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*Review Article*

# The Effect of Buerger Allen Exercise on Peripheral Tissue Perfusion in Patients with Type 2 Diabetes Mellitus: A Literature Review

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## Abstract

**Background**: Type 2 diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia due to impaired insulin secretion and/or insulin resistance. One of the most common long-term complications is impaired peripheral tissue perfusion of the lower extremities, which can progress to diabetic foot ulcers and significantly increase the risk of amputation. Consequently, identifying effective and accessible non-pharmacological interventions to improve peripheral circulation is crucial.
**Objective**: This literature review aimed to evaluate the effectiveness of Buerger Allen Exercise (BAE) in improving peripheral tissue perfusion among patients with type 2 diabetes mellitus.
**Methods**: A literature review was conducted using Google Scholar, PubMed, ScienceDirect, ProQuest, and Elsevier databases. Articles published between 2016 and 2024 were identified using the keywords “Buerger Allen Exercise,” “BAE,” “Type 2 Diabetes Mellitus,” “Peripheral Perfusion,” and “Ankle Brachial Index,” combined with Boolean operators “AND” and “OR.” Inclusion criteria comprised intervention studies published in English or Indonesian that reported outcomes related to peripheral perfusion.
**Results**: Ten studies met the inclusion criteria. Overall, BAE was associated with significant improvements in peripheral perfusion, evidenced by increased Ankle Brachial Index values, improved capillary refill time, enhanced skin temperature and color, strengthened peripheral pulses, and reduced lower extremity pain. Several studies also reported greater benefits when BAE was combined with adjunctive interventions such as vitamin C supplementation, foot spa therapy, or music therapy.
**Conclusion**: Buerger Allen Exercise is a low-cost, feasible, and evidence-supported non-pharmacological intervention that effectively enhances peripheral tissue perfusion in patients with type 2 diabetes mellitus and may help prevent vascular complications and improve patient well-being.

**Keywords**: Ankle Brachial Index, Buerger Allen Exercise, Peripheral Perfusion, Type 2 Diabetes Mellitus

## INTRODUCTION

Type 2 diabetes mellitus is a chronic metabolic disease characterized by persistent hyperglycemia due to impaired insulin secretion or action (1) . This condition contributes to various long-term complications, one of which is peripheral perfusion disorders in the lower extremities. Peripheral perfusion disorders can trigger a decrease in oxygen and nutrient supply to tissues, increasing the risk of diabetic foot ulcers, infections, and even amputation, thereby significantly impacting patients' quality of life and increasing the burden on healthcare services (2,3).

Globally and nationally, the prevalence of type 2 diabetes mellitus continues to increase, followed by an increase in cases of peripheral vascular complications. A World Health Organization report shows that diabetes mellitus is one of the major health problems with a significant increase in the number of sufferers worldwide (4) . The International Diabetes Federation also reports that peripheral vascular complications are a major cause of morbidity and disability in patients with type 2 diabetes mellitus (5) . In Indonesia, Basic Health Research data shows an increase in the prevalence of diabetes mellitus, especially in adults and the elderly, which correlates with an increased risk of peripheral circulation disorders and diabetic foot complications (6,7) . This condition emphasizes the importance of interventions that not only focus on glycemic control but also on efforts to prevent and improve peripheral tissue perfusion.

In clinical and nursing practice, the management of peripheral perfusion disorders is carried out through pharmacological and non-pharmacological approaches. In addition to drug therapy, nursing interventions play an important role in improving peripheral blood circulation through health education, physical exercise, and self-care that is easy for patients to apply (8,9) . This approach is in line with promotive and preventive efforts in the long-term management of diabetes mellitus (10,11).

One non-pharmacological intervention recommended in nursing practice is the Buerger Allen Exercise (BAE). The Buerger Allen Exercise is a simple postural exercise involving elevation, hanging position, and extreme horizontal position of the lower extremities, accompanied by dorsiflexion and plantar flexion movements (2) . This exercise utilizes the effects of gravity and calf muscle contraction to increase arterial and venous blood flow, improve microcirculation, and enhance peripheral tissue perfusion (12,13) . From a nursing perspective, BAE has advantages because it is non-invasive, low-cost, easy to teach, and can be performed independently by patients at home (8) .

