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Integration of foot massage and diabetic foot gymnastic on peripheral perfusion in patients with diabetes mellitus 2

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Abstract
The prevalence of type 2 diabetes mellitus (DMT2) shows that it is increasing every year. Peripheral neuropathy of the foot is a complication that often appears in people with DM. Neuropathy disorders that are not treated properly can risk causing diabetic ulcers, even to the point of undergoing amputation. Complementary therapies that can be done to overcome this include foot massage and diabetic foot exercises. This study aims to determine the effect of foot massage integration and diabetic foot gymnastics on overcoming complaints of peripheral tissue perfusion in the feet of DMT2 patients at the Polyclinic of Panti Nugroho Hospital. The study used a quasi-experimental method with a pretest-posttest control group design. The intervention and control groups each consisted of 15 respondents. The intervention group was given foot massage treatment and diabetic foot exercises for three consecutive days for 15 minutes. The independent t-test and the Mann-Whitney test were used to analyze the data obtained. There were significant differences in ABI scores, oxygen saturation, and monofilament scores in the intervention group's left and right legs compared to the control group (p-value < 0.05). There is also a significant effect of the integration of foot massage and diabetic foot gymnastics on peripheral tissue perfusion in both the left and right feet of T2DM patients. The contribution of this study prompted the need for further research with larger numbers of respondents and a longer time to ascertain its effectiveness before it was used as part of local nursing intervention standards.

Keywords: ankle-brachial index; diabetic foot gymnastics; diabetes mellitus type 2; foot massage; peripheral tissue perfusion

1. Introduction

Diabetes mellitus (DM) is one of the non-communicable diseases (NCDs). However, the number of cases continues to increase yearly. Globally, the prevalence of people with diabetes aged 20–70 years from 2015–2021 reached 1.84 billion, with more than 90% having type 2 diabetes (DMT2) (International Diabetes Federation, 2021). Indonesia ranks fifth in the number of people with diabetes in the world (19.47 million), after China (140.87 million), India (74.19 million), Pakistan (32.96 million), and the United States (32.22 million) (International Diabetes Federation, 2021). The prevalence of people with DM in Yogyakarta based on doctors' diagnoses at all ages reached 14,602 people, making Yogyakarta the third highest number of people with diabetes mellitus (DM) in Indonesia (Kemenkes, 2019).

Based on information obtained from the medical records of Panti Nugroho Hospital (RSPN), during the 2021–2022 period, there was an increase in the number of outpatient visits with DM from 1474 visits to 1587 visits. In January–April 2022, DM patient visits reached 1420. Almost 50% of patients who come to RSPN's internal medicine clinic are DM patients, with or without complications. The results of a preliminary study in March 2022 found that 9 out of 10 patients who visited the internal medicine clinic were DM patients. Six out of 10 DM patients often experience tingling and stiffness in the hands and soles of the feet. The results of interviews conducted by researchers found that patients do not routinely report to the doctor that they do not consume routine sugar drugs, do not comply with diet arrangements, and lack exercise associated with neuropathy conditions.

Neuropathy is one of the complications of DM and is estimated to occur in 50%–90% of DM sufferers (Schreiber et al., 2015; Zhou & Zhang, 2019). Diabetic peripheral neuropathy (DPN) is a condition where clinical and subclinical abnormalities are obtained that are characterized by somatic manifestations of the peripheral nervous system in patients with diabetes mellitus without any other cause of peripheral neuropathy (Dogiparthi et al., 2017; Pop-Busui et al., 2017). Symptoms of DPN that are often reported include severe pain such as stabbing, burning, needle pricking, and electric shock sensation, especially in the legs and calves (Ray et al., 2021; Tesfaye et al., 2023). The pain usually increases at night. There can even be numbness or loss of sensation in the affected area (Balhara et al., 2020; Sloan et al., 2018).

