Journal of Health and Rehabilitation Research 2791-156X JHRR

For contributions to JHRR, contact at email: editor@jhrlmc.com

Original Article

Effect of Buerger-Allen Exercise and Intraneural Facilitation on Lower Extremity Perfusion and Peripheral Neuropathy Symptoms Among Patients with Type II Diabetes Mellitus

Muhammad Abbas*[1], Maha Rehman[1], Isha Emaan[1], Umar Shaukat[1], Shafiq Ur Rehman Farooq[2], Muhammad Muneeb Ur Rehman[3]

[1]College of Physical Therapy, Govt College University, Faisalabad, Pakistan

[2]Federal Government Services Hospital (polyclinic) Islamabad, Pakistan

[3]College of Clinical Medicine, Dali University, Dali, Yunnan, China

**Corresponding Author: Muhammad Abbas; Email: muhammad.abbas9@yahoo.com*

Conflict of Interest: None.

A. Muhammad., et al. (2024). 4(2): DOI: https://doi.org/10.61919/jhrr.v4i2.1181

ABSTRACT

Background: Diabetes mellitus is a complex metabolic disorder characterized by chronic hyperglycemia, which can lead to severe microvascular and macrovascular complications. Peripheral neuropathy and impaired lower extremity perfusion are common among diabetic patients, significantly affecting their quality of life. Buerger-Allen Exercise (BAE) and Intraneural Facilitation (INF) are therapeutic interventions aimed at improving blood flow and reducing neuropathy symptoms in diabetic patients. This study aimed to compare the effectiveness of these two interventions in enhancing lower extremity perfusion and alleviating peripheral neuropathy symptoms.

Objective: To assess and compare the effects of Buerger-Allen Exercise and Intraneural Facilitation on lower extremity perfusion and peripheral neuropathy symptoms in patients with type II diabetes mellitus.

Methods: This quasi-experimental study was conducted at Al-Raheem Clinic and Skin Laser Center in Faisalabad over three months. A purposive sampling technique was used to recruit 12 patients with type II diabetes mellitus and peripheral neuropathy symptoms restricted to the lower limbs. Patients were divided into two groups: one received Buerger-Allen Exercise and the other Intraneural Facilitation. Assessments included the Ankle-Brachial Index (ABI) to measure lower extremity perfusion, the Michigan Neuropathy Screening Instrument (MNSI) for neuropathy symptoms, and monofilament testing for sensory function. Ethical approval was obtained, and informed consent was collected from all participants. Data were analyzed using SPSS version 25, employing paired and independent t-tests to evaluate pre- and post-intervention outcomes.

Results: The ABI scores showed significant improvement in both groups post-intervention (BAE: pre 0.6883 ± 0.10980, post 1.0250 ± 0.10968, $p < 0.001$; INF: pre 0.6467 ± 0.06919, post 0.9617 ± 0.08909, $p < 0.001$). MNSI scores also decreased significantly (BAE: pre 7.5000 ± 1.04881, post 4.5000 ± 1.37840, $p = 0.003$; INF: pre 7.3333 ± 1.21106, post 4.1667 ± 1.16905, $p < 0.001$). Monofilament testing scores improved notably in both groups (BAE: pre 3.3333 ± 2.33809, post 6.3333 ± 1.86190, $p = 0.002$; INF: pre 3.1667 ± 2.31661, post 6.0000 ± 2.44949, $p < 0.001$).

Conclusion: Both Buerger-Allen Exercise and Intraneural Facilitation effectively improved lower extremity perfusion and reduced peripheral neuropathy symptoms in patients with type II diabetes mellitus. Buerger-Allen Exercise demonstrated better patient compliance and ease of administration. Further research with larger sample sizes and longer follow-up periods is recommended to validate these findings and explore the long-term benefits of these interventions.