Several intervention studies have reported that Buerger Allen Exercises can improve peripheral perfusion indicators, such as the Ankle Brachial Index (ABI), capillary refill time, skin temperature and color, and reduce lower extremity pain in patients with type 2 diabetes mellitus (14,15) . Additionally, other studies indicate that this exercise contributes to a reduction in peripheral neuropathy symptoms and improved tissue circulation in patients at risk of diabetic foot ulcers (16) .

However, most studies on the Buerger Allen Exercise have been conducted on a small scale, using diverse designs, and with variations in intervention duration and frequency. Research results are also scattered across various clinical contexts and populations, making it difficult to draw comprehensive conclusions based on a single individual study.

To date, there remains a research gap in the form of limited evidence synthesis that systematically summarizes findings related to the effectiveness of Buerger Allen exercises in patients with type 2 diabetes mellitus. Most publications focus on the results of a single intervention without comparing the consistency of findings between studies or examining their methodological strengths and limitations. Therefore, a literature review is needed that presents a comprehensive synthesis of evidence to support evidence-based clinical decision-making and nursing practice.

Based on this background, this literature review was conducted to examine and synthesize scientific evidence regarding the effectiveness of the Buerger Allen Exercise in improving peripheral perfusion in patients with type 2 diabetes mellitus, as well as to identify its implications for nursing practice and future research directions.

## METHODS

### Study Design

This study is a narrative literature review that aims to synthesize scientific evidence regarding the effectiveness of Buerger Allen Exercises

(BAE) on peripheral perfusion in patients with type 2 diabetes mellitus. The reporting process was structured according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines as a framework for reporting transparency, without claiming to be a full systematic review Table 1.

**Table 1. Journal Criteria**

| | Criteria |
|---|---|
| Problem | Peripheral perfusion disorders in patients with type 2 diabetes mellitus |
| Intervention | Buerger Allen Exercise (BAE) |
| Control | No control group and no comparative intervention |
| Outcome | Changes in peripheral perfusion (Ankle Brachial Index/ABI, Capillary Refill Time/CRT, skin temperature, skin color, peripheral pulse, diabetic foot wound healing) |
| Study Design | Experimental Study, Randomized Control Trial (RCT), Quasi-Experimental Study, Pre-experimental Study, Literature Review |

The PICO(S) framework was used to help formulate research questions and determine the suitability of the studies reviewed. All articles analyzed must meet the criteria listed in Table 1. Literature searches were conducted systematically in the Google Scholar, PubMed, ScienceDirect, ProQuest, and Elsevier databases. To maintain methodological consistency, the publication year range was standardized from 2016 to 2024, in line with the objective of obtaining the latest and clinically relevant evidence.

The literature search process was conducted during the period of August–September 2025. Keywords were compiled using a combination of Boolean operators "AND" and "OR", including: "Buerger Allen Exercise" OR "Buerger Allen Exercise" OR "BAE" AND "Type 2 Diabetes Mellitus" AND "Peripheral Perfusion" OR "Lower Extremity Circulation" OR "Ankle Brachial Index (ABI)".

Articles considered were publications in Indonesian or English, available in full text, and published in reputable scientific journals.

**Selection Criteria**

***Inclusion Criteria***

Studies were included in the review if they involved adult patients with type 2 diabetes mellitus, particularly those experiencing peripheral perfusion disorders. The intervention had to involve Buerger Allen Exercise (BAE) or modified exercise programs specifically aimed at improving lower extremity perfusion. Eligible studies compared BAE with standard care, other exercise interventions, or no intervention when such comparisons were available. The outcomes needed to assess peripheral tissue perfusion, including measures such as the Ankle Brachial Index (ABI), lower extremity circulation, peripheral tissue perfusion, or other relevant microcirculation parameters. In terms of study design, only intervention-based studies, such as quasi-experimental studies, randomized controlled trials, or clinical trials that directly evaluated the effect of BAE on peripheral perfusion, were considered.

