Journal Of Nursing Practice
https://thejnp.org/
ISSN: 2614-3488 (print); 2614-3496 (online) Vol.9 No.3. April 2026. Page.519-531

The Effectiveness of Buerger Allen Exercise and Hydrotherapy on Changes in Peripheral Blood Circulation and Neuropathic Pain Intensity in Preventing Diabetes Mellitus Complications in the Elderly

Yammar[1*], Ratna Wardani[2], Joko Prasetyo[3], Asnuddin[4], Nirmawati Darwis[5], Ruslang[6]
[1,5] Department of Nursing, Faculty of Health Sciences, Universitas Puangrimaggalatung
[2,3] Universitas Strada Indonesia, Kediri, Indonesia
[4] Muhammadiyah Institute of Health Technology and Science Sidrap
[6] Health Administration, Faculty of Health Sciences, Universitas Puangrimaggalatung
**Corresponding author: yammarskg@gmail.com*

ABSTRACT

Background: Type 2 Diabetes Mellitus (T2DM) is a major health problem in the elderly, often leading to complications, including impaired peripheral circulation, often accompanied by neuropathic pain. Therefore, foot activity therapy, including Buerger Allen exercises and hydrotherapy, is necessary to improve peripheral blood circulation.

Purpose: This study aims to prevent complications of T2DM by improving peripheral blood circulation, as indicated by changes in Ankle Brachial Index(ABI) valuesand the intensity of neuropathic pain in the elderly.

Methods: This quantitative study used a True Experimental Design with a pretest-posttest control group design. The study was divided into three groups: Buerger Allen exercise, hydrotherapy, and a control group. The sample consisted of 45 elderly individuals with type 2 diabetes mellitus (T2DM), selected using a simple random sampling method. This study was conducted in the Tempe District, Wajo Regency. Data analysis used a paired t-test to determine the effect of the three foot activity therapies. Data were analyzed using SPSS with a significance level of $p < 0.05$.

Results: The study showed that the Buerger Allen exercises and hydrotherapy groups experienced significant changes in ABI valuesand neuropathic pain intensity before and after therapy (p-value 0.000). Meanwhile, the control group showed no significant changes in ABI values or neuropathic pain intensity from the pretest to the posttest (p-value 1.000).

Conclusion: It can be concluded that the Buerger Allen exercises and hydrotherapy groups can improve peripheral blood circulation compared to the control group, thereby preventing complications associated with type 2 diabetes in the elderly.

Keywords: ABI, Neuropathy, Pain Intensity, T2DM

Received January 10, 2025; Revised February 12, 2025; Accepted March 3, 2026
DOI: https://doi.org/10.30994/jnp.v9i3.1025

ISSN: 2614-3488 (print); 2614-3496 (online) Vol.9 No.3. April 2026. Page.519-531

BACKGROUND

The aging process will certainly impact a person's health. As we age, we become more susceptible to health problems due to decreased organ function (Kusumo, 2020). This decline in organ function increases the risk of diseases, such as type 2 diabetes mellitus (T2DM) (Kusumo, 2020). Type 2 diabetes mellitus is also classified as a multisystem disease, a non-communicable disease, and a metabolic disorder, characterized by elevated blood glucose levels resulting from impaired insulin secretion and insulin resistance, as well as a lack of physical activity (Faselis *et al.*, 2020).

Type 2 diabetes mellitus (T2DM) remains a significant health issue and a global health emergency, with its incidence increasing rapidly (IDF, 2021). This is evidenced by the statistically significant increase in incidence each year. According to a survey by the International Diabetes Federation (IDF), the global incidence of type 2 diabetes mellitus (T2DM) among people aged 20-79 has increased for three consecutive years: 463 million in 2019, 470 million in 2020, and 537 million in 2021 (IDF, 2019, 2021).This figure is predicted to increase to 643 million by 2030, and to 783 million by 2045 if effective preventive measures are not implemented (Cho *et al.*, 2018).

Indonesia is one of the countries with the highest number of T2DM sufferers worldwide, ranking 7th out of 10 countries, with 10.7 million sufferers (IDF, 2021; American Diabetes Association, 2023). South Sulawesi is one of the provinces with the highest incidence of T2DM. South Sulawesi Province has a prevalence of diabetes mellitus (DM) among residents aged 15-79 years (1.83%), with the highest prevalence in Wajo Regency (9.27%) (Kementerian Kesehatan RI., 2020).

The prevalence of T2DM in Wajo Regency has increased annually, with 1,499 cases in 2021, 1,625 cases in 2022, and 1,948 cases in 2023 (Lamaddukelleng Regional Hospital). The increasing incidence of T2DM in Wajo Regency is linked to unhealthy lifestyles, such as a poor diet and lack of physical activity, which can lead to elevated blood glucose levels (hyperglycemia) (Alidya, 2022). Over time, high blood glucose levels can cause serious damage or complications, the most common of which are peripheral vascular disorders and neuropathy, often accompanied by leg pain (Kolarić *et al.*, 2022; Patel, 2022). Pain that begins in the feet is known as neuropathic pain (Rachmantoko et al., 2021). Symptoms of neuropathic pain have been described variously, including tingling, stabbing, numbness, and itching in the feet (Rachmantoko *et al.*, 2021) .

Poor vascularization in individuals with T2DM can worsen peripheral circulation, leading to decreased peripheral perfusion. This leads to nerve ischemia due to increased and thickened blood vessel walls, leading to narrowing and blockage (Bistara *et al.*, 2022). Poor peripheral vascular health can increase the risk of diabetic foot ulcers (Embuai, Siauta and Tuasikal, 2019). Diabetic foot ulcers are foot wounds that negatively impact disease prognosis and quality of life in individuals with T2DM (Letta *et al.*, 2023). This condition is caused by peripheral vascular disorders, neuropathy, and infections in people with diabetes (Farida, 2022) These complications can certainly be fatal, including amputation and death if not given serious attention and early treatment (McDermott *et al.*, 2023).

