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Diabetic Foot Exercises as Physical Activity Therapy to Prevent Chronic Complications of Type II Diabetes Mellitus

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ABSTRACT

Background: Type 2 Diabetes Mellitus is still a global health problem. The incidence rate has statistically increased every year. The causes are excessive eating patterns and lack of physical activity, which cause blood glucose levels to be uncontrolled. Uncontrolled blood glucose levels, then chronic complications arise in patients with Type 2 DM, namely diabetic foot ulcers. Therefore, appropriate physical activity therapy is needed to prevent the early emergence of chronic complications of type 2 DM. The right therapy is diabetic foot exercise therapy.

Purpose: This study aims to determine the effect of diabetic foot exercise on preventing chronic complications of type 2 DM.

Methods: The research design employed is a rigorous pre-experimental design with a one-group pre-test and post-test design. The study population consisted of 20 type 2 diabetes mellitus patients registered at the Tempe Health Center, Wajo Regency. The study was meticulously conducted in the Tempe Health Center area, Wajo Regency, and data were analyzed using a paired sample t-test statistical test with a significant level (p-value <0.05).

Results: Diabetic foot exercise therapy is significantly related to changes in ABI values, Diabetic Foot Pain Scale, and GDS in patients with type 2 Diabetes Mellitus before and after therapy. (p-value <0.05).

Conclusion: From these findings, researchers concluded that regular diabetic foot exercise holds significant promise. It can effectively increase blood flow to the peripheral parts of the body, control blood glucose levels, and reduce foot pain. This underscores the potential of diabetic foot exercise as a proactive measure to prevent chronic complications of type 2 diabetes mellitus, instilling hope for improved patient outcomes.

Keywords: ankle brachial index, diabetic foot exercises, type 2 diabetes mellitus

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BACKGROUND

Type 2 diabetes mellitus is included in the group of multisystem diseases, non-communicable diseases, and metabolic diseases characterized by increased blood glucose levels caused not only because the body experiences impaired insulin secretion and insulin retention but also due to lack of physical activity(Faselis et al., 2020; Rothacker et al., 2021). Type 2 diabetes mellitus is still one of the leading health problems that are often encountered. The incidence rate statistically increases every year (Najafipour et al., 2021). According to the 2021 International Diabetes Federation (IDF) survey, it shows that the incidence of type 2 DM accompanied by chronic complications in the world for three consecutive years, namely in 2019 (463 million people), 2020 (470 million people), and 2021 (537 million people)(Sun et al., 2023). Then, in the next ten years, the number of Type 2 diabetes mellitus (DM) accompanied by chronic complications such as diabetic foot ulcers is projected to increase by more than 50% and is predicted to be the seventh leading cause of death in 2030(Zakiudin et al., 2022). There are around 4.2 million people who die from DM every year in the age range of 20-79 years with chronic (Linkeviciute-ulinskiene et al., 2020; Wolde, 2021).

One of the countries with the most significant number of Type 2 DM sufferers in the world is Indonesia(American Diabetes Association, 2023). The prevalence of DM in Indonesia has almost doubled compared to the previous year(Kementerian Kesehatan RI., 2020). The Ministry of Health evidences this in 2021 (537 million) and 2023 (13,470,556)(Das et al., 2023). One of the provinces in Indonesia with the highest incidence of type 2 DM is South Sulawesi. The prevalence of DM in the population of all ages in South Sulawesi Province is 1.83%, and the highest is in Wajo Regency, 9.27% (Kementerian Kesehatan RI., 2020). The prevalence of Type 2 DM in Wajo Regency increases every year in 2021 (1499 people), 2022 (1625 people), and 2023 (1948 people). (Das et al., 2023). The cause of the increasing incidence of type 2 Diabetes mellitus in Wajo Regency is related to an unhealthy lifestyle, such as excessive eating patterns and lack of physical activity so that blood glucose levels are not controlled. If blood glucose levels are not controlled and not treated early, chronic complications will arise in Type 2 DM patients, namely diabetic foot ulcers and peripheral blood circulation disorders(Primadhi et al., 2023). Diabetic foot ulcers, if not treated properly, will lead to amputation and can even cause death(Primadhi et al., 2023). Based on the results of a survey at Lamaddukelleng Hospital, Wajo Regency, 50% of type 2 DM patients per year experience diabetic foot ulcers, and 47% end in amputation and death. Every 30 seconds, a limb is amputated due to type 2 diabetes mellitus. Then, one person dies every 8 seconds, and almost half (46.2%) of deaths are at the age of 20-79 years. The cause is not getting early treatment. Therefore, proper physical activity therapy is needed to prevent the early emergence of chronic complications of type 2 DM.

