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Original Research Article

THE EFFECT OF FOOT EXERCISE ON LOWER EXTREMITY SENSORY NEUROPATHY STATUS AND BLOOD GLUCOSE LEVELS PATIENTS TYPE 2 DIABETES MELLITUS

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ABSTRACT

Introduction. The increasing prevalence of type 2 diabetes mellitus in developed and developing countries has become a global health problem or disease in society. Therefore, Type 2 Diabetes Mellitus can be prevented with regular exercise, healthy and regular life. The purpose of this study was to determine the effect of foot exercise on the status of lower extremity sensory neuropathy and changes in blood glucose levels in patients with type 2 diabetes mellitus at Tanjunganom Public Health Center, Nganjuk Regency. **Method**. The design in this study was pre-experimental with a one group pre-posttest design approach, this study sought the effect of foot exercise on the status of lower extremity sensory neuropathy and changes in blood glucose levels in patients with type 2 diabetes mellitus at Tanjunganom Public Health Center, Nganjuk Regency, in this study involved 30 respondents with purposive sampling technique. This research was conducted on October 14-21, 2022. **Result&Analysis**. From the results of the Wilcoxon test, it was found that after doing foot exercises, the sensory neuropathy status of the lower extremities in the right extremity was obtained value = 0.000<0.05, besides that after doing leg exercises, changes in blood glucose levels were obtained value = 0.000<0.05 this indicates that there was an effect of foot exercise on the sensory neuropathy status of the lower extremities and changes in blood glucose levels in people with diabetes mellitus 2. **Discussion**. Patients with type 2 Diabetes Mellitus can applicate foot exercises to change lower extremity sensory status and blood glucose level.

Keywords: Foot Exercise, Lower Extremity Sensory Neuropathy, Diabetes Mellitus.

INTRODUCTION

Diabetes mellitus has a very large incidence, as revealed by the International of Diabetic Federation (IDF, 2015) which explains that the global prevalence rate of DM sufferers in 2014 was 8.3% of the total population in the world, so diabetes mellitus requires attention. Especially because in the long term it will lead to complications, one of which is neuropathy. Neuropathy is the most common complication experienced by people with Diabetes Mellitus (DM). Neuropathy refers to a group of diseases that attack all types of nerves in the body, including sensory, motor, and autonomic nerves and are often found in the

peripheral parts of the body or known as Diabetic Peripheral Neuropathy (DPN) (Smeltzer and Bare, 2013).

Neuropathy occurs based on risk factors including age, complications of diabetes mellitus with neuropathy can attack the elderly which can be caused by degenerative factors, namely the decreasing function of the human body, especially the ability of pancreatic cells to produce insulin (Smeltzer and Bare, 2013). Complications of neuropathy can result in disturbances in the feet of people with diabetes mellitus ranging from a foot or leg injuries to the possibility of amputation of the foot or leg. Sensory (peripheral) neuropathy with initial symptoms are paresthesia's (pins and needles, tingling), burning, numbness of the feet (patirasa) (Smeltzer and Bare, 2013). The longer a person has diabetes mellitus, the greater the incidence of diabetic neuropathy is found. Lack of sports activities such as physical activity in daily activities can also worsen the situation and cause complications because fat in the body blocks the passage of insulin, thereby increasing the possibility of complications of diabetic neuropathy (Sari, 2012). The increase in glucose levels over the years has implications for the etiology of neuropathy. The average diabetic neuropathy has suffered from diabetes mellitus for 10 years (Purwanti, 2013).

Foot self-care or foot care has a positive and important role for DM sufferers as a support for controlling the causes of NPS (Neuropathic Pain Scale) through DM progression, foot care can also prevent the occurrence of more severe DM complications such as peripheral neuropathy (Sutejo, Prasetyaningati and Rahmawati, 2018). Peripheral neuropathy can cause foot deformities and antipathy, this occurs because there is a decrease in blood circulation to peripheral perfusion. Peripheral neuropathy can be treated with several treatments that can be done by DM sufferers such as foot care or foot self-care (cleaning feet, choosing footwear for DM patients, adjusting diet, pharmacological therapy) and foot exercises (Wahyuni, 2016). Peripheral neuropathy can be treated with other treatments by applying foot self care with foot exercises which can improve blood circulation in the legs and improve the strength of the small muscles of the feet to reduce the occurrence of abnormal foot shapes, reduce pain, reduce nerve damage and control blood glucose (Werfalli *et al.*, 2018 ; Black and Hawks, 2013). Foot exercises can be applied to people with diabetes because it is easier for people with diabetes mellitus to do it

independently, foot exercises do not cost money and foot exercises can be an activity in their spare time (Damayanti and Kurniawan, 2014). Foot care in DM patients needs to be improved and carried out.