***Exclusion Criteria***

Studies were excluded if they did not examine Buerger Allen Exercise or focused solely on general diabetes management without addressing peripheral perfusion. Research involving populations other than individuals with type 2 diabetes mellitus, such as pediatric patients, was also excluded. Articles were not considered if they lacked complete data, used unclear methodologies, or failed to report relevant perfusion outcomes. Non-original research publications, including reviews, commentaries, editorials, and brief reports without empirical data, were excluded. Gray literature, such as conference abstracts and unpublished reports, was not included unless explicitly permitted by the study criteria. Additionally, articles that were not available in Indonesian or English or could not be accessed in full text were excluded from the review.

**Screening and Selection Process**

The screening and selection process was conducted systematically to identify studies that met the predefined inclusion criteria. Initially, relevant articles were retrieved through database searches using keywords related to Buerger Allen Exercise, peripheral perfusion, and type 2 diabetes mellitus. All identified records were compiled, and duplicate articles were removed. The remaining titles and abstracts were then screened to assess their relevance to the

study objectives. Articles that did not focus on Buerger Allen Exercise, did not involve patients with type 2 diabetes mellitus, or did not evaluate peripheral perfusion outcomes were excluded at this stage. Full-text articles of the potentially eligible studies were subsequently reviewed in detail to determine their suitability based on the inclusion and exclusion criteria. Studies were included if they examined the effects of Buerger Allen Exercise on peripheral perfusion using appropriate intervention designs and reported relevant outcome measures such as Ankle Brachial Index or other indicators of lower extremity circulation. Articles that lacked complete data, used unclear methodologies, or did not provide adequate perfusion-related results were excluded. The final selection of studies was then used for data extraction and qualitative synthesis.

**Data analysis**

The data obtained were analyzed descriptively. The research findings were grouped according to the main thematic domains, including the effect of Buerger Allen Exercise on peripheral perfusion, the underlying physiological mechanisms involved, the effectiveness of the intervention based on various perfusion indicators, and the consistency of results across different studies. Patterns, similarities in findings, and existing research gaps were systematically identified to provide a comprehensive overview of the current scientific evidence regarding the effectiveness of Buerger Allen Exercise in patients with type 2 diabetes mellitus.

## RESULTS

Figure 1 presents the PRISMA flow diagram of the study selection process. A total of 244 records were identified from PubMed, ScienceDirect, and Google Scholar. After removing 102 duplicate articles, 145 records remained for screening. Based on title and abstract screening, 41 records were excluded due to irrelevance, non-target populations, or lack of full-text availability. Forty articles were assessed for eligibility through full-text review, of which 32 were excluded for not meeting the inclusion criteria. Finally, 10 studies were included in the literature review.

Table 2 summarizes the characteristics of the included studies and demonstrates substantial methodological variability in study design, sample size, intervention duration and intensity, and outcome indicators. Despite this heterogeneity ranging from randomized controlled trials to quasi-experimental, pre-experimental, and observational studies, the overall findings consistently indicated improvements in peripheral perfusion following the implementation of Buerger Allen Exercise (BAE). The most consistent outcome was an increase in Ankle Brachial Index (ABI) values, supported by improvements in related clinical indicators such as capillary refill time, reduced lower extremity pain, enhanced skin temperature and color, and increased skin perfusion pressure. Although methodological differences limited direct quantitative comparisons across studies, the direction of the effect remained consistent. These results suggest that Buerger Allen Exercise is associated with improved peripheral perfusion in patients with type 2 diabetes mellitus.

