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The Effect of Buerger Allen Exercise and Walking Exercise on Ankle Brachial Index among Patients with Type-2 Diabetes Mellitus with Pre-test and Post-test Design

Vani Dwi Putri [1]***; Yanti Cahyati, S.Kep, Ners, M.Kep*** [1*]***; Yudi Triguna, S.Kep, Ners, M.Kep*** [1]

*1 Department of Nursing, Poltekkes Kemenkes Tasikmalaya, West Java, Indonesia. * Corresponding Author. Email: yantinaufal@gmail.com*

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ABSTRACT

Background: The high prevalence of diabetes mellitus accompanied by the duration of suffering from the disease can increase the risk of complications of neuropathy and diabetic ulcers due to decreased blood flow to the lower extremities. Early detection is needed through measuring the Ankle Brachial Index and implementing Buerger Allen Exercise and Walking Exercise, which can increase blood circulation to the extremities as an effort to prevent and reduce the risk of diabetic ulcers. ***Purpose:*** This study aims to determine the effect of Buerger Allen Exercise and Walking Exercise on the Ankle Brachial Index in patients with Diabetes Mellitus. ***Methods:*** Using a quasi-experimental design with pre-test and post-test approach, purposive sampling technique was used with a sample size of 21 people in the intervention group and 21 people in the control group. The tool used to measure the Ankle Brachial Index is a digital sphygmomanometer. The statistical tests used are paired sample t-test and independent sample t-test with a significance level of 0.05. ***Results:*** There was a difference in the average value of the Ankle Brachial Index before and after being given exercise in the intervention group; namely, from 0.8667 to 0.9981 with a p-value of 0.001. In the control group, the difference was from 0.8810 to 0.9267 with a p-value of 0.001. The results of the statistical test showed that there was a difference in the average value of the Ankle Brachial Index after being given exercise between the intervention group and the control group with a p-value of 0.001. ***Conclusion:*** Buerger Allen exercise and walking exercise can improve and increase peripheral circulation to the extremities. ***Implications for Nursing:*** The combination of Buerger Allen Exercise and Walking Exercise is a new innovation in the field of non-pharmacological health therapy to improve blood circulation to the extremities as an effort to prevent complications of diabetic ulcers.

Keywords: Ankle brachial index, Buerger Allen exercise, Diabetes mellitus, Walking exercise.

What does this paper add?

1. The risk of developing diabetic ulcers can be experienced by all DM sufferers who do not pay attention to their lifestyle. Diabetic ulcers are caused by long-standing atherosclerosis which causes decreased blood circulation to the extremities. The longer a person suffers from DM, the greater the risk of experiencing complications, so that early detection and application of Buerger Allen Exercise and Walking Exercise are needed to improve blood circulation in the extremities.
2. Buerger Allen Exercise and Walking Exercise are physical activities used to improve blood circulation to the extremities by moving the legs and joints, which can activate muscles to take up glucose which will be converted into energy, so that glucose levels

in the body decrease, and blood circulation increases. These exercises can be an alternative for people who cannot attend and participate in Prolanis activities at the Health Center, where they can still control blood-glucose levels by implementing both exercises routinely as an effort to prevent complications of DM ulcers. Both exercises are easy, cheap, do not require tools or a long time and can be performed at home independently.

3. The findings of Kindang et al. (2023) in their research stated that BAE is effective in improving lower limb circulation in patients with type-2 DM. BAE uses the force of gravity used by the vascular system and blood vessel muscles in different positions, so that it helps empty and fill blood vessels alternately, so that it can increase vascular blood transport and increase ABI values (Pratiwi et al., 2020). In addition, Mina et al. (2017) and Dewi et al. (2020) concluded that Walking Exercise is effective in increasing peripheral vascularization and preventing the risk of chronic complications of diabetic ulcers in patients with DM. When walking, glucose is taken to be converted into energy. When glucose in the body's muscles decreases, it will use the glucose in the blood, so that glucose levels in the body are reduced and controlled.
4. Physical activity causes muscle movement to become more active. Glucose absorption by active muscles occurs because insulin triggers the release of Muscle Activating Factor (MAF), which causes increased glucose absorption by both moving and non-moving muscles (Dewi et al., 2020).