One of the therapies to prevent the emergence of complications of type 2 Diabetes mellitus is diabetic foot exercise. This diabetic foot exercise is one type of sport, or a series of movements carried out systematically that can be applied to patients with diabetes mellitus(Faizah et al., 2021)(Yulendasari et al., 2020). Diabetic foot exercise aims to minimize and prevent complications of diabetic foot ulcers or tissue damage related to neurological disorders and various peripheral vascular diseases(Yulendasari et al., 2020)(Zakiudin et al., 2022). Diabetic foot exercise can also improve blood circulation and foot sensitivity and reduce blood glucose levels. Active muscle movements can increase contractions so that cell permeability to glucose increases, insulin resistance decreases, and insulin sensitivity increases(Zakiudin et al., 2022). Diabetic foot exercise can be done routinely daily in a sitting, standing, and sleeping position by moving the legs and leg joints. Diabetic foot exercises can also be done independently by patients. Doing diabetic foot

exercise can cause restoration of peripheral nerve function by inhibiting Aldose Reductase (RA), thereby increasing Nicotinamide Adenine Dinucleotide Phosphate Hydroxide (NADPH). Increased NADPH can increase the synthesis of Nitric Oxide (NO), where NO can eliminate hypoxia in peripheral nerves and restore nerve function in clients with peripheral neuropathy (Megawati et al., 2020).

Diabetic foot exercise is essential in improving the quality of life of type 2 diabetes mellitus sufferers, preventing complications, controlling blood glucose levels, reducing cardiovascular risk factors, improving well-being, and helping to lose weight (Widiawati et al., 2020). Exercise interventions are carried out for at least eight weeks to reduce HbA1c levels by 0.66% in type 2 diabetes mellitus sufferers(Fauziyah et al., 2020). Type 2 diabetes mellitus sufferers are advised to use their time by standing, walking, or doing other light activities. Diabetic foot exercise is straightforward, can be done indoors or outdoors, and does not take a long time, only about 15-30 minutes with a duration of three times a week, and the equipment used is not too complicated (chairs and newspaper sheets) (Haskas et al., 2023)
Based on the results of interviews with nurses at the Tempe Health Center in Wajo Regency, it was stated that the number of type 2 diabetes mellitus patients in March 2024 was 20 people. Then, no nurses have applied diabetic foot exercises to patients. Then, the effect of diabetic foot exercises on preventing chronic complications of type 2 Diabetes Mellitus has not been studied further, especially its effect on reducing blood glucose levels and leg pain. So, it is crucial to research and develop as an initial effort to prevent chronic complications of type 2 diabetes mellitus.

OBJECTIVE

This study aims to determine the effect of diabetic foot exercises on preventing chronic complications of type 2 DM.

METHODS

Research Design

This type of research is quantitative research using a pre-experimental design. Then, the research design uses one group: pre-test and post-test. This study only consists of one group, namely the treatment group. This type of research is carried out by observing the blood glucose levels, peripheral blood circulation, and pain scale in the feet of patients with type 2 diabetes mellitus before being given physical activity therapy, namely diabetic foot gymnastics. After that, physical activity therapy was given, namely diabetic foot gymnastics, and after treatment, blood glucose levels, peripheral blood circulation, and pain scale in the feet were measured again. The population in this study were all type 2 diabetes mellitus patients registered at the Tempe Health Center, Wajo Regency, totaling 20 patients. The sampling technique was simple random sampling based on the inclusion and exclusion criteria set in the study. The inclusion criteria were patients with type 2 diabetes mellitus who had been diagnosed by a doctor, aged 20-79 years, suffering from type 2 diabetes mellitus for at least 1-3 years, and willing to be respondents, while the exclusion criteria were patients who suffered from diabetic foot ulcers. These patients suffered from the risk of heart disease and respiratory disorders.