Keywords: Diabetes Mellitus, Buerger-Allen Exercise, Intraneural Facilitation, Lower Extremity Perfusion, Peripheral Neuropathy, Ankle-Brachial Index, Michigan Neuropathy Screening Instrument, Monofilament Testing, Diabetic Neuropathy Treatment, Non-Pharmacological Interventions

INTRODUCTION

Diabetes mellitus is a complex metabolic disorder characterized by chronic hyperglycemia due to defects in insulin secretion, insulin action, or both. The persistent elevation of blood glucose levels adversely affects carbohydrate, lipid, and protein metabolism. This

Journal of Health and Rehabilitation Research 2791-156X JHRR

chronic hyperglycemia leads to various microvascular and macrovascular complications, including retinopathy, nephropathy, neuropathy, coronary artery disease, stroke, and peripheral arterial disease (1-3). Despite the diverse perspectives on diabetes, it is medically defined as a group of metabolic disorders brought on by partial or complete insulin insufficiency, resulting in hyperglycemia (4-7). Chronic exposure to high blood glucose levels can cause microvascular complications in the kidneys, retina, and peripheral nerves, although these are not immediate diagnostic tools due to their delayed onset. Conversely, macrovascular complications such as myocardial infarction, stroke, and peripheral arterial disease often manifest earlier and are more prevalent in pre-diabetic states, highlighting the importance of early diagnosis and management (3, 8-13).

Historically, diabetes has been recognized since ancient times, with descriptions of its symptoms and treatments found in the Ebers Papyrus circa 1500 BC. The Indian surgeon Sushruta, around 500 BC, referred to diabetes as "madhumeha," noting the sweetness of the urine, a characteristic observed by other ancient medical practitioners (5, 7, 14). The understanding of diabetes has evolved significantly, with pivotal advancements such as the identification of insulin by Frederick Banting and Charles Best in 1921, which revolutionized diabetes treatment (5). The prevalence of diabetes has dramatically increased over the past forty years, attributed to lifestyle changes, dietary habits, and physical inactivity. According to the International Diabetes Federation, approximately 415 million adults worldwide had diabetes as of 2015, with projections indicating that this number could rise to 642 million by 2040. Additionally, 542,000 children globally have type 1 diabetes, and one in seven pregnancies is affected by gestational diabetes (15-19).

Diabetes mellitus primarily exists in three forms: type 1, type 2, and gestational diabetes. Type 1 diabetes involves the autoimmune destruction of pancreatic beta cells, leading to absolute insulin deficiency. Type 2 diabetes, which accounts for over 90% of diabetes cases, is characterized by insulin resistance and relative insulin deficiency. Gestational diabetes occurs during pregnancy and increases the risk of type 2 diabetes and obesity in the offspring (20-26). Physical activity plays a crucial role in the management of diabetes, significantly improving glycemic control and reducing the risk of cardiovascular diseases. Regular exercise enhances insulin sensitivity, lowers blood glucose levels, and contributes to overall well-being (27-32).

Autoimmune diabetes, particularly type 1 diabetes, is one of the most common autoimmune diseases in children, with its incidence increasing annually by 3% since 1990. This condition involves the early destruction of pancreatic beta cells, resulting in hyperglycemia and various metabolic complications such as peripheral neuropathy, retinopathy, nephropathy, and cardiovascular disease (9). Type 1 diabetes requires lifelong management through insulin therapy, dietary regulation, and physical activity to maintain blood glucose levels and prevent complications. Obesity is a significant risk factor for both type 1 and type 2 diabetes, exacerbating insulin resistance and contributing to earlier onset and increased severity of the disease. The prevalence of overweight and obesity among individuals with type 1 diabetes ranges from 25% to 80%, further complicating disease management (33-39).

Pre-diabetes, a condition of elevated blood glucose levels not yet high enough to be classified as diabetes, is a critical period for intervention to prevent the progression to type 2 diabetes. Lifestyle modifications, including dietary changes and increased physical activity, are essential in managing pre-diabetes and preventing the onset of diabetes (11). Type 2 diabetes, characterized by insulin resistance and progressive beta-cell dysfunction, is strongly associated with obesity and physical inactivity. The global increase in type 2 diabetes prevalence parallels the rise in obesity rates, underscoring the importance of addressing these modifiable risk factors (12).

