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THE EFFECT OF LEG STRETCHING EXERCISES WITH A TENNIS BALL ON ANKLE BRACHIAL INDEX AS A PREDICTOR OF DIABETIC FOOT ULCER

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ABSTRACT
Diabetic foot ulcers are caused by impaired peripheral circulation of the lower extremities due to peripheral arterial disease (PAD) that can be assessed by measuring the ankle brachial index. Leg stretching exercises with a tennis ball have an effect on increasing ABI values and predict the incidence of diabetic foot ulcers. Objective : This stydy aims to improve the effect of leg stretching exercises with a tennis ball on the ABI value as a predictor of the incidence of diabetic foot ulcers. Method: Quasi experimental quantitative research with a pretest-posttest with control group design. The total sample was 46 respondents using a purposive sampling technique to determine the Intervention group and Control group in 2 Puskesmas work areas that have plenary accreditation. After selecting each group, identification was carried out according to the inclusion criteria and exclusion criteria, resulting in 23 respondents in the Intervention group and 23 respondents in the Control group. The intervention group was given leg stretching exercises with a tennis ball for 15 minutes 14 times in 2 weeks and the control group received treatment from the Community Health Center, namely PROLANIS exercises. Data analysis uses univariate analysis and bivariate analysis, Paired Sample t-Test and Independent t-Test. Results: The ankle brachial index average increased to 0,300 mmHg and the prediction of the incidence of foot ulcers were decreased on the Intervention group (p=0,000) wheras the Control group ankle brachial index average decreased to 0,082 mmHg and the prediction of the incidence of foot ulcers were increased (p=0,008). Conclusion: Leg stretching exercises with a tennis ball have an effect on increasing ankle brachial index and can be used as a predictor of diabetic foot ulcers in type 2 diabetes mellitus.

Keywords: abi; diabetes mellitus; stretching; tennis-ball; ulcer

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INTRODUCTION

Diabetes Mellitus is a group of diseases or metabolic disorders characterized by high blood sugar levels accompanied by disorders of carbohydrate lipid and protein metabolism which occur due to abnormalities in insulin secretion, insulin action or both. (John B.Buse, Deborah J.Wexler, Apostolos Tsapas, Peter Rosing, Geltrude Mingrone, Chantal Mathieu, 2020) The prevalence and incidence rate of type 2 Diabetes Mellitus from 2019 International Diabetes Federation data is 463 million aged 20-79 years or equivalent to a prevalence rate of 9.3% of the total population of the same age. WHO estimates that the prevalence of type 2 Diabetes Mellitus will increase with increasing age of the population, by 2045 it is predicted that there will be 700 million people suffering from type 2 DM.(P2PTM Kemenkes, 2020).

Type 2 Diabetes Mellitus who have poor blood sugar control can cause various complications. One complication that often occurs is diabetic foot ulcers that occur in the plantar area of the foot. The incidence of diabetic foot ulcers is estimated at 19-34% with costs among the 10th highest of all medical conditions. Apart from that, this complication causes sufferers to experience loss of limbs and even their lives. The mortality rate after 5 years of lower limb amputation reaches 50% so that diabetic foot ulcers and amputation are associated with a decrease in the quality of life, both physical and psychological, social and life of diabetes sufferers. (Melanie M. Lyon, 2022)

Diabetic foot complications start from assessing the vascularization of the lower extremities by measuring the Ankle Brachial Index. Vascular disorders characterized by a decrease in ABI values can cause disruption of nutrition and oxygen to the skin, especially in the lower extremities and this contributes to the risk of ulcer formation.(Arisanty, 2015) Diabetic foot ulcers are caused by a combination of microvascular and macrovascular complications starting from DM sufferers who are at risk, including neuropathy, peripheral arterial disease, foot deformities and trauma and suffering for more than 5 years. (Kementerian Kesehatan Republik Indonesia, 2020) The most dominant factor increasing the incidence of foot ulcers is peripheral artery disease (PAD), which is a condition of nerve damage that affects the integrity of small joints and intrinsic muscles which has the effect of causing deformity, increasing plantar pressure and increasing the risk of foot ulcers. Changes in the blood vessel walls result in a decrease in blood circulation (perfusion) to the lower extremities, characterized by a decrease in the Ankle Brachial Index value. (Monteiro et al., 2018)