Diabetic peripheral neuropathy is associated with sleep disturbances, mood instability, decreased concentration, mental health disorders, decreased daily activities and exercise, reduced work productivity, and decreased quality of life (Davoudi et al., 2021; Degu et al., 2019; Tesfaye et al., 2023) as well as an increased risk of diabetic ulcers, infections, and amputations (Baltzis et al., 2014; Boulton, 2014). However, treatment in most cases of peripheral neuropathy cannot be done entirely because the cause is unknown or incurable, so improving and managing disturbing symptoms is the main goal of DPN treatment (Nathan & DCCT/EDIC Research Group, 2014). Foot care carried out consistently can minimize foot disorders in DM patients by 50–60% (Black & Hawks, 2019). Exercise and foot massage can increase the number of metabolic components that affect nerve health (Nimmo et al., 2013; Sunarmi et al., 2023).

Black & Hawks (2019) found that diabetic foot gymnastics can improve vascularity through some foot movements. Smooth blood circulation will help supply oxygen and nutrients to nerve cells, allowing nerves to work properly and reducing the number of complaints of peripheral neuropathy and diabetes. Increased peripheral blood flow can be measured by an ankle-brachial index (ABI) examination, a circulation examination, and a monofilament score (Aminuddin, 2020). Some research results of peripheral perfusion enhancement interventions are more dominated by single interventions such as foot exercise (Ren et al., 2021; Sukartini et al., 2019) and foot massage (Agustini et al., 2020; Chatchawan et al., 2015; Cicek et al., 2021).

Yusnanda et al. (2019) stated that evaluating whether combination interventions are more effective than other approaches in improving peripheral perfusion in patients with T2DM is important. More in-depth research is needed to evaluate the extent to which such interventions can improve blood flow to the lower extremities, as studies investigating the direct effects of the integration of foot massage and foot gymnastics on the peripheral perfusion of T2DM patients involving representative samples with adequate sample sizes are lacking. Based on the background above, researchers wanted to know the effect of foot massage integration and diabetic foot gymnastics on peripheral tissue perfusion in the feet of DMT2 patients at the Polyclinic of Panti Nugroho Hospital. This study aims to determine the effect of foot massage integration and diabetic foot gymnastics on the complaints of peripheral tissue perfusion in the feet of DMT2 patients at the Polyclinic of Panti Nugroho Hospital.

2. Research Methods

This study used a quasi-experimental method with a pretest-posttest control group design. The study population of all DMT2 patients who visited the internal medicine polyclinic of Panti Nugroho Hospital on July 29–August 14, 2022, amounted to 263 people. Sampling using the accidental sampling technique. The sample was 30, comprising 15 intervention group patients and 15 control group patients.

Researchers gave an integration of foot massage and diabetic foot gymnastics to 15 people in the intervention group. The intervention was carried out for three consecutive days, with the duration of each intervention lasting 15 minutes. As for the control group, as many as 15 respondents were not given treatment. Researchers measured ABI values, oxygen saturation, and leg sensitivity. Measuring foot sensitivity using monofilament (10 g) aims to find out earlier the symptoms of neuropathy in the feet of people with DM. In addition to monofilament (10 g), other tools used in this study are digital tension to measure ABI values and oxymetry to measure oxygen saturation. The tools used have been tested and checked by electromedical engineering officers at Panti Nugroho Hospital, and the results show that these tools are suitable for use.

Following the Shapiro-Wilks test, only the right foot ABI value data is normally distributed, so the data analysis uses an independent t-test. While the ABI value data of the left leg, oxygen saturation, and monofilament are not normally distributed, they use the Mann-Whitney U test. This study has received ethical approval from the Health Research Ethics Commission (STIKES BETHESDA YAKKUM), ethical feasibility information No.133/KEPK.02.01/VII/2022.