Complications of diabetes are extensive and can significantly impact quality of life. Coronary artery disease is the most common complication, followed by renal failure, blindness, and a combination of microvascular and macrovascular complications. Diabetes-related comorbidities, including arthritis, depression, dyslipidemia, and hypertension, further exacerbate the disease burden (13). Diabetic neuropathy, particularly distal symmetric polyneuropathy, is a common and debilitating complication of diabetes, affecting up to 50% of individuals with diabetes. This condition leads to sensory loss, pain, and a higher risk of foot ulcers and amputations (40-43).

Interventions to improve lower extremity perfusion and alleviate peripheral neuropathy symptoms are crucial for managing diabetes-related complications. Buerger-Allen exercises, which involve a series of postural changes to promote blood flow, have been shown to enhance lower limb perfusion and reduce neuropathy symptoms in diabetic patients (15). Similarly, intraneural facilitation, a novel manual therapy technique, aims to restore blood flow to ischemic nerves, potentially improving clinical function in patients with diabetic neuropathy (16). This study aims to compare the effectiveness of Buerger-Allen exercises and intraneural facilitation on lower extremity perfusion and peripheral neuropathy symptoms among patients with diabetes. By evaluating these interventions, we hope to identify the most effective strategies for managing and mitigating the complications associated with diabetic neuropathy.

Journal of Health and Rehabilitation Research 2791-156X JHRR

MATERIAL AND METHODS

The study was a quasi-experimental research conducted at Al-Raheem Clinic and Skin Laser Center (Al Raheem Tower) in Faisalabad over a duration of three months. The aim was to compare the effectiveness of Buerger-Allen Exercise (BAE) and Intraneural Facilitation (INF) on lower extremity perfusion and peripheral neuropathy symptoms among patients with type II diabetes mellitus experiencing complications due to peripheral sensorimotor neuropathy. A sample size of 12 patients was selected based on previous literature (55). The sampling technique employed was purposive sampling, targeting patients with type II diabetes and neuropathy symptoms localized to the lower limbs, particularly below the ankles (36-39).

Patients were recruited based on specific inclusion and exclusion criteria. Inclusion criteria were patients aged 25 to 60 years, diagnosed with type II diabetes mellitus regardless of the duration, and exhibiting symptoms of distal symmetrical neuropathy restricted to the lower limbs, below the ankle joint. Patients were required to walk without assistance and be free from any other systemic diseases or severe co-morbidities. Exclusion criteria included the presence of foot sores or ulcers, other metabolic diseases, hypertension, uncontrolled blood glycemic index, critical illnesses, and autonomic neuropathy (13, 27).

Data collection involved several assessment tools to ensure comprehensive evaluation. The Michigan Neuropathy Screening Instrument (MNSI) was used to assess neuropathy symptoms, featuring a total score of 13 divided between a patient questionnaire and a foot examination form. Lower extremity perfusion was measured using the Ankle Brachial Index (ABI) scale, utilizing a sphygmomanometer and hand-held Doppler. Monofilament testing with a 10-gram monofilament was conducted to assess sensory function on the plantar surface of the feet. Vibration perception was evaluated with a tuning fork, and ankle reflexes were tested to ensure the inclusion of only those with intact motor functions (2, 17).

Ethical considerations were strictly adhered to, in line with the principles of the Declaration of Helsinki. Participants were assured of the confidentiality of their personal information, and informed consent was obtained. The study received approval from the clinic's management and authorities. Patients were briefed on the study's aims and methods and were provided with demonstrations of the techniques to be performed.

The data collected were meticulously organized, coded, and processed using the Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics, including percentages, frequencies, means, standard deviations, and graphical representations, were used to define the study population. Paired sample t-tests were employed to compare pre- and post-intervention values within each group. Independent t-tests were used to compare the outcomes between the BAE and INF groups.

The results were evaluated to determine the effectiveness of Buerger-Allen Exercise and Intraneural Facilitation in improving lower extremity perfusion and reducing peripheral neuropathy symptoms. The findings aimed to provide insights into the most effective therapeutic strategies for managing diabetic neuropathy and improving patient outcomes.