Introduction

Diabetes Mellitus (DM) is a serious health case in the category of non-communicable diseases (PTM) which threatens human survival in the 21st-century era (Saputri, 2020). Based on data from the Ministry of Health of the Republic of Indonesia (Kemenkes RI), the prevalence of DM continues to increase in Indonesia, causing a health crisis that must be considered in terms of improving the health system to prevent and reduce the risk of DM (Salam & Laili, 2020).

Based on the World Health Organization (WHO) (2016), 422 million people suffer from DM with a death rate of 1.6 million people every year. This number is predicted to increase in 2035 to 592 million people and to 700 million people in 2045. The results of Basic Health Research (Riskesdas) (2018) explain that 8.5% or 24.4 million people of the national population are affected by DM in Indonesia, and this is the 4th cause of death in the PTM category. Sambongpari Community Health Center is in the 4th place after Tamansari Community Health Center with the highest number of DM sufferers; namely, 584 people (Tasikmalaya City Health Service Data, 2023). The high prevalence rate of diabetes combined with the long duration of suffering from the disease can increase the risk of complications neuropathy and diabetic ulcers, which are caused by decreased blood flow to the arteries, veins and capillaries.

Diabetic ulcers in type-2 DM sufferers are caused by neuropathy or peripheral arterial disease of the lower extremities, characterized by wounds or ulceration on the feet (Doupis et al., 2012 in Aryani et al., 2022). The risk factors for diabetic ulcers are age, gender, duration of diabetes >5 years, 2 times greater risk of experiencing ulcers, obesity, high blood pressure, blood glucose levels, unhealthy lifestyles, such as smoking, foot care, use of footwear, history of diabetic ulcers, lack of diet management and lack of physical activity (Deribe, 2014).

IDF (2021) reported that 9.1-26.1 million people with DM each year have the potential to experience diabetic ulcers. Indonesia has a prevalence of DM sufferers with ulcers of 15% (Oktorina et al., 2019). Riskesdas (2018) estimated that almost 50% of diabetes patients are likely to develop diabetic ulcers in their lives with an 8%-35% death rate and 15%-30% amputation. Diabetic ulcers are caused by long-lasting hyperglycemia, causing hyperglycolia, which is a condition of an abundance of glucose in cells.

Around 44%-85% of diabetic ulcer factors can be reduced through prevention efforts that focus on controlling blood glucose levels as an effort to prevent neuropathy as a cause of diabetic ulcers and early detection (Eltrikanawati, 2021). Ankle Brachial Index (ABI) is used to detect blood flow resistance in the lower extremities due to narrowing of the arterial lumen due to hyperglycemia. One effort to prevent diabetic ulcers is by early detection through measuring the Ankle Brachial Index (ABI) to detect resistance to blood flow in the lower extremities due to narrowing of the arterial lumen due to hyperglycemia. ABI is obtained by measuring blood pressure in both hands as well as in both feet and then dividing the highest systolic pressure value in the

feet by the highest systolic pressure value in the hands (Kartikadewi et al., 2022). The interpretation of normal ABI values is ≥0.91-1.30 (ADA, 2014).

The findings of two studies by the Diabetes Control and Complication Trial Forum (DCCT) in the USA and the United Kingdom Prospective Diabetes Study (UKPDS) have proven that blood glucose control and physical activity can reduce the incidence of retinopathy, nephropathy and neuropathy (Bachri et al., 2022).

Physical activity, such as moving the legs and stretching the joints, can help increase blood circulation to the lower extremities to prevent diabetic ulcers (Sari et al., 2019). Physical activity causes muscle movement to become more active. Glucose absorption by active muscles occurs because insulin triggers the release of Muscle Activating Factor (MAF), which causes increased glucose absorption by both moving and non-moving muscles (Dewi et al., 2020). Buerger Allen Exercise (BAE) and Walking Exercise are two types of physical exercise that DM sufferers can do to prevent peripheral perfusion disorders and increase vascularization to the extremities.

