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The Effectiveness of Lower Extremity 45° on Ankle Brachial Index (ABI); A Quasi-Experimental Study

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Abstract*—The prevalence of diabetes mellitus has always experienced a dramatic increase in the number of patients contributing to an increase in the number of patients with prolonged diabetic foot ulcers. One adjunctive treatment that can be given to improve vascularization is lower extremity elevation. The aim of this study was to analyze the effectiveness of lower Extremity Elevation at 45° on Ankle Brachial Index (ABI). Method: This study employed a quasi-experimental research design with an approach of pre post test control group design, with a total sample of 60 Participants who were divided into two groups. The control group was given standard wound care using modern dressing. While the intervention group was given standard wound care using a modern dressing that was added with the lower extremity elevation at 45° for 15 minutes. The sampling technique used was simple random sampling with a bivariate analysis using Independent test. The elevation tool used was independently created by researcher using stainless materials that have been tested for accuracy. Which means that to emphasize the accuracy of the tool, several experts in wound/ulcers care expertise were involved. As for the tool to measure ABI, the researcher used Doppler which is already in a form of a product that scientifically have been declared valid and reliable. Results: The elevation of Lower extremity as high as 45° has a statistical significance with a value (p = 0.001). Conclusion: The elevation of the lower extremity at 45° can increase venous return (VR) in patients with diabetic foot Ulcers.*

***Keywords*—** *ABI, Lower Extremity Elevation, Modern Dressing*.

I. INTRODUCTION

Diabetes Mellitus (DM) is one of the main problems in the health system and the threat of public health globally that has increased dramatically over the last 2 decades [1]. One complication of DM is Diabetic Foot Ulcers (DFU). The prevalence of patients with diabetic foot Ulcers has not been clearly recorded either in the world or in developing countries like Indonesia. However, this can be predicted based on the occurrence of patients diagnosed with DM as reported by the results of cross-sectional studies data that show 7.4% of patients with DM will experience DFU, and 84% of them will go through foot amputations with life expectancy post-amputation at 39-68% [2; 3; 4]. In this regard, there are several factors that can affect the healing of diabetic foot ulcers including circulation problems [5; 6]. The healing of wounds or ulcers that lack oxygen will be hampered. Moreover, prolonged or chronic hypoxia inhibits wound or ulcer healing such as the impeded angiogenesis process, inadequate function of macrophages and increasing number of bacteria [7]. One of the inhibiting factors for diabetic foot ulcers healing is the decrease in blood flow to the wounded area [8].

Handling of circulatory problems in diabetic foot ulcers has not been maximally implemented. Most experts solely focus on medications that have a high risk. For this reason, therapies that have smaller risks are necessary, especially which can be useful to increase the circulation and speed up the healing of diabetic foot ulcers [9]. In particular, in the Pontianak Kitamura Clinic many cases of diabetic foot ulcers require a long healing process despite using standard wound care, both for treatment techniques and the use of dressings. The average time needed for the healing process for class 3 is 4 to 6 months. This is inseparable from several factors inhibiting wound or ulcer healing, one of which is circulation disorders. Thus, one form of intervention that is feasible in dealing with this circulation problem is to apply a lower extremity elevation at an angle 45°. Elevation of the lower extremity reduces the effect of gravity by helping venous return to the heart. As a result, decreased venous return (VR) will reduce venous pressure, which then reduces blood vessel circulation stagnation so that the end result is a more adequate perfusion change [5].

II. METHOD

Quasi-experimental design was used in this study to compare the two groups. This research was conducted at the Pontianak Kitamura Clinic for 3 months. Pontianak Kitamura Clinic is one of the Diabetic Wound/Ulcer Care Centers in Indonesia which handles around 50 to 60 Patient visits per day

A. Subject

The sample in this study were patients aged 45-60 years who experienced diabetic foot ulcers in the proliferation phase accompanied by edema in the lower extremities. They were categorized in grades 2 and 3 based on the Wagner scale and have an ABI value of > 6.00. The sample of this study consisted of 60 patients who were divided into a control group and a randomly selected intervention group. The control group was treated with standard clinical wounds/ulcers care while the intervention group was given standard clinical care added with the application of lower extremities elevation as high as 45 degrees for 15 minutes post-treatment.

