mellitus can be easily overlooked, especially in its early stages, but it affects major organs including the heart, blood vessels, kidneys, eyes, and nerves. Controlling blood sugar levels can help prevent these complications.

Diabetic peripheral neuropathy (DNP) is a very common complication of diabetes, manifesting as symptoms of paresthesia, especially in the legs and hands. The prevalence of DNP may be underestimated due to its lack of diagnosis and asymptomatic nature (Win et al., 2020). Neuropathy in diabetes mellitus involves decreased sensation in the patient's legs due to damage to peripheral nerve circulation (sensorimotor), autonomic nerves, and the spinal cord, marked by trauma or unconsciousness of the sufferer regarding mechanical pressure on their legs. Common types of diabetic neuropathy include autonomic neuropathy and sensory polyneuropathy. Autonomic neuropathy affects cardiovascular function, the gastrointestinal tract, urinary system, adrenal glands, and sexual function. Meanwhile, sensory polyneuropathy (peripheral) presents symptoms such as stabbing pain, tingling (paresthesia), burning, and feet feeling *baal* (*patirasa*) (Latifah et al., 2019).

One literature source notes that DNP occurs in almost 50% of people with long-standing type 1 and type 2 DM and can manifest as diffuse neuropathy (distal symmetrical polyneuropathy and/or autonomic neuropathy), mononeuropathy, radiculopathy, or polyradiculopathy. As with other DM complications, neuropathy development correlates with diabetes duration and glycemic control. Additional risk factors include body mass index (BMI)—the greater the BMI, the higher the neuropathy risk—and smoking. Cardiovascular disease (CVD), elevated triglycerides, and hypertension are also associated with DNP (Kasper et al., 2019).

Uncontrolled blood glucose levels cause changes in nerve tissue due to sorbitol and fructose accumulation, resulting in axon disappearance, decreased conduction speed, paresthesia, reduced muscle reflexes, muscle atrophy, excessive sweating, dry skin, and loss of taste (Nusdin, 2022). If nerve damage affects the legs, sufferers cannot feel pain, including wounds, placing them at high risk for neuropathic foot ulcers. If not treated properly, this leads to inflammation; infection can spread to the bones (osteomyelitis), potentially requiring amputation (Tandra, 2017).

Nurses' vigilance in controlling DM can be realized through preventive, promotive, curative, and rehabilitative efforts. In preventive measures, nurses conduct foot examinations to detect vascular disease or peripheral neuropathy, enabling faster prevention and management of DM complications. Common examination scores include the Neuropathy Disability Score (NDS), Neuropathy Impairment Score in the Lower Limbs (NIS-LL), modified NDS, Neuropathy Deficit Score, Ipswich Touch Test (IpTT), and Michigan Neuropathy Screening Instrument (MNSI)—an easy-to-use screening tool for detecting DNP. The researcher selected

the MNSI because it assesses neuropathy signs based on cranial nerve damage, muscle strength, reflex loss, and sensory loss (Pamungkas et al., 2023).

Many modalities improve lower limb perfusion; one is the Buerger-Allen exercise, considered an inexpensive and simple physical intervention to stimulate collateral circulation in the lower extremities. Proposed by Leo Buerger in 1924 and modified by Arthur Allen in 1931 (El-Fattah et al., 2019), many studies on BAE have proven its effectiveness in significantly increasing ABI values.

A study by Radhika et al. (2020) showed that Buerger-Allen exercise (BAE), when given to patients, effectively improved lower extremity perfusion and reduced peripheral neuropathy symptoms. In the pretest, over 50% of participants had mild perfusion disorders, and 16–18% had normal perfusion in the right and left limbs. Posttest results showed reduced mild impairment and increased normal perfusion by 34–36%; average peripheral neuropathy symptom scores decreased from 9.02 to 8.36 and from 4.24 to 3.70.

While previous studies demonstrated Buerger-Allen exercise (BAE) benefits for improving perfusion and reducing neuropathy symptoms in diabetic patients, they often examined BAE as a standalone intervention. The novelty of this study lies in its structured integration of comprehensive diabetes education with the BAE protocol, delivered via in-person sessions, video-based materials, and monitored home practice over 14 days. Based on the description above, the researcher is interested in examining the effectiveness of education and Buerger-Allen exercise on peripheral neuropathy symptoms and fasting blood sugar in type 2 diabetes patients at Hospital X, Bandar Lampung. This study is expected to provide scientific evidence on effective non-pharmacological interventions for comprehensive type 2 DM management.