Management of the risk of developing diabetic foot ulcers is carried out by means of comprehensive and regular foot examinations, including foot stretching exercises. Leg stretching exercises are activities that stretch the lower extremity muscles with the aim of increasing flexibility and range of joint movement to improve blood circulation, strengthen small muscles and overcome joint limitations in the lower extremity area. (Gotera W, Nugraha I, 2023) Leg stretching exercises with a tennis ball were modified from the Ministry of Health's diabetic foot exercises which added the movement of rolling a tennis ball in the plantar area of the right and left feet and rolling it simultaneously on both plantars of the foot. The purpose of this tennis ball rolling movement is to get a friction effect, namely the effect of relaxing the muscles in the soles of the feet so that circulation in the blood vessels of the lower legs becomes smooth, marked by an increase in the Ankle Brachial Index value. (Muryadi et al., 2023)

METHOD

The sample in this study were type 2 DM, the inclusion criteria, namely type 2 DM, physically and mentally healthy, willing to be respondents, age ≥ 35 years, long suffering from DM ≥ 5 years, no ulcers in the lower extremity, able to perform leg stretching exercise for 15 minutes and the respondent was able to communicate verbally and non-verbally. Meanwhile, the exclusion criteria are musculoskeletal disorders, mental disorders/depression, not participating in the complete intervention and participating in other similar research interventions. This type of study is a quasi-experimental pretest-posttest with control group design, which consists of 2 groups, the Intervention group and the Control group, selected from 2 community health centers with complete accreditation and taking into account the program excellence of each community health center. Furthermore, there were 23 respondents in the Intervention group and 23 respondents in the Control group. The study was conducted from November 6th 2023 to December 5th 2023. The intervention group was given leg stretching exercises with a tennis ball for 15 minutes 14 times in 2 weeks and the control group received treatment from the

Community Health Center, namely PROLANIS exercises according to the Community Health Center. Before each group was given treatment, an initial measurement (pretest) of the ABI value was carried out in both groups. Next, the research groups received their respective treatments, after which the final measurement (posttest) of the ABI value was carried out.

RESULTS

Based on research regarding the effect of leg stretching exercises with a tennis ball on the ABI value as a predictor of the incidence of foot ulcers in type 2 DM at Lahat Public Health Center in 2023, the following results were obtained: Univariate analysis of this research is the ABI value before and after each treatment (ABI *pretest-posttest*) for the Intervention group and the Control group. From the results of the analysis that has been carried out on the ABI value as a predictor of the incidence of foot ulcers in type 2 DM sufferers.

Table 1.
Characteristics of Respondents

Variable	Intervention (n=23)		Control (n=23)		*p*
	Mean ± SD	Min-Max	Mean ± SD	Min-Max	
Age (years)	59.74 ± 6.784	47 - 73	57.30 ± 10.115	43 - 77	0.038
Long time DM	6.348 ± 1.633	5 - 10	7.283 ± 2.055	5 - 12	0.226
BMI	23,683 ± 5,117	16.0 – 36.3	25,739 ± 6,312	16.0 – 39.0	0.275
Variable	Intervention (n=23)		Control (n=23)		*p*
	f	%	f	%	
Gender					
1.Female	14	60.9	14	60.9	1.00
2. Male	9	39.1	9	39.1	
Obesity					
1. Obesity	10	43.5	10	43.5	1.00
2.No	13	56.5	13	56.5	
Smoking History					
1.Smoking	9	39.1	9	39.1	1.00
2.No	14	60.9	14	60.9	
DM medication					
1.Oral	22	95.7	22	95.7	1.00
2.Insulin	1	4.3	1	4.3	

The characteristics of respondents in both groups were homogeneous (p >0.05). The highest average age data is in the Intervention group, namely 59.74 and the lowest age of respondents is in the Control group, namely 43 years