RESULTS

The results of this study are presented below, detailing the demographics of the participants and the effects of Buerger-Allen Exercise (BAE) and Intraneural Facilitation (INF) on lower extremity perfusion and peripheral neuropathy symptoms. The analysis was conducted using SPSS version 25, with descriptive statistics and paired sample t-tests employed to evaluate pre- and post-intervention outcomes.

Table 1: Age Distribution of Participants

Age Group	Frequency	Percent	Valid Percent
31-40	4	33.3%	33.3%
41-50	5	41.7%	41.7%
51-60	3	25.0%	25.0%
Total	12	100.0%	100.0%

Table 2: Gender Distribution of Participants

Gender	Frequency	Percent	Valid Percent
Female	7	58.3%	58.3%
Male	5	41.7%	41.7%

Gender	Frequency	Percent	Valid Percent
Total	12	100.0%	100.0%

Table 3: Duration of Diabetes

Duration	Frequency	Percent	Valid Percent
Less than a year	2	16.7%	16.7%
1-5 years	4	33.3%	33.3%
5-10 years	6	50.0%	50.0%
Total	12	100.0%	100.0%

Table 4: Pre- and Post-Intervention ABI Scores

Group	Pre-Intervention ABI (Mean ± SD)	Post-Intervention ABI (Mean ± SD)	p-value
BAE	0.6883 ± 0.10980	1.0250 ± 0.10968	<0.001
INF	0.6467 ± 0.06919	0.9617 ± 0.08909	<0.001

The ABI scores significantly improved in both groups post-intervention, indicating enhanced lower extremity perfusion.

Table 5: Pre- and Post-Intervention MNSI Scores

Group	Pre-Intervention MNSI (Mean ± SD)	Post-Intervention MNSI (Mean ± SD)	p-value
BAE	7.5000 ± 1.04881	4.5000 ± 1.37840	0.003
INF	7.3333 ± 1.21106	4.1667 ± 1.16905	<0.001

Both groups showed a significant reduction in MNSI scores, indicating a reduction in peripheral neuropathy symptoms.

Table 6: Pre- and Post-Intervention Monofilament Testing Scores

Group	Pre-Intervention Monofilament (Mean ± SD)	Post-Intervention Monofilament (Mean ± SD)	p-value
BAE	3.3333 ± 2.33809	6.3333 ± 1.86190	0.002
INF	3.1667 ± 2.31661	6.0000 ± 2.44949	<0.001

The monofilament testing scores significantly improved in both groups post-intervention, indicating enhanced sensory function.

Table 7: Independent t-test for Pre- and Post-Intervention ABI Scores

Variable	Group	N	Mean	Std. Deviation	p-value
Pre-Intervention ABI (Pre-tech)	BAE	6	0.6883	0.10980	0.450
	INF	6	0.6467	0.06919	
Post-Intervention ABI (Post-tech)	BAE	6	1.0250	0.10968	0.298
	INF	6	0.9617	0.08909	

The independent t-test showed no significant difference between the groups pre- and post-intervention in ABI scores, suggesting that both interventions were similarly effective in improving lower extremity perfusion.

DISCUSSION

The study aimed to evaluate and compare the effects of Buerger-Allen Exercise (BAE) and Intraneural Facilitation (INF) on lower extremity perfusion and peripheral neuropathy symptoms in patients with type II diabetes mellitus. The findings demonstrated significant improvements in both groups, indicating the efficacy of these interventions in managing diabetic neuropathy and enhancing lower extremity blood flow (12).

The improvements in Ankle-Brachial Index (ABI) scores in both BAE and INF groups were statistically significant, reflecting enhanced lower extremity perfusion. These results align with previous studies, such as those by Radhika et al., which showed that Buerger-Allen Exercise effectively increased ABI values and improved blood flow in diabetic patients (20). Similarly, the reduction in Michigan Neuropathy Screening Instrument (MNSI) scores and the improvements in monofilament testing scores suggest a significant reduction in neuropathy symptoms and enhanced sensory function. These findings corroborate earlier research indicating the benefits of exercise and manual therapy in managing diabetic neuropathy (1, 7, 13).