**Table 2. Summary of Included Studies**

| No | Title & Year | Methods & Sample | Intervention | Duration / Intensity | Key Results |
|---|---|---|---|---|---|
| 1 | Effect of BAE on Lower Extremities Perfusion, 2021 | Quasi-experimental, n=70 | BAE | Routine for 6 months | ABI increased significantly (p=0.002); improved capillary refill, skin temperature, pulse |
| 2 | BAE on Circulation in Diabetic Foot Ulcers, 2018 | Pre-experimental, n=43 | BAE | 20 min, 2×/day, 3 weeks | ABI increased from 0.84 to 0.95 (p=0.000) |
| 3 | Implementation of BAE, 2022 | Quasi-experimental, n=42 | BAE | 10–15 min, 2×/day, 5 days | ABI increased significantly in intervention group |
| 4 | BAE & Neuropathy Symptoms, 2020 | Quasi-experimental, n=50 | BAE | 5×/day, 4 days | ABI increased; neuropathy symptoms reduced |
| 5 | BAE on Tissue Perfusion, 2022 | Quasi-experimental, n=60 | BAE | 4×/day, 2 weeks | ABI improved significantly |
| 6 | BAE on Perfusion & Pain, 2021 | Quasi-experimental, n=100 | BAE | 8–13 min, 2×/day, 6 weeks | ABI improved; pain reduced |
| 7 | BAE on ABI, 2025 | Pre-experimental, n=40 | BAE | Single 20-min session | ABI higher in intervention group |
| 8 | Effectiveness of BAE, 2018 | True experimental, n=60 | BAE | 15 min, 3×/day, 5 days | ABI increased from 0.7 to 0.9 |
| 9 | Skin Circulation Assessment, 2016 | Observational, n=30 | BAE | 3 sessions/day, 3 months | Skin perfusion pressure increased |
| 10 | RCT of BAE, 2019 | RCT, n=30 | BAE | 10–15 min, 2×/day, 5 days | ABI increased significantly |

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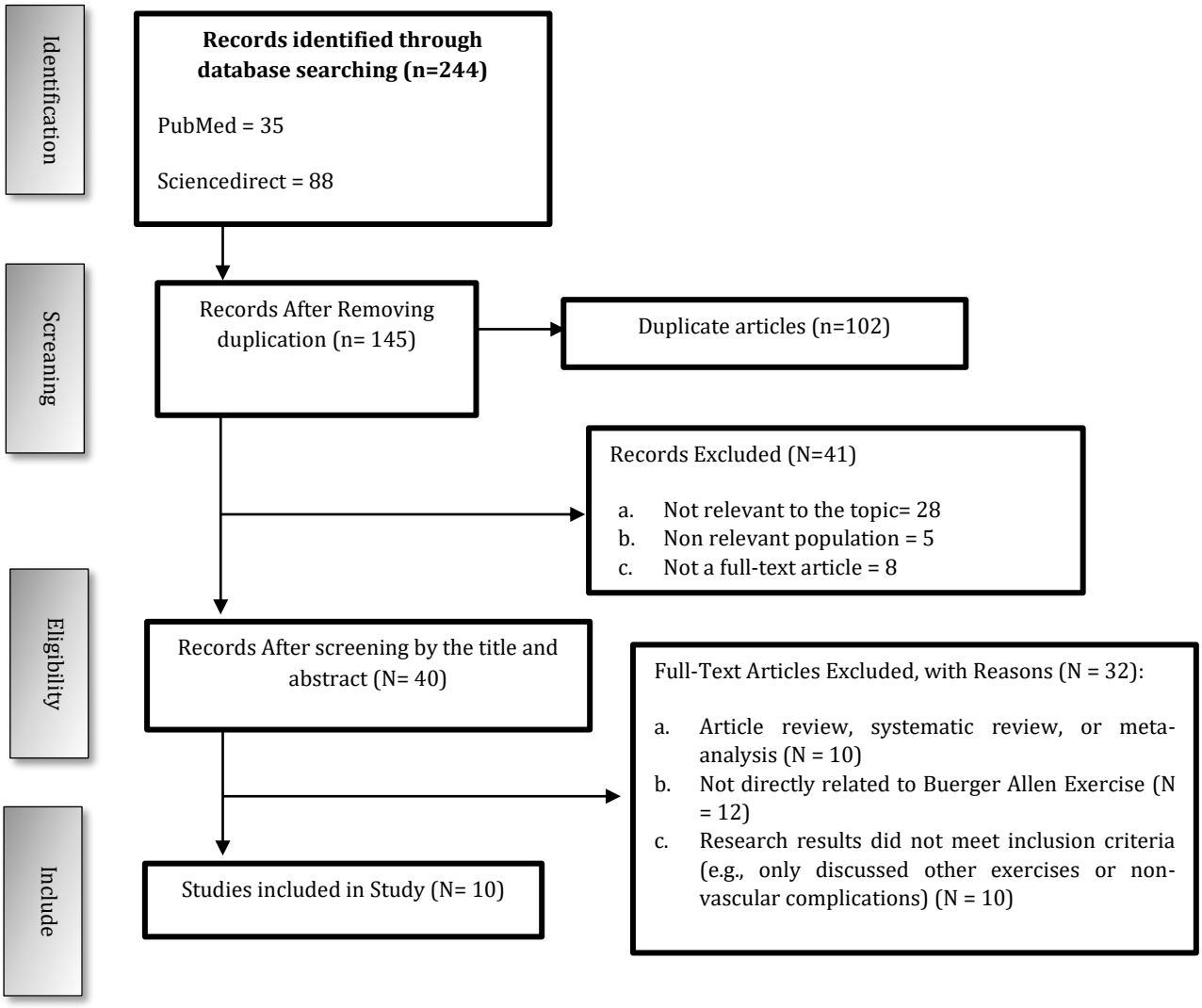