Table 2.
Descriptive analysis of *pretest-posttest ABI*

Variable		Intervention (n=23)		Control (n=23)	
		Mean ± SD	Min-Max	Mean ± SD	Min-Max
ABI	*Pretest*	0.775 ± 0.152	0.49-1.08	0.933 ± 0.212	0.58-1.30
	Posttest	1.075 ± 0.190	0.70-1.36	0.850 ± 0.148	0.56-1.10

The average ABI value before treatment in the Intervention group was 0.775 (n=23) and in the Control group the average ABI was 0.933 (n=23). After treatment for each group, the average ABI value increased in the Intervention group by 1,075, which is included in the normal ABI value level, while in the Control group the average ABI value decreased by 0.850, which is included in the ABI value level below normal (mild PAD).

Table 3.
Prediction of foot ulcers based on normal values (*cut off point*) *posttest* ABI for the Intervention group and Control group

Cut Point Posttest Ankle Brachial Index	Group			
	Intervention (n=23)		Control (n=23)	
	Normal ≥0.90 mmHg	Prediction of foot ulcers <0.90 mmHg	Normal ≥0.90 mmHg	Prediction of foot ulcers <0.90 mmHg
f	18	5	10	13
%	78.2	21.8	43.5	56.5

Based on the posttest normal value *(cut off point)* of ABI, namely ≥0.90 mmHg, respondents in the intervention group with leg stretching exercises with a tennis ball achieved normal values as many as 18 people (78.2%) and respondents who were predicted to develop foot ulcers were 5 people (21 .8%) while in the Control group there were 10 respondents (43.5%) who achieved normal values and 13 respondents (56.5%) predicted foot ulcers. The prediction of the incidence of foot ulcers in the intervention group with leg stretching exercises with a tennis ball was less than the prediction of the incidence of foot ulcers in the Control group

Table 4.
Analysis of differences in *pretest-posttest ABI scores* between groups

Mark ABI	Intervention (n=23)		Control (n=23)		t	(Λ) Mean	*p**
	Mean	Deviation Standard	Mean	Deviation Standard			
Pretest	0.775	0.152	0.933	0.212	-2,893	-0.157	0.006
Posttest	1,075	0.190	0.850	0.148	4,479	0.225	0,000

Table 4, the results of the *Independent t-test* mean pretest ABI value for the Intervention group was 0.775 and for the Control group was 0.933. After being given treatment to each group (Intervention and Control), the average *posttest ABI value* for the Intervention group increased to 1.075, while the average *posttest ABI value* for the Control group decreased to 0.850. The *p value is* < 0.05, which means there is a difference in the mean *pretest* and *posttest ABI values* for the intervention group and the control group.

Table 5.
Analysis of changes in *pretest-posttest ABI values* for the intervention group and control group

Group	**Variable**	**Mean**	**Λ Mean**	***p***
Intervention	*Pretest*	0.775	-0.300	0,000
	Posttest	1,075		
Control	*Pretest*	0.933	0.082	0.008
	Posttest	0.850		

Table 5, the results of the *Paired sample t-test show* that the ABI value of the Intervention group and the Control group *is p* <0.05, which means that there is an influence of the treatment of each group on the ABI value, where in the Intervention group the effect of treatment is leg stretching exercises with a tennis ball during 15 minutes 14 times in 2 weeks increased the average ABI value by 0.300 mmHg, while in the Control treatment group from the research health center the average ABI value decreased by 0.082 mmHg.

Table 6.
Cohen's effect size test results

Group	ABI *posttest*		*Cohen's*
	Mean	elementary school	
Intervention	1,075	0.190	1,321*
Control	0.850	0.148	

The results of Cohen's effect size test show that leg stretching exercises with a tennis ball have a strong effect *on* the ABI *posttest value.*

