



The Effectiveness of Diabetic Foot Gymnastics with Newspaper and Thorn Ball Media to Increase Foot Sensitivity in Type II Diabetes Mellitus Patients

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Abstract

Diabetes Mellitus (DM) is a metabolic disorder in the body that occurs due to insulin function insufficiency resulting in high blood sugar levels. One of the complications of DM that is often experienced is neuropathy syndrome in the form of symptoms of peripheral nerve dysfunction which can affect foot sensitivity. Management of DM, namely physical activity in the form of leg exercises, can increase blood circulation, strengthen small muscles, thigh and calf muscles and reduce limitations in joint movement. The aim is to analyze the effectiveness of diabetes foot exercises using newspaper and thorn ball media to increase foot sensitivity in type II diabetes mellitus (DM) patients. Random Control Trial with pre post design involving 48 respondents in 3 intervention groups. Statistical analysis using *Wilcoxon test* with a 5% confidence interval using newspaper media obtained mark *p value* 0.013 and thorn ball media with value *p value* 0,029. *Mann-Whitney test* Newspaper foot exercises with values *p value* 0.008 and thorn ball media with value *p value* 0.012 is less than 0.05. In conclusion is DM foot exercises using newspapers and thorn balls are effective in increasing the sensitivity of the feet of patients with Diabetes Mellitus.

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INTRODUCTION

Diabetes Melitus (DM) occurs due to disruption of lipid, carbohydrate and protein metabolic processes where glucose levels in the blood tend to increase due to damage to beta cell synthesis in the pancreas in producing insulin so that it is unable to utilize insulin properly (Grossman, S.C & Porth, C.M., 2014). The prevalence of DM cases continues to increase every year. This increase is driven by factors such as population aging, economic development and increasing urbanization, leading to a sedentary lifestyle and increased consumption of unhealthy foods and obesity (Basu S, et al, 2013). Quoting the report *International Diabetes Federation* (2021) that the prevalence of Diabetes Mellitus is 9.3% and affects 463 million adults aged 20 – 79 years throughout the world and it is estimated that the figure will continue to increase to 700 million in 2045. Meanwhile 4.2 million deaths occurred. due to cases of Diabetes Mellitus (Pouya, et al 2020). According to 2018 RI Riskesdas data, the Indonesian population aged 20-79 years is in the 3rd highest position with an incidence rate of 11.3%. Apart from that, it is also in 7th place out of 10 countries with cases of Diabetes Mellitus amounting to 10.7 million people. According to data sources from the Semarang City Health Service, in 2021, the number of DM sufferers in Semarang City is 147,734 people, where DM cases are spread across several health centers in Semarang City.

Uncontrolled Diabetes Mellitus (DM) can often damage organs without the patient feeling it. Complications from DM disease consists of metabolic complications and long-term vascular complications, namely micrangiopathy and macrangiopathy which can occur if DM disease is not managed properly (Eraydin, 2018). The most serious complications of Diabetes Mellitus involving foot health are neuropathy and foot ulcers (Mariam et al, 2017). There are symptoms of tom and/or signs of peripheral nerve dysfunction in diabetes sufferers and this is one of the most common complications (Hicks CW, 2015). Type 2 DM causes chronic complications in the form of macrovascular and microvascular complications that can reduce the quality of life of sufferers. Macrovascular complications are the

main cause of death, although microvascular complications are more prevalent. Research results show that type 2 DM patients have chronic macrovascular complications (66.5%) and microvascular (81.7%), while the most common chronic complication is diabetic nephropathy (42.6%) in women <60 years (Edwina et al., 2015).

One of the pillars of Diabetes Mellitus management that needs to be pursued is physical activity according to each individual's abilities. To stimulate foot sensitivity, physical activity in the form of foot exercises is useful for preventing the formation of wounds and improving blood circulation, especially in the foot area in people with diabetes mellitus (Hardika, 2018). Apart from that, diabetic foot exercises can be an effective program because they help reduce symptoms of neuropathy, although it is not statistically significant Graciella & Prabawati (2020).

Interviews with 10 patients with diabetes mellitus and neuropathy at Bulu Lor Community Health Center revealed that 7 patients complained of frequent tingling, numbness, and cramps in their feet, and 3 patients stated that their feet often felt painful, thus disrupting daily activities. Based on the description above, researchers were interested in conducting foot exercise interventions using newspapers and spiked balls to see the effectiveness of these foot exercises on foot sensitivity in patients with type 2 diabetes mellitus.