RESEARCH METHOD

The research design used in this study was a quasi-experimental pretest-posttest one-group design. The researcher assessed neuropathy scores and blood sugar levels at the pretest stage. The researcher then conducted a DM educational intervention using educational videos and PowerPoint presentations at the initial meeting, followed by a Zoom meeting one week later, and Buerger-Allen exercise (BAE) for two weeks at a frequency of twice daily. After the two-week intervention, the researcher reassessed neuropathy scores and blood sugar levels for the posttest stage. The researcher then compared differences in neuropathy scores and blood sugar levels before and after the intervention.

The population was a generalized area consisting of subjects with certain quantities and characteristics determined by the researcher for study and conclusion-drawing (Nursalam, 2020). The population in this study comprised all type 2 DM patients treated at Hospital X, Bandar Lampung. Samples were parts of the population sharing its number and characteristics (Nursalam, 2020). The sample consisted of type 2 DM patients treated at the Internal Medicine Polyclinic of Hospital X, Bandar Lampung. The sampling technique was purposive sampling, a method of selecting samples from the population based on the researcher's criteria (Nursalam, 2020). The number of research samples was 120 people.

The inclusion criteria were: (1) patients diagnosed with type 2 DM with medical records at Hospital X, (2) initial screening showing peripheral neuropathy symptoms with an MNSI

score of ≥ 4 , (3) patients without diabetic ulcers, (4) aged 17–60 years, (5) able to interact well, and (6) willing to participate as respondents. The exclusion criteria were: (1) physical limitations preventing BAE performance, (2) severe psychiatric disorders or cognitive impairments, (3) severe pain complications, and (4) pregnancy.

This research was conducted at the Internal Medicine Polyclinic of Hospital X, Bandar Lampung, in July–August 2023. The location was selected because Hospital X had a high number of DM patient visits and had not conducted similar research.

This research received ethical approval from the Health Research Ethics Committee, adhering to principles of research ethics: (1) respect for persons, with full explanations of research purpose, benefits, procedures, and withdrawal rights provided to each respondent; (2) beneficence, aiming to benefit respondents through interventions; (3) non-maleficence, minimizing risks and avoiding harm; and (4) justice, with fair respondent selection without discrimination.

The research instruments included: (1) a demographic data questionnaire covering age, gender, education, occupation, DM duration, and treatment history; (2) the Michigan Neuropathy Screening Instrument (MNSI), consisting of a neuropathy history questionnaire (15 questions) and foot physical examination (total score 0–8 points: 0–2 normal, 3–5 mild neuropathy, 6–8 moderate neuropathy, >8 severe neuropathy); and (3) digital glucometers for fasting blood sugar (FBS) levels (hypoglycemia <70 mg/dL, normal 70–125 mg/dL, hyperglycemia >126 mg/dL).

The researcher obtained permits from the educational institution and Hospital X, Bandar Lampung. After permission, the researcher coordinated with the head of the unit and nurses at the Internal Medicine Polyclinic to explain the research purpose and objectives. The researcher also prepared instruments, educational media (videos and booklets), and trained three research assistants on BAE procedures and data collection.

The researcher identified potential respondents via medical records and conducted initial MNSI screening. Respondents meeting inclusion criteria received research explanations and signed informed consent. Pretest measurements included MNSI neuropathy scores and FBS levels using digital glucometers.

In the first meeting, the researcher delivered 45–60 minutes of health education on DM and peripheral neuropathy definition, risk factors, signs and symptoms, complications, management, and diabetic foot treatment, using lecture, discussion, and demonstration methods with video and booklet aids. The researcher then demonstrated the BAE procedure in three stages: (1) elevation (legs raised $45\text{--}90^\circ$ for 2–3 minutes), (2) dependent position (sitting with feet hanging for 3–5 minutes while moving toes), and (3) horizontal position (lying with legs straight for 3–5 minutes), repeated 3–4 times per session.

Respondents performed BAE independently at home for 14 consecutive days, twice daily (morning and evening) for 15–20 minutes per session. Researchers and assistants monitored via video calls and weekly home visits to ensure correct and consistent performance. Respondents completed a training diary for compliance documentation.

After 14 days, the researcher and assistant collected posttest data by remeasuring neuropathy scores and FBS levels. The data were analyzed for pre- and post-intervention differences.

