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Foot Exercise Intervention for Diabetic Peripheral Neuropathy in Patients with Diabetes Mellitus: A Literature Review

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ABSTRACT

Background: Among individuals with type 2 diabetes mellitus, diabetic peripheral neuropathy (DPN) frequently develops as a long-term complication and substantially increases the likelihood of foot ulcer formation and lower-limb amputation. Non-pharmacological approaches, including foot exercise programs, have been proposed to improve foot function and mitigate the progression of DPN. Existing evidence suggests that foot exercises may enhance peripheral circulation, optimize foot biomechanics, and improve sensory nerve function. Objective: The present review was undertaken to critically examine and integrate recent findings regarding the impact of foot exercise interventions on patients with type 2 diabetes mellitus experiencing DPN.
Method: : A systematic literature search was performed in Google Scholar, PubMed, and ScienceDirect to identify studies published within the last five years. Article selection was guided by the PICOS framework. Experimental and quasi-experimental studies investigating foot exercise interventions were included. Eleven eligible articles were reviewed and synthesized narratively.
Result: The findings indicate that foot exercise interventions contribute to improvements in foot sensation, peripheral perfusion, sensory nerve function, balance, walking speed, gait performance, and foot biomechanics. Furthermore, these interventions may decrease the likelihood of diabetic foot ulcer formation.
Conclusion: As a non-pharmacological intervention, foot exercise offers a practical and effective option for improving outcomes in individuals with DPN. Future research employing randomized controlled trial designs and longer follow-up periods is recommended to establish the most effective exercise protocol.

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INTRODUCTION

Diabetes mellitus is one of the most significant global public health challenges, with prevalence trends continuing to rise each year (Setyowati et al., 2021). The chronic hyperglycemia associated with diabetes mellitus contributes to various microvascular complications that increase patient morbidity and disability (Arafah & Agustin, 2025). One of the most common chronic complications is Diabetic Peripheral Neuropathy (DPN), characterized by impaired protective sensation, neuropathic pain, and reduced neuromuscular function (Ferreira et al., 2024). DPN increases the risk of diabetic foot ulcers, which can lead to amputation and a reduced quality of life for patients (Suryani et al., 2021).

Efforts to manage and reverse the progression of Diabetic Peripheral Neuropathy (DPN) are critical steps in strategies to prevent diabetic foot complications (Artha & Deswita, 2021). Non-pharmacological approaches are increasingly being developed as complementary strategies in DPN management because they are relatively safe and can be performed independently (Ansari et al., 2022). Web-based foot and ankle exercise interventions have been reported to effectively reduce DPN symptoms and demonstrate good cost-effectiveness compared to standard care (Junior et al., 2024). A 12-week ankle exercise program has also been shown to improve foot function and reduce pain, although it does not always result in significant changes in the severity of neuropathy (Ferreira et al., 2024). These findings suggest that the benefits of foot exercises may be more pronounced in functional aspects than in specific clinical parameters of neuropathy (Monteiro et al., 2022).

Foot exercises have also been shown to improve biomechanical parameters and mobility in patients with DPN (Monteiro et al., 2022). A 24-week intervention involving flexibility and resistance training of the ankle was associated with a lower incidence of recurrent plantar ulceration among individuals with diabetic peripheral neuropathy (Suryani et al., 2021). Exercise programs emphasizing weight-bearing activities and targeted foot–ankle training were found to enhance intrinsic foot muscle performance while increasing ankle joint mobility in individuals with diabetes and DPN (Ansari et al., 2022). Other studies have shown that ankle mobilization combined with home stretching results in significant improvements in balance and range of motion in patients with DPN (Lepesis et al., 2023). Eight weeks of intrinsic foot muscle strengthening exercises also significantly improved ankle dorsiflexion and big toe grip strength (Francis et al., 2024).

Findings from an Indonesian study by Arafah & Agustin (2025) suggested that diabetic foot exercise may contribute to better vascular status, reflected by increased ABI values, while simultaneously lowering pain intensity and blood glucose levels. Participation in a structured foot exercise program for twelve weeks was associated with enhanced protective sensory function among individuals with diabetes mellitus (Dewi et al., 2024). Compared with traditional exercise approaches, multisystem training demonstrated superior outcomes in postural control, functional mobility, and pain reduction among patients with DPN (Khurshid et al., 2025). A 12-week multifaceted sand training intervention also improved plantar flexor strength and walking speed without side effects (Prokai et al., 2023).