B. Material and Procedure

The elevation tool used is an elevator that has been modified by the researcher and has been tested for accuracy. This instrument is made portable and is installed next to the patient's bed in the recovery room, height is set at an angle of 45 °. The researcher set the same form of instrument for all

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participants. While the instrument used to measure the Ankle Brachial Index (ABI) is a Doppler type B3-100V3 with a frequency range of 80/200 Hz up to 5 kHz. This tool has been in the form of a product that has gone through proper testing, so this tool can already be considered valid and reliable.

C. Ethicall Consideration

The researcher has obtained research ethics statements from the research ethics committee of the Faculty of Medicine and Health Sciences of Muhammadiyah University, Yogyakarta, as well as Pontianak Kitamura clinic as the research location.

D. Statistical Analysis

Bivariate analysis was used to see the relationship between independent and dependent variables. Before conducting a statistical test on each variable, the data normality test was first performed using *Shapiro Wilk* where the results were normally distributed. Furthermore, the Paired T test was used to analyze the pre and post in the control and intervention groups. While, the Independent T test was used to determine the difference in effectiveness of the two groups

III. RESULT

TABLE 1. Frequency distribution based on Participants' characteristics

Variable	Category	Control		Intervention	
		N	%	n	%
Sex	Male	16	53.7	11	36.7
	Female	14	46.7	19	63.3
Education	SD (ES)	8	26.7	4	13.3
	SMP (JHS)	12	40	12	40
	SMA (SHS)	9	30	9	30
	PT(UNI)	1	3.3	5	16.7
Smoking History	Yes	16	53.7	11	36.7
	No	14	46.7	19	63.3
Wound location	Dorsal	6	20	4	13.3
	Plantar	14	46.7	19	63.3
	Fingers	8	26.7	7	23.3
	Location Others	2	6.7	0	0

In the control group, the number of male participants was 16 (53.7%) greater than female participants. Whereas in the intervention group female participants were 19 people (63.3%) more than male participants. As for the education level, the data shows that in the control and intervention group, the highest level of education possessed by all participants was the junior high school level. Each group consists of 12 people (40%) who have a junior high school education background. Meanwhile, based on smoking history, it was found that in the control group there were 16 people (53.7%) of all participants who had a history of smoking. Whereas in the intervention group, the participants with a history of smoking were 11 people (36.7%). Therefore, the number of participants who have smoking history in the control group is greater than in the intervention group

TABLE 2. Distribution of Frequency based on blood glucose values

Variable	Control		Intervention	
	Mean±SD	Min-Max	Mean±SD	Min-Max
Age	53.83±6.449	44-69	53.27±7.395	41-65
Blood Glucose	213.03±48.643	157-300	213.67±50.276	150-300

The table above shows the distribution of homogeneous data in each group. The average age in control group was 53.83 years, and in the intervention group the average age of participants was 53.27 years. As for Blood glucose, the average in the control group was 213.03 and in the intervention group it was 213.67, this shows that each group has same data distribution.

TABLE 3. Difference in ABI scores before and after in the control group

Variable	n	Mean±SD	Difference Mean±SD	CI 95%	*P*
		ABI	ABI		
Before	30	0.8213±0.135	0.0483±0.093	0.083 - 0.013	0.168
After	30	0.8530±0.124			

The table above indicates the difference in ABI values before and after treatment in the control group. The average ABI scores in the control group prior to treatment was 0.8213 ± 0.135. While, after the standard treatment based on the SPO without elevation was given, the average ABI value increased to 0.8530 ± 0.124. Statistical results show that the value of p = 0.168, thus it can be interpreted that there is no significant difference in the value of ABI before and after standard wound care.