METHOD

This research design is quantitative experimental ie *Randomised Controlled Trials* (RCT) with pre-post test design namely measuring before and after the intervention (Murti, 2020). The research was conducted at the Bulu Lor Health Center Semarang in November 2023. The intervention in this study involved 48 respondents who were obtained using the formula *Lamshow*. Samples were taken randomly (*random*) using a lottery which was divided into 2 treatment groups, namely a foot exercise group using newspaper media and a foot exercise group using thorn balls as media, as well as 1 control group. The inclusion criteria were set

for all DM patients with symptoms of neuropathy at any age and regardless of how long they had suffered from Diabetes Mellitus and the exclusion criteria set were DM patients who had foot wounds.

Foot sensitivity when pre and post test was measured using a 10 g Monofilament instrument in the form of a ball of thorny algae attached to nylon *monofilamen*, so that you can detect any sensory abnormalities affecting the nerve fibers (Amstrong D, 2012). Monofilament complies with standards released in 2011 by *British Columbia Provincial Nursing Skin and Wound Commite*. Before the intervention, respondents had foot sensitivity measured (pre test) then foot exercises using newspaper media and thorn ball media were carried out for 6 consecutive days and on the 7th day, foot sensitivity was measured again. (post test). Data normality test using *Kolmogorov-Smirnov* and data analysis using non-parametric statistical *Wilcoxon test* and *Mann Whitney test* with 5% sensitivity.

RESULTS AND DISCUSSIONS

Table 1. Respondent Characteristics

	N	%	Comulative (%)
Age			
36 – 45	12	25	25
46-55	30	62.5	87.5
56 – 60	6	12.5	12.5
Gender			
Man	19	39.6	39.6
Woman	29	60.4	100.0
Level of Education			
Elementary School	1	2.1	6.3
Junior High School	1	2.1	100.0
Senior High School	44	91.7	97.9
Diploma	1	2.1	2.1
Bachelor	1	2.1	4.2
Work			
Trader	6	12.5	12.5
House Hold	1	2.1	14.6
Government employees	1	2.1	16.7
Private employees	40	83.3	100.0

The intervention for the 48 respondents who took part in the intervention from the beginning to the end of the study, in terms of age, was mostly in the 46-55 years range, with 30 respondents (62.5%). The gender of the respondents was 19 male respondents (39.6%), and there were 29 female respondents (60.4%). The level of education was dominated by high school level with 44 respondents (91.7%) and the occupation of the largest number of respondents was in the private sector with 40 respondents (83.3%).

The data normality test was carried out to see whether the dependent and independent variables in this research process were normally distributed or not. In this research using *Kolmogorov-Smirnov Test* because the number of respondents was more than 30 people so we could draw direct conclusions that the data is normally distributed or not.

From the normality test, the *Asymp.Sig* value was obtained. (2-tailed) *p value* <0.001 <0.05 or 5% means the residual data is not normally distributed. The next statistical test is used to determine the effect is a *Wilcoxon test* and test what is used to determine effectiveness is the *Mann-Withney test*.

The statistical test results used the *Wilcoxon test* on foot exercises for newspaper media (pre and post) with statistical analysis results, a significant *p value* of 0.013 <0.05 while for the thorn ball media (pre-post) the results were significant *p value* 0.029 <0.05.

Based on the *Mann-Witney statistical test*, the z count for post-intervention patients with newspaper media was -2652 with a significance *p value* of 0.008. This value is <0.05 so that the decision-making criterion H0 is rejected, which means there is increased effectiveness. Meanwhile, the z count post intervention for the thorn ball media was -2508 with a significant *p value* of 0.012 where this value was also <0.05 so that the decision-making criterion H0 was rejected, which means there was effectiveness in increasing foot sensitivity. If we look at the *p value* between newspaper media and thorn ball media, foot exercise intervention with newspaper media is more effective with a *p value* of 0.008 <0.05 than thorn ball media in increasing foot sensitivity in Type 2 Diabetes Mellitus patients.

