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Effect of Cold Hot Water Soaking in the Feet on the Value of Ankle Brachial Index in Diabetes Mellitus Patients

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Abstract: Diabetes mellitus is a metabolic disease characterized by an increase in blood sugar levels that cause vascular complications and circulatory disorders. Hot and cold water soaking in the feet can increase blood flow and blood vessel pumping. Objective: to assess the effect of hot and cold water soaking in the foot blood circulation in patients with diabetes mellitus. Methods: A quasi-experimental was conducted with pre-test and post-test approach with control. Respondents were 35 people per group by consecutive sampling. Data were analysed using Wilcoxon signed ranks test and the Mann Whitney Test. Result: there was a significant effect between the average value of Ankle Brachial Index before 0.823 (SD 0.025) and after treatment 0.95 (SD 0.95), p-value = 0.00. The mean difference was obtained p = 0.00, if the p value <0.05, there was a significant difference in the difference in the mean value. Conclusion: it was found that the leg blood circulation was getting better after the hot cold water soaking. It is recommended for nurses to make hot and cold water immersion into one of the independent nursing interventions in providing nursing care to diabetes mellitus patients.

Keywords: Hot and Cold Water Soaking, Ankle Brachial Index, Diabetes Mellitus

1. INTRODUCTION

Diabetes mellitus (DM) is a chronic disease characterized by blood glucose levels greater than normal, insufficient insulin production, and excessive blood glucose production. High blood glucose levels cause damage to the body and failure of various organs and tissues [1]. Uncontrolled DM results in complications such as heart disease, stroke, high blood pressure, blindness, kidney disease, nervous system diseases, leg amputations, and death [2]. World Health Organization [3] states that the number of DM sufferers in the world reaches 422 million people. It is estimated that it will increase to 592 million people in 2035. Indonesia is ranked the seventh highest DM sufferer in the world, after China, India, the United States, Brazil, Russia and Mexico with an estimated number of around 10 cases in 2015 [1]. The prevalence of DM in Indonesia has shown an increase, from 5.7% in 2007 to 6.9% in 2016 [4].

DM sufferers have a higher risk of experiencing foot problems due to changes in the shape of the legs, blood vessel disorders that cause leg blood circulation to decrease [5]. Blood circulation in the limbs decreases due to damage to the vascular endothelium, due to a decrease in blood flow in DM patients compared to healthy individuals [6][7][8]. The decrease in blood flow causes nutrition to the body's tissues to be disturbed, which can have serious effects on different organs.

Management of DM aims to normalize insulin activity and blood glucose levels to reduce vascular complications and neuropathy [9]. Hot cold water soaking in the feet is a thermal treatment modality using hot water (38°-42°C) and cold water (15°-18°C) on the extremities [10][11]. The difference in water temperature causes increased blood flow and vascular pumping. With an increase in blood flow and vascular pumping it is hoped that it can bring nutrients and oxygen for soft tissue repair, reduction of pain, stiffness, oedema and increased mobility [12][13]. Hot and cold water soaking alternately in certain areas can cause vasoconstriction and vasodilation [14]. Hot water soaking can increase vasodilation of blood vessels. And cold water soaking causes local vasoconstriction of blood vessels. So that the alternating hot and cold soaking is expected to increase the elasticity of blood vessels in DM patients which has an impact on smooth circulation and the fulfillment of blood flow and nutrients to the tissues.

Hot and cold water soaking is chosen as a complementary therapy to improve blood circulation in DM patients because both are easy to obtain, do not require expensive costs and are easy to do by the patient independently.

2. METHODS

The study was a quasi-experimental design with pre-test and post-test methods in two groups, the control and intervention groups. In this study, respondents were given a pre-test by measuring the skin temperature using a digital infrared beurer FT 65 thermometer before the treatment was carried out. Then after post-test the respondent, an assessment of skin temperature was conducted again to see the difference in skin temperature between the two groups that had been given. The treatment given to respondents is hot and cold water soaking in the feet.

Seventy persons were as participants who were selected by consecutive sampling with inclusion criteria, namely: 1) DM patients, 2) aged 26-65 years, 3) can communicate well, 4) can feel hot and cold sensations, 5) are willing to be respondents and 6) never get the same intervention from researchers or other health workers . While the exclusion criteria, namely : 1) the patient suffered from heart disease, 2) the presence of sensory neuropathy, 3) the presence of injury to the leg, 4) lower limb strength $\leqslant$5, 5) not cooperative, and 6) unwilling to become respondents.