METHOD AND ANALYSIS

The design in this study is pre-experimental with a one group pre-posttest design approach, which is a research design used to reveal causal relationships by involving one group of research subjects. Subjects were observed before the intervention, then the intervention was carried out and observed again after the intervention. In this study, trying to explore how the effect of foot exercise on the status of lower extremity sensory neuropathy and changes in blood glucose levels in patients with type 2 diabetes mellitus at Tanjunganom Health Center, Nganjuk Regency, in this study involved 30 respondents with purposive sampling technique. This research was conducted on October 14-21, 2022 in patients with type 2 diabetes mellitus at the Tanjunganom Health Center, Nganjuk Regency.

The independent variable or independent variable in this study is foot exercise, while the dependent variable or dependent variable in this study is lower extremity sensory neuropathy and changes in blood glucose levels in patients with type 2 diabetes. Statistical test using Wilcoxon with output significance <0.05 and the correlation coefficient.

RESULTS

1. Effect of foot exercise on lower extremity sensory neuropathy status in patients with type 2 diabetes mellitus at Tanjunganom Public Health Center, Nganjuk Regency.

Table 1. Analysis of the Effect of Foot Gymnastics on Lower Extremity Sensory Neuropathy Status in Type 2 Diabetes Mellitus Patients

Neuro-pathy Value	Pre Right		Post Right		Pre Left		Post Left	
	F	%	F	%	F	%	F	%
1/10	0	0	0	0	0	0	0	0
2/10	1	3	0	0	1	3	0	0
3/10	2	7	0	0	2	7	0	0
4/10	1	3	0	0	0	0	0	0
5/10	10	33	0	0	11	37	0	0
6/10	11	37	0	0	10	33	0	0
7/10	4	13	2	7	5	17	0	0
8/10	1	3	6	20	1	3	1	3
9/10	0	0	14	47	0	0	18	60
10/10	0	0	8	27	0	0	11	37
Total	30	100	30	100	30	100	30	100
Wilcoxon test *ρ value* = 0.000					Wilcoxon test *ρ value* = 0.000			

Based on the results of the study in table 1, it was found that the value of lower extremity sensory neuropathy status in patients with type 2 diabetes mellitus at Tanjunganom Health Center Nganjuk Regency before foot exercise was carried out on the right extremity of 10 points where the neuropathy status examination

was almost half, namely 11 respondents (37%) with a value of 6/10, while in the lower left extremity almost half of them are 11 respondents (37%) with a score of 5/10.

Based on table 1, the value of lower extremity sensory neuropathy status in patients with type 2 diabetes mellitus at the Tanjunganom Health Center, Nganjuk Regency after foot exercise on the right extremity of 10 points where the neuropathy status examination was carried out was almost half that of 14 respondents (47%) with a value of 9/10 , while in the lower left extremity most of them were 18 respondents (60%) with a score of 9/10

Based on table 1, it shows that the Wilcoxon statistical test results were obtained after foot exercise with lower extremity sensory neuropathy status in the right extremity obtained value = 0.000 0.05 so that Ho was rejected and Ha was accepted, while in the left extremity value = 0.000 0.05 so that Ho is rejected and Ha is accepted.

2. The effect of foot exercise on changes in blood glucose levels in patients with type 2 diabetes mellitus at the Tanjunganom Health Center, Nganjuk Regency.

Based on table 2, it was found that the value of blood glucose levels in people with type 2 diabetes mellitus before the foot exercise was carried out, showed that a total of 30 respondents had an average blood glucose level of 254 mg/dl. After the foot exercise showed that 30 respondents had an average blood glucose level of 171 mg/dl.