Buerger Allen Exercise is a basic physical exercise to prevent peripheral artery disease in DM patients (Mataputum et al., 2020). BAE involves movement of the legs and stretching of the flexion and extension joints accompanied by changes in position to improve peripheral blood circulation to the extremities (Mataputum et al., 2020). Saleha (2022) concluded that there is a difference in the effectiveness between leg exercises and BAE on peripheral blood circulation and blood sugar levels for type-2 DM, where BAE is more effective than leg exercises in increasing ABI values. BAE also has advantages; namely, the movements are simple, easy to learn, do not require special equipment, do not require costs, can be done at home and are effective in improving peripheral circulation to the extremities, so that it is highly recommended for DM sufferers to do it routinely as an effort to prevent diabetic ulcers (Pratiwi et al., 2020).

Based on the American College of Sports Medicine (ACSM) (2011) in Tasman (2017), Walking Exercise is recommended to be done every day as an effort to reduce the risk of developing metabolic disease. Regular physical activity 3-4 times a week for 30 minutes each time is recommended for DM sufferers (Rakhmatullah, 2022).

Walking causes contractions of large muscles, such as the hamstrings, quadriceps and gluteus muscles as well as lower muscles, such as the tibialis anterior and achilles muscles in the legs which compress blood vessels throughout the body. Mina et al. (2017) and Dewi et al. (2020) concluded that Walking Exercise is effective in increasing peripheral vascularization and preventing the risk of chronic complications of diabetic ulcers in DM sufferers. When walking, glucose is taken up to be converted into energy. When glucose in the muscles decreases, the body will use the glucose in the blood, so that glucose levels in the body are reduced and controlled. This affects the smoothness and causes improvements of peripheral circulation to the extremities.

Active muscles convert glucose into energy. If glucose in the muscles does not meet the needs, the muscles will take glucose from the blood to continue to get energy. There is a decrease in blood glucose levels and blood flow to the extremities becomes smoother. One of the recommended physical activities in managing diabetes is walking (Amelia, 2028 in Qodir, 2022).

Many researchers have proven that the two activities above can affect blood circulation to the feet. However, there has been no research combining BAE and Walking Exercise. If the two are combined conceptually, they can have a better effect on ABI values. This study will find out the effect of the combination of BAE and Walking Exercise on the ABI value of type-2 Diabetes Mellitus patients.

Method

Study Design

The research design used was quasi-experimental with non-equivalent control group design approach to determine the effect of Buerger Allen Exercise and Walking Exercise on Ankle Brachial Index in patients with Diabetes mellitus. This type of design does not have strict limits on randomization; it could introduce bias or limit the ability to conclude causal relationships. However, to prevent bias, careful planning and implementation of the study are carried out where researchers seek respondents based on pre-determined inclusion and exclusion criteria, collect data that is intended, validate data, conduct research transparently, so that researchers and participants can know the origin, method of collection, and method of data analysis, and

use a structured research design; namely, a quasi-experimental study design, where researchers involve placing participants into groups.

Respondents in the study were divided into 2 groups; namely, the intervention group and the control group selected by researchers without randomization. The intervention group was given BAE and Walking Exercise, while the control group was given training according to the Chronic Disease Management Program (Prolanis). The effect of treatment was assessed by comparing the Ankle Brachial Index values before and after the intervention was given to the two groups of DM patients.

The instruments used were the Standard Operating Procedure Walking Exercise and BAE leaflets, as well as a digital spygmomanometer and a worksheet to measure and record ABI values. The digital spygnomanometer used has been tested for validity and reliability. The respondent identity questionnaire component contains the respondent initials, respondent code, gender, age, smoking history, co-morbidities, duration of suffering from DM, blood sugar levels and ABI value.

Ankle Brachial Index values were calculated before and after the respondents were given a combination of BAE and Walking Exercise for 7 days. The researchers chose a 7-day study duration, because several previous studies with a duration of 5 days were able to increase circulation to the extremities with the aim of preventing DM complications.

The ABI value is obtained by dividing the highest systolic value in the feet and the highest systolic value in the hands (Prihatiningsih, 2016). ABI is obtained by measuring blood pressure in both hands and in both feet and then dividing the highest systolic pressure value in the feet by the highest systolic pressure value in the hands (Kartikadewi et al., 2022).