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Data were analyzed using IBM SPSS Statistics version 22, including: (1) univariate analysis describing respondent characteristics, MNSI scores, and FBS levels (frequency, percentage, mean \pm standard deviation); (2) bivariate analysis with Wilcoxon Signed Rank Test for pre-post differences in neuropathy scores and FBS (chosen for non-normal distribution, $\alpha=0.05$); and (3) multivariate analysis with MANCOVA to assess education and BAE effects on peripheral neuropathy symptoms and FBS, controlling for confounders (age, sex, DM duration).

RESULTS AND DISCUSSION

Overview of the Research Location. This research was conducted at RS X Bandar Lampung which is a type C hospital that is fully accredited, located at Jalan Teuku Umar no 48 Kedaton, Bandar Lampung. Based on data from RS X's medical records, in the March-April 2023 period there were a total of nearly 150 DM patients per month at the internal medicine poly. The researcher sees that there have been no neuropathy prevention measures that have been taken by nurses that are the body's motor activities, the preventive measures taken by nurses are limited to health education and about the diet consumed. So that this study can help efforts from nursing to increase preventive measures and is expected to help DM patients in controlling glucose and preventing complications of the disease.

Characteristics of Respondents. This study involved 120 type 2 DM patients who met the inclusion criteria. Here is the distribution of the characteristics of the study respondents:

Table 1. Distribution of Research Respondent Characteristics (N=120)

Characteristic	n	%
Gender		
Man	37	30,8
Woman	83	69,2
Age Group		
17-35 years old	7	5,8
36-45 years old	13	10,8
46-55 years old	30	25,0
56-60 years old	70	58,3
Long Suffering from DM		
< 5 years	74	61,7
\geq 5 years	46	38,3

Source: Primary Researcher Data, 2023

Based on Table 1, the majority of respondents were female (69.2%), were in the age range of 56-60 years (58.3%), and had suffered from DM for less than 5 years (61.7%).

Peripheral Neuropathy Score Analysis. The results of MNSI score measurement before and after the intervention are presented in Table 2.

Table 2. Pre-Post Intervention Average Neuropathy Values

Variable	N	Mean	Std. Dev	Min	Max	Difference
Pre Neuropathy Value	120	5,600	3,1138	0	13	2,604
Neuropathy Value Post	120	2,996	1,8781	0	8	

Source: MNSI Measurement Results, 2023

Table 2 shows that the mean value of the neuropathy score before treatment was 5,600 (± 3.1138) and after treatment decreased to 2.996 (± 1.8781) with a decrease difference of 2.604 points. The distribution of the level of neuropathy of the respondents is presented in Table 3.

Table 3. Distribution of Pre- and Post-Intervention Neuropathy Rates

Interpretation of Neuropathy	Score	Pre-test		Post-test	
		n	%	n	%
Usual	0-2	32	26,7	75	62,5
Mild Neuropathy	3-5	32	26,7	45	37,5
Moderate Neuropathy	6-8	36	30,0	0	0
Severe Neuropathy	>8	20	16,7	0	0

Source: MNSI Data Analysis, 2023

Based on Table 3, before the intervention, the majority of respondents experienced moderate neuropathy (30.0%) and severe neuropathy (16.7%). After the intervention, there was an increase in the number of respondents with the normal category to 62.5% and mild neuropathy to 37.5%, while there were no more respondents with moderate or severe neuropathy.

Fasting Blood Sugar Levels Analysis. The results of fasting blood sugar levels measurements before and after the intervention are presented in Table 4.

Table 4. Average Blood Sugar Values of Pre-Post Intervention Fasting

Variable	N	Mean	Std. Dev	Min	Max	Difference
GDP Pre (mg/dL)	120	146,48	53,685	70	294	33,89
GDP Post (mg/dL)	120	112,59	26,670	74	230	

Source: FBS Measurement Results Using Digital Glucometer, 2023

Table 4 shows that the average GDP value before treatment was 146.48 (± 53.685) mg/dL and after treatment decreased to 112.59 (± 26.670) mg/dL with a difference of about 20% at 33.89 mg/dL. The distribution of respondents' GDP interpretation is presented in Table 5.