Table 2. Analysis of the Effect of Foot Exercise on Changes in Blood Glucose Levels in Type 2 Diabetes Mellitus Patients

No. Respondent	Measurement Results Before Performing Foot Gymnastics (mg/dl)	Measurement Results After Performing Foot Gymnastics (mg/dl)
1	350	150
2	250	200
3	300	250
4	300	230
5	240	190
6	250	185
7	300	150
8	270	210
9	260	150
10	200	150
11	280	130
12	287	140
13	320	145
14	330	167
15	254	174
16	150	120
17	460	110
18	365	136
19	357	250
20	300	168
21	358	178
22	327	156
23	430	145
24	340	167
25	260	210
26	200	150
27	280	160
28	287	170
29	320	185
30	330	190
Total Respondents = 30	Average = 254	Average 171

Wilcoxon test *ρ value* = 0.000

Based on table 2, it shows that the Wilcoxon statistical test showed that after doing leg exercises, changes in blood

glucose levels were obtained value = 0.000<0.05 so Ho was rejected and Ha was accepted.

DISCUSSIONS

1. Value of Lower Extremity Sensory Neuropathy Status in patients with type 2 diabetes mellitus at Tanjunganom Public Health Center, Nganjuk Regency, before doing foot exercises.

Based on the results of the study in table 1, it was found that the value of lower extremity sensory neuropathy status in patients with type 2 diabetes mellitus at Tanjunganom Health Center Nganjuk Regency before foot exercise was carried out on the right extremity of 10 points where the neuropathy status examination was almost half, namely 11 respondents (37%) with a value of 6/10, while in the lower left extremity almost half of them are 11 respondents (37%) with a score of 5/10.

Lower extremity neuropathy is a common consequence of Type 1 and Type 2 diabetes mellitus and chronic hyperglycemia involving vascular or metabolic disorders. There are three main ways in which diabetes is thought to damage peripheral nerves. First, neural tissue does not require insulin for glucose transport and instead uses an alternative metabolic polyol pathway for glucose metabolism. Glucose is converted to Sorbitol, and in turn, sorbitol is very slowly converted to fructose. Glucose buildup from chronic hyperglycemia combined with a very slow rate of conversion from sorbitol to fructose results in the accumulation of sorbitol in peripheral nerves. The increase in sorbitol causes disruption of the ion pump by generating osmotic pressure by Fig in the fluid. This reduces nitric oxide and causes an increase in molecular reactive oxygen and an increase in oxidative stress. This element damages Schwann cells and causes disruption of nerve conduction. Second, protein C kinase is inappropriately activated because of hyperglycemia, which may also contribute to neurologic complications. Protein C kinase is an intracellular signaling molecule that regulates many vascular functions; Levels are elevated in diabetes. Activation of this protein C kinase in vascular nerves can cause vascular damage and decrease nerve conduction. Third, advanced glycosylation products (AGEs) are the result of the binding of glucose metabolites to proteins. Although it is a normal component of protein, basement membranes in smaller blood vessels, uncontrolled blood glucose levels favor the overproduction of AGEs. The increase in AGEs causes thickening of the basement membrane, contributing to a

reduced oxygen supply. Because neuronal dysfunction is closely related to vascular abnormalities and nerve damage due to AGE. Additional microvascular damage includes protein trapping (including LDL), nitric oxide inactivation, and loss of vasodilation due to accumulation of sorbitol and polyol pathways, activation of protein C kinase, and excess accumulation of AGEs all contribute to nerve damage through degeneration of myelin, causing nerves to lose their ability to transmit signals.

Lower extremity neuropathy occurs when nerves are damaged enough to cause decreased or absent nerve transmission with a number of possible symptoms including numbness, pain, or tingling. The presence of lower extremity neuropathy will cause loss or decrease in the sensation of pain in the feet so that they will experience trauma without feeling which results in ulcers on the feet. The clinical manifestations of diabetic neuropathy depend on the type of nerve fibers involved in the lesion. Considering that the nerve fibers affected by the lesion can be small or large, proximal or distal location, focal or diffuse, motor or sensory or autonomic, the clinical manifestations vary including: tingling, numbness, numbness, burning like tearing (Smeltzer and Bare, 2013)

Based on the description above, the researcher believes that there is an incidence of lower extremity sensory neuropathy in people with type 2 diabetes mellitus; diabetic neuropathy is associated with problems with blood supply to the feet, which can cause foot ulcers and slow wound healing. This infection can result in wound amputation, all lower extremity amputations are caused by diabetes mellitus. The management of diabetes mellitus consists of pharmacological therapy, which includes oral anti-diabetic drugs and insulin injection. The two non-pharmacological therapies include lifestyle changes by adjusting eating patterns known as medical nutrition therapy, increasing physical activity, and educating various problems related to diabetes mellitus, which are carried out continuously.