Table 2. Normality Test

		Pre Intervention data	Post intervention data	Pre intervention control data	Post intervention controldata
N		48	48	48	48
Normal Parameters ^{a,b}	Mean	1.77	3.52	1.04	1.23
	Std. Deviation	0.515	1.091	0.289	0.692
Most Extreme Differences	Absolute	0.401	0.247	0.537	0.505
	Positive	0.287	0.247	0.537	0.505
	Negative	-0.401	-0.191	-0.443	-0.349
Test Statistic		0.401	0.247	0.537	0.505
Asymp. Sig. (2-tailed)		0.000 ^c	0.000 ^c	0.000 ^c	0.000 ^c

Table 3. Foot Sensitivity Before and After Intervention

Respondent	Foot Sensivity			
	Pre News paper	Post News paper	Pre Thorn ball	Post Thorn ball
R1	1	4	2	4
R2	2	5	2	5
R3	2	4	1	3
R4	3	3	1	3
R5	4	6	2	4
R6	3	7	3	7
R7	3	3	3	3
R8	5	8	3	7
R9	3	3	2	3
R10	3	6	3	2
R11	3	4	2	4
R12	1	2	2	2
R13	4	8	4	6
R14	1	2	3	5
R15	2	5	3	4
R16	4	7	3	5

Table 4. Wilcoxon Test on Pre-post Intervention of Newspaper Foot Exercises and Thorn Balls

Variable	Amount	Mean	Z	p value
Pre-post Newspaper media	16	4.00 – 7.00	-2.488	0.013
Pre-post Thorn ball media	16	5.00 – 7.60	-2.183	0.029
Pre-post Control	16	0.00 – 0.00	0.00	1

Source: SPSS 2023 primary data

Table 5. The Results of The Statistical Test Analysis after The Intervention on Newspaper, Thorn Ball Media and The Control Group Using The Mann-Whitney Test in The Intervention Group

Variable	Amount	Mean	Z	p value
Pre-post Newspaper media	16	5.44 – 11.56	-2.652	0.008
Pre-post Thorn ball media	16	5.63 – 11.38	-2.508	0.012
Pre-post Control	16	7.50 – 9.50	-1.00	0.317

Source: SPSS 2023 primary data

a. The Effect of Diabetic Exercises Using Newspaper and Thorn Balls on The Level of Foot Sensitivity in Type 2 DM Patients

The results of statistical tests using the *Wilcoxon test* for foot exercises in newspaper media (pre and post) obtained a significant *p value* of $0.013 < (0.05)$ and for thorn ball media (pre-post) the result was a significant *p value* of $0.029 < (0.05)$. From the *p value*, it can be concluded that both interventions have the same effect on increasing foot sensitivity.

DM disease makes the sufferer's body unable to control glucose in the blood, which can cause complications that develop gradually. These complications arise in the blood vessels, nerves, eyes, kidneys and cardiovascular. A complication that often occurs in the lower limbs is called Diabetic foot disease, where the blood vessels narrow, which then becomes neuropathy (nerve disorders) so that it can reduce or decrease the sensitivity of the legs with the manifestation of loss of sensation/taste which is often called diabetic ulcers (Yusuf Ah et al., 2019). Through

physical activity in the form of diabetes foot exercises which include relaxation and stretching movements, it is believed to be very effective in widening blood vessels (dilation), improving blood circulation to the feet, being able to increase insulin work in the process of lowering blood glucose thereby increasing blood circulation to the extremities of the feet. (Ratnasari, 2019). On the other hand, according to Arif (2018), the results showed that doing foot exercises 3 times a week for 4 weeks can increase Nitrous Oxide synthesis and arterial vasodilation so that capillary refill in the feet increases so that blood circulation in the feet becomes good.

Several studies that also support the results of this research include Ningrum et al, (2020) where giving foot exercises 2x/day for 3 consecutive days, increases foot sensitivity by 1-2 levels from the maximum level. Similar research by Ramayanti E, et al (2020) stated that before foot exercises were carried out, almost all people with diabetes mellitus had a moderate level of foot sensitivity and after being given foot exercise intervention had foot sensitivity at a normal level. Diabetic foot exercises can also reduce the symptoms of diabetic neuropathy in DM patients, this is in accordance with the statement of Suhertini & Subandi (2016) which states Foot exercise in the intervention group had a significant effect on reducing the foot assessment scores for diabetic neuropathy sufferers ($p=0.000$, $\alpha=0.05$) so that there was a difference in the average value of foot sensitivity in the physical assessment of the feet, after the foot exercise intervention between the control group and the control group. Intervention ($p=0.000$, $\alpha=0.05$).