Table 5. Distribution of Pre and Post Intervention Fasting Blood Sugar Values

GDP Interpretation	Value (mg/dL)	Pre-test		Post-test	
		n	%	n	%
Hypoglycemia	<70	0	0	0	0
Usual	70-125	46	38,3	95	79,2
Hyperglycemia	>126	74	61,7	25	20,8

Source: FBS Data Analysis, 2023

Based on Table 5, before treatment, it was found that more than half of the respondents had hyperglycemia (61.7%). After 2 weeks of education and BAE, it was found that a doubling of the normal fasting blood sugar values to 79.2% compared to the hyperglycemia value group of only 20.8%.

Analysis of the Difference in Neuropathy Score and GDP. The results of the Wilcoxon Signed Rank Test to see the difference in neuropathy and GDP scores before and after the intervention are presented in Table 6.

Table 6. Analysis of Differences in Neuropathy Score and Pre-Post Intervention GDP

Variable	Red Pre	Mean Post	p-value
Neuropathy Score	5,600	2,996	0,000
GDP (mg/dL)	146,48	112,59	0,000

Source: Wilcoxon Signed Rank Test Results, 2023

Based on Table 6, the results of the Wilcoxon Signed Rank Test showed a value of $p=0.000$ ($p<0.05$) for both variables, which means that there was a significant difference in peripheral neuropathy symptom scores and fasting blood sugar levels before and after education and BAE in type 2 DM patients.

Multivariate Analysis. The results of the multivariate analysis using the MANCOVA test to see the influence of patient characteristics on peripheral neuropathy symptoms and GDP are presented in Table 7.

Table 7. Results of the Influence of Type 2 DM Patient Characteristics Partially

Confounding Variable	DNP Correlation Coefficient	GDP Correlation Coefficient	SE DNP	SE GDP
Age	0,348	-0,129	8,5%	2,5%
Gender	0,003	-0,001	0%	0,0028%
Long suffering from DM	0,515	0,247	24%	7,3%
R Square	0,324	0,099		

Source: Multivariate MANCOVA Analysis, 2023

Based on Table 7, the R Square value of the confounding variable for peripheral neuropathy symptoms is 0.324 which means that the contribution of the confounding variable to the DNP variable is 32.4% and the remaining 67.6% are other variables that affect peripheral

neuropathy symptoms but are not studied. The R Square value of the confounding variable for GDP is 0.099 which means that the contribution of the confounding variable to the GDP variable is 9.9% and the remaining 90.1% is another variable that affects fasting blood sugar levels but has not been studied. The variable of length of suffering from DM had a more dominant influence on neuropathy symptoms (SE=24%) and fasting blood sugar values (SE=7.3%) compared to the variables of age and sex.

Table 8. MANCOVA Test Results

Variable	Beta DNP	Beta GDP	p-value DNP	p-value GDP	R Square DNP	R Square GDP
Intercept	0,070	133,955	0,930	0,001	0,442	0,188
Intervention Methods	-2,604	-33,892	0,001	0,001		
Age	0,802	-5,890	0,001	0,081		
Gender	-0,315	1,690	0,308	0,774		
Long Suffering from DM	2,219	19,829	0,001	0,001		

Source: MANCOVA Analysis with IBM SPSS 22, 2023

Based on Table 8, the results of the multivariate analysis of MANCOVA showed that simultaneously there was a significant influence of intervention methods (Education and BAE) on the symptoms of peripheral neuropathy (p value 0.001) and fasting blood sugar levels (p value 0.001) after controlling for age, sex and length of suffering from DM which contributed 44% to DNP ($R^2=0.442$) and contributed 18% to GDP ($R^2=0.188$). The age variable was significantly related to peripheral neuropathy (p value 0.001) but not significantly related to fasting blood sugar (p value 0.081), gender was not significantly related to both dependent variables, while the long-term variable suffering from DM had a significant relationship with both variables (p value 0.001).

Discussion

Characteristics of Respondents. The results showed that the majority of respondents were female (69.2%). This is in line with several studies that show that neuropathic complications in DM patients are more common in women than in men. Women have a higher risk of developing neuropathic complications due to several factors such as hormonal changes, lifestyle, and physiological differences. The majority of respondents were in the age range of 56-60 years (58.3%). Age is one of the risk factors for the occurrence of diabetic neuropathy. The longer a patient suffers from DM, the greater the risk of DM complications. This is caused by degenerative factors, namely decreased body function, especially the ability of pancreatic cells to produce insulin. Most of the respondents had had DM for less than 5 years (61.7%). However, symptoms of diabetic neuropathy can occur in 35-40% of DM patients with a duration of more than 3 years and up to 70% of DM patients over 5 years. This is due to the occurrence of dysfunction of nerve cells that progresses due to a state of persistent hyperglycemia.

