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Original Article

Complementary/Alternative Medicine Section

Effectiveness of Buerger-Allen Exercise on Lower Extremity Perfusion and Peripheral Neuropathy Symptoms among Patients with Type 2 Diabetes Mellitus: A Quasi-experimental Study from Puducherry, India

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ABSTRACT

Introduction: Type 2 Diabetes Mellitus (T2DM) is a prevalent chronic condition frequently associated with poor circulation and peripheral neuropathy, leading to complications such as foot ulcers and amputations. Non pharmacological interventions, including Buerger-Allen Exercises (BAE), have demonstrated efficacy in enhancing blood flow and alleviating neuropathic symptoms.

Aim: To assess the effectiveness of BAE in improving lower extremity perfusion and mitigating peripheral neuropathy symptoms among patients with T2DM.

Materials and Methods: The present study used a quasi-experimental design (two-group pre-test and post-test) and was conducted from April 2025 to June 2025 at the Diabetic Outpatient wards of Mahatma Gandhi Medical College and Research Institute, Puducherry, India. A total of 110 subjects were purposively sampled, with 55 participants allocated to each group: the study group received BAE alongside routine care for 14 days, and the comparison group received routine care exclusively. Data collection involved a structured interview schedule, Ankle-Brachial Index (ABI) for perfusion assessment, and the Michigan Neuropathy Screening Instrument (MNSI) for neuropathy evaluation. Data were analysed using Statistical Package for the Social Sciences (SPSS) version 19.0, employing descriptive statistics and Mann-Whitney U test, with $p<0.05$ considered statistically significant.

Results: The mean age±Standard Deviation (SD) of the study group was 50.52±5.77 years, and of the comparison group was 50.66±6.42 years. In the study group, mean right ABI scores improved from 0.71±0.12 to 0.87±0.08, while mean MNSI scores decreased significantly from 4.49±1.27 to 2.02±0.85 ($p<0.001$). In contrast, the comparison group showed no significant change in ABI (0.71±0.11 to 0.71±0.12) and only minimal improvement in MNSI scores (4.69±1.26 to 4.49±1.43). Post-test comparisons demonstrated significantly better perfusion and reduced neuropathy symptoms in the study group compared to the comparison group ($p<0.001$).

Conclusion: The BAE is an effective, non pharmacological intervention for improving lower-extremity perfusion and reducing peripheral neuropathy symptoms among patients with T2DM.

Keywords: Ankle-brachial index, Exercise therapy, Microcirculation, Nursing intervention, Quality of life

INTRODUCTION

The T2DM is one of the most common metabolic disorders worldwide. Insulin resistance and improper insulin secretion result in chronic high blood sugar and issues with the vascular or nervous systems [1]. The International Diabetes Federation states that more than 540 million adults globally have diabetes. By 2030, this figure will increase to 643 million, with India alone accounting for over 101 million cases [2].

Complications of T2DM, such as cardiovascular disease, nephropathy, retinopathy, and neuropathy, lead to serious health challenges, with peripheral neuropathy and impaired lower limb perfusion being especially perilous [3]. About half of all people with diabetes experience neuropathy, and 20-30% develop peripheral arterial disease, causing ischaemia, foot ulcers, infections, and amputations [4].

Exercise therapy is generally considered a part of the diabetic management principles, which leads to improvement in glycaemic control and enhancement in endothelial function and peripheral circulation [5]. BAE is a clinical intervention used to improve lower limb blood flow and reduce neuropathic symptoms in people with diabetes [6]. The procedure involves a simple technique of elevating the dependent and elevated alternating the limb between dependent and elevated positions to increase venous return and promote collateral circulation, thereby improving tissue oxygenation and microvascular perfusion [7].