DISCUSSION

The mechanism of leg stretching exercises with a tennis ball can increase the ankle brachial index value starting from the definition of leg stretching exercises is an exercise that involves many moving muscles, when the muscles are actively moving there is an increase in glucose demand but this does not increase insulin level (Nurasiah, 2022). In this study, foot stretching exercises were carried out by rolling a tennis ball in the plantar area of the foot with the aim of getting a friction effect, namely the effect obtained by relaxing the muscles in the foot area, especially the soles of the feet. When leg stretching exercises with a tennis ball are carried out, the actively moving leg muscles will increase blood flow in the lower extremity area which contributes to the capillaries in the blood vessels to open the capillary nets. By opening the capillary network, insulin receptors become more active so that peripheral blood circulation in the lower leg area becomes smooth. The condition of smooth blood vessel capacity in the lower extremities will be indicated by an increase in the ankle brachial index value. (Ervanti et al., 2023)

In line with Jihan Astrie's study, 2021, the foot exercise intervention was 30 minutes of foot exercise 3 times a week, statistical results showed an increase in the average ABI value of 0.2 mmHg and reduced tingling in the feet. (Astrie & Sugiharto, 2021) I Putu Adi Suryawan's study, systematic review, 2022, namely identifying the effect of resistance exercise on the effect of increasing peripheral circulation. From a literature review, it was proven that there was an increase in the ABI value. By reducing the thickness of the carotid intima media, the peripheral arterial stiffness index decreases, resulting in an increase in the ABI value ($p = 0.002$). The intervention of resistance exercise provides benefits in preventing damage to the vascular endothelium by increasing the production of NO (Nitric Oxide) which can relax blood vessels, increase insulin receptor sensitivity, increase vascularization and improve skeletal muscle mitochondrial function. (Suryawan et al., 2022)

According to study by Suyanto, 2019, another factor that influences increasing the ABI value is pharmacological therapy. In this study, the dominant pharmacological therapy was oral hypoglycemic drugs (95.7%) with the type frequently consumed being Metformin. Relevant research results state that type 2 DM patients with PAD and taking Metformin for more than 6 months have low serum vitamin B12 and clinical signs will be more severe compared to patients who are not exposed to Metformin. DM patients who experience a decrease in vitamin B12 will experience tingling in the feet and hands and numbness. (Suyanto, 2017) contrast to research by Tae Jung Oh, et.al, 2019, of 187 type 2 DM patients aged 20-70 years undergoing an OHO therapy program, a combination of Metformin for 24 weeks with a reduction in HbA1c levels ($p=0.003$). Metformin has antihyperglycemic effect, beneficial effect on body weight, low risk of hypoglycemia at a lower cost (Oh et al., 2019). This research was denied by Willi Wahyu, et al., that there was no significant difference in activity levels found when using a combination of metformin with GDS and HbA1c ($p=0.815$) so it was more effective to use a single dose of metformin. (Timur et al., 2022)

The results of the cut off point analysis based on the normal posttest ABI value, namely ≥ 0.90 mmHg, predicted the incidence of foot ulcers in patients with type 2 DM in the Intervention group to be less than those in the Control group. The prediction of foot ulcers occurring in the Intervention group was 5 respondents (21.8%) while the prediction of foot ulcers occurring in the Control group was 13 respondents (56.5%). Yulia, et al, 2023 on the effect of resistance exercise on ABI values and reducing blood sugar levels in type 2 DM patients, it was found that the posttest ABI average value increased by 0.2 mmHg, (p = 0.020) which means that the average ABI value was significantly different, but from the results Cohen's effect size test showed a result of 0.40, which means that resistance exercise treatment in the intervention group had a weak effect on increasing ABI. The factor that causes this exercise to have a small impact on ABI is because the respondents in the Intervention group were mostly women who work as housewives who only do light activities at home so that lack of activity causes reduced use of glucose by muscle tissue, causing the body's need for insulin to increase..(Ervanti et al., 2023)

Line in this study, by Gunawan, et al, 2021, it is stated that the amount of fat in women is 20-25% of body weight, while in men the amount of fat is 15-20% of body weight. High levels of fat in women cause insulin sensitivity to decrease, causing blockage of blood vessels which results in poor peripheral circulation.(Gunawan & Rahmawati, 2021) The intervention of leg stretching exercises with a tennis ball resulted in a Cohen's effect size = 1.321, namely a large effect even though the number of female respondents was greater. This is because the leg stretching exercise activity with a tennis ball is routinely carried out for 15 minutes 14 times in 2 weeks. This study is in line with Teresa, 2020 titled *A lower leg phisical activity intervention fpr individuals with chronic venous leg ulcer; randomized controlled trial* that individuals with leg ulcers need a web-based physical activity program of leg stretching exercises so that there is an increase in the intensity and duration of leg stretching exercises and has an impact on the contractility of the calf muscles to become stronger thereby increasing blood vessel circulation in the lower extremities.(Kelechi et al., 2020)