The interpretation of the ABI value according to (ADA, 2014) is as follows:

1. Blood vessel calcification >1,3

   Experience stiffness in peripheral blood vessels due to calcium blockage which causes impaired blood flow.
2. Normal ≥0,91 - 1,30

   Blood circulation is still good; there is no obstruction of peripheral vessels, nutritional and oxygen needs are met in the lower extremities.
3. Mild ischemia/borderline perfusion ≤ 0,90 - 0,81

   The initial symptoms of PAD are pain in the buttocks or calves when walking (intermittent claudication). Mild occlusion of blood vessels causes pain, because blood flow cannot meet nutritional needs, when metabolism increases, especially in the lower extremities.
4. Moderate ischemia ≤ 0,78 - 0,50

   Caused by decreased peripheral perfusion due to prolonged occlusion, resulting in decreased heart rate and arterial pressure. In this condition, the tissue becomes deprived of oxygen, which causes ischemia in the leg. As a result, the wound becomes difficult to heal except with revascularization.
5. Severe ischemia ≤ 0,50

   Characterized by the presence of diabetic ulcers and gangrenous wounds.

Sample

The population is 584 people suffering from type-2 DM who live in the Sambongpari Health Center Working Area. The sample size was calculated using the Lemeshow formula with an error rate of 5% = 0.05; namely 19 people plus 10% (1.9 = 2), to avoid drop out to 21 people per group in the intervention and control groups with a total sample of 42 people. Lemeshow formula is also used to determine the minimum sample required in the research, if the population is very large and it is not possible to study the entire population due to time, funding and research personnel limitations.

The minimum number of sample members that can be accepted in experimental research is 15 people per group (Gay & Diehl, 1992 in Sefriani, 2021). The sampling method uses a purposive sampling technique with inclusion and exclusion criteria. The inclusion criteria were:

1. Type-2 DM sufferers who are willing to participate and sign a consent form as respondents.
2. Type-2 DM sufferers who have families accompanying them during the exercises.
3. Type-2 DM sufferers in the Sambongpari Community Health Center Working Area.
4. Type-2 DM sufferers who do not experience acute complications.
5. Type-2 DM sufferers who do not experience diabetic ulcers.
6. ABI value ≤0.9.
7. Blood sugar level ≤300 mg/dL
8. Respondents who consume oral antidiabetic drugs.

Exclusion criteria are specific criteria that cause potential respondents who meet the inclusion criteria to be excluded from the research group. The exclusion criteria in this study were respondents who had physiological disorders, such as shortness of breath,

chest pain, and joint or bone disorders.

The reason for choosing the inclusion and exclusion criteria above is because the research to be conducted is related to leg movements; namely, Burger Allen Exercise and Walking Exercise in type-2 DM patients in the Sambongpari Health Center Working Area; so this study is on respondents who suffer from DM in the Sambongpari Health Center Working Area, have families who accompany them and document, blood sugar >300 mg/dL because Walking Exercise is contraindicated for respondents who have high blood sugar, consume oral antidiabetic drugs to prevent bias in both groups, do not experience physiological disorders and joint/bone disorders, because BAE and Walking Exercise will be carried out, and do not experience diabetic ulcers, with an ABI value of ≤0.9, because the purpose of this study is to prevent diabetic ulcers.

Data Collection

The researchers conducted the research assisted by a person in charge of PTM and a person in charge of the fostered village (cadre) of the Sambongpari Health Center during the posbindu and door-to-door activities in finding respondents, collecting information and identifying and placing respondents in the intervention group and in the control group according to the inclusion and exclusion criteria that had been determined before the research was conducted.

To avoid bias in this study, respondents were selected based on inclusion and exclusion criteria, so that respondents in the intervention and control groups had the same characteristics. Respondents who meet the inclusion criteria will be collected and later divided into 2 groups; namely, the intervention group and the control group.

Documenting the ABI value obtained as the value before the intervention is given and then, the researchers provide an informed consent which must be signed by the prospective respondents as a form of agreement to be willing to become respondents in the research to be carried out. The researchers explained to the intervention group respondents the purpose, benefits, procedures of BAE and Walking Exercise and trained respondents to perform BAE movements. BAE was performed twice a day; namely, in the morning and in the evening for a week. Regular physical activity 3-4 times a week for 30 minutes each time is recommended for DM sufferers (Rakhmatullah, 2022). Walking Exercise is done 3 times a week for 30 minutes each time. For the control group, respondents were advised to carry out Prolanis activities, such as checking blood sugar, diet, exercise and taking medication.