According to researchers, getting information about foot exercise and education has a role in the incidence of diabetic neuropathy in patients with Type 2 DM at the Tanjunganom Health Center, Nganjuk Regency. Education is a factor, which can affect the level of knowledge of respondents about self-care management and how to capture any information conveyed by the media and other people. This is in accordance with the results of research conducted by (Widyasari, 2017) showing that there is a relationship

between the last education and a person's diabetes status. Lack of knowledge about foot exercises, if foot exercises are not carried out regularly can cause diabetic neuropathy problems.

2. Value of Lower Extremity Sensory Neuropathy Status in Type 2 Diabetes Mellitus Patients at Tanjunganom Public Health Center, Nganjuk Regency, after doing foot exercises.

Based on table 2, the value of lower extremity sensory neuropathy status in patients with type 2 diabetes mellitus at the Tanjunganom Health Center, Nganjuk Regency after foot exercise on the right extremity of 10 points where the neuropathy status examination was carried out was almost half that of 14 respondents (47%) with a value of 9/10 , while in the lower left extremity most of them were 18 respondents (60%) with a score of 9/10.

The decrease in lower extremity sensory neuropathy after doing this foot exercise occurs because foot exercises can improve the nerves in the feet aiming to accelerate blood flow to the periphery and train the leg muscles of people with Type 2 DM so that there is no immediate lower extremity neuropathy problem. treated will lead to problems such as amputation. According to researcher Samendawai, (2013) in Novita, Nawangsari and Yosdimyati (2019), explained that foot exercise can show the development of effectiveness in both lower extremity sensory neuropathy in Type 2 DM patients before and after giving foot exercises.

Foot exercise can reduce the value of neuropathic disorders because it can improve blood flow to the periphery, increase the strength of the leg muscles, and improve sensory, motor, and autonomic functions. Leg exercises has 10 movements that aim to improve blood circulation in the legs, strengthen leg muscles, prevent foot deformities, increase calf and ankle muscles, increase joint motion and prevent injuries. Leg exercises movements are very easy and do not require a long time, can be done sitting. Foot exercise can improve vascularization in the feet more smoothly to prevent complications of neuropathy in the feet, which can prevent amputation and diabetic foot in type 2 diabetes mellitus. regularly can reduce foot disorders in people with type 2 diabetes mellitus by 50-60% which can affect the quality of life (Wardhani, 2021).

Based on this description, the researcher argues that there is a change between before doing foot exercises and after doing foot exercises because in diabetics, increased blood glucose in the long term will cause nerve disorders called neuropathy and blood vessel disorders. This situation results in

decreased sense of painful stimuli, changes in motor strength resulting in changes in foot pressure. One of the goals of doing diabetic foot exercises is to facilitate blood circulation, especially peripheral blood circulation, so that by doing foot exercises, blood circulation to the periphery will be smooth and reduce the risk of neuropathy.

3. The effect of foot exercise on the status of lower extremity sensory neuropathy in patients with type 2 diabetes mellitus at the Tanjunganom Public Health Center, Nganjuk Regency.

Based on the results of research conducted at the Tanjunganom Health Center, Nganjuk Regency with the provision of foot exercise therapy as much as 2 meetings for 2 weeks, it was found that almost all respondents experienced a decrease in lower extremity sensory neuropathy.

Based on table 5 shows that the Wilcoxon statistical test results were obtained after foot exercise with lower extremity sensory neuropathy status in the right extremity obtained value = 0.000<0.05 so that Ho was rejected and Ha was accepted, while in the left extremity value = 0.000<0.05 so that Ho is rejected and Ha is accepted.

The theory conveyed by Guyton & Hall, (2008) exercises in leg exercises, there is movement in the legs, which results in stretching of the leg muscles, and compressing the veins around the muscles, this will push blood towards the heart and venous pressure will decrease, this mechanism is known as with a "venous pump". This mechanism will help improve blood circulation in the legs, improve blood circulation, strengthen small muscles, prevent foot deformities, increase calf and thigh muscle strength, and overcome joint limitations. Smooth blood circulation will inhibit the demyelination process or the tearing process of the myelin sheath on the neurons which will damage the axons, if the neuron cells are in good condition then the impulse transmission process in the sensation, motor and autonomic receptor cells will also provide adequate protection.