Based on survey results at Lamaddukelleng Regional Hospital, Wajo Regency, data showed that 20% of T2DM patients experience diabetic foot ulcers per year, and 15% of these cases result in amputation and death, among those aged 45 and over. The cause is that 13-15% of all patients with diabetes mellitus experience impaired peripheral blood circulation accompanied by neuropathy in the form of pain in the lower extremities (Lamaddukelleng Regional Hospital, 2024). Then, this year, data from Lamaddukelleng Regional Hospital showed that the number of T2DM patients (outpatients) residing in the Tempe District was 65

people, aged 60-70 years. Interviews with nurses at Lamadukelleng Regional Hospital revealed that the average blood glucose level of elderly patients at check-ups consistently increases, and they often begin to complain of leg pain, putting them at risk of developing peripheral circulatory disorders. Therefore, effective management of diabetes mellitus is necessary to prevent serious complications in T2DM patients and maintain their overall health.

Management of diabetes mellitus in the elderly can be done with pharmaceutical and non-pharmacological treatment therapy. Non-pharmacological therapy can be in the form of diabetic gymnastics with the Buerger Allen exercises method and hydrotherapy (soaking feet in warm water) (Putra et al., 2023). Buerger Allen exercises are an ideal and non-invasive physical therapy that can be applied to patients with T2DM, which is intended to improve peripheral blood circulation in the lower extremities (Chang *et al.*, 2015, 2016).Buerger Allen Exercises are very effective in improving peripheral blood circulation in the lower extremities and are recommended for use in patients with T2DM (Patidar, 2018; El-Fattah *et al.*, 2019; Patel, 2022). These foot exercises can also be considered for pain management in patients with T2DM(Pebrianti *et al.*, 2020). Buerger Allen Exercises were first described by Buerger in 1926 and later modified by Allen in 1930 to alleviate leg symptoms of arterial insufficiency. Buerger exercises can stimulate peripheral blood circulation by modulating gravity and muscle contractions (W.Allen, 1930).

Buerger Allen exercises can be an alternative or complementary procedure to improve peripheral circulation because they are easy to perform, easy to learn, economical, and low-risk, making them safe for the elderly (Chang *et al.*, 2016). Buerger-Allen exercises can be performed in several steps. The first step involves lying on your back with your legs elevated at a 45° angle, which aims to empty the blood vessels and increase blood flow into the right atrium, which in turn increases cardiac output. The second step involves sitting in bed with your legs dangling, which plays a role in increasing blood flow into the arterioles. The following ankle movements can strengthen distal circulation due to the strength of muscle contractions. The next step is dorsiflexion and plantar flexion, followed by inward and outward movements of the foot, which train the Achilles tendon to prevent contractures or joint stiffness that can lead to further foot deformities. The final step is lying on your back with your feet covered with a warm blanket, which helps improve the condition of the reperfused foot when the effects of gravity are removed. Meanwhile, hydrotherapy, or soaking your feet in warm water at 38°C, can cause peripheral blood vessels to dilate (vasodilation), improving blood circulation, relieving joint discomfort and muscle tension, killing germs in the feet, lowering blood sugar levels, and reducing foot pain(Harnani and Axmalia, 2017; Kartini *et al.*, 2022).

Hydrotherapy causes muscle relaxation and vasodilation, allowing oxygen-carrying blood to reach the tissues more quickly (Yuningsih, 2022). Research conducted by Yammar *et al.*(2021), showed that immersing the lower legs in 24 liters of fresh water without CO2 at 37°C for 10 minutes can repair microvascular damage, thereby inhibiting the decline in peripheral blood circulation.

Until now, there has been no intervention that can be used as additional therapy besides pharmaceutical treatment to improve peripheral blood circulation in the elderly with T2DM in Wajo Regency. Meanwhile, previous studies stated that Buerger Allen exercises and Hydrotherapy therapy have beneficial effects in improving peripheral blood circulation in the lower extremities in people with T2DM (Chang *et al.*, 2015, 2016; Patidar, 2018; El-Fattah *et al.*, 2019; Patel, 2022; Yuningsih, 2022). Then based on a preliminary study conducted through a survey in Tempe District, it was found that the elderly experienced symptoms of changes in peripheral blood circulation so that these changes caused disturbances in elderly walking activities because the elderly complained of pain in the legs which were described with various symptoms ranging from tingling, numbness and feet feeling stabbed or cut. Buerger Allen

ISSN: 2614-3488 (print); 2614-3496 (online) Vol.9 No.3. April 2026. Page.519-531

exercises and hydrotherapy are therapies that can improve peripheral blood circulation in T2DM. This study is typically conducted to assess its impact on peripheral blood circulation. However, there has been no research focused on the effectiveness of Buerger Allen exercises combined with hydrotherapy in enhancing peripheral blood circulation and reducing the intensity of neuropathic pain. This is particularly important for preventing complications associated with Type 2 Diabetes Mellitus (T2DM) in the elderly. Consequently, the author is interested in conducting this research.

OBJECTIVE

To assess the level of effectiveness of providing Buerger Allen exercises and hydrotherapy therapy on changes in peripheral blood circulation and the intensity of neuropathic pain in preventing complications of T2DM in the elderly.

METHODS

Design

The type of research used in this study is quantitative, employing a True Experimental design, specifically a pretest-posttest control group design method. This study was divided into three groups: the first intervention group received the Buerger Allen exercise, the second intervention group underwent hydrotherapy, and the third group served as the control group. For the intervention group, each received treatment for eight weeks; group A did Buerger Allen exercises 3 times a week (in 8 weeks), and group B did hydrotherapy 3 times a week (in 8 weeks). While the control group was not given treatment.