**Figure 1. PRISMA Flow Chart**

## DISCUSSION

This literature review shows that Buerger Allen Exercises (BAE) are generally associated with improved peripheral perfusion in patients with type 2 diabetes mellitus. Despite methodological variability, the overall trend across various studies demonstrates a relatively consistent effect, particularly in terms of increased Ankle Brachial Index (ABI) and improvements in related clinical parameters such as capillary refill time, skin perfusion, and lower extremity pain (17–22). However, these findings should not be interpreted as conclusive evidence but rather as an indication of potential clinical benefits that must be understood in the context of methodological limitations and heterogeneity across studies.

Substantial variation in study design and intervention protocols is a major factor influencing the consistency of findings. The duration, frequency, and overall period of BAE interventions varied widely, ranging from a single exercise session to repeated programs lasting several weeks or months. Studies with longer intervention durations tended to report more stable perfusion improvements, whereas short-term studies primarily demonstrated acute increases in ABI (20,21). These differences make it difficult to determine the optimal exercise dose and limit direct comparison of effect sizes. In addition, variations in population characteristics—such as baseline ABI values, severity of peripheral artery disease, duration of diabetes, and adherence to exercise protocols—

likely contributed to differences in clinical response.

Methodologically, most of the included studies employed quasi-experimental or pre-experimental designs with relatively small sample sizes and limited randomization or blinding (18). These limitations increase the risk of selection bias, measurement bias, and reporting bias. Although some randomized controlled trials reported stronger outcomes (17), their number remains limited, and follow-up periods were generally short. Consequently, evidence regarding the long-term effects of BAE on clinically meaningful outcomes—such as prevention of diabetic foot ulcers, limb ischemia, or amputation—remains insufficient. Furthermore, the lack of formal risk-of-bias assessment in most studies reduces confidence in the overall certainty of the evidence.

From a physiological perspective, the potential benefits of BAE can be explained by mechanisms relevant to the vascular pathology of diabetes. The combination of limb elevation, dependency, and horizontal positioning, along with calf muscle contractions, activates the muscle pump, enhances venous return, and improves arterial perfusion through gravity-assisted blood flow. This process increases shear stress on vascular endothelium, which may enhance nitric oxide bioavailability and promote vasodilation. These mechanisms are particularly relevant in diabetes mellitus, a condition characterized by endothelial dysfunction, reduced vascular elasticity, and impaired collateral circulation. However, most studies included in this review did not directly measure hemodynamic parameters or vascular biomarkers, making mechanistic interpretations largely inferential.