To monitor respondent activities, researchers were assisted by enumerators to carry out direct observations by filling in respondents' daily sheets and through WhatsApp groups which had been created as a medium to remind researchers of intervention and monitoring. In the control group, respondents were advised to carry out prolanis activities that are usually carried out by DM sufferers, such as taking medication, eating patterns, exercising, checking blood sugar, and participating in socialization activities about PTM.

Each respondent, both in the intervention group and in the control group, was given a daily observation sheet held by a cadre as an enumerator and must be signed and stamped if the respondent had carried out the intervention according to the schedule as a proof that the respondent had actually done the exercise.

After 7 days, a re-evaluation was carried out by re-measuring the ABI values in both the intervention group and the control group, which was carried out door-to-door to each respondent's house to determine the difference in ABI values in the intervention group and in the control group.

Researchers gave respondents the freedom to make decisions regarding their availability to become respondents in the study. Informed consent must be signed by prospective respondents as a consent form confirming that they are willing to become respondents in the study to be conducted. Whatever the respondent's decision, the researchers respected it without any coercion.

To ensure the confidentiality of the respondent's identity, the initials of the name are listed and will later be given codes. During the study, the respondent's face is not shown. All data and information related to respondents in the document are not disseminated to other parties, only known to researchers and stored in a safe place with access restrictions.

Analysis

Analysis was carried out using statistical tests. The data collected from the intervention group and the control group was tested for homogeneity and normality using the Shapiro-Wilk test. The normality test was carried out using the Shapiro-Wilk test, because the number of sample members was <50. Then, a

homogeneity test was carried out to ensure that the population to be measured was homogeneous. After the data normality test was carried out on both groups with a sample size of 21 people in the intervention group and 21 people in the control group, the results showed that the data was normally distributed with a p-value of > 0.05. Then, the homogeneity test showed that the data in the intervention group and the control group was homogeneous with a p-value of > 0.05.

Since data in the intervention and control groups is normally distributed and homogeneous, the tests carried out are parametric tests; namely, paired sample t-tests and independent sample t-tests with the basis for drawing conclusions is that if the p-value is <0.05, then Ha is accepted and H_0 is rejected. The independent t-test, on the other hand, is used to analyze the comparison of the means of two groups. The dependent t-test is used to analyze the comparison of the means in one group. If the data is not normally distributed, the Mann Whitney test should be used.

Ethical Considerations

This research has received ethical clearance from the Health Research Ethics Commission (KEPK) of Jenderal Achmad Yani University, Cimahi City, Indonesia, with No.044//KEPK/FITkes-Unjani/II/2024.

Results

Sample Characteristics

Table 1 shows that the average age of respondents is dominated by the age range 46-65 years with 16 people (38.1%). The respondents' gender was dominated by 35 women (83.33%). The most significant percentage of the long-term diabetes mellitus factor was ≤5 years, with 34 people (81.0%). Most of the respondents, apart from suffering from DM, also suffered from hypertension; namely, 16 people (38.0%) and 38 people (90.5%) had no history of smoking. Most research respondents had blood sugar levels >200 mg/dL; namely, 26 people (61.9%).

Table 1. Frequency distribution and percentage of respondent characteristics (N=42)

No.	Respondent Characteristics	Group				Frequency	Percentage (%)
		Intervention		Control			
		Frequency		Percentage (%)			
1.	**Respondent's current age**						
	26-35 years	0	0	1	4.8	1	2.4
	36-45 years	1	4.8	2	9.5	3	7.1
	46-55 years	10	47.6	5	23.8	15	35.7
	56-65 years	8	38.1	8	38.1	16	38.1
	>65 years	2	9.5	5	23.8	7	16.7
2.	**Respondent's gender**						
	Man	4	19.0	3	14.3	7	16.67
	Woman	17	81.0	18	85.7	35	83.33
3.	**Duration of suffering from DM**						
	≤5 years	17	81.0	17	81.0	34	81.0
	>5 years	4	19.0	4	19.0	8	19.0
4.	**Respondent's co-morbidities**						
	No	4	19.0	3	14.3	7	16.7
	Heart disease	3	14.3	4	19.0	7	16.7
	Vertigo	2	9.5	0	0	2	4.8
	Gout	4	19.0	4	19.0	8	19.0
	Stomach	1	4.8	1	4.8	2	4.8
	Hypertension	7	33.3	9	42.9	16	38.0
5.	**Respondent's smoking history**						
	Yes	3	14.3	1	4.8	4	9.5