Population and Sample

The study population consisted of T2DM patients registered as outpatients at Lamaddukelleng Regional Hospital with peripheral vascular disorders, residing in Tempe District, Wajo Regency, and meeting the criteria established by the researcher between June 2024 and July 2024. The population in this study consisted of 65 elderly individuals with type 2 diabetes mellitus (T2DM) in the Tempe District.

The sampling technique used in this study was probability sampling, specifically the simple random sampling method, which is employed when the population is considered homogeneous. Therefore, the sample size for this study was 45 older adults who met the following inclusion and exclusion criteria:

1. Inclusion Criteria
   a. Elderly people aged 60-69 years
   b. Elderly people with T2DM diagnosed by a doctor
   c. Elderly people with Type 2 DM for at least 1-4 years
   d. Elderly people willing to participate
2. Exclusion Criteria
   a. Elderly people with diabetic foot ulcers
   b. Elderly people with activity intolerance

Data Collection Instruments

The tools and materials used in this study:

1. A sphygmomanometer and stethoscope to measure peripheral blood circulation.
2. A stopwatch to measure the duration of the intervention.
3. A 32-liter water container for hydrotherapy.
4. A bed with minimum standards.
5. A water thermometer.
6. Books and stationery.
7. Towels.

This study involved 45 elderly individuals with type 2 diabetes mellitus who agreed to participate and met the following criteria: Inclusion criteria: patients with type 2 diabetes diagnosed by a doctor, supported by laboratory results, and with a history of type 2 diabetes for at least five years. Exclusion criteria included those with complications of diabetic foot ulcers, activity intolerance, and complications of heart and respiratory disease. The 45 individuals with type 2 diabetes were then divided into three groups. The first group, consisting of 16 elderly individuals, received Buerger Allen exercises. The second group, composed of 15 elderly individuals, received hydrotherapy. The third group, comprising 14 elderly individuals, served as the control group.

The Buerger Allen exercises were performed three times a week for 10-15 minutes over eight weeks. The hydrotherapy group involved immersing both legs in a provided immersion solution for 10 minutes, three times a week for eight weeks at a water temperature of 38°C. The control group received no treatment. Measurement of peripheral blood circulation in each group

Data Analysis

To determine the effect of the Beurger Allen exercise, hydrotherapy, and control groups on peripheral blood circulation and neuropathic pain intensity in elderly people with Type 2 Diabetes, a paired t-test was used. Data were processed using SPSS. Significant values were considered if the p-value was <0.05.

Research Ethics

This research has been approved by the Research Ethics Committee of STRADA Indonesia University, under registration number 001443/EC/KEPK/I/07/2024.

RESULTS

Table 1. Respondent Characteristics

Variables	Buerger Allen Exercises n=16	Hydrotherapy n=15	Control Group n=14
[a]**Age**	64.43± 3.07	63.00 ± 2.104	62. 85 ± 2.107
[b]**Gender**			
Male	1 (6.3)	1 (6.7)	-
Female	15 (93.8)	14 (93.3)	14 (100.0)
[b] **Duration of Type II Diabetes**			
1-2 Years	2 (12.5)	4 (26.7)	6 (42.9)
3-4 Years	14 (87.5)	11 (73.3)	8 (57.1)
>5 Years	-	-	-
[b]**Physical Activity**			
Sports	-	1 (6.7)	-
Recreation	1 (6.3)	1 (6.7)	1 (7.1)
Household	2 (12.5)	1 (6.7)	-
None	13 (81.3)	12 (80.0)	13 (92.9)
[a]**Random Blood Glucose (mg/dL)**	268.00 ± 27.82	259.00 ±28.39	265.00 ± 35.46

n= Number of Samples
[a]=Variable for numerical data (Mean±SD)
[b]=Variable for categorical data (n%)

Table 1 shows that the study included 45 elderly individuals with type 2 diabetes mellitus (T2DM). The 16 respondents were given Buerger Allen exercises, 15 respondents were given hydrotherapy, and 14 respondents were not given treatment (control group). Among the respondents who received Buerger Allen exercise therapy, the average age was 64 years. Gender: In this group, it was dominated by women, namely 15 people and 1 man, with an average history of suffering from T2DM of 3-4 years. The physical activity that respondents often engaged in was, on average, inactive, resulting in random blood glucose levels that were, on average, above the normal limit before they were given the Buerger Allen exercise. Meanwhile, in the group of respondents given hydrotherapy, the average age was 63 years, which was more dominated by women, namely 14 people, compared to men, namely 1 person, with an average history of suffering from T2DM of 3-4 years. The physical activity that respondents often engaged in was also, on average, inactive, resulting in initial blood glucose levels above the normal limit before they received hydrotherapy. Meanwhile, in the control group, the average age of respondents was 62 years, with a predominance of women compared to 14 men, with an average history of T2DM of 3-4 years. Respondents were generally inactive, so baseline blood glucose levels in the control group were also above normal.

Table 2. Effect of Buerger Allen Exercise, Hydrotherapy, and Control Group on ABI Values and Neuropathy Pain Intensity in the Elderly with T2DM

Group	N	ABI Value		Neuropathic Pain Intensity	
		Mean± SD	*p-value*	*Mean*± SD	*p-value*
Buerger Allen Exercise	16				
Pre Test		0.77± 0.09	0.001	7.75± 0.77	0.001
Post Test		1.21± 0.10		3.62± 1.88	
Hydrotherapy	15				
Pre Test		0.79 ± 0.10	0.001	8.00 ± 0.75	0.001
Post Test		1.03 ± 0.11		2.86 ± 0.51	
Control Group	14				
Pre Test		0.74 ± 0.12	0.194	8.07± 0,73	1.000
Post Test		0.76 ± 0.15		8.06± 0.61	

Paired T Test

Table 2 shows that there were significant differences in ABI values and neuropathic pain intensity before and after therapy in the Buerger Allen Exercises and hydrotherapy groups (p-value < 0.05). Meanwhile, in the control group, there were no significant differences in ABI values and neuropathic pain intensity between the pre and post-tests (p-value > 0.05).