Despite the generally positive outcomes reported for foot exercise interventions, differences in methodological approaches, exercise protocols, intervention periods, and outcome measurements contribute to considerable variability across studies (Ferreira et al., 2024). While improvements in functional performance and mobility are frequently reported, the effects on clinical indicators, including HbA1c and ABI, remain inconsistent among studies (Suryani et al., 2021). These varying results indicate a need for a comprehensive synthesis of evidence to understand the effectiveness of foot exercise interventions in patients with DPN (Junior et al., 2024). Therefore, this literature review was conducted to identify, analyze, and synthesize the latest scientific evidence regarding the effectiveness of foot exercise interventions in patients with DPN as a basis for the development of evidence-based nursing practice.

METHOD

A systematic review methodology guided by the 2020 PRISMA statement was employed to ensure a transparent and structured process for study identification, screening, eligibility assessment, and evidence synthesis. Relevant studies were retrieved through electronic searches performed in PubMed, ScienceDirect, and Google. To maximize study retrieval, the reference sections of eligible articles were also examined manually for potentially relevant publications. These databases were selected because they provide broad access to peer-reviewed literature related to healthcare, nursing science, rehabilitation, and diabetic foot management.

Search terms were developed based on MeSH terminology and concepts relevant to diabetic peripheral neuropathy and exercise-based interventions. The primary keywords used included "diabetic peripheral neuropathy," "DPN," "foot exercise," "foot and ankle exercise," and "therapeutic exercise." Keyword combinations were created using the Boolean operators AND and OR to improve the sensitivity and specificity of the search results. The primary search strategy used was: ("diabetic peripheral neuropathy" OR "DPN") AND ("foot exercise" OR "foot ankle exercise" OR "therapeutic exercise").

Eligibility criteria and study selection procedures were formulated according to the PICOS framework, encompassing population characteristics, intervention types, comparators, outcomes of interest, and study design. The target population included adult individuals diagnosed with diabetes mellitus and diabetic peripheral neuropathy. Interventions of interest included a variety of exercise-based approaches targeting foot and ankle function, such as therapeutic exercise, stretching, mobility training, home-based programs, and technology-assisted exercise interventions. Comparator groups comprised usual care, absence of intervention, or alternative exercise modalities. Outcomes evaluated across studies encompassed both clinical and functional indicators, including neuropathic manifestations, sensory function, pain levels, range of motion (ROM), intrinsic foot muscle strength, balance, walking speed, ankle-brachial index (ABI), plantar pressure, blood glucose levels, HbA1c, and risk of foot ulcers. The Study Design (S) used includes randomized controlled trials, quasi-experimental investigations, pre–post intervention studies, and other clinical research designs evaluating intervention outcomes.

The inclusion criteria for this literature review included original research articles published within the last five years, using experimental or quasi-experimental research designs, involving patients experiencing both diabetes mellitus and diabetic peripheral neuropathy, and focusing primarily on foot and ankle exercise interventions. Review articles, systematic reviews, meta-analyses, articles not available in full text, articles irrelevant to the research topic, and studies with populations other than individuals diagnosed with diabetic peripheral neuropathy were excluded from this literature review.

Study selection followed the PRISMA 2020 framework, consisting of four sequential stages comprising article identification, screening, eligibility evaluation, and study inclusion. At the beginning of the literature search, a total of 566 articles were retrieved from various databases, including PubMed (n = 7), ScienceDirect (n = 37), and Google Scholar (n = 522). After eliminating 45 duplicate articles, 521 articles remained for screening based on title and abstract. A total of 480 articles were excluded because they were irrelevant to the research topic. Subsequently, 41 articles underwent a comprehensive full-text assessment to determine their eligibility based on the predefined inclusion and exclusion criteria. A total of 30 articles were excluded because they used an inappropriate population, irrelevant interventions, were review articles, or were not available in full text. In the final stage, 11 articles that met all inclusion criteria were identified and used in this literature review synthesis. The article study screening and selection procedures are illustrated in the PRISMA flowchart shown in Figure 1.

The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal instruments, with the assessment tool chosen based on the design

of each study. Quality assessment findings were considered to confirm that the included studies demonstrated acceptable methodological standards and aligned with the objectives of the review.