	No	18	85.7	20	95.2	38	90.5
6.	**Respondent's blood sugar levels**						
	≤200 mg/dL	7	33.3	9	42.9	16	38.1
	>200 mg/Dl	14	66.7	12	57.1	26	61.9

Table 2 shows that the average Ankle Brachial Index value in the intervention group before intervention was 0.8667, and after intevention, it increased to 0.9981. The results of the interval estimation concluded that 95% believe that the average Ankle Brachial Index in the intervention group before being given Buerger Allen Exercise (BAE) and Walking Exercise was 0.8605-0.8728, while after being given Buerger Allen Exercise (BAE) and Walking Exercise it was 0.9810-1.0152. Meanwhile, in the control group, before being given Prolanis activities, it was 0.8810, while after being given exercise, it increased to 0.9267. The interval estimation results concluded that 95% believe that the average Ankle Brachial Index in the control group before being given Prolanis activities was 0.8747-0.8872, while after being given Prolanis activities it was 0.9169-0.9365.

Table 2. Distribution of mean ABI values before and after being given exercise in the intervention and control groups

Variable	Mean	SD	Min.	Max.	95% CI
Ankle Brachial Index					
Before	0.8667	0.01354	0.84	0.89	0.8605-0.8728
After	0.9981	0.03750	0.95	1.10	0.9810-1.0152
Intervention Group (n) = 21					
Before	0.8810	0.01375	0.85	0.90	0.8747-0.8872
After	0.9267	0.02153	0.89	0.96	0.9169-0.9365
Control Group (n) = 21					

Bivariate Analysis

Table 3 shows that the average ABI value in the intervention group before intervention was 0.8667, and after intervention was 0.9981, with a difference of 0.13143. The paired sample t-test results obtained a p-value of 0.001 < α (0.05), which showed a significant difference between the average ABI values before and after intervention in the intervention group.

The table also shows that the average ABI value in the control group before being given exercise was 0.8810, and after being given exercise it was 0.9267, where the difference was 0.04571. The paired sample t-test results obtained a p-value of 0.001 < α (0.05), which showed a significant difference between the average ABI values before and after being given exercise in the control group.

Table 3. Differences in mean ABI values before and after exercise in the intervention group and thecontrol group

Variable	Mean	Difference	SD	SE	p-value
Ankle Brachial Index					
Before	0.8667	0.013143	0.01354	0.00295	0.001
After	0.9981		0.03750	0.00818	
Intervention Group (n) = 21					
Before	0.8810	0.04571	0.01375	0.00300	0.001
After	0.9267		0.02153	0.00470	
Control Group (n) = 21					

Table 4 shows independent sample t-test results, demonstrating that the p-value was 0.001 < α (0.05), meaning that there was a significant difference in the average ABI values between the intervention group and the control group.

Table 4. The average differences in ABI values between the intervention group and the control group after being given exercise

Variable	Group	Mean	SD	SE	p-value	N
Ankle Brachial Index	Intervention	0.9981	0.03750	0.00818	0.001	21
	Control	0.9267	0.02153	0.02153	0.001	21

Discussion

The research results showed that the age of the respondents was dominated by the age range 46-65 years. These results are supported by a study conducted by Masruroh (2018), which stated that type-2 diabetes mellitus increases from the age of 45 years and above. As individuals get older, they experience progressive shrinkage of pancreatic β cells, so that too little hormone is produced causing glucose levels to rise. Increasing age in people with type-2 diabetes mellitus also causes decreased body function, decreased blood flow to the peripheral areas, especially to the lower extremities, so that this causes an increased risk of worse neuropathy (Rasyid et al., 2020). This aligns with a study by Jannaim et al. (2018) on 43 respondents, 62.8% of whom were in the 56-65-year age range and had peripheral circulation problems in the lower extremities.