After getting the skin temperature value, the respondent was given intervention. The researcher explained about the procedure of cold hot water soaking in the feet of the respondent who would be intervened (intervention group). The intervention given was soaking the feet in water with a temperature of 38-42°C for 4 minutes and followed by soaking in water with a temperature of 10-18°C for 1 minute. This intervention was repeated five times, without cold water soaking at the end of the soaking, so that the duration of the intervention was 24 minutes. The intervention was carried out twice on different days. It was carried out in the morning at the respondent's house and the researchers themselves intervened. In the control group no intervention was carried out, but respondents received information related to hot and cold water soaking. After the intervention, the researchers measured the skin temperature in both groups to identify the blood circulation experienced by the respondents. After obtaining the respondent's skin temperature value, the researcher then documents it in a tabulated data sheet.

3. RESULTS

The majority of respondents in the intervention group were aged 36-45 years 19 people (54.3%). The female gender was 21 people (60%). High school education level was 22

people (62.9%). The majority of employment status were self-employed 16 people (45.7%) followed by various other jobs. The duration of suffering from diabetes was <1 year, amounting to 15 people (42.9%). The use of oral anti-diabetes drugs was 29 people (82.9%). While the control group based on the majority of age were 36-45 years 15 people (42.9%). The female gender was 19 people (54.3%). Two thirds of them had high school education (24 people) (68.6%). 18 people (51.4%) did not work/housekeeping/retired, followed by various other jobs. Duration of suffering from diabetes mellitus ranged from 1-5 years 17 people (48.6%). And the use of anti-diabetes drugs was 31 people (88.6%) (Table 1).

Table 1: Frequency and Percentage Distribution Based on Respondent Characteristics

Variable	Intervention group (N=35)		Control group (N=35)	
	f	%	f	%
Age				
26-35 years	9	25.7	5	14.3
36-45 years	19	54.3	15	42.9
46-55 years	6	17.1	13	37.1
56-65 years	1	2.9	2	5.7
Gender				
Male	14	40	16	45.7
Female	21	60	19	54.3
Educational				
Primary school	2	5.7	4	11.4
Junior high school	2	5.7	3	8.6
Senior high school	22	62.9	24	68.6
Diploma 3	3	8.6	0	0
Bachelor/Magister	6	17.1	4	11.4
Employment				
Not work/housewife/retired	15	42.9	18	51.4
Self-employed	16	45.7	11	31.4
Private employee	3	8.6	3	8.6
Civil officer	1	2.9	3	8.6
long suffered				
<1 year	15	42.9	10	28.6
1–5 years	14	40	17	48.6
>5 years	6	17.1	8	22.9
Use of drug				
Oral	29	82.9	31	88.6
Injection	6	17.1	4	11.4

mean post-test ABI: 0.95, SD 0.08, min 0.77, max 1.11. The control group mean ABI pre-test was 0.82, SD 0.02, min 0.77, max 0.85. The mean value of the ABI post-test in the control group was 0.91, SD 0.06, min 0.81, max 1.00 (Table 2).

Table 2: ABI before and after hot and cold water soaking intervention

ABI	Intervention group (N=35)				Control group (N=35)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Before	0.82	0.02	0.77	0.85	0.82	0.02	0.77	0.85
After	0.95	0.08	0.77	1.11	0.91	0.06	0.81	1.00

The results showed that there were differences in ABI before and after the intervention in the intervention and control groups. There was an increase in the mean ABI value in the intervention group 0.127 and in the control group an increase in the average ABI was 0.089. The results of the Wilcoxon signed ranks test in the intervention group obtained p value = 0.000, 95% confidence level, it can be concluded that the p value <0.05 means that there is an effect of immersion in cold hot water in the feet on the ABI value in DM subjects (Table 3).

Table 3: the results of *Wilcoxon Sign Rank Test* on ABI mean differences

Group	Mean	SD	z	sig	n
Intervention					
Before After	0.823 0.95	0.025 0.08	-5.019	0.000	35
Control					
Before After	0.821 0.91	0.024 0.06	-4.866	0.000	35

The results of the Mann Whitney Test on the ABI obtained p value = 0.000, it can be concluded that if the p value <0.05, it means that there is a difference in the average ABI value between the intervention group that was immersed in hot and cold water and the control. The mean difference in the intervention group was greater than the control group, meaning that the intervention group had a more significant increase in ABI than the control group. (Table 4)

Table 4: the results of *Mann Whitney Test* mean differences ABI between after and before

Variable	Group	Mean Rank	z	sig
ABI	Intervention Control	40.43 30.57	-2.033	0.000

4. DISCUSSION

The results showed that the subjects suffering from diabetes varied, the intervention group found the majority of respondents aged 36-45 years, 19 people (54.3%). The aging process is associated with reduced muscle mass. This is related to a decrease in muscle contraction capacity which has an impact on decreased physical activity and decreased glucose uptake so that the risk of developing DM disease [15]. The majority of gender was female the intervention group, 21 people (60%) and 19 controls (54.3%). This is because the proportion of respondents in the study was more female than male. In theory, the male gender is influenced by the hormone testosterone in stimulating lipolysis in adipose tissue. Testosterone levels lead to obesity in the stomach and insulin resistance and is a risk factor for DM so that insulin is more sensitive to changes in testosterone [16].