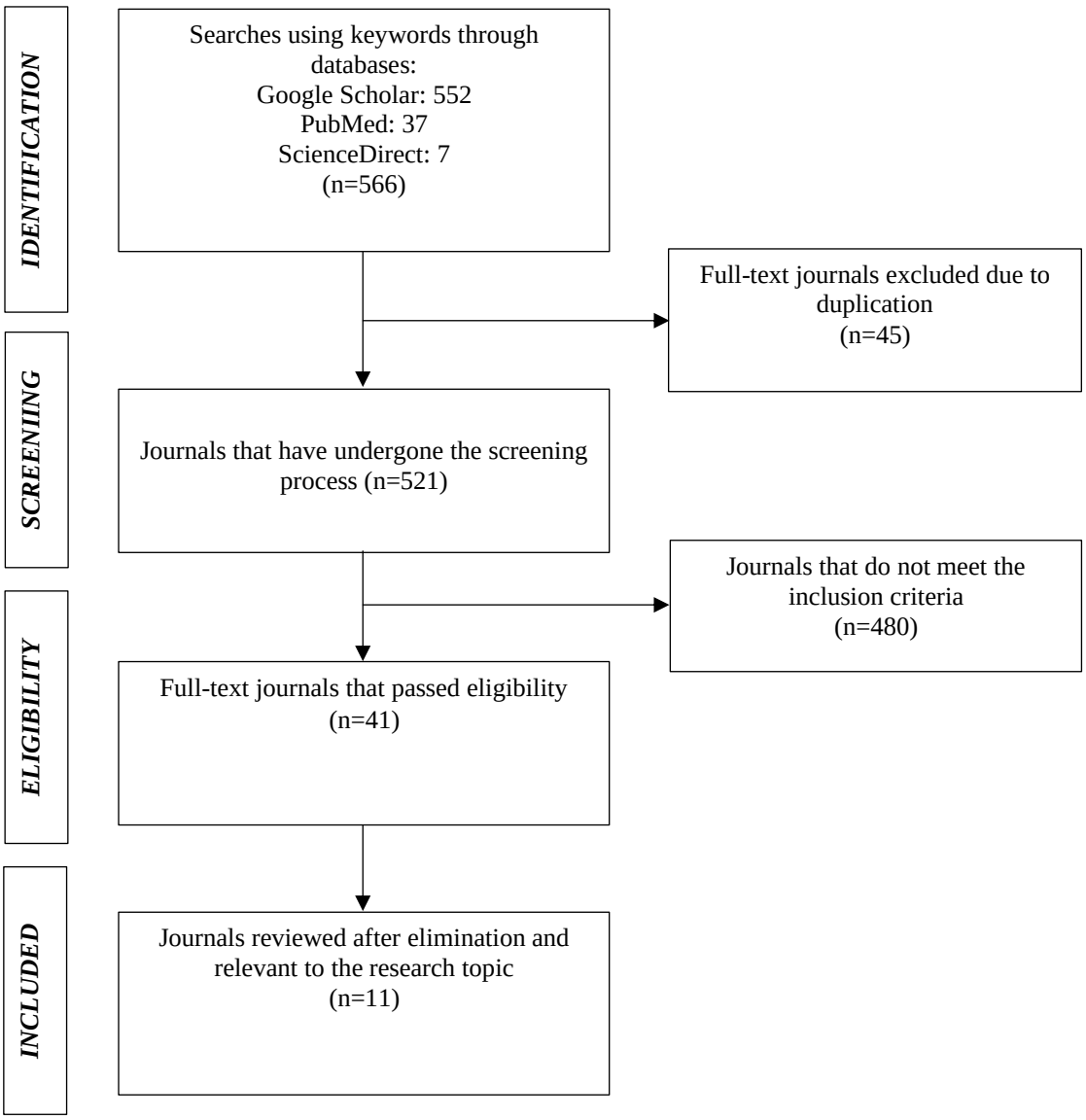

Figure 1. PRISMA diagram

RESULTS AND DISCUSSION

Results

Based on the results of the literature search and article selection, 11 research articles were identified that met the inclusion criteria and were relevant to the topic. The following are the findings of the articles:

Table 1. Article Findings

No	Author & Year	Title	Purpose	Country	Design	Method	Instrument	Sampling	Respondents	Data Analysis	Results
1	Junior et al. 2024	Affordable Web-Based Foot–Ankle Exercise Program Proves Effective for Diabetic Foot Care in a Randomized Controlled Trial with Economic Evaluation	To determine the cost-effectiveness and cost-utility of a novel web-based foot therapy exercise program (SOPeD) designed to address risk factors for ulcers in patients with DPN	Brazil	Randomized controlled trial with economic evaluation	Diabetic foot care, diabetes medication, education for all participants; provision of the web-based SOPeD application to the intervention group for 12 weeks	MNSI-BR, fuzzy DPN score, FHSQ-BR, EQ-5D-3L (utility)	Randomized Controlled Trial (with inclusion and exclusion criteria)	62	GEE for repeated measures; bootstrapping for ICER; ITT analysis	Web-based programs effectively reduce DPN symptoms and are cost-effective; the results show that web-based programs are effective in treating DPN at the same cost as standard care.
2	Ferreira et al. 2024	Effectiveness of a Web-Based Foot-Ankle Exercise Program for Treating Ulcer Risk Factors in Diabetic	Assessing the effectiveness of a web-based foot-ankle exercise program on DPN symptoms,	Brazil	Randomized Controlled Trial, single-blind	12-week foot exercise intervention via the SOPeD app in the intervention group, standard care in the	MNSI, Fuzzy DSS, Monofilament 10 g, tuning fork 128 Hz, FHSQ, emed-plate, motion capture	Random Allocation	62 participants (31 control, 31 intervention)	Generalized Estimating Equation (GEE), Bonferroni post-hoc	There were no significant changes in DPN symptoms or severity, but there was an improvement in foot function, a

No	Author & Year	Title	Purpose	Country	Design	Method	Instrument	Sampling	Respondents	Data Analysis	Results
		Neuropathy in a Randomized Controlled Trial	severity, and gait biomechanics			control group					reduction in pain, an increase in functional reach, changes in plantar pressure- , and an increase in plantar flexion during push-off, particularly by week 24
3	Monteiro et al. 2022	Foot–Ankle Therapeutic Exercise Program Can Improve Gait Speed in People With Diabetic Neuropathy: A Randomized Controlled Trial	Examined the effects of a 12-week foot–ankle exercise program on daily physical activity and gait speed in patients with DPN	Brazil	Randomized Controlled Trial, single-blind	12-week exercise intervention in the intervention group, standard care in the control group	Accelerometer, gait speed test, MNSI, Monofilament 10g, tuning fork, FHSQ, ROM test, pressure platform	Random allocation	78 participants (39 in the control group, 39 in the intervention group)	Intention-to-treat analysis, mixed models	Significant improvements in fast gait speed, ankle range of motion, and vibration perception were observed at week 12. These effects persisted for up to 1 year. No significant changes were observed in daily step count or normal gait speed

No	Author & Year	Title	Purpose	Country	Design	Method	Instrument	Sampling	Respondents	Data Analysis	Results
4	Arafah & Agustin 2025	Diabetic Foot Exercises as Physical Activity Therapy to Prevent Chronic Complications of Type II Diabetes Mellitus	Determining the effect of foot exercises on the prevention of chronic complications of type II diabetes	Indonesia	Pre-experimental (one-group pretest-posttest)	Regular diabetic foot exercises	ABI, Diabetic Foot Pain Scale, blood glucose testing (glucometer)	Convenience sampling	20	Paired sample t-test	After the intervention, there was an increase in ABI, a decrease in foot pain scores, and a decrease in random blood glucose levels in the test group ($p<0.05$).
5	Suryani et al. 2021	*Effect of Foot-Ankle Flexibility and Resistance Exercise in the Secondary Prevention of Plantar Foot Diabetic Ulcer*	Assessing the effects of foot-ankle exercises on the recurrence of plantar ulcers in , HbA1c, DNE, ABI, and walking speed at 12 and 24 weeks in patients with type 2 diabetes	Indonesia	Double-blind randomized clinical trial (RCT)	Flexibility and resistance exercises three times per week at home and education during the hospital stay	Outcomes: recurrent ulcers (clinical criteria), HbA1c, DNE score, ABI, walking speed	Simple random sampling	50 (25 control, 25 interventions)	Independent T-test and Mann-Whitney	Significantly reduced ulcer recurrence in the intervention group, with improvements in DNE and walking speed; no significant differences in HbA1c and ABI.