Based on gender, the majority of respondents in the study were females. This aligns with a study by Simarmata et al. (2021), which was dominated by women (66.7%). This is because women have higher LDL or lousy cholesterol triglyceride levels than men, and there are also differences in carrying out all daily activities and lifestyles. In addition, women experience greater fat accumulation, which inhibits blood flow to the extremities, affecting blood sugar levels and ABI values (Masruroh, 2018). Gestational diabetes also occurs in women during pregnancy, which causes a higher risk of developing DM in the future.

The majority of respondents in the study had suffered from diabetes mellitus for ≤5 years, with ABI values in the mild category. Research by Purwanti (2013) in Mufidah (2018) proved that ten respondents (29.4%) who suffered from DM <5 years, and 24 respondents (70.6%) who suffered from DM ≥5 years experienced complications from diabetic ulcers. Respondents who have just been diagnosed with DM or have suffered from DM for <5 years are likely to experience complications of diabetic ulcers if preventive measures are not taken immediately with early detection. The longer the diagnosis of DM, the greater the risk of atherosclerosis caused by endothelial dysfunction due to glucotoxicity. This has an impact on blood circulation to the periphery, so that the ABI value tends to decrease (Kartikadewi et al., 2022).

Apart from suffering from DM, most of the respondents in the study had hypertension. This can certainly affect the ABI value, because high blood pressure has an influence on decreasing the ABI value and indicates a peripheral vascularization disorder.

Hypertension influences the incidence of peripheral arterial disease (PAP), which is a condition where blood vessels are narrowing, causing blood flow to the hands and feet not to flow smoothly, indicated by an ABI value ≤0.9. This is caused by atherosclerosis, which results in vascular insufficiency, so that blood flow to the dorsal pedis, popliteal, and tibialis decreases, affecting the ABI value and indicating a disturbance in peripheral vascularization.

In terms of smoking habits, the majority of respondents did not have a history of smoking. This is in line with a study by Kartikadewi et al. (2022), which stated that in their research, abnormality in ABI values in DM sufferers who did not smoke was 96.3% (26 people). Research by Chang et al. (2015) and Salam and Laili (2020) stated that peripheral perfusion disorders will get worse in DM sufferers who have a long history of smoking. The more prolonged DM sufferers are exposed to cigarettes, the worse the decrease in ABI values.

Most of the respondents in the study had blood sugar levels >200 mg/dL, where high glucose levels cause dysfunction of the endothelium and vascular muscles as well as a decrease in vasodilator function by the endothelium, causing narrowing of the lumen of blood vessels and inhibiting blood circulation, especially to the legs, which has an impact on reducing ABI values (Pramestui, 2019). Research by Widyanata et al. (2023) showed a relationship between blood sugar levels and the ABI value, where the higher the blood sugar level, the lower the ABI value.

The intervention group showed an increase in the

average ABI value before and after intervention. The results of this research are supported by research conducted by Simanjuntak et al. (2019), concluding that there is a significant difference in the ABI value of DM sufferers with an average of 1.04 after being given the Walking Exercise intervention and research by Zamaa et al. (2021) regarding the application of the BAE, which showed that there is a significant difference in the average ABI value; namely, 0.981 in DM sufferers. So, the combination of the BAE and Walking exercise is very efficient, because the muscles in the lower extremities can move optimally to increase blood vessel transportation, so that blood vessel perfusion in the extremities increases. DM sufferers can do these two exercises combined to prevent complications, especially diabetic ulcers, through this physical activity.

The combination of BAE and Walking Exercise is very efficient, because the muscles in the lower extremities can move optimally to increase blood vessel transportation, so that blood vessel perfusion in the extremities increases.

The control group also showed an increase in the average ABI value before and after being given Exercise according to Prolanis activities. There is a difference in the average Ankle Brachial Index value of the control group before and after being given Prolanis activities.

This happens because many factors can affect the ABI value, including physical activity and blood sugar levels. The control group only did the usual activities in their respective homes, such as checking blood sugar and blood pressure, taking medicine, dieting, and performing gymnastics. In their research, Hariyanto's (2015) and Hasfika et al. (2020) stated that gymnastics can be done to lower blood sugar, which can affect ABI values, and maintain the health of the elderly. However, this study stated that the Prolanis exercise program was ineffective in reducing blood sugar, because the implementation was carried out once a week. Prolanis activities can influence the blood sugar levels of DM patients.