The majority of high school education was in the intervention group 22 people (62.9%) and the control group 24 people (68.6%). Fattahi, Barati, Bashirian and Moghadam [17] state that education level is related to attitude and self-confidence which is an important strategy for increasing physical activity. The majority of jobs in the intervention group were self-employed 16 people (45.7%), while the control group did not work / housewives / retirees 18 people (51.4%). Mohamed [18] shows that there is a link between income and DM self-management, the higher the level of income the better control over DM self-management.

The majority of patients suffering from diabetes mellitus in the intervention group <1 year were 15 people (42.9%), while the control group was in the 1-5 years range for 17 people (48.6%). Black and Hawks [19] state that the length of time a patient has suffered from diabetic foot wounds is one of the factors that can affect and exacerbate the disruption of peripheral blood circulation. The length of time suffering from diabetes will affect the blood viscosity which continues to increase due to high glucose levels which cause thickening of the capillary membrane, where erythrocytes, platelets and leukocytes attach to the lumen of blood vessels which have the potential to become leg injuries, or interfere with circulation.

The majority of oral anti-diabetes drugs used in the intervention group were 29 people (82.9%) and the control group was 31 people (88.6%). Management of DM can be done through diet, exercise (exercise), medicine, and counseling so that DM patients become independent. The balance between diet, exercise, medicine and education is very important [20]. A diet that suits your needs, adherence to taking medication, and accompanied by regular exercise will help take glucose in the blood by the muscles that are active during exercise. DM management can be done with pharmacological management [21].

The ABI value is influenced by blood flow and blood vessels. Inadequate blood flow causes the extremities to become cold and pale. The blood vessels are unable to enlarge and shrink in the lower limb area, which can result in stiff joints. Blood vessels of DM sufferers are unable to dilate and constrict due to decreased nitric oxide. The function of nitric oxide is to relax smooth muscle in blood vessels to dilate and constrict. According to Potenza, Gagliardi, Nacci, Carratu, and Montagnani [22] the decrease in nitric oxide is caused by the high concentration of free radicals in the body which is associated with obesity. DM causes nitric oxide to be immediately converted to peroxynitrite, thereby reducing the availability of nitric oxide as a vasodilator, and decreasing insulin receptors resulting in vasoconstriction of blood vessels. In addition, the decrease in nitric oxide in DM subjects is also influenced by factors of age, blood pressure, body weight and the activities carried out by the subject. According to Gogg, Smith, and Jansson [23] it is insulin resistance that reduces vasodilation, but increases vasoconstriction of smooth muscle in blood vessels.

The ABI value in DM subjects after immersion in hot and cold water has increased. Soaking in hot and cold water can dilate blood vessels due to isovolemic ventricular relaxation which can increase blood flow [24]. Meanwhile, constricted blood vessels are caused by reflex action of smooth muscle arising from stimulation of the autonomic nervous system and the release of epinehrin and norepinephrine [25]. This will take place during the hot cold water immersion that will be given, where the hot water immersion will dilate the blood vessels, and the cold water immersion makes the blood vessels constrict. The body's response to hot immersion is vasodilation of blood vessels and decreased muscle tension, which is caused by obstruction of the sympathetic center in the posterior hypothalamus causing vasoconstriction. The body's response to cold immersion is vasoconstriction, this is caused by stimulation of the sympathetic center of the posterior hypothalamus by activating piloerection.

Hot and cold water soaking can increase blood flow so that blood circulation will be fulfilled. The hot and cold water immersion given to the feet will hit the blood vessels in the skin. The affected blood vessels narrow and dilate which acts as a pump in the muscles thereby increasing blood flow. According to Gatlin & Schulmeister [26] the heat contained in hot cold immersion therapy can increase blood flow to the skin, dilate blood vessels, increase oxygen and nutrient delivery to local tissues, and reduce joint stiffness by increasing muscle elasticity. Meanwhile, cold water immersion can reduce nerve conduction, inhibit skin irritation, vasoconstriction blood vessels, relax muscles in the affected area and reduce metabolic activity both systemically and locally [27]. In a study by Fiscus, Kaminski, and

Powers [28] found that blood flow in the legs increased significantly with hot and cold water immersion. Alternating hot and cold water immersion is a method used to reduce muscle stiffness/spasm, inflammation, edema and increase mobility, and improve blood flow [7][23].

5. CONCLUSIONS

Hot and cold water immersion increases the ankle brachial index (ABI), this condition indicates increased peripheral blood circulation in the legs.

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