Foot exercise is included in the management of foot care, where based on the information and evidence above, it can be concluded that foot exercise can reduce the state of lower extremity sensory neuropathy in Type 2 DM Patients. The above theory is in accordance with the reality in the lower extremity sensory neuropathy field in Patients with Type 2 DM can be prevented by doing regular foot exercises. Foot exercise that is not done regularly will be at risk of experiencing lower extremity sensory

neuropathy which can cause problems in the feet of people with Type 2 DM, namely dry skin, tingling, unable to feel sensitivity when the soles of the feet are touched and muscle stiffness which is at risk for diabetic foot problems.

4. The effect of foot exercise on changes in blood glucose levels in patients with type 2 diabetes mellitus at Tanjunganom Public Health Center, Nganjuk Regency

Based on table 6 shows that the Wilcoxon statistical test showed that after doing leg exercises, changes in blood glucose levels were obtained value = 0.000<0.05 so Ho was rejected and Ha was accepted.

The results of the research conducted by researchers showed changes in blood glucose levels before and after the foot exercise intervention was given. Researchers provide exercise intervention 2x in two weeks. The results of these differences were obtained from the results of observation sheets carried out on patients with diabetes mellitus and then analyzed using statistical tests, so that there were differences in blood glucose levels before and after the foot exercise intervention was given, namely before the intervention with an average value of 254 mg/dl and a value after the average value of the intervention was 171 mg/dl, so there was a decrease in the average value of 83 mg/dl. These changes indicate that foot exercise has an effect on blood glucose levels in people with diabetes mellitus.

This research is in line with research conducted by Damayanti and Kurniawan (2014), when physical activity (exercise) insulin resistance decreases, when a person does physical exercise, the body will increase the body's fuel needs by active muscles and complex body reactions occur. It includes the functions of circulation, metabolism, and the autonomic nervous system. Where glucose is stored in the muscles and liver as glycogen, glycogen is quickly accessed to be used as an energy source in physical exercise, especially at some or the beginning of physical exercise starting after 10 minutes of physical exercise, there will be an increase in glucose 15 times in usual needs. After 60 minutes, it will increase to 35 times (Damayanti and Kurniawan, 2014).

If the exercise continues for more than 30 minutes, the main energy source becomes free fatty acids derived from lipolysis of adipose tissue. Various hormones, especially insulin, as well as catecholamine’s, cortisol, glucagon, and growth hormone (GH), regulate the availability of glucose and free fatty acids. During physical exercise, the secretion of

glucagon increases, as well as catecholamine's to increase glikogenolisis, but also cortisol which increases protein catabolism, releasing amino acids that are used in gluconeogenesis. All of these mechanisms lead to increased blood glucose levels. In type 2 diabetes, physical exercise plays a major role in regulating blood glucose levels. The main problem in type 2 diabetes is the lack of response to insulin (insulin resistance). The presence of these disorders causes insulin cannot help transfer glucose into cells. Membrane permeability increases in contracting muscles so that during physical exercise insulin resistance decreases while insulin sensitivity increases. Regular physical exercise can improve the regulation of blood glucose levels and cells (Damayanti and Kurniawan, 2014).

The discussion above can be concluded that foot exercise on changes in blood glucose levels in patients with diabetes mellitus has a significant effect on changes in blood glucose levels in patients with diabetes mellitus.

CONCLUSION

From the research it can be concluded that the value of the lower extremity sensory neuropathy status in patients with type 2 diabetes mellitus at the Tanjunganom Health Center, Nganjuk Regency, before doing foot exercises on the extremities. almost half of the 10 points that were examined for neuropathic status were 11 respondents (37%) with a score of 6/10, in addition, after doing leg exercises on the right extremity of the 10 points that were examined for neuropathy status almost half were 14 respondents (47%) with a value of 9/10, while the lower left extremity was mostly 18 respondents (60%) with a score of 9/10, while in the lower left extremity almost half were 11 respondents (37%) with a score of 5/10. In addition, the value of blood glucose levels in patients with type 2 diabetes mellitus at the Tanjunganom Health Center, Nganjuk Regency after the foot exercise showed that 30 respondents had an average blood glucose level of 171 mg/dl.

It is recommended for people with type 2 diabetes mellitus to do foot exercises to determine the status of lower extremity sensory neuropathy and changes in blood glucose levels.

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