Healthcare in Low-resource Settings

eISSN: 2281-7824

https://www.pagepressjournals.org/index.php/hls/index

Healthc Low-resour S 2024 [Online ahead of print]

To cite this Article:

Widiastuti HP, Paonganan R, Setiani D, et al. **Buerger-Allen exercises' effectiveness for improving lower limb circulation.** *Healthc Low-resour S* doi: 10.4081/hls.2024.11965

Buerger-Allen exercises' effectiveness for improving lower limb circulation

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Key words: Buerger Allen exercise, Type 2 DM, lower limb circulation.

Contributions: HPW carried out the conception, design, and statistical analysis of this article, and RP and JSP conducted the analysis and interpretation of the data. DS and HD completed data collection and assembly. HPW and RP drafted the article. All the authors have read and approved the final version of the manuscript and agreed to be held accountable for all aspects of the work.

Conflict of interest: the authors declare no potential conflict of interest.

Funding: none.

Ethics approval and consent to participate: this research has received ethical approval from the Health Research Ethics Commission of Poltekkes Kemenkes Kalimantan Timur, based on ethical certificate number LB.01.01/7.3/002339/2021. During the research, the researcher pays attention to the ethical principles of information to consent, respect for human rights, beneficence, and non-maleficence.

Availability of data and materials: all data generated or analyzed during this study are included in this published article.

Acknowledgments: we would like to thank the Director of Poltekkes Kemenkes Kalimantan Timur and the Head of Bengkuring Public Health Center who had given access and data clarification on Diabetes Mellitus patient prevalency in Bengkurian, Samarinda.

Abstract

Impaired peripheral perfusion in the legs is the most common complaint experienced by patients with type 2 Diabetes Mellitus (DM). One nursing intervention in the form of physical exercise that can be administered to DM patients to prevent peripheral perfusion disorders and increase vascularization of the lower extremities is the Buerger-Allen Exercise (BAE). The goal of this study was to analyze the effectiveness of BAE in improving lower extremity circulation. The population consisted of patients with type 2 DM. The research design employed a quasi-experiment with pre-test and post-test, including a control group. A sample of 24 respondents was divided into an intervention group and a control group. The sampling technique used was purposive sampling. Data were obtained through direct Ankle-Brachial

Index (ABI) measurement using a Doppler ultrasound and an aneroid sphygmomanometer, temporary blood sugar level measurements using a glucometer, and leg sensitivity measurements using a monofilament tool. Paired T-tests and independent T-tests were used as statistical tests. The results of the Paired T-test for lower limb circulation in the intervention group yielded a p-value of 0.000, indicating a significant difference in the circulation of the lower extremities before and after the intervention. The results of the independent T-test also showed a p-value of 0.000, indicating significance. Thus, BAE can improve lower limb circulation in patients with type 2 DM.

Introduction

Diabetes prevalence has been growing globally in recent years.[1] Diabetes Mellitus (DM) has become a major health concern worldwide, particularly in developing countries, due to the high number of complications it causes.[2] DM is infamous as the 'silent killer' because of its slow-paced symptoms; therefore, most patients remain unaware until complications have severely formed.[3] Diabetes is characterized by elevated blood glucose concentrations related to the effects of abnormal β-cell biology on insulin action.[4] The complications of DM, particularly on blood vessels for both microvascular and macrovascular, as well as neuro systems, have a significant impact on higher therapy costs and lower patient productivity.[5] Impaired peripheral perfusion in the legs is one of the most common complications in DM patients. The right treatment is necessary to minimize this complication. Physical exercise is considered the primary treatment to prevent its occurrence in patients.[6,7]

As one of the most rapidly developing countries in Southeast Asia, Indonesia currently ranks fifth in the number of people with type 2 DM.[8] The International Diabetes Federation (IDF)