Journal of Health and Rehabilitation Research 2791-156X JHRR

The strengths of this study included the use of validated assessment tools like the ABI scale, MNSI, and monofilament testing, which provided comprehensive and reliable measures of neuropathy symptoms and lower extremity perfusion. Additionally, the quasi-experimental design allowed for a controlled comparison of the two interventions. However, the study also had limitations, including a small sample size and a short duration, which may limit the generalizability of the findings. The small sample size, although based on previous literature, may not fully represent the broader diabetic population. Furthermore, the study duration of three months might not capture long-term effects and sustainability of the interventions (42).

A significant finding of this study was the ease of compliance with Buerger-Allen Exercise, which patients could perform independently. This active exercise routine was well-tolerated and led to significant improvements in perfusion and neuropathy symptoms. In contrast, Intraneural Facilitation, while effective, required a trained therapist to administer the treatment, making it less feasible for routine self-care and possibly affecting patient adherence. This distinction is crucial for clinical practice, as interventions that patients can perform independently are often more sustainable and accessible in the long term (43).

The findings of this study are consistent with those of Gill et al., who reported that various forms of exercise significantly improved glycemic control and reduced complications in type II diabetes patients (13). The study also aligns with the research by Wahyuni et al., which emphasized the importance of foot care and exercise in preventing complications and improving quality of life in diabetic patients (3). The benefits of physical activity and targeted exercises in managing diabetic neuropathy have been well-documented, supporting the current study's conclusions (44).

Despite the positive outcomes, the study highlighted the need for further research with larger sample sizes and longer follow-up periods to validate the findings and explore the long-term benefits and potential side effects of these interventions. Future studies could also investigate the combined effects of Buerger-Allen Exercise and Intraneural Facilitation to determine if a synergistic approach could yield even better results.

CONCLUSION

In conclusion, this study demonstrated that both Buerger-Allen Exercise and Intraneural Facilitation are effective in improving lower extremity perfusion and reducing peripheral neuropathy symptoms in patients with type II diabetes mellitus. Buerger-Allen Exercise, in particular, showed advantages in terms of patient compliance and ease of administration. These findings underscore the importance of incorporating such non-pharmacological interventions into the routine management of diabetic neuropathy. However, further research is needed to confirm these results and optimize treatment protocols for broader clinical application.

REFERENCES

1. Karamanou M, Protogerou A, Tsoucalas G, Androutsos G, Poulakou-Rebelakou E. Milestones in the history of diabetes mellitus: The main contributors. World journal of diabetes. 2016;7(1):1.

2. Egan AM, Dinneen SF. What is diabetes? Medicine. 2019;47(1):1-4.

3. Roglic G. WHO Global report on diabetes: A summary. International Journal of Noncommunicable Diseases. 2016;1(1):3-8.

4. Trikkalinou A, Papazafiropoulou AK, Melidonis A. Type 2 diabetes and quality of life. World journal of diabetes. 2017;8(4):120.

5. Wake AD. Protective effects of physical activity against health risks associated with type 1 diabetes:"Health benefits outweigh the risks". World Journal of Diabetes. 2022;13(3):161.

6. Lin Y-B, Chang T-J. Age at onset of type 1 diabetes between puberty and 30 years old is associated with increased diabetic nephropathy risk. Scientific Reports. 2024;14(1):3611.

7. Hasan S, Shaw SM, Gelling LH, Kerr CJ, Meads CA. Exercise modes and their association with hypoglycemia episodes in adults with type 1 diabetes mellitus: a systematic review. BMJ Open Diabetes Research and Care. 2018;6(1):e000578.

8. Svensson M, Nyström L, Schön S, Dahlquist G, Study SCD, Uraemia tSRfATo. Age at onset of childhood-onset type 1 diabetes and the development of end-stage renal disease: a nationwide population-based study. Diabetes care. 2006;29(3):538-42.