Time and setting

This study was conducted in the Tempe Health Center area of Wajo Regency and at the homes of each respondent if there were obstacles in coming to the Health Center. This study was conducted for two months.

Data Collection

The first movement is the movement of the toes of both feet. Second movement:

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lifting the tip of the foot, then lowering it back. Third movement: lifting the tip of the foot, then rotating the foot at the ankle to the side. Fourth movement: lifting both heels, then rotating them to the side. Fifth movement: Lift one knee, straighten the toes forward, and lower it back. Sixth movement: Straighten one leg on the floor, lift the foot, and move the tips of the fingers towards the face. Seventh movement: Lift both legs simultaneously. Eighth movement: Lift both legs and straighten them, then maintain the position and continue moving the toes. Ninth movement: Lift one leg, then write the numbers 0 to 9 with the tips of the fingers. Tenth movement: Put a piece of newspaper on the floor and then collect it into a ball using the feet. Eleventh movement: Flatten the newspaper again, tear it in the middle into two parts, and then tear one part into smaller pieces using the toes. Twelfth movement: The paper torn by the feet will be collected by both feet and then wrapped into a ball with both feet. Each movement is repeated ten times.

Research instruments

The tools and materials used in this research are:

1. Blood glucose measuring device "Nesco MultiChack"

Blood glucose levels were measured before and after treatment.

2. Blood pressure measuring device "Mercury sphygmomanometer and Stethoscope"
   a. Check the dorsalis pedis artery or posterior/anterior tibial artery using 3 fingers,then feel the strength of the patient's pulse.
   b. Place the cuff on the ankle properly and not too tight.
   c. Palpate the dorsalis pedis artery and pump the cuff rapidly to approximately 30 mmHg above the pulse pressure (last pulse disappears).
   d. Slowly lower the cuff pressure until you hear the first pulse sound, which is called the ankle systolic pressure.
   e. Performing a brachial artery systolic examination is like checking the systolic pressure at the ankle.
   f. Check the brachial artery using 3 fingers and feel the strength of the patient's pulse.
   g. Put the cuff on the arm and don't make it too tight or too loose.
   h. Position the patient's arm in a flexed position
   i. Palpate the brachial artery and pump the cuff rapidly to approximately 30 mmHg above the pulsatile pressure (pulse disappears)
3. Chairs used for respondents to sit on during diabetic foot exercises
4. Newspapers used for diabetic foot exercises

Data analysis

Univariate analysis was performed on each variable, and the study results were in the form of frequency distribution and percentage of each variable. Bivariate data tested using a paired t-test with a significance level of $p < 0.05$.

RESULTS

Univariate Analysis

Table 1. Respondent Characteristics

Variable	Diabetic Foot Exercises (n=20)
[a]**Age**	65.43± 4.07
[b]**Gender**	
Male	1 (5.0)
Female	19 (95.0)
[b] **Duration Suffering from Type II DM**	
1 Year	

2 Years	2 (10.0)
3 Years	4 (20.0)
	14 (70.0)
[b]**Daily activities**	
Cleaning the house	2 (10.0)
Farming	2 (10.0)
Gardening	2 (10.0)
Not exercising	14 (70.0)
[a]**Random blood sugar**	270.0 ± 28.84

n= Number of Samples
a=Variabel untuk data numerik (Mean±SD)
b=Variable for categorical data (n %)

Table 1. shows that the number of respondents in this study was 20 patients with type 2 diabetes mellitus, with an average age of 65 years, who were predominantly female. Respondents had diabetes mellitus for more than three years, and more were inactive, so their blood glucose levels were not controlled.