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Effectiveness of Education and BAE on Symptoms of Peripheral Neuropathy. The results showed that there was a significant decrease in MNSI scores after providing education and BAE for 14 days ($p=0.000$). The average score of neuropathies decreased from 5,600 to 2,996 with a decrease difference of 2,604 points. In addition, the distribution of neuropathy rates also showed positive changes, with the normal category increasing from 26.7% to 62.5% and no more respondents experiencing moderate or severe neuropathy after the intervention. These findings are in line with the research of Radhika et al (2020) who found that BAE is effective in reducing symptoms of peripheral neuropathy and improving lower extremity perfusion in DM patients. Another study by Riyanto et al (2021) also showed that the combination of BAE with resistance exercise had an effect on improving sensory neuropathy responses ($p=0.001$) and autonomic neuropathy responses ($p=0.001$).

The mechanism of improvement of peripheral neuropathy symptoms through BAE can be explained through several physiological aspects. Sloan et al (2021) stated that the peripheral neurons that innervate the legs are the longest cells in the body that need a proper supply of vascular, mitochondria, and glucose and lipid metabolism. In DNP, the distal terminal of sensory nerve fibers is first affected by the polyol pathway, where glucose is converted into sorbitol and fructose. Excessive flux through this pathway results in oxidative stress and dysfunction of Na^+/K^+ ATPase activity, resulting in impaired nerve conduction.

BAE is an exercise system for lower limb arterial insufficiency by using gravitational changes in the applied position and muscle pumping through active movements from the ankle for smooth vascular muscle (Sari et al., 2019). Smooth blood circulation allows the blood to deliver more oxygen and nutrients to the body's cells. It is associated with dilation of the arteries (vasodilation) and increased capillary permeability, so that more insulin receptors become more active. Exercises performed to improve the circulation of microvascular blood flow in the muscles must be done continuously and repeatedly to prevent circumstances that cause microvascular damage that includes the blood vessels that bleed the nerves (vasa nervorum).

The educational interventions provided in this study also played an important role in the success of the intervention. The study subjects were educated about Buerger Allen Exercise, DM, DNP complications and foot care in DM, so that the study subjects practiced BAE at home and maintained ongoing foot care. This attitude is in line with Orem's theory of self-care, namely The Supportive-Educative System which focuses individuals on performing tasks specific to their current condition or needs (Alligood, 2022). Self-care, according to Orem, is an activity that meets the needs of maintaining the life, health, and welfare of individuals both in health and in a state of illness. BAE is a type of exercise that can be incorporated into a self-care routine to improve lower extremity circulation and relieve symptoms of peripheral neuropathy.

The Effectiveness of Education and BAE on Fasting Blood Sugar Levels. The results showed that there was a significant decrease in GDP levels after providing education and BAE for 14 days ($p=0.000$). The average value of GDP decreased from 146.48 mg/dL to 112.59 mg/dL with a difference of about 20% of the decrease of 33.89 mg/dL. In addition, the distribution of GDP interpretation also showed a positive change, where the normal category increased from 38.3% to 79.2% and the hyperglycemia category decreased from 61.7% to 20.8%. The decrease in fasting blood sugar levels in the study subjects is in line with the

research of Kumarijati (2020) where BAE has a significant effect on fasting blood glucose levels. Research by Mataputun et al (2020) also found that BAE is able to reduce blood sugar levels in patients with type 2 diabetes mellitus.

The mechanism of lowering blood sugar levels through BAE can be explained through several physiological mechanisms. Physical activity encompasses all activities that involve the physical, whereas physical exercise refers to structured and planned physical exercise. Increased physical activity and exercise are important in achieving and maintaining weight loss, in addition to improving insulin resistance, lowering insulin levels in hyperinsulinemia patients, improving dyslipidemia, and lowering blood pressure (PERKENI, 2019, 2021).

Reduced physical activity triggers a decrease in the number of insulin receptors that are ready to bind to insulin so that the translocation speed of GLUT-4 also decreases and affects the speed of the amount of glucose intake. A person who is less active will cause an increase in blood glucose levels. Lower extremity exercises are also beneficial in increasing glucose utilization by active muscles and open capillaries so that more insulin receptors become more active and affect blood glucose reduction (Sandra, 2017). Regular physical activity can help increase glucose uptake into muscles and cell sensitivity to insulin (Lubis & Kanzanabilla, 2021).