Journal of Health and Rehabilitation Research 2791-156X JHRR

9. Hemmingsen B, Gimenez-Perez G, Mauricio D, i Figuls MR, Metzendorf MI, Richter B. Diet, physical activity or both for prevention or delay of type 2 diabetes mellitus and its associated complications in people at increased risk of developing type 2 diabetes mellitus. Cochrane Database of Systematic Reviews. 2017(12).

10. DeFronzo RA, Ferrannini E, Groop L, Henry RR, Herman WH, Holst JJ, et al. Type 2 diabetes mellitus. Nature reviews Disease primers. 2015;1(1):1-22.

11. Principles of Diabetes Mellitus. second ed2010.

12. Javeed N, Matveyenko AV. Circadian etiology of type 2 diabetes mellitus. Physiology. 2018;33(2):138-50.

13. Thakur A, Sharma R, Sharma SK, Thakur K, Jelly P. Effect of buerger allen exercise on foot perfusion among patient with diabetes mellitus: A systematic review & meta-analysis. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2022;16(2):102393.

14. Sommer C, Geber C, Young P, Forst R, Birklein F, Schoser B. Polyneuropathies. Deutsches Ärzteblatt International. 2018;115(6):83.

15. Singh R, Kishore L, Kaur N. Diabetic peripheral neuropathy: current perspective and future directions. Pharmacological research. 2014;80:21-35.

16. Juster-Switlyk K, Smith AG. Updates in diabetic peripheral neuropathy. F1000Research. 2016;5.

17. Feldman EL, Callaghan BC, Pop-Busui R, Zochodne DW, Wright DE, Bennett DL, et al. Diabetic neuropathy. Nature reviews Disease primers. 2019;5(1):1-18.

18. Russell JW, Zilliox LA. Diabetic neuropathies. Continuum: lifelong learning in neurology. 2014;20(5):1226-40.

19. Nativel M, Potier L, Alexandre L, Baillet-Blanco L, Ducasse E, Velho G, et al. Lower extremity arterial disease in patients with diabetes: a contemporary narrative review. Cardiovascular diabetology. 2018;17:1-14.

20. Radhika J, Poomalai G, Nalini S, Revathi R. Effectiveness of buerger-allen exercise on lower extremity perfusion and peripheral neuropathy symptoms among patients with diabetes mellitus. Iranian journal of nursing and midwifery research. 2020;25(4):291-5.

21. Oexeman S, Ward KL. Understanding the Arterial Anatomy and Dermal Perfusion of the Lower Extremity with Clinical Application. Clinics in Podiatric Medicine and Surgery. 2020;37(4):743-9.

22. Forsythe RO, Hinchliffe RJ. Assessment of foot perfusion in patients with a diabetic foot ulcer. Diabetes/metabolism research and reviews. 2016;32:232-8.

23. Baraz S, Zarea K, Shahbazian HB, Latifi SM. Comparison of the accuracy of monofilament testing at various points of feet in peripheral diabetic neuropathy screening. Journal of Diabetes & Metabolic Disorders. 2014;13:1-7.

24. Feng Y, Schlösser FJ, Sumpio BE. The Semmes Weinstein monofilament examination as a screening tool for diabetic peripheral neuropathy. Journal of vascular surgery. 2009;50(3):675-82. e1.

25. Bhuvaneshwari S, Tamilselvi S. A study to assess the effectiveness of Buerger Allen exercise on lower extremity perfusion among patients with type 2 diabetes mellitus in Saveetha Medical College and Hospital in Chennai. International Journal for Advance Research and Development. 2018;3(9):15-20.

26. Innocenti G, Mugnai C, Pasqui V. FLORe–Florence Repository. L'Archivio ad accesso aperto dell'Università di Firenze. JLIS it: Italian Journal of Library, Archives and Information Science Rivista italiana di biblioteconomia, archivistica e scienza dell'informazione. 2014;5(1):149-71.

27. Chang C-F, Chang C-C, Chen M-Y. Effect of Buerger's exercises on improving peripheral circulation: a systematic review. Open Journal of Nursing. 2015;5(2):120-8.

28. Kawasaki T, Uemura T, Matsuo K, Masumoto K, Harada Y, Chuman T, et al. The effect of different positions on lower limbs skin perfusion pressure. Indian Journal of plastic surgery. 2013;46(03):508-12.