In the Buerger-Allen exercise group, the average ABI value after exercise (post-test) was 1.21, compared to 0.77 before exercise. Meanwhile, in the hydrotherapy group, the average ABI value after exercise (post-test) was 1.03, compared to 0.79 after immersion. Meanwhile, in the control group, the average ABI post-test score remained unchanged, at 0.76, the same as the pre-test average of 0.74. The data also show that the average ABI score in the Buerger Allen exercise and hydrotherapy groups changed significantly from pre-test to post-test compared to the control group.

In the Buerger Allen Exercise group, the average neuropathic pain intensity scale after exercise (post-test) was 3.62, down from the average neuropathic pain intensity scale before exercise (pre-test) of 7.75. Meanwhile, in the hydrotherapy group, the average neuropathic pain intensity scale after immersion (post-test) was 2.86, down from the average neuropathic pain scale before immersion (pre-test) of 8.00. Meanwhile, in the control group, the average

neuropathic pain intensity scale (Post-test) did not show any significant change, namely 8.06 from the neuropathic pain intensity scale (Pre-test), namely 8.07. Judging from the data, the average change in the neuropathic pain intensity scale in the Buerger Allen exercise and hydrotherapy group was much better compared to the control group.

DISCUSSION

Since the Middle Ages, the beneficial effects of Buerger Allen Exercises have been known and clinically applied in humans (W.Allen, 1930). Several previous studies have demonstrated that Buerger Allen exercises can significantly enhance peripheral blood circulation in individuals with type 2 diabetes, as evidenced by an increase in the ankle-brachial index. Therefore, they can be used as an ideal, non-invasive physical therapy to improve peripheral blood circulation in the lower extremities (W.Allen, 1930; Chang *et al.*, 2015, 2016)

Previous studies have also demonstrated that Buerger Allen exercises can be utilized as a treatment for neuropathic pain in patients with type 2 diabetes, thereby improving their quality of life and comfort (Pebrianti *et al.*, 2020). Therefore, several studies are ongoing on the effects of Buerger Allen exercises. Among them, our study aims to determine whether Buerger Allen exercises affect changes in peripheral blood circulation or ABI values and reduce the intensity of neuropathic pain in elderly patients with type 2 diabetes. Our research results show that applying Buerger Allen exercises to elderly patients with type 2 diabetes can significantly improve ABI values (p-value < 0.05) and reduce neuropathic pain intensity (p-value < 0.05) after physical activity therapy. This is indicated by an average ABI value after the exercise (post-test) of 1.21, compared to 0.77 before the exercise (pre-test), and an average neuropathic pain intensity scale (post-test) of 3.62, compared to 7.75 before the exercise (pre-test). This indicates improved peripheral circulation in the lower extremities.

Based on the results of this study, Buerger Allen Exercises have an effect on the intensity of brachial ankle pain in patients with type 2 diabetes mellitus. These results indicate that the intervention has a significant impact on pain. During the exercise, participants did not request to stop or rest before completing the exercise. Participants demonstrated an active and cooperative attitude during the treatment. When they experienced pain, they immediately informed the researcher.

Research by Margiyanti, Lavisa and Ivon (2018), explains the impact of diabetic foot exercises on diabetic neuropathic pain in individuals with type 2 diabetes. To improve comfort and quality of life, this intervention can be considered for managing neuropathic pain in people with type 2 diabetes. These include exercise, relaxation and distraction techniques, transcutaneous electrical stimulation, and educational support interventions (Pebrianti *et al.*, 2020).

Buerger Allen Exercises are a series of foot treatments or exercises that can improve peripheral blood circulation and increase lower extremity perfusion, thereby addressing and reducing symptoms of peripheral neuropathic pain in patients with diabetes (Romlah, 2021; Patel, 2022).

The mechanism by which Buerger Allen exercises improve peripheral circulation and reduce the intensity of neuropathic pain involves changes in position, where gravity causes blood vessels to empty and refill. During elevation, gravity causes venous emptying, thereby increasing cardiac output. Gravity-dependent leg movements increase blood flow to arterioles. Furthermore, ankle movements force muscles to contract, strengthening distal circulation. This final step improves leg reperfusion (Patel, 2022). Increased leg perfusion can reduce neuropathic pain symptoms in individuals with T2DM, thereby improving patient comfort. (Salam, 2012).

ISSN: 2614-3488 (print); 2614-3496 (online) Vol.9 No.3. April 2026. Page.519-531

BAE consists of three stages. In the first stage, with a 45° leg elevation, gravity acts to empty the veins, thereby increasing right atrial flow and, consequently, cardiac output. In the second stage, muscle pump contractions stimulate the release of nitric oxide, which helps increase blood vessel flexibility, allowing oxygen and nutrients to flow smoothly to the lower extremities, thereby improving circulation (Chang *et al.*, 2016).

The Effect of Hydrotherapy on Peripheral Blood Circulation (ABI) and Neuropathy Pain Intensity. Hydrotherapy, or warm water foot soaks, is recognized for its benefits to patient health. They are used as a complementary therapy to treat various physical and motor disabilities. Warm water foot soaks naturally reduce stress, maintain psychological well-being, and effectively affect the vascular system through vasodilation, which can improve blood flow to the heart.

A foot soak is a therapeutic method that involves immersing the feet in warm water to a depth of 10-15 cm. The primary goal is to increase blood flow in the feet. This method is often used to reduce symptoms of both acute and chronic pain. Furthermore, warm water foot soaks, also known as hydrotherapy, are effective in reducing muscle tension, helping to address hormonal issues, and improving blood flow, as measured by the AnkleBrachial Index (ABI). (Astutiningrum, 2022).