(2019) stated that 429 million people out of the world's total population have DM. On the other hand, the prevalence of DM in Indonesia has increased from 6.9% in 2013 to 8.5% in 2018, equivalent to 20.4 million people suffering from DM. According to the Indonesia Health Ministry data in 2018, the highest prevalence of DM was in the Special Capital Region of Jakarta (3.4%), Special Region of Yogyakarta (3.1%), East Kalimantan (3.1%), South Sulawesi (3.0%), and East Java (2.6%). In Indonesia, as per the 2018 National Health Survey report, the prevalence of DM in the population aged ≥15 years was 2.0%.[9] DM affects 10,276,100 of Indonesia's 166,531,000 adults (aged 20-79 years), with a prevalence of 6.2%.[10] The latest estimation from the Samarinda Public Health Office in 2020 recorded a total of 546 type 2 DM cases. Particularly in the Public Health Center of Bengkuring Samarinda, a total of type 2 DM visits from April until June 2020 were 176 patients. Data shows that globally, there are 425 million people, or 8.8% of the world's population, estimated to suffer from DM. This situation is projected to increase to 629 million people in 2045.[11]

The complications that may occur in people with DM are classified into two parts: acute complications and chronic complications. Chronic complications consist of microvascular and macrovascular complications, with macrovascular complications including coronary artery disease, stroke, and peripheral artery disease.[12] However, the lack of knowledge or understanding of DM is an obstacle in the healing process.[13] Impaired peripheral vascularization in DM patients needs to be detected early. One examination to detect impaired peripheral vascularization is the implementation of the Ankle-Brachial Index (ABI) test.[14] ABI is a non-invasive vascular test and a simple method that functions to identify vascularization within the leg by measuring the systolic blood pressure ratio (ankle) and limb systolic blood pressure (brachial). An ABI score >1.0 is considered normal, and a score >0.9

is considered at risk of impaired peripheral circulation. Moreover, early proper treatment for DM patients can be obtained through ABI measurement.[15]

One nursing intervention in the form of physical exercise that may be given to DM patients to prevent impaired peripheral vascularization and enhance vascularization towards the lower extremities is the Buerger-Allen Exercise (BAE). BAE was suggested by Leo Buerger in 1924 and was later modified by Arthur W. Allen in 1931. It is an exercise system for arterial insufficiency of the lower ankle that applies gravitational position changes and muscle pumps by implementing ankle movements to drive blood vessel smooth muscle. Gravitation gradually helps empty and fill the blood column, eventually enhancing blood transportation through the blood vessels.[16]

Research by Hassan and Mehani stated that BAE has a positive effect on improving peripheral blood circulation into extremities, thus improving the oxygen and nutrition required by metabolism up to the body cells. Furthermore, the research by John and Rathiga (2015) shows that practicing BAE for 10-17 minutes twice a day for five consecutive days can improve circulation. A post-test was conducted on the fifth day using an ABI measuring instrument.[17] Previous arguments and an earlier study by the researcher about type 2 DM patients inspired the researcher to conduct a study on the effectiveness of BAE towards lower extremities circulation changes in type 2 DM patients.

Materials and Methods

The quasi-experimental design with pre and post-tests and a control group plan are employed in this research. A total of 24 samples are divided between the intervention group (Buerger-Allen intervention) and the control group (given education), chosen using the purposive sampling technique with inclusion criteria. The characteristic criteria for the intervention and

control groups include individuals with type 2 DM, lower extremity muscle strength scores of 4-5, blood sugar levels higher than 6.7 mmol/L, absence of ulcers, and taking oral diabetic medicine. Exclusion criteria involve individuals with type 2 DM who have hypoglycemia and complications such as diabetic foot ulcers, joint problems, arterial calcification, or an ABI score greater than 1.3. The number of samples in this study was determined using the Roscoe formula, resulting in several respondents greater than or equal to 10. To anticipate potential dropouts, an additional 10% was added, making the number of subjects per group 12. The independent variable in this study was BAE, while the dependent variable was lower limb circulation (ABI, temporary blood sugar level, and leg sensitivity). Data were obtained through direct ABI measurements using a Doppler ultrasound and an aneroid sphygmomanometer, temporary blood sugar level measurements using a glucometer, and leg sensitivity measurements using a monofilament tool. Paired T-test and Independent T-test were used as statistical tests.

The responses were initially evaluated/pre-tested by the researchers using a vascular Doppler ultrasonography probe and an aneroid sphygmomanometer for ABI measurement, a glucometer for temporary blood sugar level measurement, and a monofilament for leg sensitivity measurement for both the intervention group (BAE) and the control group (given education). After six visits over six days, the researcher administered the BAE intervention to the intervention group. This intervention took place for about 21 minutes per session per day. Using a vascular Doppler ultrasonography probe, an aneroid sphygmomanometer, glucometer, and monofilament, the researcher performed a final assessment/post-test on the responders in the intervention group and the control group after 6 days.