Differences in foot sensitivity in Type 2 DM patients between the newspaper-based foot exercise group and the spike ball-based foot exercise group, where foot sensitivity was better in the newspaper-based foot exercise group because there was improvement in most points of the foot including the plantar toes and metatarsal heads of toes 1, 3 and 5, the medial arches, lateral arches and dorsum of the foot. However, foot sensitivity was still seen to be low in the heel area. Meanwhile, in the spike ball-based foot exercise group, increased foot sensitivity was seen in the medial arches, lateral arches and dorsum of the arches on both the left and right feet. Foot

sensitivity was still low in the plantar toes, metatarsal heads and heel area. Movements in foot exercises can affect the level of foot sensitivity in DM patients. Foot exercises also make the body relax and improve blood circulation and cause vasodilation in blood vessels, especially peripheral blood vessels (Wahyuni & Arisfa, 2016).

b. The Effectiveness of Diabetic Foot Exercises Using Newspapers and Thorn Balls on Foot Sensitivity in Type 2 DM Patients.

Based on the results of the difference in effectiveness test using *Mann Witney* statistics, the z count for patients post newspaper media intervention was -2652 with a significance p value of 0.008. which means there is a difference in the effectiveness of leg exercises using newspaper media. Meanwhile, the z count at the post-intervention ball of thorns was -2508 with a significant p value of 0.012. This significant value is also $< (0.05)$ so there is a difference in the effectiveness of leg exercises using thorn balls as a medium.

There is a change in foot sensitivity values between pre and post foot exercise intervention, this is because foot exercise movements increase peripheral circulation in the feet which helps stimulate peripheral nerves to receive stimulation so that the feet are more sensitive. Similar results were also reported by Oktorina, et al (2021) that there was a significant difference in foot sensitivity in the newspaper foot exercise group pre and post intervention, amounting to 0.002, while in the foot exercise group using marbles, the difference was 0.012. The comparison results found a difference in foot sensitivity values between the two groups, namely (0.003). It can be concluded that foot exercise intervention using newspapers is more effective in increasing foot sensitivity in people with type II diabetes mellitus.

Colberg, S.R et al (2016) revealed that regular physical exercise improves muscle capillary mass and increases muscle insulin sensitivity in people with type 2 Diabetes Mellitus and those with prediabetes. Adequate blood circulation contains more oxygen and nutrients to the body's cells. Foot exercises using newspapers are considered effective because the foot exercises involve muscle and nerve contractions in the feet.

The movement of squeezing, opening and locking the toes when doing newspaper foot exercises can stimulate the nerves in the feet so that improve the condition of the feet, namely the feet become more flexible (not stiff), the acral sensation becomes warmer, the feeling of numbness in the feet decreases and the foot muscles that shrink (atrophy) gradually return to normal. Apart from that, leg movements in newspaper exercises where the heels of the feet are lifted pointing up and down can increase the strength of the calf and thigh muscles, reduce stiffness in joint movements and prevent changes in shape (deformity).

Furthermore, foot exercise intervention using a spiked ball is effective in increasing foot sensitivity because the stimulation provided is similar to the principle of reflexology to increase blood flow so that the feet become relaxed, blood circulation becomes smooth because the nerve points of the feet press the soft ball spikes so that the blood delivers more oxygen to the cells of the foot tissue while transporting more toxins to be excreted. The massaged soles of the feet are focused on problematic organs, which will provide stimulation to the nerve points so that the pancreas becomes active in producing insulin. The above theory is supported by Aplihah & Wulandari (2017) that foot exercises using thorn balls use the concept of acupressure to improve blood flow and reorganize the work of the body's organs. Acupressure points are median lines on the human body that connect organs and tissues that are important in controlling the human body's communication system. Next, the nerve endings of the fingers send signals to the brain and connect with certain organs according to their meridian points, thereby increasing the sensitivity of the feet.

Diabetic foot exercises are quite beneficial for diabetes sufferers who have poor blood flow and neuropathy in the feet, but the implementation is adjusted to the individual's body and condition (Colberg SR, 2016). Foot exercises can reduce symptoms of sensory neuropathy including tingling, crunching, and pain in the feet. Diabetic foot exercises have other benefits such as preventing foot deformities, increasing the strength of the leg muscles including the calf muscles, thigh muscles

(gastrocnemius, hamstring, quadriceps), and other small muscles and overcoming joint movement restrictions. So, exercises such as diabetic foot exercises can increase muscle contractions in the moving extremities (Silva EQ, 2020). Exercise activities are a priority for structured health education programs, which are given to diabetes sufferers and have a positive impact on the patient's health level, apart from that, exercise is able to control blood sugar levels within the normal range (Zhang and Chu, 2018).