Several previous studies have shown that hydrotherapy can improve peripheral blood circulation or ABI values and can be used as an adjunctive treatment to reduce neuropathic pain symptoms in individuals with type 2 diabetes mellitus (T2DM) and peripheral vascular disorders (Nyimas Maryama, 2021;Astutiningrum, 2022). Therefore, several studies are currently underway to investigate the effects of warm foot soaks, also known as hydrotherapy. Among them, our study aims to determine whether hydrotherapy affects changes in peripheral blood circulation or ABI values and reduces the intensity of neuropathic pain in elderly people with type 2 diabetes mellitus (T2DM).

The results of this study indicate that warm water foot soaks, or hydrotherapy, significantly increased ABI values and reduced neuropathic pain intensity (p-value <0.05) in elderly patients with T2DM after the immersion. This was indicated by an average ABI score after exercise (post-test) of 1.03, compared to 0.79 after immersion, and an average neuropathic pain intensity scale after immersion (post-test) of 2.86, compared to 8.00 before immersion (pre-test). This indicates improved lower extremity peripheral circulation, which can improve the quality of life of elderly patients.

These results support previous research by Suandika (2015), which found that the average AnkleBrachial Index (ABI) before the foot immersion was 0.73, indicating that most respondents experienced moderate foot problems. The results after the foot immersion indicated a significant improvement in blood circulation in the respondents' feet. The average Ankle Brachial Index value before and after warm water foot soaking was 0.73-0.83. An increase in the Ankle Brachial Index value was seen from moderate to mild impairment. The results of this study are supported by previous research conducted byNyimas Maryama (2021), which found that warm water foot soaking affects changes in the Ankle Brachial Index in patients with type 2 Diabetes Mellitus. This is indicated by the difference in changes in the Ankle Brachial Index before and after warm water foot soaking. After warm water foot soaking, an average increase in the Ankle Brachial Index was found to be 0.281 with a p value = 0.001, smaller than the α value (0.05), which means there is an effect of Warm Water Foot Soaking on changes in the Ankle Brachial Index in clients with Diabetes Mellitus.

The results of this study are also supported by previous research conducted by Kartini *et al.*(2022),which found that four weeks of hydrotherapy reduced the average joint pain intensity in elderly patients from 5 to 3 on a 10-point scale. It can be said that before

hydrotherapy, the average patient had moderate pain (VAS 4-6), but after four weeks of hydrotherapy, the pain decreased to mild (VAS 0-3).

The mechanism of warm water can improve peripheral blood circulation in the lower extremities. This occurs because warm water can dilate blood vessels, resulting in smoother blood flow and increased oxygen delivery to parts of the body that need it (Yuningsih, 2022).The heat/warmth effect can affect blood vessels, resulting in improved blood circulation. The warm response is used for relaxation purposes, providing a warm sensation to the skin, which can stimulate endorphins to induce relaxation, reduce stress, increase capillary permeability, relax muscles, and improve blood flow (Alfillaturrohman, Wibowo and Nursing, 2020)

Hydrotherapy can increase blood flow in elderly people with type 2 diabetes mellitus. This therapy can improve blood flow in the veins and arteries, thereby enhancing blood circulation in the patient's feet and helping to prevent complications, such as foot ulcers, which are often associated with diabetes. Warm foot soaks can also lower blood pressure in elderly people with type 2 diabetes mellitus and hypertension (Dera Nur Anisa Ain, Sholichin, 2022; Putra, Supatmo and Setiawati, 2023).

Soaking feet in warm water increases the flexibility of connective tissue and muscle structure, reduces pain, and affects the vascular system, specifically heart and lung function(Dera Nur Anisa Ain, Sholichin, 2022). Hydrotherapy can reduce lower extremity pain, thereby improving the quality of life of the elderly (Kartini *et al.*, 2022).

There was no significant difference (p-value > 0.05) in the effect of the control group on ABI (Peripheral Blood Circulation) values and Neuropathic pain intensity between the pretest and posttest. The average ABI pretest score was 0.74 with an SD of 0.12, while the average ABI posttest value was 0.15. Then, for the neuropathic pain intensity variable, the average value of the pretest pain scale was 8.07 with an SD of 0.73. The average value of the posttest pain scale was 8.06 with an SD of 0.61. This indicates that the control group was unable to improve peripheral blood circulation in elderly individuals with T2DM, resulting in persistent pain in the lower extremities.

This study aligns with the work conducted by Sathya K and Karthi R, (2019), the study showed that in the control group, the average ABI pre-test value was 0.720 with SD 0.077. The average post-test value was 0.734 with SD 0.063. The data show that there is no significant change (p-value > 0.05) in the ABI value in patients with type 2 diabetes mellitus. Thus, the control group was unable to repair the blockage of peripheral blood flow in the lower extremities, resulting in decreased blood circulation in these areas.

This study aligns with the one conducted by Nadrati, Hadi and Rayasari (2020), their study showed that in the control group, there was no significant effect on changes in the ABI values of the left and right legs, which were carried out twice a day for 4 days. While the ABI before and after the Buerger Allen exercise in the intervention group (Buerger Allen Exercise) appeared significant on the 4th day, namely on the 8th measurement, with a p-value = 0.001 <0.050 on the ABI value of the right leg, and a p-value = 0.002 <0.050 on the ABI value of the left leg.

CONCLUSION

There was a significant effect on changes in the average ABI value and neuropathic pain intensity before and after administration of Buerger Allen exercises and hydrotherapy. Meanwhile, in the control group, there was no significant effect on changes in the average ABI value and neuropathic pain intensity. Therefore, in this study, Buerger Allen exercises and hydrotherapy can improve peripheral blood circulation, thereby preventing chronic complications in elderly people with type 2 diabetes mellitus.