Results

Table 1 displays the characteristics of respondents in the intervention and control groups. It can be observed that the most dominant gender in the intervention group is female, comprising 9 respondents (75%). The control group is evenly distributed between 6 female and 6 male respondents. Furthermore, regarding age characteristics in the intervention group, ages 40-48 (33.3%) and ages 49-57 (33.3%) are equally dominant, each consisting of 8 respondents. In contrast, the control group is predominantly in the age range of 49-57 (66.7%), with 6 respondents.

Examining respondents' latest education, the intervention group is half-dominated by senior high school graduates, comprising 5 respondents (41.7%), while the control group is also evenly split, with 6 respondents (50%) having completed senior high school. In terms of occupation, the intervention group is mostly dominated by housewives, accounting for 66.7%, while the control group is similarly divided, with 33.3% being housewives.

Table 2 shows that the ABI values increased by 0.25, blood glucose decreased by 55.17 dL/g, and right leg sensitivity increased by 2.08 in the control group, while the ABI value decreased by 0.01 in the control group.

The paired T-test results in Table 3 indicate that the p-value for the intervention group is 0.000, which is less than 0.05. Based on this value, it can be concluded that BAE has a significant impact on the change in lower extremities circulation in the intervention group. Furthermore, the control group results in a p-value of 0.241, which is greater than 0.05. The conclusion is that education has no significant impact on the change in lower extremities circulation in the control group.

Table 4 displays a significant change in values regarding lower extremities circulation in both the intervention and control groups, with a p-value of 0.000, which is less than 0.005. This

value indicates a significant difference in circulation change in the lower extremities between the intervention group and the control group.

Discussion

Ankle-Brachial Index (ABI) circulation value variations in the extremity bottom before Buerger-Allen's intervention exercise

According to the study's findings, the ABI resulted in a mean of 0.82 before the BAE. Disorders of arterial and venous ulcers numerous factors, including the age profiles of responders (66.6%) and as many as 8 individuals in the early elderly (40-57 years), affect the veins in respondents. Disorders of arterial and venous ulcers are influenced by numerous factors, including the age profiles of responders (66.6%), with as many as 8 individuals in the early elderly age group (40-57 years) affecting the veins in the respondents. Thiruvoipati, Kielhorn, and Armstrong (2015) claim that individuals older than 50 are at a higher risk of developing high-risk peripheral vascular diseases.[18] According to Dick et al. (2009), a person's risk of developing arteriosclerosis and endothelial blood vessel diseases increases with age.[19]

This is consistent with a study in Indonesia's assertion that the condition of diabetic foot is a result of various factors, including neuropathy and a lack of sensitivity.[20] Sensitive feet in DM patients are the first sign of excessive blood sugar levels that interfere with metabolism. Increasing physical activity, especially in the legs, can help address this issue. Based on sex, the majority of respondents are male (75%). According to Arnetz, Ekber, and Alvarsso (2014), testosterone levels in males can lead to abdominal fat and insulin resistance, increasing the risk of type 2 DM.[21] Meanwhile, according to McIntosh and Karen (2008),

distal occlusion in geriatrics with diabetes and atherosclerosis variables are the main causes of lower limb arterial circulation insufficiency in men.[22]

Ankle-Brachial Index (ABI) circulation value variations in the extremity bottom after Buerger Allen's intervention exercise

According to the study's findings, the ABI resulted in a mean value of 1.07, with the ABI value increasing by 0.25 following the BAE. According to Rosales-Velderrain *et al.* (2013), continuous and repetitive exercise is necessary to improve the blood flow of muscle microvascular flow.[23] This is related to artery dilation (vasodilation), resulting in an increase in capillary permeability and enabling muscle cells to absorb glucose.[24]