Several studies reported the use of BAE in combination with other non-pharmacological interventions, such as structured foot care, wound management, and neuropathy support for patients with diabetic foot ulcers or peripheral neuropathy. While these combined interventions were associated with improvements in perfusion indicators and clinical symptoms, most studies lacked adequate control groups. As a result, it is not possible to isolate the specific contribution of BAE from the effects of other therapeutic components. Therefore, current evidence does not allow firm conclusions regarding the independent or additive efficacy of BAE in multimodal treatment programs.

In the context of nursing practice, BAE offers several practical advantages as a safe, low-cost, and easy-to-teach non-pharmacological intervention. Nurses play a crucial role in educating patients on correct exercise techniques, monitoring clinical responses, and ensuring adherence to individualized exercise regimens (21). However, given the moderate certainty of the available evidence, BAE should be implemented as a complementary intervention rather than a substitute for standard medical management. Screening for contraindications, routine monitoring of peripheral perfusion, and comprehensive self-care education remain essential components of diabetes management. Future research should prioritize large-scale randomized controlled trials with standardized BAE protocols, systematic risk-of-bias assessments, and the inclusion of long-term clinical outcomes such as ulcer prevention, limb salvage, and quality of life. Strengthening methodological rigor will enhance the evidence base and support the development of more precise, evidence-based nursing practice recommendations.

**Clinical Implications**

The findings of this literature review indicate that Buerger Allen Exercise (BAE) is a practical and evidence-supported non-pharmacological intervention for improving peripheral tissue perfusion in patients with type 2 diabetes mellitus. From a nursing practice perspective, BAE is simple, low-cost, non-invasive, and easily incorporated into routine diabetes self-management education. Nurses can integrate BAE into health promotion and preventive care, particularly for patients at risk of peripheral arterial disease or diabetic foot complications. Regular implementation may improve Ankle Brachial Index, capillary refill time, and lower extremity circulation, potentially reducing ulcer risk and enhancing patient comfort. BAE should be applied as a complementary intervention alongside standard medical management, glycemic control, and routine foot care with continuous monitoring of perfusion outcomes.

**Study Limitations**

This literature review has several limitations. First, substantial heterogeneity existed among the included studies regarding design, sample size, intervention duration, and outcome measures, limiting direct comparison and preventing meta-analysis. Second, most studies

used quasi-experimental or pre-experimental designs with small samples and limited randomization or blinding, increasing the risk of bias. Third, follow-up periods were generally short, restricting conclusions about long-term outcomes such as ulcer prevention or amputation risk. Fourth, adherence monitoring and standardized Buerger Allen Exercise protocols were often insufficiently reported. Finally, the absence of formal risk-of-bias assessment and limited reporting of vascular biomarkers reduced confidence in mechanistic interpretations. These limitations underscore the need for more rigorous and longitudinal research.

## CONCLUSION

Based on this literature review, Buerger Allen Exercise (BAE) shows potential as a non-pharmacological intervention for improving peripheral perfusion in patients with type 2 diabetes mellitus, as indicated by improvements in Ankle Brachial Index, capillary refill time, skin temperature and color, and reduced lower extremity pain. However, the evidence is derived from heterogeneous studies with varied designs, sample sizes, intervention protocols, and outcome measures, predominantly quasi-experimental in nature, resulting in moderate certainty. In nursing practice, BAE may be applied as a safe and easily integrated supportive intervention within patient self-care education, alongside ongoing perfusion monitoring. Further well-designed randomized controlled trials with standardized protocols are needed to strengthen the evidence base and inform definitive clinical recommendations.

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**Author Contributions**
ADSN: Conceptualization, literature search and selection, data extraction, synthesis and analysis of findings, manuscript drafting, and final approval.
FNR: Study supervision, methodological guidance, critical manuscript revision, and final approval.

**Conflict of Interest**
The authors declare that there is no conflict of interest related to this study.

**Data Availability Statement**
All data analyzed in this study are derived from published articles. The datasets used and/or analyzed during the current study are available within the article and its reference list.

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