ACKNOWLEDGMENT

We would like to express our gratitude to the Ministry of Education and Technology for its research and development funding and publication of reputable articles for the 2025 fiscal year.

We would also like to thank our fellow lecturers from the Faculty of Health Sciences, Puangrimaggalatung University, ITKES Muhammadiyah Sidrap, and Universitas Strada Indonesia for their involvement in this research.

CONFLICTS OF INTEREST

Nothing

REFERENCES

Alfillaturrohman, K., Wibowo, T. H. and Nursing, A. S. (2020) 'The Effect of Feet Soaking Using Warm Water with Ginger Aromatherapy to Decrease Blood Pressure on Hypertension Patients in the Working Area of Community Health Center 1 Sumbang Banyumas', 20(Icch 2019), pp. 356–363. doi: 10.2991/ahsr.k.200204.074.

Alice R Bernheim, I. M. L. (1937) 'Arteriosclerosis and Thrombo Angitis Obliterans', *JAMA*, 108(25), pp. 2102–2109.

Alidya, F. (2022) *Hubungan Pola Makan dan Aktivitas Fisik dengan Kontrol Glukosa Darah Pada Penderita Diabetes Mellitus Tipe 2*.

Amalia, L., Mokodompis, Y. and Ismail, G. A. (2022) 'Hubungan Overweight Dengan Kejadian Diabetes Mellitus Tipe 2 Di Wilayah Kerja Puskesmas Bulango Utara', *Jambura Journal of Epidemiology*, 1(1), pp. 11–19. doi: 10.37905/jje.v1i1.14623.

American Diabetes Association (2023) 'American Diabetes Association Releases 2023 Standards of Care in Diabetes to Guide Prevention, Diagnosis, and Treatment for People Living with Diabetes', *News Relaase*, 13(3), pp. 136–136. doi: 10.1177/155005948201300303.

Astutiningrum, D. (2022) 'Penerapan senam kaki dan Rendam Kaki Dengan Air Hangat Untuk Meningkatkan Aliran Darah Pada Pasien Diabetes melitus', *Nursing St*, p. 56.

Bistara, D. N. *et al.* (2022) 'The effect of discharge planning on the stability of blood sugar levels in type 2 diabetes mellitus patients', *Bali Medical Journal*, 11(3), pp. 1180–1184. doi: 10.15562/bmj.v11i3.3537.

Care, D. and Suppl, S. S. (2022) 'Classification and diagnosis of diabetes : standards of medical care in diabetes — 2022', *Diabetes Care*, 45(Suppl), pp. 517–38.

Chang, C.-F., Chang, C.-C. and Chen, M.-Y. (2015) 'Effect of Buerger's Exercises on Improving Peripheral Circulation: A Systematic Review', *Open Journal of Nursing*, 05(02), pp. 120–128. doi: 10.4236/ojn.2015.52014.

Chang, C. C. *et al.* (2016) 'A quantitative real-time assessment of Buerger exercise on dorsal foot peripheral skin circulation in patients with diabetes foot', *Medicine (United States)*, 95(46), pp. 1–5. doi: 10.1097/MD.0000000000005334.

Chang, C. F. *et al.* (2015) 'Effects of Buerger Exercise Combined Health-Promoting Program on Peripheral Neurovasculopathy Among Community Residents at High Risk for Diabetic Foot Ulceration', *Worldviews on Evidence-Based Nursing*, 12(3), pp. 145–153. doi: 10.1111/wvn.12091.

Chawla, A., Chawla, R. and Jaggi, S. (2016) 'Microvasular and macrovascular complications in diabetes mellitus: Distinct or continuum?', *Indian Journal of Endocrinology and Metabolism*, 20(4), pp. 546–553. doi: 10.4103/2230-8210.183480.

Cho, N. H. *et al.* (2018) 'IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017

and projections for 2045', *Diabetes Research and Clinical Practice*, 138, pp. 271–281. doi: 10.1016/j.diabres.2018.02.023.

Dagfinrud, H. and Christie, A. (2007) 'Patients with rheumatoid arthritis feel better after exercises in warm water than after similar exercises on land', *Australian Journal of Physiotherapy*, 53(2), p. 130. doi: 10.1016/S0004-9514(07)70047-8.

Decroli, E. (2019) *Diabetes Mellitus Tipe 2*, *Вестник Росздравнадзора*.

Dera Nur Anisa Ain, Sholichin, M. K. L. R. (2022) 'Pengaruh Rendaman Kaki Air Hangat Terhadap Penurunan Tekanan Darah Lansis Penderita Diabetes Melitus Di Kelurahan Loa Tebu'.

El-Fattah, H. S. A. *et al.* (2019) 'Effect of buerger exercises on improving peripheral circulation of the lower extremities among patients with type 2 diabetes mellitus at selected university hospital-Egypt', *Indian Journal of Public Health Research and Development*, 10(6), pp. 692–697. doi: 10.5958/0976-5506.2019.01358.5.

Embuai, S., Siauta, M. and Tuasikal, H. (2019) 'Efektifitas Diabetes Self care Activity Terhadap Status Vaskuler Pasien Diabetes Melitus', *Moluccas Health Journal*, 1(1), pp. 1–9. doi: 10.54639/mhj.v1i1.36.

Farida, M. dkk (2022) 'The Peripheral Vascular Status in Individuals with Type 2 Diabetes Mellitus', *Jurnal Ilmiah Kesehatan*, 15, pp. 231–238.

Faselis, C. *et al.* (2020) 'Microvascular Complications of Type 2 Diabetes Mellitus', *Current Vascular Pharmacology*, 18(2), pp. 117–124. doi: 10.2174/1570161117666190502103733.