Among the various exercise regimens, the BAE has gained clinical attention for its specific efficacy in improving lower-limb blood flow and mitigating neuropathic symptoms in diabetic populations [8]. A systematic review and meta-analysis by Thakur A et al., provided empirical evidence of the clinical significance of the BAE as an effective intervention for improving ABI scores [9]. Studies support the use of BAE to improve the ABI, enhance sensory perception, and reduce neuropathic discomfort in people with Type 2 diabetes [10]. Similar studies have reported positive outcomes in lower-limb sensitivity and perfusion following physical activity practice among hospital-based diabetic cohorts [11,12].

Due to diabetes and neuropathic problems becoming more common in India, especially in South Indian states like Puducherry [13], diabetic care plans should include affordable physiotherapy methods. Consequently, the current study sought to evaluate the efficacy of the BAE in enhancing blood circulation to the lower extremities and alleviating peripheral neuropathy symptoms in individuals with Type 2 Diabetes.

MATERIALS AND METHODS

The present study used a quasi-experimental design (two-group pre-test and post-test) and was conducted from April 2025 to June 2025 at the Diabetic Outpatient wards of Mahatma Gandhi Medical College and Research Institute, Puducherry, India. Ethical approval was obtained from the Institutional Human Ethics Committee (Ref. No. KGNC/IHEC/2025/063, dated 07 April 2025). Written informed consent was obtained.

Inclusion criteria: Patients aged 40 to 60 years diagnosed with Type 2 diabetes using the diagnostic criteria of the American Diabetes Association (ADA) [14], and experiencing Peripheral Neuropathy symptoms, regardless of gender. Individuals with a diagnosis of Type 2 diabetes, an ABI score above 0.41 to 0.99 (mild to borderline) were included [15]. An ABI value ≤0.40 indicates severe peripheral arterial disease or critical limb ischaemia, for which exercise interventions may be contraindicated. Therefore, participants with ABI ≥0.41 were selected to ensure patient safety and suitability for the BAE. Participants with MNSI scores [16] ≤7 were included to include patients with Normal-to-moderate neuropathy and to exclude those with severe neuropathy requiring advanced clinical management.

Exclusion criteria: Patients diagnosed with cardiovascular diseases, including acute coronary syndrome and coronary artery diseases, presenting with foot ulcers and gangrene, and exhibiting critical illness are excluded.

Sample size calculation: The sample size was calculated using the formula for a standardised mean difference (Cohen's d) between two independent groups: $n=2(Z\alpha/2+Z\beta)^2/d^2$, assuming a two-sided $\alpha=0.05$ ($Z_{\alpha/2}=1.96$), 80% power ($Z_{\beta}=0.84$), and a moderate effect size $d=0.56$, $n=2(1.96+0.84)^2/0.56^2$. After accounting for an anticipated 10% attrition, the final sample size was N=110 participants (55 per group).

Study Procedure

Description of the tool: The data were collected using a structured instrument comprising four parts. Part A consisted of the following sociodemographic variables: age, gender, education, occupation, dietary pattern, duration of diabetes, family history of DM, alcohol and smoking habits, current exercise pattern, and frequency and duration of physical activity. Part B: Lower extremity perfusion was evaluated by using the ABI scale. The score was interpreted as above 0.91-1.30 was considered normal, 0.71-0.90 was mildly obstructed, 0.41-0.70 was moderately obstructed, and 0-0.40 was severely obstructed [16]. Part C: Symptoms of peripheral neuropathy were assessed using the MNSI, which includes a 15-question patient questionnaire. It examines sensory symptoms such as numbness, tingling, scorching pain, loss of sensation, sensitivity to warmth, cramping, and a history of foot ulcers or amputation, reflecting early and advanced nerve dysfunction. In the questionnaire component, 13 symptom-based items are scored; each abnormal response is assigned one point, yielding a maximum score of 13. Scores ≥7 indicate severe neuropathy, whereas lower scores reflect Normal to moderate involvement [17].

Data Collection

Phase 1-Pre-test: During the pre-test phase, demographic and clinical variables were collected utilising a semi-structured questionnaire.