TABLE 4. ABI Scores before and after treatment in Intervention Group

Variable	n	Mean±SD	Difference Mean±SD	CI 95%	*P*
		ABI	ABI		
Before	30	0.7977±0.131	0.038±0.085	0.078 - 0.021	0.003
After	30	0.8510±0.110			

The table above displays the difference in ABI values before and after treatment in the intervention group. The average ABI value in the control group before was 0.7977 ± 0.131, after giving standard care based on the SPO and added with lower extremity elevation for 15 minutes, the average ABI value increased to 0.8510 ± 0.110. Statistical results show that *p=0.003*, so it can be interpreted that there is a significant difference in the value of ABI before and after the standard wound care.

TABLE 5. The Effectiveness of Lower Extremity Elevation at 45° on ABI

Variable	Mean ABI Differences Score		
	Control	Intervention	P value
ABI Differences score	0.0483±0.093	0.038±0.085	0.001

From the table above, it can be interpreted that when compared with the standard treatment given in the control group, the application of the lower extremity elevation at 45° for 15 minutes is more effective on the Ankle Brachial Index in diabetic foot ulcers (*p*=0.001)

IV. DISCUSSION

The study results show that the ABI values before and after treatment in the control group was not significant with (*p=>0.005*), due to confounding factors. Multivariate test results of the inhibiting factors in this study found two main factors that influence the results of this study such as Blood glucose and age. Statistically, these two factors affect the increase in ABI in the control group by 38.4%.

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Male participants tend to have smoking habits so that patients with DFU with edema will experience obstacles in increasing vascularization. In this study, the data show that smoking history in men influences and contributes to the increasing Ankle Brachial Index. This shows that the more participants smoke, the greater the decrease in circulation becomes. Nevertheless, according to [10], women tend to have lower ABI values compared to men. This is in accordance with [11] who affirms that women tend to have lower ABI values than men do, so they are at risk of cardiovascular and blood vessel disease.

The average age in the control group was 53.83 years, while the mean blood glucose was 213 mg / dl. Age is very closely related to blood glucose, which is the higher the age of someone who has diabetes, the higher the value of blood glucose. Meaning, the older the respondent's age is, the greater the decrease in circulation is. Age is associated with decreased circulation because there are some changes in the functions of human body parts in older people. One of them is blood vessels, especially the function of the endothelial lining which plays an important role in maintaining smooth muscle tone and vasodilation [6; 12].

Aging of blood vessels results in differences in the structure and function of its existence. This difference is influenced by differences in structural, mechanical and biochemical walls due to the age factor, which results in the decrease of arterial compliance as well as stiffness of blood vessel walls [6]. Additionally, prolonged and uncontrolled hyperglycemia can cause vascular-related complications [13].

Arterial stiffness is related to the effects of endothelial regulation on arterial smooth muscle tone. In the endothelial layer there is an increase in cells with the prolipid nucleus, increased endothelial permeability, and cytoskeleton differences from cells. In endothelial cells there is also an increase in PAI-1 secretion which is the cause of thrombosis. In addition, there is an increase in endothelin and vasoconstrictor growth factors released by endothelial cells, which are then followed by a decrease in NO [14; 12].

Circulation in the area of the wound / ulcer refers to the extent to which blood flow to the area of the wound / ulcer can meet the adequacy of oxygen that affects the healing of wounds or ulcers. Circulation is an important component and one of the priority interventions in the treatment of diabetic foot ulcers [15]. Decreased circulation causes disruption of the angiogenesis process in which the decrease in angiogenesis inhibits the wound healing phase, especially the inflammatory and proliferation phase, as a result the wound closure takes a long time [16].

The results of this study indicate the average value of ABI increased in the intervention group. The increase in the value of the Ankle Brachial Index in the intervention group was significant. Besides, the statistical value that showed significance in this group was influenced by factors such as blood glucose and age. While, the multivariate test results of factors in ABI in the intervention group were only age and blood glucose with a percentage of 47.1%.