3. Results and Discussion

3.1.Results

3.1.1.Characteristics of Respondents

Almost all respondents were female (90.0%), the majority of whom were aged ≥ 60 years (60%). There was only one respondent aged ≤ 45 years in the control group. Most respondents had type 2 DM ≤10 years (70%), and four in the control group had type 2 DM ≥ 20 years. More than half of respondents had controlled sugar levels (53.3%), but when viewed per group, respondents in the intervention group had the majority of uncontrolled blood sugar levels (60%). Blood sugar levels are controlled if the GDS test results are <180 mg/dl, while blood sugar levels are not controlled if the GDS test results are >180 mg/dl. The characteristics of the respondents can be seen in Table 1.

Table 1. Characteristics of respondents

Characteristics	Intervention Group		Control Group		Total	
	n	%	%	%	n	%
Gender						
Male	1	6.7	2	13.3	3	10
Female	14	93.3	13	86.7	27	90
Age						
≤ 45 years			1	6.7	1	3.3
46–59 years	5	33.3	6	40	11	36.7
≥ 60 years	10	66.7	8	53.3	18	60
Duration diagnosed with DM.						
≤ 10 years	11	73.3	10	66.7	21	70
11–19 years	4	26.7	1	6.7	5	16.7
≥ 20 years			4	26.6	4	13.3
Blood Sugar Levels						
Controlled	6	40	10	66.7	16	53.3
Uncontrolled	9	60	5	33.3	14	46.7

Source: Primary data, 2022

3.1.2.Differences in Right-Leg Ankle Brachial Index Value

The results of the independent t-test sample showed a calculated t-result of 3,811 with a sig. A value of 0.00 indicates a significant difference in right-leg ABI values between the intervention and control groups. The mean difference in right-leg ABI values in the intervention and control groups was 0.0867 and -0.0180, respectively, as presented in Table 2.

Table 2. The Difference of right-leg ABI values in the intervention group and Control Group

Right-Leg ABI Values Group	n	Mean-SD	95-CI	P Value
ABI Intervention Value	15	0.0867 ± 0.05972	0.10467±	0.001
ABI Control Value	15	-0.0180 ± 0.8801	(0.04841- 0.16092	

Source: Primary data, 2022

3.1.3.Difference in Left-Leg Ankle Brachial Index Value

Table 3. The Difference of Left-Leg ABI Values in the intervention group and Control Group

Left-Leg ABI Values Group	n	Median (Min-Max)	P Value
ABI Intervention Value	15	0.1200 (0.03-0.8)	0.000
ABI Control Value	15	-0.0100(-0.13- 0.21)	

Source: Primary data, 2022

Table 3 above describes that the *Mann-Whitney U test* value on the difference in left foot ABI values obtained a sig.2-tailed value of the difference in left foot ABI values of 0.000 ($p<0.05$), which showed there was a significant difference in the results of the difference in left foot ABI values between the intervention group and the control group. The mean difference in left foot ABI scores in the intervention group was 0.1540, and in the control group was -0.0173.

3.1.4.Differences in Right and Left Leg Oxygen Saturation in The Intervention Group and Control Group

Based on Table 4, the results of the *Mann-Whitney U test* showed a significant difference in the oxygen saturation of the right leg. The left foot is between the intervention and control groups ($p<0.05$). The difference in the mean value of right leg oxygen saturation in the intervention group and the control group was 2.4667 and 0.7333, respectively. While the difference in the average left leg oxygen saturation value in the intervention group was 2.0667, and in the control group was 0.4667.

Table 4. The difference in Oxygen Saturation of the Right and Left Foot between the Intervention Group and the Control Group

Oxygen Saturation	N	Median (Min-Max)	P Value
Right Leg			
Intervention Group	15	2.000(1.00-4.00)	0.000
Control Group		0.000(-1.00-200)	
Left Leg			
Intervention Group	15	2.00(1.00-4.00)	0.000
Control Group	15	0.00(-1.00-2.00)	

Source: Primary data, 2022

3.1.5.Differences in Right and Left Foot Monofilament Scores in the Intervention Group and Control Group

Table 5. Differences in right and left foot monofilament scores in the intervention group and control group

Monofilament Scores	n	Median (Min-Max)	P Value
Right Leg			
Intervention Group	**15**	0.500(0.500- 2.00)	0.000
Control Group	**15**	0.000(-0.50- 0.50)	
Left Leg			