The results obtained from this research, using the Paired T-test, show that there is a significant difference before and after the BAE intervention, with a p-value of 0.000, which is less than 0.005. This means that BAE can improve lower extremities circulation in type 2 DM patients. Impaired peripheral blood vessels in type 2 DM patients may result in diabetic foot ulcers caused by static flow in veins, resulting from blood vessel physiology function being agitated by the stream from the lower extremities to the heart. Effective contraction of extremities muscles is required by performing routine 90o dorsiflexion movements on the ankle. BAE, in improving peripheral circulation, utilizes the muscle pump principle on the ankle, consisting of two movements. The first movement is dorsiflexion and plantarflexion, which are expected to set contraction and lower extremities muscle relaxation to improve peripheral blood circulation.[25] Additionally, the BAE's gravitational principle affects body fluid distribution by helping each blood vessel to empty and fill the blood column, eventually aiding in improving blood transportation through blood vessels.[26] Impaired neuropathy and vascular issues are among the main factors contributing to the formation of wounds in type 2

DM patients. Wounds occurring in these patients correlate with the presence of peripheral neuropathy. Additionally, DM patients often experience poor circulation, which is related to peripheral arterial disease and is characterized by a decreased ABI.[16]

The BAE is effective in improving lower extremities perfusion and minimizing the pain in lower extremities for type 2 DM patients. It enhances blood supply to the extremities and triggers the formation of new vascular structures, aiding in the wound-healing process.[27] Patients with DM who have diabetic foot ulcers are at risk of foot amputation. Those with peripheral circulatory insufficiency, defined by an ankle-brachial index of less than 0.9 or a Michigan Neuropathy Screening Index of more than 2, can benefit from diabetes treatments that include foot exercises, such as the BAE.[28] This research is supported by previous studies that found BAE has a positive impact on circulation, strengthens footwork, decreases necrosis, prevents embolism, minimizes pain, and reduces cyanosis in blood vessels. The study's limitations include a lack of control for other variables that can affect lower extremity circulation, such as a history of hypertension, smoking, and dietary patterns in type 2 DM patients.

Conclusions

BAE can improve lower limb circulation in patients with type 2 DM. These exercises do not require expensive equipment and can be done at home. For future researchers, we recommend conducting research with a larger sample size and exploring additional parameters and characteristics that have not been previously studied concerning the symptoms of patients with type 2 DM. Additionally, comparing BAE with other physical exercises in improving lower extremity circulation in patients with type 2 DM would be valuable.

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Table 1. Frequency distribution based on respondents' characteristics.

Characteristic	**Intervention group**		**Control group**	
	n	**%**	**n**	**%**
Gender				
Female	3	25.0	6	50.0
Male	9	75.0	6	50.0
Age (years)				
31-39	0	0	1	8.3
40-48	4	33.3	0	0
49-57	4	33.3	6	66.7
58-66	3	25.0	2	16.7
67-75	1	8.3	1	8.3
Latest education				
Elementary school	3	25.0	1	8.3
Junior High school	3	25.0	3	25.0
Senior High school	5	41.7	6	50.0
University	1	8.3	2	16.7
Occupation				
Self-employed	1	8.3	2	16.7
Farmer	2	16.7	3	25.0
Civil servant	1	8.3	2	16.7
Housewife	8	66.7	4	33.3
Others	0	0	1	8.3
Total	**12**	**100%**	**12**	**100%**

Table 2. Frequency distribution based on Ankle-Brachial Index (ABI), temporary blood sugar level, and leg sensitivity.

Variable	Pre-test	Post-test	Difference
	Mean	Mean	
Intervention group (n=12)			
Ankle Brachial Index	0.82	1.07	+0.25
Temporary blood sugar level	244.17	189	-55.17
Right leg sensitivity	6.5	8.58	+2.08
Left leg sensitivity	7.42	9.33	+1.91
Control group (n=12)			
Ankle Brachial Index	0.65	0.64	-0.01
Temporary blood sugar level	198	225.25	+27.25
Right leg sensitivity	5.58	5.58	0
Left leg sensitivity	7.42	9.33	+1.91

Table 3. The paired T-test of the intervention group and control group.

Variable	Pre-test	Post-test	p
Intervention group			
Lower extremities circulation	0.82±0.97	1.07±0.15	0.000
Control group			
Lower extremities circulation	0.65±0.22	0.64±0.21	0.241

Table 4. Independent T-test on intervention group and control group.

Lower extremities circulation	**N**	**Mean**	**p**
Pre-test			
Group 1	12	0.82±0.97	0.028
Group 2	12	0.65±0.22	
Post-test			
Group 1	12	1.07±0.15	0.000
Group 2	12	0.64±0.21	

Submitted: 13 October 2023

Accepted: 18 March 2023

Early access: 12 April 2024