Most participants in this study experienced an increase in the value of ABI. This is indicated by improved circulation after 4 weeks of lower extremity elevation therapy given to participants in the intervention group. Increased circulation indicates that oxygen has increased in the lower extremities or wounds or ulcers. Thus, this confirms the findings of [14] proving that elevation therapy is important because adequate oxygen in the area of wounds or ulcers can facilitate various components that support the healing of wound such as nutrition, angiogenesis, growth factors, macrophage action, and the formation of fibroblasts, thereby, the healing of wounds or ulcers gets better and faster.

The results show that the use of lower extremity elevation for 15 minutes was more effective in increasing ABI compared to the group that was not given the lower extremity elevation with $p < 0.005$. In this study, the researcher did not do the same characteristics of participants in each group, especially on gender and smoking history. It is possible that the results delivered might be biased because there were more male participants in the control group who tend to have a smoking history. Nonetheless, the statistical test of the ABI differences in the control and intervention groups was $p = 0.001$, which can be interpreted that standard wound care using modern dressing plus lower extremity elevation is more significant in increasing circulation in the form of increased ABI values, compared to the standard wound care group. This is influenced by confounding factors including age and blood glucose in which multivariate test results of the factors on ABI was 39.8%.

The use of elevation of the lower extremities has been carried a lot of in research, one of which was a study by [17], which found that the use of elevation as an *adjunctive therapy* can help improve blood vessel circulation. This is in line with the study presentation delivered by [18] which states that one of the factors inhibiting wound healing is caused by edema which inhibits the circulation of oxygen and nutrients needed by the wound so that elevation can be used as one of the therapies to overcome these problems.

The volume of blood in veins amounts to about 60% in edema when there is a buildup in the distal area. By elevating the lower extremities, the buildup is reduced due to the effect of gravity. However, capillaries, venules and arteries will respond to the elevation depending on the severity of edema caused by the width of veins [17].

At the beginning of this research process, in the mobilization the participants were asked to not putting excessive pressure on the foot having wounds or ulcers, so they were required to use a wheelchair, crutches, or family assistance. In the implementation there were also participants who did not optimally implement the suggestions due to their difficulty to move, limited tools, or they were not used to it. However, after being motivated most participants were willing to use aids. Thus, to anticipate the shortage of tools the researcher recommend using a walking stick or crutch.

Elevation of the lower extremity is useful for restoring blood flow and reducing pressure in the distal extremity. Activity carried out for more than15 (>15) minutes can increase distal pressure by up to 20%, thereby increasing the risk of peripheral edema. Edema will increase distal area pressure which reduces perfusion due to arterial pressure. Therefore,

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with lower extremity elevation this pressure can be reduced [18].

V. Limitation and Recommendations

Inhibiting factors such as smoking history and gender have different proportions in each group. In this study, the researcher only examined ABI. Whereas the comfort level of patients in the intervention group was not considered. Use of elevation therapy was only done when the participants came to the Kitamura Clinic. Another confounding factor that was not controlled by the researcher is psychological conditions. It is difficult for the researcher to fully control the psychological conditions of each respondent. Therefore, further research examining the relationship of the effects of stress on healing diabetic foot ulcers during lower extremity elevation therapy process needs to be done. In addition, other confounding factors such as nutrition, type of dressing, radiation, friction and et cetera which can affect the healing process of wounds or ulcers were not strictly controlled. Thus, further researchers are suggested to pay attention to other confounding and inhibiting factors. It is also necessary that the therapy of lower extremity elevation not only be done in the Clinic, but must also be done at home and monitored by medical personnel in each patient's home. Especially, the researchers can also conduct research using other various elevation angles, for example at 60 degrees or 90 degrees

VI. Conclusion

Patients with Diabetic Foot Ulcers with leg edema can be given therapy to increase the lower extremity at an angle of 45 degrees for 15 minutes to increase venous return (VR). With an increase in venous return, the wound has the potential to recover more quickly so that treatment costs will also be lower and the quality of life of patients with diabetic foot ulcers will increase.

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