Intervention Group	**15**	0.500(0.500- 2.00)	0. 002
Control Group	**15**	0.000(-0,50- 0.50)	

Source: Primary data, 2022

The results of the *Mann-Whitney U test* showed a difference in the right foot and left foot monofilament scores between the intervention group and the control group ($p<0.05$). The difference in the mean value of the right foot monofilament score in the intervention group was 0.8000 and in the control group was 0.0333, while the difference in the mean value of the left foot monofilament score in the intervention group and the control group was 0.4667 and -0.0667, respectively, as seen in Table 5.

3.2.Discussion

In this study, the respondents were almost entirely female (90%). Several research results showed similar results (Akhtar et al., 2022; Ghassab-Abdollahi et al., 2023; Yan et al., 2022; Zhang et al., 2019). The high prevalence of type 2 diabetes in women is associated with a higher body mass index (BMI), high triglyceride levels, a history of gestational diabetes mellitus (GDM), and menopause (Ciarambino et al., 2022; Kautzky-Willer et al., 2016; Zhang et al., 2019). Higher BMI is a major risk factor for diabetes (Chen et al., 2018; Gray et al., 2015; Gupta & Bansal, 2020; Medhi et al., 2021; Tang et al., 2021). Medhi et al. (2021) found that, compared to people who have a normal weight, obese people have an 8-fold higher risk of suffering from diabetes. Obesity is more experienced by women than men (Cooper et al., 2021).

In addition to a higher BMI, GDM is associated with a high prevalence of type 2 DM in women. Several previous research results showed that women with GDM had up to 10 times the risk of developing type 2 DM after 6.5–10 years of being diagnosed with GDM compared to those who were non-GDM, with a prevalence ranging from 16.64%–61.3% (Chamberlain et al., 2013; Eades et al., 2015; Herath et al., 2017; Vounzoulaki et al., 2020). Optimal prevention and treatment of GDM, including follow-up screening in women with a history of GDM, is an important part that must be done to reduce the prevalence of type 2 DM in the future.

Contrary to this study's results, previous studies showed that the prevalence of type 2 DM was higher in men (Muilwijk et al., 2022). Differences in sex dominance in the prevalence of type 2 DM are influenced by age. Type 2 DM in males is more prevalent at a younger age, especially before puberty, with a lower BMI (Ciarambino et al., 2022; Kautzky-Willer et al., 2016; Tramunt et al., 2020), while the prevalence of type 2 DM in women is more common in old age and after menopause (Ciarambino et al., 2022). Menopause results in estrogen deficiency, which contributes to the development of type 2 DM through several mechanisms, including changes in insulin secretion from pancreatic β cells, decreased insulin sensitivity in target organs and tissues, and increased glucose sensitivity in major organs related to diabetes (Mauvais-Jarvis et al., 2017).

It was found in the research that 70% of respondents had DM for ≤10 years, and 13.3% had had type 2 DM for ≥ 20 years. The duration of diabetes >5 years is associated with an increased risk of decreased bone mineral density (Jang et al., 2018), macrovascular and microvascular complications, and death (Zoungas et al., 2014). Uncontrolled diabetes can occur due to poor glycemic control, which is also associated with many complications of diabetes. Uncontrolled blood sugar levels in this study were high, reaching 46.7%; even in the intervention group, uncontrolled blood sugar levels reached 60%. Uncontrolled diabetes can occur due to poor glycemic control, which is also associated with many complications of diabetes. Optimal glycemic control is important in diabetes management to prevent and reduce the risk of complications, increase life expectancy, and improve the quality of life of DM patients (Abdissa & Hirpa, 2022; Yigazu & Desse, 2017). Unfortunately, previous studies have shown a high prevalence of poor glycemic control ranging from 45.2%–93% (Bin Rakhis et al., 2022; Traoré et al., 2021; YimamAhmed et al., 2020).