No	Author & Year	Title	Purpose	Country	Design	Method	Instrument	Sampling	Respondents	Data Analysis	Results
6	Ansari et al., 2022	Effects of Weight-Bearing Exercise on a Minitrampoline, and Foot-Ankle Therapeutic Exercise Program on Foot-Ankle Functionality in People With Diabetic Peripheral Neuropathy	Analyzing the effectiveness of a weight-bearing exercise program using a mini-trampoline and a foot-ankle therapeutic exercise program on foot function in patients with DPN	Iran	Randomized Controlled Trial (RCT), single-blinded	Two-arm parallel group (intervention vs. control); with pre-post evaluation	MNSI, FHSQ, ankle ROM measurement, intrinsic foot muscle strength test	Random allocation	44 patients with DPN	Repeated Measures ANOVA and post-hoc test	There was a significant improvement in leg function, muscle strength, and ankle mobility in the intervention group compared to the control group
7	Lepesis et al., 2023	Effects of Foot and Ankle Mobilisations Combined with Home Stretches in People with Diabetic Peripheral Neuropathy: A Proof-of-Concept RCT	Evaluating the effectiveness of foot-ankle mobilization combined with home stretching for patients with DPN	Chile	Proof-of-Concept Randomized Controlled Trial	Parallel-group RCT; manual mobilization intervention and home stretching program; pre-post evaluation	MNSI, FAAM, ROM ankle measurement and balance test	Convenience sampling with random assignment	30 pasients with DPN	Mixed-model ANOVA	The intervention showed significant improvements in ankle ROM, balance, and foot function; suitable for large-scale studies

No	Author & Year	Title	Purpose	Country	Design	Method	Instrument	Sampling	Respondents	Data Analysis	Results
8	Francis et al., 2024	Effect of Exercises for Strengthening the Intrinsic Muscles of the Foot and Improving Ankle Mobility on Patients of Diabetic Peripheral Neuropathy	Assessing the effectiveness of exercises for strengthening the intrinsic muscles of the foot and improving ankle mobility on ROM and hallux grip force in patients with DPN	India	Quasi-eksperimental	Two groups (standard care vs. structured exercise), 8-week intervention	Goniometer (ankle and MTP range of motion), Paper Grip Test	Consecutive sampling	200 patients with DM and mild peripheral neuropathy (ages 40–70 years)	Intergroup comparison using SPSS	Foot exercises significantly improved ankle dorsiflexion ROM and thumb grip strength ($p < 0.01$)
9	Khurshid et al., 2025	Effects of Multisystem Exercises on Balance, Postural Stability, Mobility, Walking Speed, and Pain in Patients with Diabetic Peripheral Neuropathy	Comparing multisystem exercises and conventional exercises on balance, mobility, and pain	Pakistan	Randomized Controlled Trial (double blind)	Multisystem exercise vs. conventional exercise, 30 min/session, 3×/week, 8 weeks	BBS, FRT, TUG, 10-MWT, NPRS	Convenience sampling with randomization	50 patients with DPN	Repeated measures and between-group analysis	Multisystem exercise is more effective at improving balance, mobility, walking speed, and reducing pain

No	Author & Year	Title	Purpose	Country	Design	Method	Instrument	Sampling	Respondents	Data Analysis	Results
10	Dewi et al., 2024	The Effect of 12-Weeks Foot Exercise on Blood Glucose and Protective Sensation in Diabetes Mellitus Patients	Assessing the effect of foot exercises on blood glucose, protective sensation, and ABI	Indonesia	Quasi-eksperimental pre–post	12 week foot exercise program	Monofilament test, ABI, blood glucose testing	Total sample	Type 2 diabetes patients	Pre–post statistical analysis	Foot exercises improve blood glucose and protective sensation, but have no significant effect on ABI
11	Prokai et al., 2023	Effects of a 12-Week Sand Training Intervention in Patients with Diabetic Peripheral Neuropathy	Evaluating the effects of sand training on muscle strength, balance, walking speed, and ankle ROM in patients with DPN	Hungaria	Quasi-eksperimental pre–post	12-week multifaceted sand training intervention	Dynamometer, TUG, gait analysis, ROM ankle	Purposive sampling	Adult patients with DPN	Parametric pre–post test	There was an increase in plantar flexor strength, balance, walking speed, and ankle ROM without side effects