Phase 2-Intervention (study group): The study group was given BAE, which involves a series of positional changes and active exercises of the lower limbs to augment circulation. Elevation is done by lifting the legs to a 45° elevation until pallor is achieved (2-3 minutes). Dependency requires the patient to sit with the legs hanging while doing dorsiflexion, plantar flexion, inversion, eversion, and toe flexion/extension (3-5 minutes). Horizontal positioning involves laying the legs flat on the bed and covering them with a warm blanket (3-5 minutes). Each session consisted of doing the exercises for 12-13 minutes. BAE makes use of gravitational changes to stimulate vascular smooth muscles, causing blood to flow due to the difference between filling and emptying the vessels [18]. The teaching program was conducted using the demonstration BAE method for four consecutive days. The demonstration consisted of three stages of the BAE procedure. The intervention was repeated five times a day twice in the morning, from 7 AM to 12 PM, and three times in the afternoon, from 3 PM to 6 PM. Following the educational phase, the second phase, the performance phase, began. During this stage, participants were asked to conduct BAE five to six times a day for five days under the researcher's supervision. The third phase was the post-test measurement of lower extremity perfusion and peripheral neuropathy symptoms on the fourteenth day, using the same measuring instruments. The comparison group received routine diabetic care per hospital protocol, which included standard medical management, general physical activity advice, and foot care education. No structured BAE or supervised lower-limb positional exercise was provided to the comparison group during the study period.

Phase 3-Post-test: Post-test assessments were conducted for both the study and comparison groups to measure ABI and MNSI scores and to evaluate changes in lower-extremity perfusion and neuropathy symptoms after the intervention. Following the completion of post-test assessments, participants in the comparison group were given instructions and demonstrated the BAE as part of routine ethical care.

STATISTICAL ANALYSIS

Data were analyzed using SPSS version 19 (IBM Corporation, Armonk, NY, USA). Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to summarize the data. Between-group differences at baseline (pre-test) and after the intervention (post-test) were analyzed using the Mann–Whitney U test. Within-group pre and post-test comparisons were not performed. A p-value <0.05 was considered statistically significant.

RESULTS

The mean age±SD of the study group was 50.52±5.77 years, and of the comparison group was 50.66±6.42 years. In the study group, the majority of participants were aged 46-60 years (76.4%), whereas in the comparison group, most were aged 56-60 years (32.7%). Females predominated in the study group (60%), while males were more prevalent in the comparison group (56.4%). Regarding the frequency and duration of physical activity, nearly 50% of participants in both groups reported no physical activity [Table/Fig-1].

Variables	Study group (n=55)		Comparison group (n=55)	
	n (%)		n (%)	
Age (in years)				
40-45	13	23.63%	17	30.90%
46-50	14	25.45%	8	14.54%
51-55	14	25.45%	12	21.81%
56-60	14	25.45%	18	32.72%
Gender				
Male	22	40.00%	31	56.36%
Female	33	60.00%	24	43.63%
Educational status				
No formal education	5	9.10%	13	23.63%
Primary education	14	25.45%	15	27.27%
Secondary education	14	25.45%	16	29.09%
Higher secondary education	11	20.00%	9	16.36%
Graduate and above	11	20.00%	2	3.63%
Occupational status				
Employed	18	32.72%	27	49.10%