Foot exercise interventions using a ball of spikes are also effective in increasing foot sensitivity because the stimulation given to the feet is similar to the principle of reflexology, which is to improve blood flow and thus relax. Blood circulation is smooth because the nerve points in the feet press on the soft ball spikes, so that blood delivers more oxygen to the cells of the foot tissue while removing toxins for excretion. The soles of the feet that are given reflexology massage focus on problematic organs, which will provide stimulation to the nerve points so that the pancreas becomes active in producing insulin through the nerve points on the soles of the feet. The above theory is supported by Aplihah & Wulandari (2017) who stated that foot exercise using a ball of spikes carries the concept of acupressure to improve blood flow and reset the function of the body's organs. Acupressure points are median lines in the human body that connect organs and important tissues in controlling the human body's communication system. Furthermore, the nerve endings of the fingers send signals to the brain and connect with specific organs according to their meridian points, thereby increasing foot sensitivity. Diabetic foot exercises are effective in increasing foot sensitivity and also have an impact on increasing peripheral perfusion of the foot, resulting in tissue repair and alleviating the degree of Diabetic foot ulcers (wounds). Research by Puryanti, et al (2023) found significant differences in ABI (Ankle Brachial Index) scores, oxygen saturation, and monofilament scores in the left and right feet of the intervention group compared to the control group with a *p value* <0.05. So there is a significant effect of the integration of foot massage and diabetic foot exercises on peripheral

tissue perfusion in both the left and right feet of Type 2 DM patients. Increased sensitivity and perfusion of peripheral foot tissue indirectly also accelerates the process of tissue regeneration so that healing of Diabetic foot ulcers is also faster. This is supported by research by Eraydin & Avsar (2018) which states that at week 12 the average size of DFU (Diabetic Foot Ulcer) in the control group decreased by 25%, while in the intervention group decreased by 75%. A significant difference ($p=0.000$) was found in the mean ulcer size between the control and intervention groups. This indicates a significant benefit of foot exercise, despite the short duration of exercise used as an intervention to reduce the area of diabetic foot ulcers.

In addition to physical activity factors such as foot exercises, foot sensitivity is also influenced by the body's blood sugar levels where the higher the blood sugar levels in a person's body, the foot sensitivity decreases because high blood sugar levels cause thickness or viscosity in the blood vessels so that blood flow that carries oxygen throughout the body is disrupted, especially in the furthest areas of the body, namely the feet. This can cause diabetic ulcers that begin with a decrease in foot sensitivity or even no foot sensitivity at all (Priyanto in Herliawati, 2019). Physical activity in the form of foot exercises performed on the soles of the feet will provide stimulation to the nerve points connected to the pancreas to become active so that it produces insulin to be able to lower blood sugar. The research that supports the effect of foot exercises on lowering blood sugar is by Syaipuddin, et al (2021) at Tamalanrea Puskesmas Jaya, Makassar City that diabetic foot exercises affect lowering blood sugar levels, statistically tested against the paired sample t-test obtained a $p\text{ value} = 0.000 < \alpha = 0.05$. In addition, according to Nurlinawati, et al (2018) before being given foot exercises, 11 respondents (100%) in the intervention and control groups had high blood sugar levels. However, after being given the foot exercise intervention, it was found that 11 respondents (100%) in the intervention group had lower blood sugar levels so that there was an effect of foot exercises on reducing blood sugar levels of respondents in the intervention group. Significant results were also obtained in changes in foot

sensitivity values and average blood glucose levels in the intervention group from before the intervention, namely from 203.88 to 184.81 after the intervention (Rusandi et al, 2019).

Limitations in this study include determining the short duration of the intervention, namely only 1 week (adapting from the results of previous research which stated that foot exercises 3 times a week had an effect on the peripheral tissue of the feet) due to the researchers' limitations in monitoring respondents so that they consistently carried out foot exercise interventions. Apart from that, the researchers only measured the effectiveness of foot exercises on foot sensitivity and were not linked to blood sugar levels due to the researchers' limitations in controlling respondents' food intake during the 1 week intervention, so there were concerns that drug (pharmacological) factors could be a confounder in the research.

CONCLUSION

Based on data analysis and discussion of research results, it can be concluded that the results of the Wilcoxon test stated that foot exercises using newspaper and thorn balls had an effect on increasing the sensitivity of the feet of Type II DM patients. The results of the effectiveness test with Mann Withney concluded that foot exercises using newspaper media and thorn ball media were effective in increasing the sensitivity of the feet of Type II DM patients.

Further research is needed regarding the duration of leg exercises if they are carried out longer and the impact on the patient's sugar levels. apart from that, foot exercises can be modified using other media as complementary therapy in the non-pharmacological management of diabetes mellitus.

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