Giacomozzi, C. *et al.* (2008) 'Muscle performance and ankle joint mobility in long-term patients with diabetes', *BMC Musculoskeletal Disorders*, 9, pp. 1–8. doi: 10.1186/1471-2474-9-99.

Gisolf, J. (2005) *Postural changes in humans: effects of gravity on the circulation*. Available at: http://dare.uva.nl/document/12441.

Gito, Reni. d, R. t (2016) 'Pengaruh Terapi Air Hangat Terhadap Penurunan', *Jurnal viva medika*, 9(16), pp. 1–11.

GUYTON (2012) *Medical Physiology*. 12th edn. Jakarta.

Hafid, M. A. *et al.* (2021) 'The effect of buerger allen exercise on the lower extremity peripheral circulation in type 2 diabetic patients', *STRADA Jurnal ilmiah kesehatan*, 10(1), pp. 612–621. doi: 10.30994/sjik.v10i1.669.

Harnani, Y. and Axmalia, A. (2017) 'Terapi Rendam Kaki Menggunakan Air Hangat Efektif Menurunkan Tekanan Darah pada Lanjut Usia (Soak Feet Warm WaterTherapy Effective To Reduce Blood Pressure in The Elderly)', *Jurnal Kesehatan Komunitas (Journal of Community Health)*, 3(4), pp. 129–132. Available at: https://doi.org/10.25311/keskom.Vol3.Iss4.127.

IDF (2019) *IDF Diabetes Atlas, 9th edn*.

IDF (2021) *International Diabetes Federation, Diabetes Research and Clinical Practice*. doi: 10.1016/j.diabres.2013.10.013.

Jannaim (2018) 'Pengaruh Buerger Allen Exercises Terhadap Sirkulasi Ekstremitas Bawah Pada Pasien Luka Kaki Diabetik', *Jurnal Kpeperawatan Indonesia*, 21(2), pp. 101–108.

Jannaim, J., Dharmajaya, R. and Asrizal, A. (2018) 'Pengaruh Buerger Allen Exercise Terhadap Sirkulasi Ektremitas Bawah Pada Pasien Luka Kaki Diabetik', *Jurnal Keperawatan Indonesia*, 21(2), pp. 101–108. doi: 10.7454/jki.v21i2.652.

Kartini, Y. *et al.* (2022) 'Penerapan Hidroterapi Untuk Mengurangi Keluhan Nyeri Kaki Pada Lansia', *Seminar Nasional Pengabdian Kepada Masyarakat 2021*, 1(1), pp. 836–842. doi: 10.33086/snpm.v1i1.886.

Kementerian Kesehatan RI. (2020) 'Infodatin tetap produktif, cegah, dan atasi Diabetes

Melitus 2020', *Pusat Data dan Informasi Kementerian Kesehatan RI*, pp. 1–10.
Kolarić, V. *et al.* (2022) 'Chronic Complications of Diabetes and Quality of Life', *Acta Clinica Croatica*, 61(3), pp. 520–527. doi: 10.20471/acc.2022.61.03.18.
Kusumo, M. prasetyo (2020) *Buku Lansia*. Available at: https://id1lib.org/book/17513624/1d56ea.
Lestari, Zulkarnain and Sijid, S. A. (2021) 'Diabetes Melitus: Review Etiologi, Patofisiologi, Gejala, Penyebab, Cara Pemeriksaan, Cara Pengobatan dan Cara Pencegahan', *UIN Alauddin Makassar*, (November), pp. 237–241. Available at: http://journal.uin-alauddin.ac.id/index.php/psb.
Letta, S. *et al.* (2023) 'Diabetes knowledge and foot care practices among type 2 diabetes patients attending the chronic ambulatory care unit of a public health hospital in eastern Ethiopia: A cross-sectional study', *BMJ Open*, 13(11), pp. 1–10. doi: 10.1136/bmjopen-2022-070023.
Lloyd, T. (1957) 'Traumatic Peripheral Aneurysme', *American Journal Of Surgery*, 93, pp. 1–10.
Margiyanti, I., Lavisa, H. and Ivon, N. (2018) 'Pengaruh Senam Kaki Diabetik Terhadap Intensitas Nyeri Neuropati Diabetik Pada Penderita Diabetes Melitus Tipe 2 Di Smc Rs …', *Jurnal Ilmu …*, 001. Available at: http://ejournal.stikestelogorejo.ac.id/index.php/jikk/article/view/384.
Martín-Timón, I. (2014) 'Type 2 diabetes and cardiovascular disease: Have all risk factors the same strength?', *World Journal of Diabetes*, 5(4), p. 444. doi: 10.4239/wjd.v5.i4.444.
McDermott, K. *et al.* (2023) 'Etiology, Epidemiology, and Disparities in the Burden of Diabetic Foot Ulcers', *Diabetes Care*, 46(1), pp. 209–211. doi: 10.2337/dci22-0043.
Nadrati, B., Hadi, M. and Rayasari, F. (2020) 'Pengaruh Buerger Allen Exercise terhadap sirkulasi ekstremitas bawah bagi penyandang diabetes melitus', *Holistik Jurnal Kesehatan*, 14(2), pp. 248–256. doi: 10.33024/hjk.v14i2.2742.
Nyimas Maryama, R. S. (2021) 'Pengaruh Rendam Kaki Air Hangat Terhadap Ankle Brachial Index Pada Pasien Diabetes Mellitus', *Jurnal Keperawatan Merdeka (JKM)*, 1(1), pp. 1–7. Available at: https://journals.ekb.eg/article_243701_6d52e3f13ad637c3028353d08aac9c57.pdf.
Patel, R. (2022) 'A study to assess the effectiveness of burger allen exercise on improving peripheral circulation among type 2 Diabetes Mellitus patients in selected hospitals of Nadiad, Gujarat', *Journal Of Pharmaceutical Negative Results*, 13(9), pp. 2390–2398. doi: 10.4172/clinical-practice.1000425.
Patidar, V. (2018) 'A Study to Assess the Effectiveness of Buerger Allen Exercise on Lower Extremity Perfusion among Patients with Type 2 Diabetes Mellitus in selected hospitals at Kanyakumari District', *Clinical Practice*, 15(6), pp. 895–900. doi: 10.5958/2349-2996.2019.00066.1.
Pebrianti, S. *et al.* (2020) 'Manajemen nyeri neuropati pada pasien diabetes melitus tipe 2 : Studi literatur', 14(2), pp. 276–282.
Putra, E. N., Supatmo, Y. and Setiawati, E. (2023) 'Effectiveness of Foot Exercises Together with the Hydrotherapy Program on Blood Sugar Levels in Elderly People without Diabetes', *Medica Hospitalia*, 11(1), pp. 53–57.
Rachmantoko, R. *et al.* (2021) 'Diabetic neuropathic pain', pp. 8–12. doi: 10.21776/ub.jphv.2021.002.01.3.
Rahmi, H. and Rasyid, W. (2023) 'Pengaruh Burger Allen Exercise Terhadap Nilai Angkle Brachial Index (Abi) Pada Pasien Diabetes Melitus Tipe II di Puskesmas Lubuk Buaya Padang', *Jik Jurnal Ilmu Kesehatan*, 7(2), p. 431. doi: 10.33757/jik.v7i2.912.
Refani, D. (2020) *Efektivitas Senam Kaki Kaki Diabetik Terhadap Nilai Ankle Brachial Index*