Kanaley et al (2022) explain that regular physical activity can improve β cell function, insulin sensitivity, blood vessel function, and gut microbiota and can all lead to better diabetes and health management and reduced risk of disease. Loscalzo et al (2022) also stated that prevention and treatment of DPN is to control blood sugar levels by modifying lifestyle foods and physical activity. Orem's Self Care Theory emphasizes the importance of self-care activities in maintaining health and well-being, including physical activity (Alligood, 2022).

Influence of Patient Characteristics. The results of the MANCOVA multivariate analysis showed that the long-term variable suffering from DM had a more dominant influence on neuropathy symptoms (SE=24%) and fasting blood sugar values (SE=7.3%) compared to the age and gender variables. The variable of long suffering from DM had a significant relationship with both dependent variables (p value 0.001). This is in accordance with the theory that the longer a person has DM, the greater the risk of developing complications due to DM. Symptoms of diabetic neuropathy occur in 35-40% of DM patients with a duration of more than 3 years and reach 70% of DM patients over 5 years. This is due to the occurrence of dysfunction of nerve cells that progresses due to a state of persistent hyperglycemia.

Research Limitations. This study has several limitations, including: (1) The confounding factors that affect the symptoms of neuropathy and fasting blood sugar levels in this study only consist of three variables, namely age, gender, length of suffering from DM, while there are many other factors such as blood glucose levels, history of comorbidities, history of smoking, adherence to medication, stress, and dietary history that can affect the results of the study, (2) The best method to evaluate blood sugar control is needed to use HbA1c but it takes more than 3 months of research, (3) The quasi-experimental design used does not allow full randomization so the possibility of selection bias cannot be completely eliminated.

Research Implications. Based on the results of the study, nurses who work in the health service setting both in hospitals, health centers and independent practices can use education and Buerger Allen Exercise in standard operating procedures (SPO) of nursing interventions in preventing and reducing symptoms of peripheral neuropathy and controlling fasting blood sugar

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in type 2 DM patients. The results of this research can be used as library documents and reference materials to add insight and knowledge related to neuropathy and DM education. The results of this research can be used as evidence-based practice in the world of education and can be used as basic information to be developed in follow-up research.

CONCLUSION

Research on the effectiveness of education and Buerger Allen Exercise on the symptoms of peripheral neuropathy and fasting blood sugar of type 2 DM patients at RS X Bandar Lampung which was carried out from July to August 2023 on 120 subjects showed the following results: The majority of research subjects were female (69.2%), in the age range of 56-60 years (58.3%), and have had DM for less than 5 years (61.7%). There was a significant difference in the score of peripheral neuropathy symptoms before and after education and BAE ($p=0.000$) with a decrease in the mean score from 5,600 to 2,996. There was a significant difference in fasting blood sugar levels before and after education and BAE ($p=0.000$) with an average decrease from 146.48 mg/dL to 112.59 mg/dL. The results of the multivariate analysis of MANCOVA showed that there was a significant influence of educational intervention methods and BAE on peripheral neuropathy symptoms and fasting blood sugar levels after being controlled by confounding variables which contributed 44% to DNP ($R^2=0.442$) and contributed 18% to GDP ($R^2=0.188$). The variable of long-term suffering from DM had a more dominant influence on neuropathy symptoms and fasting blood sugar values. Education and BAE are effective interventions and can be recommended as self-care measures in preventing and reducing symptoms of peripheral neuropathy and controlling fasting blood sugar in type 2 DM patients. For further studies, it is recommended to use a randomized controlled trial design, a longer follow-up period, conduct research in multiple centers, and add other confounding variables such as medication adherence, dietary history, and stress.

REFERENCES

- Alligood, M. R. (2022). *Nursing theorists and their work* (9th ed.). Elsevier.
- El-Fattah, N. A. A., Ibrahim, A. A., & Kamal, H. M. (2019). Efficacy of Buerger-Allen exercises in diabetic peripheral neuropathy. *Journal of Nursing Science*, 9(2), 86–95.
- International Diabetes Federation. (2021). *IDF diabetes atlas* (10th ed.). International Diabetes Federation.
- 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 & Science in Sports & Exercise*, 54(2), 353–368.
- Kasper, D. L., Fauci, A. S., Hauser, S. L., Longo, D. L., Jameson, J. L., & Loscalzo, J. (2019). *Harrison's manual of medicine* (20th ed.). McGraw-Hill Education.
- Kementerian Kesehatan Republik Indonesia. (2018). *Hasil Riset Kesehatan Dasar (Riskesdas) 2018*. Kementerian Kesehatan Republik Indonesia.
- Kumarijati, E. N. (2020). The effect of Allen exercise Buerger on blood glucose levels of type 2 diabetes mellitus in Prolanis members, 5(10).