Bivariate Analysis

Table 2. Effect of Diabetic Foot Exercise on ABI Values, Diabetic Foot Pain Scale, and Random Blood Sugar in Type 2 Diabetes Mellitus Patients
Uji Paired T Test

Group	N	ABI value		Diabetic Foot Pain Scale		Random Blood Sugar	
		Mean± SD	*p-value*	*Mean*± SD	*p-value*	*Mean (mg/dl)*± SD	*p-value*
Diabetic Foot Exercise	20	0,77± 0,10		8,75± 0,87		263.0± 25.38	
Pre Test		1,27± 0,27	0,001	2,63± 1,98	0,001	110.0± 19,60	0.003
Post Test							

Table 2 shows that diabetic foot exercise therapy has a significant relationship to changes in ABI values, Diabetic Foot Pain Scale, and Random Blood Sugar in patients with type 2 Diabetes Mellitus before and after therapy. (p-value <0.05). The average ABI value after being given exercise (post-test) increased by 1.27 from the ABI value before exercise (pre-test), which was 0.77. For the diabetic foot pain scale, the average foot pain scale after exercise (post-test) experienced a decrease in the pain scale of 2.63 from the foot pain scale value before exercise (pre-test), which was 8.75. Then, the average Random Blood Sugar level after exercise (post-test) decreased by 110.0 mg/dL from the Random Blood Sugar level before exercise (pre-test), which was 263.0 mg/dL. Judging from the data, changes in ABI values and Random Blood Sugar levels after administering diabetic foot exercise therapy can improve peripheral blood circulation so that pain complaints from type 2 diabetes mellitus sufferers decrease. Thus, diabetic foot exercise can prevent chronic complications for type 2 diabetes mellitus sufferers.

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DISCUSSION

Respondent Characteristics

As we age, the body experiences a physical decline, such as a decline in the central nervous system, which means fewer neurons, less blood flow, less brain mass, less synaptic function, changes in neurotransmitter activity, and less glucose, experiencing a decrease in oxygen levels (Lestari, 2019). One of the common diseases that people suffer from as they age is diabetes, which is caused by the ability of pancreatic beta cells to produce insulin decreasing with the aging process. This is evidenced by the results of this study, which show that the average respondent who experienced type 2 diabetes mellitus was 65 years old. Previous research also showed that the elderly with an age who have a higher risk of developing type 2 DM, namely 60-75, are higher than the elderly aged 76-90 years(Rosita et al., 2022). Diabetes usually starts at the age of 30 years and is even more vulnerable when entering the age of 40 years. As we age, the risk of glucose intolerance problems also increases, with risks ranging from 50 to 92% (Ratnawati et al., 2019). This study found that blood glucose levels in type 2 diabetes mellitus sufferers were above normal limits.

Based on the 2018 Basic Health Survey, women (1.8%) are more likely than men (1.2%) to suffer from diabetes in Indonesia. Although the overall prevalence between women and men is the same, risk factors indicate that women have a higher risk of developing diabetes. They were physically caused by a significant increase in women's body mass index. In addition, in premenstrual syndrome and after menopause, body fat tends to accumulate due to the influence of female hormones, increasing the risk of developing type 2 diabetes(Rosita et al., 2022). The results of the study show that based on gender, women are more likely to suffer from type 2 diabetes, with a total of 19 people (95%), while men are one person with a percentage (5%). How long they have type 2 diabetes may affect their quality of life. Previous research has shown this in humans. People who have had type 2 diabetes for more than three years. Lower quality of life compared to patients with type 2 diabetes mellitus before the age of 3 years. As the disease progresses, quality of life may decrease due to restrictions on daily activities (Sulistiani & Rahim, 2023). The results of the study showed the duration of suffering from Type 2 DM in most respondents was three years, as many as 14 (70.0%)

In addition to age, another factor that contributes to the occurrence of type 2 diabetes in respondents is lack of physical activity. Lack of physical activity will impact weight gain, insulin resistance, and impaired glucose metabolism. Moderate physical activity helps control weight, increases insulin sensitivity, and regulates blood sugar levels. In addition, this lack of physical activity can affect blood circulation and abnormal ABI (ankle-brachial index) values in people with type 2 diabetes mellitus. Sufficient physical activity helps maintain healthy blood vessels, including in the legs. When physical activity is lacking, the risk of blood vessel blockage increases so that it can interfere with blood circulation, including in the leg area. Abnormally of ABI values indicate problems with blood circulation in the legs and hands. So, maintaining sufficient physical activity is essential to prevent complications of type 2 diabetes mellitus and maintain healthy blood circulation, blood glucose levels, and ABI values(Ningrum, 2023). The study results obtained data on the daily activities of respondents, but the most common activities were not sports activities.