Unemployed	5	9.10%	3	5.45%
Retired	3	5.45%	10	18.18%
Self employed	7	12.72%	8	14.54%
Home maker	22	40.00%	7	12.72%
Dietary pattern				
Vegetarian	12	21.80%	6	10.90%
Non-vegetarian	43	78.18%	49	89.10%
Physical nature of the job				
Sedentary	9	16.36%	10	18.20%
Active	10	18.18%	7	12.72%
Mixed activity	31	56.36%	32	58.18%
None	5	9.10%	6	10.90%
Time since diagnosis of Diabetes mellitus in years				
1-5	28	50.90%	28	50.90%
6-10	12	21.81%	15	27.27%
Above 10	15	27.27%	12	21.80%
Family history of Type 2 Diabetes Mellitus (T2DM)				
Yes	32	58.18%	30	54.54%
No	23	41.81%	25	45.45%
Habit of alcoholism				
Yes	7	12.72%	15	27.27%
No	48	87.27%	40	72.72%
Habit of smoking				
Yes	4	7.27%	11	20.00%
No	51	92.72%	44	80.00%
Currently pattern of exercise				
Walking	30	54.54%	23	41.81%
Aerobic workout	3	5.45%	4	7.27%
Others	2	3.63%	1	1.81%
None	20	36.36%	27	49.10%
Frequency of physical activity				
1-3 times a week	20	36.36%	20	36.36%
3-5 times a week	15	27.30%	8	14.54%
None	20	36.36%	27	49.10%
Duration of physical activity				
Less than 1 hour per day	15	27.27%	14	25.45%
1-2 hours per day	5	9.10%	4	7.27%
3-4 hours per day	10	18.18%	6	10.90%
More than 4 hours per day	5	9.10%	4	7.27%
None	20	36.36%	27	49.10%

[Table/Fig-1]: Demographics of the study and comparison groups (N=110).

There was no notable difference in the pre-test scores for right ABI (p=0.82), left ABI (p=0.322), and MNSI (p=0.449). However, the post-test results showed significant improvements in the study group for both right (p<0.001) and left (p<0.001) ABIs. Similarly, the study group's MNSI scores showed a significant decrease (p<0.001) [Table/Fig-2].

Observation		Groups	Mean	Mann-Whitney U test	p-value
Right ABI	Pre-test	Study group	0.71±0.12	1474	0.82
		Comparison group	0.71±0.11		
	Post-test	Study group	0.87±0.08	2574.5	<0.001***
		Comparison group	0.71±0.12		
Left ABI	Pre-test	Study group	0.69±0.07	1347	0.322
		Comparison group	0.7±0.09		
	Post-test	Study group	0.86±0.10	2497.5	<0.001***
		Comparison group	0.7±0.11		
MNSI	Pre-test	Study group	4.49±1.27	1399.5	0.449
		Comparison group	4.69±1.26		
	Post-test	Study group	2.02±0.85	198	<0.001***
		Comparison group	4.49±1.43		

[Table/Fig-2]: Comparison between pre-test and post-test of ankle-brachial index and Michigan Neuropathy Screening Instrument (MNSI) in the study group and the comparison group (N=110).
ABI: Ankle-Brachial index; MNSI: Michigan neuropathy screening instrument; p<0.05; **p<0.01; ***p<0.001

DISCUSSION

The present quasi-experimental investigation indicated that BAE is an effective non pharmacological intervention that improves lower extremity perfusion and reduces peripheral neuropathy symptoms in patients with T2DM.

Regarding lower-extremity perfusion, the present investigation observed a substantial increase in post-test ABI values in the study group relative to the comparison group. Radhika J et al., (2020) reported that foot perfusion was significantly improved with BAE, as evidenced by increased ABI and a marked reduction in MNSI scores in both lower limbs (p<0.001) [7]. Another comparative research by Abbass M et al., (2024) showed that the BAE significantly improved blood flow and reduced nerve-related symptoms in patients with type 2 diabetes [8]. The ABI increased significantly after the exercise, going from a mean right ABI of 0.6883 to 1.0250; p<0.001. The MNSI score also decreased significantly, from 7.5 to 4.5 (p=0.003). Similarly, Chang CF et al., (2015) showed that a combination of complex treatment, including the BAE, with a systematic health-promoting program significantly improved ABI, MNSI scores, and leg discomfort in patients at risk of diabetic foot ulceration [19].