- Latifah, S., Fahdi, F. K., & Hafidzah, R. (2019). The effect of diabetic foot gymnastics on foot sensitivity in type 2 diabetes mellitus patients. *Paper Knowledge: Toward a Media History of Documents*.
- Loscalzo, J., Fauci, A. S., Kasper, D. L., Hauser, S. L., Longo, D. L., & Jameson, J. L. (2022). *Harrison's principles of internal medicine* (21st ed.). McGraw-Hill Education.
- Lubis, R. F., & Kanzanabilla, R. (2021). Exercise can lower blood glucose levels in people with type II diabetes mellitus. *Journal of Biostatistics, Population, and Health Informatics*, 1(3), 177.
- Mataputun, D. R., Prabawati, D., & Tjandrarini, D. H. (2020). The effectiveness of Buerger-Allen exercise compared with warm water foot soaking on ankle brachial index and blood sugar values in patients with diabetes mellitus. *Media Publikasi Promosi Kesehatan Indonesia (MPPKI)*, 3(3), 253–266.
- Nursalam. (2020). *Metodologi penelitian ilmu keperawatan: Pendekatan praktis* (5th ed.). Salemba Medika.
- Nusdin, S. K. N. M. K. (2022). *Mengenal ulkus diabetikum, penyebab, dan penatalaksanaannya*. Rizmedia Pustaka Indonesia.
- Pamungkas, R. A., Usman, A. M., & Chamroomsawadi, K. (2023). Clinical features of peripheral neuropathy among onset type 2 diabetes mellitus: A Michigan Neuropathy Screening Instrument (MNSI) approach. 7(2), 46–52.
- Perkumpulan Endokrinologi Indonesia. (2019). *Pengelolaan dan pencegahan diabetes melitus tipe 2 di Indonesia*. PERKENI.
- Perkumpulan Endokrinologi Indonesia. (2021). *Pedoman pengelolaan dan pencegahan diabetes melitus tipe 2 di Indonesia 2021*. PERKENI.
- Radhika, J., Poomalai, G., Nalini, S. J., & Revathi, R. (2020). Effectiveness of Buerger-Allen exercise on lower extremity perfusion and peripheral neuropathy symptoms among patients with diabetes mellitus. *Iranian Journal of Nursing and Midwifery Research*, 25(4), 291–295.
- Riyanto, A., Lindayani, L., & Badrujamaludin, A. (2021). Effects of combination of Buerger-Allen exercise with resistance exercise on improving diabetic neuropathy in type 2 DM patients. *Journal of TSCNers*, 6(2), 2503–2453.
- Sandra. (2017). Buerger-Allen exercise and ankle brachial index (ABI) in diabetic foot ulcer patients. *Indonesian Journal of Nursing Sciences and Practice*, 94–110.
- Sari, A., W., A. W., & Sofiani, Y. (2019). Comparative effectiveness of Buerger-Allen exercise and foot exercise on ABI values in patients with type II diabetes mellitus. *Journal of Telenursing (JOTING)*, 1(1), 1–16.
- Sloan, G., Selvarajah, D., & Tesfaye, S. (2021). Pathogenesis, diagnosis and clinical management of diabetic sensorimotor peripheral neuropathy. *Nature Reviews Endocrinology*, 17(7), 400–420.
- Tandra, H. (2015). *Diabetes bisa sembuh*. Gramedia Pustaka Utama.
- Tandra, H. (2017). *Semua yang harus Anda ketahui tentang diabetes*. Gramedia Pustaka Utama.
- World Health Organization. (2021). *WHO global diabetes compact forum: Report of the first meeting of the WHO global diabetes compact forum*. WHO.

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Win, M. M. T. M., Fukai, K., Nyunt, H. H., & Linn, K. Z. (2020). Hand and foot exercises for diabetic peripheral neuropathy: A randomized controlled trial. *Nursing & Health Sciences*, 22(2), 416–426.