The Effect of Diabetic Foot Exercises on ABI Values, Diabetic Foot Pain Scale, and Random Blood Sugar Levels in Type 2 Diabetes Mellitus Patients

Foot exercises for people with diabetes are a great way to improve blood circulation, especially in the legs. Circulation is the movement of blood pumped by the heart throughout the body, including the legs. Circulatory disorders in the legs can be influenced by three main

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factors, namely blood viscosity, length, and diameter of blood vessels. Abnormal blood viscosity can limit blood flow to the body and reduce blood flow to body tissues. The most significant decrease in blood flow usually occurs in the extremities or legs. If this condition continues for a long time, diabetic patients can experience chronic complications such as gangrene. Gangrene occurs when the blood supply is decreased, causing the tissue not to get enough nutrients and oxygen. Therefore, therapy is needed to improve blood circulation or normalize ABI value and blood glucose levels in type 2 diabetics; physical activity such as foot exercises is the solution. This sport is included in the aerobic exercise category, meaning that the movements meet the required standards, such as continuous, rhythmic, interactive, progressive, and continuous movements requiring careful implementation at each step. The recommended foot exercises for diabetic patients are aerobic exercises that require oxygen and can improve circulation. In addition, this exercise strengthens the small muscles of the legs, prevents foot disorders that can increase the risk of diabetes feet, and increases insulin production used to transport glucose into cells. In addition to losing weight, leg exercises also relax the body and improve blood circulation (Riska, 2019).

According to research conducted in Tempe District, up to 80% of respondents' blood circulation was included in the category of non-compression or abnormal arteries before doing diabetic feet; it turned out that only 20% had average arterial blood circulation. After doing foot exercises, 100% of respondents' peripheral blood flow was within normal limits. The research showed that exercise performed by diabetic patients three times a week can improve blood circulation, as indicated by the ankle-upper arm index (ABI) value. These results are supported by the statistical test "Sample T-test with correspondence" and a ρ value of 0.000 <0.05, so it can be concluded that after being given foot exercises, the elderly's blood circulation becomes stable, which means this exercise is effective.

These results align with previous studies showing that leg exercises three times a week can increase peripheral blood flow as measured by the ankle-brachial index (ABI) value in diabetic patients (Riska, 2019).Through statistical testing using the Wilcoxon test, these results were proven to have a ρ value of 0.001 <0.05, so it can be said that there is a significant effect on the pre-and post-test results in the diabetic foot treatment group. In addition, in the study (Prihatin & Dwi, 2019), the p-value obtained when examining the ABI value before and after leg exercises was 0.001 <0.05, so it can be concluded that it is acceptable. This means leg exercises affect changes in the ankle-brachial index value in type 2 diabetes patients at the Vergas Health Center, Semarang Regency. However, a study (Salihun et al., 2022) disagrees with the study, namely that Burger Allen exercise therapy (BAE) is more effective in increasing ABI values. Through statistical testing using the Wilcoxon test, the results were proven to have a ρ value of 0.001 <0.05, so it can be said that there is a significant effect on the pre-and post-test results in the diabetic foot treatment group.

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The results showed a ρ value of less than 0.05, indicating that participants who did diabetic foot exercises thrice a week experienced increased blood flow to the extremities, decreased blood glucose levels, and leg pain scales. From these findings, researchers concluded that regular diabetic foot exercises can effectively increase blood flow to the peripheral parts of the body. Increased blood flow to this area affects the Ankle Brachial Index (ABI) value. It can also lower blood glucose levels and reduce leg pain and stiffness, helping participants perform better in athletic activities.

CONCLUSION

From these findings, researchers concluded that regular diabetic foot exercises can effectively increase blood flow to the body's peripheral parts, control blood glucose levels, and reduce the scale of pain in the feet. This means that Diabetic foot exercises has the effect of on preventing chronic complications of type 2 DM. Hope, Diabetic Foot Exercises can be applied every day to get more effective results.

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CONFLICTS OF INTEREST

Nothing

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