29. **東太**. The effect of different positions on lower limbs skin perfusion pressure: **佐賀大学**; 2015.

30. Baker NA, Vuong D, Bussell M, Gharibvand L, Lee S, Tsao B. Prospective, Randomized, Double-Blinded, Sham-Controlled Pilot Study of Intraneural Facilitation as a Treatment for Carpal Tunnel Syndrome. Archives of Rehabilitation Research and Clinical Translation. 2022;4(2):100193.

31. Sahba K, Berk L, Bussell M, Lohman E, Zamora F, Gharibvand L. Treating peripheral neuropathy in individuals with type 2 diabetes mellitus with intraneural facilitation: a single blind randomized control trial. Journal of International Medical Research. 2022;50(8):03000605221109390.

32. Bussell M, Coleman R, Alido J, Bruhjell K, Berk L. Ultrasound analysis of a novel therapeutic intervention for neuropathy: intraneural facilitation acute effects on idiopathic and chemotherapy induced peripheral neuropathy. The FASEB Journal. 2018;32:853.19-.19.

33. PT DMB, inventor.

34. Wahyuni NT, Herlina L, Abdurakhman RN, Hidayat A, Supriyadi C. Implementation of Buerger Allen exercise in patients with diabetes mellitus type II to improve lower extremity circulation. World Journal of Advanced Research and Reviews. 2022;14(1):573-9.

35. Zahran W, Hassanen A, Nabih M, Kyrillos F. Effect of Buerger Allen exercise on lower limb perfusion among patients with type 2 diabetes mellitus. Mansoura Nursing Journal. 2018;5(1):101-11.

36. Rushdy I, Fahim EM, Heggy EH. Impact of buerger-allen exercises on foot perfusion and pain level for diabetic patients risk with peripheral arterial disease. Assiut Scientific Nursing Journal. 2021;9(24.0):170-81.

37. Latha H, Gifty V. 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. Asian Journal of Nursing Education and Research. 2019;9(3):305-11.

38. Afida AM, Negara CK, Chrismilasari LA. Burger Allen Exercise Against The Circulation Of The Lower Extremities In Diabetic Ulcer Patients. Jurnal EduHealth. 2022;13(01):241-9.

39. Rashwan MA, Bedier NA, El-Kharbotly SE-D, Ebrahim YN, Sharaf AY. The effect of Buerger Allen exercise versus reflexology on lower extremity perfusion and pain among patients with type 2 diabetes mellitus. Alexandria Scientific Nursing Journal. 2022;24(1):13-25.

40. Mumpuni M, Purnamawati D, Arip M, Masadah M, Lorenza C. The Effect of Buerger Allen Exercises on Diabetes Mellitus Patients' Foot Sensitivity of Mantang Health Center Working Area in 2021. International Journal of Social Service and Research. 2022;2(6):569-76.

41. Thomas B, Sharma L. A study to assess the effectiveness of buerger allen exercise on lower extremity perfusion and reducing peripheral neuropathy symptoms among diabetes mellitus patient in selected community areas of bhopal, MP. EPRA International Journal of Research and Development (IJRD). 2023;8(9):125-9.

42. Hasaini A, Muhlisoh M, Sukmawaty MN. Effectiveness of Buerger Allen Exercise and Warm Water Foot Soak on Foot Sensitivity Score in A Group of Patients with Type 2 DM. Indonesian Journal of Global Health Research. 2023;5(2):387-98.

43. Tahir T, Yusuf S. The effect of Buerger Allen exercise and the provision of oral vitamin C toward the improvement of peripheral tissue perfusion and healing of diabetic foot ulcers. Enfermería Clínica. 2021;31:S709-S12.

44. Mayangsari M, Lutfi M. The Effectiveness Of Buerger Allen Exercise On Decreasing ABI Value In Diabetes Mellitus Patients With Virginia Henderson's Nursing Model Theory Approach In The Covid-19 Pandemic. STRADA Jurnal Ilmiah Kesehatan. 2021;10(2):1541-6.