The current study demonstrated a significant reduction in MNSI scores among participants who engaged in the BAE, indicating a decrease in the severity of peripheral neuropathy-related neuropathic symptoms. Saleh MA et al., (2024) observed that BAE resulted in substantial improvements in ABI and neuropathy symptoms, with highly significant improvements (p<0.01) in ABI, clinical signs of peripheral vascular disease, and neuropathy scores among 62 diabetic patients following the BAE intervention, indicating better nerve function and reduction of symptoms [20]. The clinical signs of peripheral vascular disease improved in the patients studied after implementing the BAE, with a highly significant statistical difference (p<0.01). Moreover, there was also a notable enhancement in the history and symptoms of peripheral neuropathy post-exercise, again with a highly significant difference (p<0.01). Enhanced perfusion and oxygen transport to peripheral nerves may help explain the decrease in neuropathic symptoms observed in those studies and in the present investigation. From a clinical and nursing perspective, the results of this study endorse the integration of BAE into routine diabetic management as a basic, economical, and practical intervention. Given its non invasive nature and minimal resource requirement, BAE may be particularly beneficial in resource-limited settings and tertiary care hospitals catering to large diabetic populations.

Limitation(s)

The present study does have some limitations, the first of which is the rather small sample size and the short duration of the intervention. This precludes generalising the findings to a wider diabetic population. The quasi-experimental design, not randomised, may have introduced selection bias, and reliance solely on ABI and MNSI limited the scope of vascular and neuropathic evaluation. Besides, long-term adherence to BAE and its long-term effects could not be verified, and confounders such as diet, glycemic control, and medication adherence could not be fully controlled.

CONCLUSION(S)

These findings indicate that the BAE is a simple, inexpensive, evidence-based non pharmacological intervention that significantly improves peripheral perfusion and reduces neuropathic symptoms in patients with T2DM. Analysis of post-intervention data showed significant increases in ABI values and decreases in MNSI scores in patients who performed BAE.

REFERENCES

[1] Chinnaiyan S, Palanisamy B, Ayyasamy L. Prevalence of diabetes mellitus in Indian tribal population: A systematic review and meta-analysis. Int J Diabetes Dev Ctries 2023;43:173-83.

[2] Kumar A, Gangwar R, Ahmad Zargar A, Kumar R, Sharma A. Prevalence of Diabetes in India: A review of IDF diabetes atlas 10th Edition. Curr Diabetes Rev. 2024;20(1):e130423215752. Available from: https://doi.org/10.2174/1573399819666230413094200.

[3] Kulkarni A, Thool AR, Daigavane S. Understanding the clinical relationship between diabetic retinopathy, nephropathy, and neuropathy: A comprehensive review. Cureus. 2024;16:e56674. Available from: https://doi.org/10.7759/CUREUS.56674.

[4] Spiliopoulos S, Festas G, Paraskevopoulos I, Mariappan M, Brountzos E. Overcoming ischemia in the diabetic foot: Minimally invasive treatment options. World J Diabetes. 2021;12(12):2011-2026. Available from: https://doi.org/10.4239/WJD.V12.I12.2011.

[5] Syeda USA, Battillo D, Visaria A, Malin SK. The importance of exercise for glycemic control in type 2 diabetes. Am J Med Open. 2023;9:100031. Available from: https://doi.org/10.1016/J.AJMO.2023.100031.

[6] Ahmad AM, Mohammed AA, Khalifa WA, Ali HM, Abdel-Aziz A. Effect of Buerger-Allen exercise on wound healing in patients with diabetic foot ulcers: A randomised controlled trial. J Wound Care. 2024;33(Sup4a):xci-xcviii.

[7] Radhika J, Poomalai G, Nalini SJ, Revathi R. Effectiveness of buerger-allen exercise on lower extremity perfusion and peripheral neuropathy symptoms among patients with diabetes mellitus. Iran J Nurs Midwifery Res. 2020;25(4):291-95. Available from: https://doi.org/10.4103/IJNMR.IJNMR_63_19.