The researchers concluded that the increase in ABI values in the intervention group could occur because the combination of BAE and Walking Exercise for seven consecutive days through joint and leg movements helped activate the muscles in the legs, which caused glucose absorption, where when doing physical activity, there was more active muscle movement. Glucose absorption by active muscles occurs, because insulin triggers the release of Muscle Activating Factor (MAF), which causes increased glucose absorption by the muscles, so that blood glucose levels are controlled and blood flow to the extremities becomes smoother and ABI values increase. In the intervention group respondents, there was an increase in ABI values after doing BAE and Walking Exercise for 7 days. This proves that with physical activity, that can cause muscle movement to become active and absorb glucose, because insulin triggers the release of Muscle Activating Factor (MAF), so that blood flow becomes smoother. The increase in ABI value in the control group can occur because of Prolanis activities carried out by respondents, such as taking medication, checking blood sugar, performing gymnastics, and dieting, even though the control group does not routinely carry out these activities. However, this can help control blood sugar levels, which impacts increasing ABI values.

There is a difference in the average value of ABI between the intervention group and the control group after being given exercise. The combination of BAE and Walking Exercise better influences the value of ABI. Through the movement of changing gravity and muscle movements of flexion, extension, and then dorso flexion and plantar flexion, the blood vessel muscles are combined with active muscles when moving, causing glucose uptake in the blood by the muscles, because the body needs energy, so that vascularization to the periphery is smooth and the ABI value increases. Walking Exercise also provides a sense of relaxation. It lowers stress and cortisol levels, which can prevent gluconeogenesis, increase glucose use by cells, and maintain glucose levels in the normal range (Mina et al., 2017).

The increase in the ABI value in the intervention group respondents was also due to the respondents' compliance to doing BAE and Walking Exercises routinely and according to the specified schedule. Meanwhile, the Prolanis activities carried out by the control group still needed to be more effective, because Prolanis was carried out only once a month, so it did not have a good impact on lowering blood sugar. Controlling levels can prevent gluconeogenesis, increase glucose use by cells, and maintain glucose levels in the normal range (Mina et al., 2017).

This can affect the circulation of blood flow to the extremities and the ABI value of patients with type-2 DM. As for Buerger Allen Exercise and Walking

Exercise, they can be done independently at home by each respondent regularly, where the movement in the joints and legs carries blood circulation to the lower extremities to prevent diabetic ulcers (Sari et al., 2019).

Implications for Nursing

The combination of Buerger Allen Exercise and Walking Exercise is a new innovation in the field of non-pharmacological health therapy to improve blood circulation to the extremities as an effort to prevent complications of diabetic ulcers. Nurses are advised to implement BAE and Walking Exercise for DM patients, noting that these exercises can be done at home, in addition to being easy, cheap, simple and can be done routinely and independently.

Limitations

Limited research time results in a small number of samples members, so that they do not provide consistent results and are less diverse. The data validity level could be more optimal and describe the actual situation.

Conclusions

1. The average value of the Ankle Brachial Index in the intervention group before being given Buerger Allen Exercise and Walking Exercise was 0.8667 and after being given Buerger Allen Exercise and Walking Exercise increased to 0.9981. On the other hand, the average value of the Ankle Brachial Index in the control group before being given Prolanis activities was 0.8810 and after being given Prolanis activities became 0.9267.
2. There is a difference in the average value of the Ankle Brachial Index before and after being given Buerger Allen Exercise and Walking Exercise in the intervention group, which is 0.13143 with a p-value of 0.001 <0.05 and in the control group before and after being given Prolanis activities of 0.04571 with a p-value of 0.001 <0.05.
3. There is a difference in the average value of the Ankle Brachial Index between the intervention group after being given Buerger Allen Exercise and Walking Exercise and the control group after being given Prolanis activities, where the intervention group experienced a higher increase in the average value of the Ankle Brachial Index compared to the control group, as shown by the change in the average value of the Ankle Brachial Index in the intervention group of 0.9981, while in the control group it was only 0.9267, with a p-value of 0.001 <0.05.

Conflict of Interests

There is no conflict of interests to be declared by the researchers.

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