(ABI) Pada Penderita Diabetes Mellitus Tipe 2, *SELL Journal*.

Richard Mataputun, D., Prabawati, D. and Hapsari Tjandrarini, D. (2020) 'Efektivitas Buerger Allen exercise dibandingkan dengan Rendam Kaki Air Hangat terhadap Nilai Ankle Brachial Index dan Gula Darah pada Pasien Diabetes Mellitus', *Media Publikasi Promosi Kesehatan Indonesia (MPPKI)*, 3(3), pp. 253–266. doi: 10.56338/mppki.v3i3.1330.

Romlah (2021) 'Efektifitas Buerger Allen Exercise Terhadap Nilai Ankle', *Efektifitas Buerger Allen Exercise terhadap nilai Ankle Brachial Index (ABI) Pada Pasien Diabetes Melitus*, 12(1), pp. 67–74.

Salam, A. Y. (2012) *Perbedaan perfusi pada kaki klien diabetes melitus sebelum dan sesudah dilakukan senam kaki diabetes di desa sukowono kecamatan sukowono*.

Sathya K and Karthi R (2019) 'A Ssudy to assess the effectiveness of buerger allen exercise to prevent risk of diabetic foot by improving lower extremity perfusion among clients with type-2 diabetes mellitus in selected hospitals at Villupuram District, Tamilnadu', *International Journal of Research & Review* , 6(3), pp. 83–88. Available at: www.ijrrjournal.com.

Sherwood, L. (2013) 'Pembuluh Darah dan Tekanan Darah', *Introduction to Human Physiology*, pp. 361–403.

Sunaryo, T., Lestari, S. and Sevendor Khor, B. F. A. (2020) 'The effect of oral hydrotherapy on risk reduction of diabetic feet ulcer among people with type-2 diabetes mellitus', *Enfermeria Clinica*, 30, pp. 192–195. doi: 10.1016/j.enfcli.2019.11.052.

Sutomo, N. H. P. (2023) 'Pengaruh Komsumsi Tonase Daun Belimbing Wuluh Terhadap Perubahan Kadar Gula Dalam Darah Pada Penderita Diabetes Mellitus Tipe 2', *SEMERGEN - Medicina de Familia*, 27(3), pp. 146–148. doi: 10.1016/s1138-3593(01)73932-9.

Utami, R. (2019) 'Efektivitas Pemberian Senam Kaki Diabetik dan Senam Tai Chi Terhadap Tingkat ABI Pada Lansia Dengan Diabetes Mellitus Tipe 2 di Puskesmas Kebonsari Surabaya'.

W.Allen (1930) 'RECENT ADVANCES IN THE TREATMENT OF CIRCULATORY DISTURBANCES OF THE EXTREMITIES', in, pp. 931–946.

Widiasari, K. R., Wijaya, I. M. K. and Suputra, P. A. (2021) 'Diabetes Melitus Tipe 2: Faktor Risiko, Diagnosis, Dan Tatalaksana', *Ganesha Medicine*, 1(2), p. 114. doi: 10.23887/gm.v1i2.40006.

Yachmaneni, A. *et al.* (2023) 'A Comprehensive Review of the Vascular Consequences of Diabetes in the Lower Extremities: Current Approaches to Management and Evaluation of Clinical Outcomes', *Cureus*, 15(10). doi: 10.7759/cureus.47525.

Yammar, Y. *et al.* (2021) 'Effect of Carbon Dioxide (CO 2) -Rich Water Immersion on Changes of Peripheral Blood Flow in Patients with Kidney Disease', *STRADA Jurnal Ilmiah Kesehatan*, 10(1), pp. 431–438. doi: 10.30994/sjik.v10i1.618.

Yuenyongchaiwat, K. and Boonsinsukh, R. (2021) 'Type 2 Diabetes Mellitus Related to Decreased Peripheral and Respiratory Muscle Strength in Sarcopenic Thai Elderly', *Current Aging Science*, 14(3), pp. 235–241. doi: 10.2174/1874609814666210715141903.

Yuningsih, L. R. (2022) 'Sirkulasi Darah Perifer Pada Pasien Dm Di Wilayah', *Edu Dharma Journal: Jurnal Penelitian dan Pengabdian Masyarakat*, 06(02), pp. 306–314.