Achieving optimal glycemic level control over the long term is challenging in clinical practice due to the complex causes of poor glycemic control in T2DM. Comorbidities, lack of social support and physical activity, use of multiple medications, lack of self-monitoring of blood sugar, living in rural areas, less education, and longer duration of diabetes are factors associated with poor glycemic control (Dawite et al., 2023; Fiseha et al., 2018; Mamo et al., 2019). Mamo et al. (2019) found that using a combination of metformin and insulin, lack of physical activity, using insulin, and duration of diabetes for more than seven years increased the risk by 9.22, 4.79, 4.48, and 3.08-fold, respectively, of poor glycemic control in DM patients. Glycemic control is also significantly associated with decreased peripheral vascularization in DM patients (Janitra & Sandika, 2018).

Foot massage and foot gymnastics can affect endorphins, which have the effect of reducing pain, increasing excitement, and causing vasodilation of blood vessels so that blood circulation becomes smooth (Affiani, 2017). Participants in the intervention group felt the same way. They felt comfortable and achy—leg aches were reduced. There was a significant difference in the values of right-footed ABI and left-footed ABI in the intervention group and control group ($p<0.05$). The mean difference in right-leg ABI values in the intervention and control groups was 0.0987 and -0.0180, respectively. The difference in the ABI value of the left leg of the intervention group was 0.1540, and the control group was -0.0173. The results of this study showed a higher average difference in ABI values compared to previous studies by Hijriana & Miniharianti (2021) about foot massage and lower extremity joint movement against ABI values in Type 2 DM patients, with a difference in ABI values before and after the intervention of 0.08.

Related to oxygen saturation, we found there was a significant difference in the difference in oxygen saturation of the right and left legs between the intervention group and the control group ($p<0.05$). The mean difference in right leg oxygen saturation values in the intervention group was 2.4667; in the control group, it was 0.7933. While the difference in the mean oxygen saturation of the left leg of the intervention group and the control group was 2.6667 and 0.4667, respectively, Previous research has shown that foot massage has a positive impact on vital signs such as lowering blood pressure, heart rate, breathing, and increasing oxygen saturation (Jing et al., 2022).

There was a significant difference in the monofilament scores of the right and left foot in the intervention group against the control group ($p<0.05$). The difference in the right leg monofilament score of the intervention group was 0.800, and the control group was 0.333, while the difference in the average value of the left foot monofilament score in the intervention group and the control group was 0.4667 and –0.0667, respectively. The integration of foot massage and diabetic foot exercises can improve the vascularity of blood vessels can help increase foot sensitivity. Research conducted by (Sukarja, 2018) showed an average post-foot gymnastics score of 8.45 and an average post-foot spa score of 9.52, so the group that got a foot spa got better foot sensitivity.

Foot massage and exercise can also improve blood circulation and endothelial tissue function in people with DPN (Chatchawan et al., 2020; Liao et al., 2019; Mueller et al., 2013). Diabetic foot gymnastics move joints and leg muscles to improve blood circulation, strengthen small muscles, prevent foot deformities, increase calf and thigh muscle strength, and overcome joint motion limitations (Ferreira et al., 2019). The sensitivity of contracting muscle cells to insulin will increase so muscles can use high blood glucose levels in blood vessels as an energy source (Colberg et al., 2010). With a decrease in blood glucose levels, sorbitol and fructose will be deposited inside the nerve cells less, thereby improving circulation and nerve cell function, increasing nerve sensitivity in the legs, and reducing the risk of developing diabetic foot ulcers (Pang et al., 2020; Papachristoforou et al., 2020).

4. Conclusion

The integration of foot massage and diabetic foot gymnastics is effective in improving blood circulation, increasing oxygen saturation, and increasing foot sensitivity. There is a significant effect of the integration of foot massage and diabetic foot gymnastics on peripheral tissue perfusion in both the left leg and right foot of T2DM patients. The contribution of this study requires further research with a larger number of respondents and a longer time to ascertain its effectiveness before it is used as part of standard local nursing interventions.

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