[8] Abbass M, Rehman M, Emaan I, Shaukat U, Farooq SUR, Rehman MM. Comparative effect of Buerger-Allen exercise and intraneural facilitation on lower extremity perfusion and peripheral neuropathy symptoms among patients with type II diabetes mellitus. Journal of Health and Rehabilitation Research. 2024;4(2):1511-17. Available from: https://doi.org/10.61919/jhrr.v4i2.1181.

[9] 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 Metab Syndr: Clinical Research & Reviews. 2022;16(2):102393. Available from: https://doi.org/10.1016/J.DSX.2022.102393.

[10] Zhao Y, Huang L, Zhou X, Liu J, Yu J. The early diagnostic value of ankle-brachial index combined with feet electrochemical skin conductance for peripheral artery disease in type 2 diabetes. J Diabetes Investig. 2022;13(3):525-531. Available from: https://doi.org/10.1111/JDI.13687.

[11] Francis D, Kandaswami K, Padinhare Veedu P, Ponniah Subramanian A. Effect of exercises for strengthening the intrinsic muscles of the foot and improving ankle mobility on patients of diabetic peripheral neuropathy. Cureus. 2024;16(3):e56553. Available from: https://doi.org/10.7759/cureus.56553.

[12] Kishore TNR, Kalluri SS, Sarveswaran V. A prospective study on independent risk factors for lower limb amputation in diabetic foot patients. Eur J Cardiovasc Med. 2025;15(10):405-11.

[13] Mathiyalagen P, Kanagasabapathy S, Kadar Z, Rajagopal A, Vasudevan K. Prevalence and determinants of peripheral neuropathy among adult Type II Diabetes Mellitus patients attending a non-communicable disease clinic in rural south India. Cureus. 2021;13(6):e15493. Available from: https://doi.org/10.7759/cureus.15493.

[14] American Diabetes Association. Diagnosis [Internet]. Arlington (VA): American Diabetes Association; [cited 2026 Mar 25]. Available from: https://diabetes.org/about-diabetes/diagnosis.

[15] Guirguis-Blake JM, Evans CV, Redmond N, Lin JS. Screening for Peripheral Artery Disease Using the Ankle-Brachial Index: Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. JAMA. 2018 Jul 10;320(2):184-196.

[16] Cleveland Clinic. Ankle-brachial index: Test & what it means [Internet]. Cleveland (OH): Cleveland Clinic; [cited 2026 Mar 12]. Available from: https://my.clevelandclinic.org/health/diagnostics/17840-ankle-brachial-index-abi.

[17] Herman WH, Pop-Busui R, Braffett BH, Martin CL, Cleary PA, Albers JW, et al. Use of the Michigan Neuropathy Screening Instrument as a measure of distal symmetrical peripheral neuropathy in Type 1 diabetes: Results from the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications. Diabet Med. 2012;29(7):937. Available from: https://doi.org/10.1111/j.1464-5491.2012.03644.x.

[18] Afida AM, Negara CK, Chrismilasari LA. Burger Allen exercise against the circulation of the lower extremities in diabetic ulcer patients. J EduHealth. 2022;13(1):241-42. Available from: http://ejournal.seaninstitute.or.id/index.php/healt.

[19] Chang CF, Chang CC, Hwang SL, Chen MY. Effects of buerger exercise combined health-promoting program on peripheral neurovasculopathy among community residents at high risk for diabetic foot ulceration. Worldviews Evid Based Nurs. 2015;12(3):145-53. Available from: https://doi.org/10.1111/WVN.12091.

[20] Saleh MA, Ahmed SS, Bakr ZH. Effect of Buerger Allen exercise on lower limb perfusion and peripheral neuropathy among patients with peripheral vascular diseases. Egyptian Journal of Health Care. 2024;15(1):1248-61.

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