DM type 2 with impaired lower extremity vascular circulation are indicated by low ABI values and are associated with a more rapid decline in function and contribute to multifactorial impairment and decline including muscle size and composition, inflammation, lower extremity strength, mitochondrial function and behavioral factors. (Aboyans et al., 2012). This is in line with study by Heru Purnomo, 2020, that there is a correlation between leg stretching exercises and capillary filling time with measurements on day I and day III (sig=0.000<α), so there is a relationship between before exercise and after exercise and the value of capillary filling time. Capillary refill time in DM type 2 will slow down > 2 seconds. In this condition, the peripheral pulse rate decreases, the skin color of the legs becomes pale, and the skin acral is cold, which is an indication of ischemia (Purnomo et al., 2020).

The benefits of leg stretching exercises are increasing blood circulation in the leg area, increasing insulin work and dilating blood vessels which play a role in increasing systolic blood pressure in the leg (Puspita et al., 2022). According to study by Desalu, et.al., there is a relationship between compliance with foot care and the risk of foot injuries. This is in line with Sari Haroen's research that regular foot care can reduce diabetic foot disease by 50-60%. Foot examination and care includes foot stretching exercises, an effort to prevent the appearance of diabetic foot wounds. (Saprianto et al., 2022). The factor that causes the risk of developing foot ulcers is age, people with type 2 DM have a 6 times greater risk of developing foot ulcers when they are over 50 years old. In this study, the average age of respondents was 58 years in the two groups. People over 50 years of age with DM generally

do not realize the early signs of diabetic foot ulcers such as numbness and loss of pain sensation, resulting in trauma and motor disorders..(Mildawati et al., 2019)

Another factor that is at risk of developing foot ulcers is the length of time suffering from DM, research by Wiwik, et al, 2021, regarding the description of the risk of foot ulcers in DM sufferers in Solo. The average level of risk of developing foot ulcers in DM sufferers who have suffered for more than 5 years, this is also This is confirmed by research by Rosa, et al, that the majority of respondents who were at 4.3 times greater risk of developing diabetic gangrene were those who had suffered from DM for > 5 years. (Suprihatin & Purwanti, 2021). Furthermore, Teresa, 2020, shows that suffering from DM for more than 5 years is a risk factor for diabetic foot ulcers because long suffering allows continuous hyperglycemia to occur, resulting in complications of DM, retinopathy, nephropathy, chronic heart disease and diabetic foot ulcers. (Rasyid et al., 2020). Suffering from DM for a long time causes a continuous buildup of glucose in the blood which results in atherosclerosis so that blood flow, especially in the lower leg area, experiences circulation problems which causes complications of diabetic feet. (Hidhayah et al., 2021).

The limitation of this research is that factors that can influence blood glucose levels, ABI and diabetic foot ulcers include food recall, HbA1c, stress and hypertension, which have not been analyzed. Furthermore, a foot sensitivity examination using a 128 Hz tuning fork and 10 gr Semmes-Weinstein Monofilament on both plantar feet to detect the presence of peripheral neuropathy in the feet was not carried out, this study only focused on the blood circulation status in the lower extremities (ankle brachial index).

CONCLUSION

Rata-rata The average increase in Ankle Brachial Index values before and after treatment was 0.300 mmHg, Cohen's effect size shows that leg stretching exercises with a tennis ball have a large effect on increasing ABI values (strong effect). The average increase in ABI values due to the intervention of leg stretching exercises with a tennis ball for 15 minutes 14 times in 2 weeks can be used as a predictor of the incidence of foot ulcers in type 2 Diabetes Mellitus

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