DISCUSSION

Diabetic Peripheral Neuropathy (DPN) is a common microvascular complication of diabetes mellitus that manifests as sensory, motor, and autonomic impairments caused by prolonged exposure to hyperglycemia (Ferreira et al., 2024). Peripheral nerve dysfunction in DPN leads to a reduction in protective sensation and biomechanical changes in the foot, thereby increasing susceptibility to ulcer formation (Suryani et al., 2021). DPN may lead to sensory deficits and pain while substantially elevating the likelihood of foot ulceration and subsequent amputation (Yang et al., 2023). Furthermore, the condition adversely affects mobility and is associated with a decline in patients' quality of life (Monteiro et al., 2022). One intervention that can help address Diabetic Peripheral Neuropathy (DPN) is diabetic foot exercises (Arafah & Agustin, 2025).

Various non-pharmacological strategies, particularly foot and ankle exercise programs, have been developed to improve neuromuscular function and peripheral circulation in individuals with DPN (Ansari et al., 2022). Evidence from a 12-week web-based foot exercise program demonstrated a reduction in neuropathic symptoms and favorable cost-effectiveness compared with usual care (Junior et al., 2024). Exercise interventions have also been associated with enhanced foot function and decreased pain, although their effects on neuropathy severity are not consistently significant across studies (Ferreira et al., 2024). Collectively, these findings indicate that lower-extremity exercise programs may contribute to better physical functioning and represent a feasible rehabilitation option for individuals living with DPN.

Among the reported benefits of exercise interventions for patients with DPN, improvements in physical and biomechanical performance appear to be the most consistently observed outcomes. Studies have shown that exercise programs emphasizing ankle mobility and strengthening of the intrinsic foot musculature can enhance joint range of motion (ROM), postural stability, gait velocity, and foot stability (Monteiro et al., 2020; Francis et al., 2024). Furthermore, comprehensive exercise regimens have been linked to better mobility and walking performance than conventional exercise approaches (Khurshid et al., 2025). Additional evidence suggests that weight-bearing activities performed on a mini-trampoline, combined with ankle mobilization and home-based stretching exercises, can further improve muscle strength and joint flexibility in individuals with DPN (Ansari et al., 2022; Lepesis et al., 2023).

These improvements in biomechanical function likely occur because foot exercises can enhance the activation of intrinsic muscles, the flexibility of periarticular tissues, and sensorimotor control of the lower extremities (Francis et al., 2024). Improved joint mobility and postural stability contribute to gait efficiency and a reduced risk of injury due to instability in patients with DPN (Prokai et al., 2023). Additionally, a 12-week sand training intervention has also been reported to increase plantar flexor strength without significant side effects.

Regarding diabetic foot ulcer prevention, foot-focused flexibility and resistance training have demonstrated effectiveness in lowering the recurrence of plantar ulcers compared with untreated control groups (Suryani et al., 2021). These benefits may be attributed to enhanced plantar pressure redistribution and improved sensory function, both of which contribute to reducing diabetes-related foot complications (Ferreira et al., 2024). Furthermore, evidence indicates that foot exercise programs can enhance protective sensation among individuals with Type 2 Diabetes Mellitus and DPN (Dewi et al., 2024). Collectively, these findings support the role of foot exercises as a preventive approach for minimizing long-term diabetic foot complications.

However, the effects of the intervention on metabolic parameters such as HbA1c and ABI have shown results that are not yet fully consistent (Suryani et al., 2021). Some investigations have reported improved ABI values alongside reductions in blood glucose levels following diabetic foot exercise programs (Arafah & Agustin, 2025). However, other studies indicate that changes in ABI do not occur significantly even though improvements in sensory function have been demonstrated (Dewi et al., 2024).

Ferreira et al. (2024) note that differences in research findings may be influenced by variations in study design, intervention duration, exercise intensity, and respondent characteristics. Studies with a randomized controlled trial design tend to provide stronger evidence compared to quasi-experimental designs (Junior et al., 2024). Heterogeneity in the measured outcomes also leads to varying interpretations of the effectiveness of foot exercise interventions (Ansari et al., 2022).

Overall, this literature review indicates that foot exercise interventions provide consistent benefits in terms of functional and biomechanical aspects, as well as the prevention of foot complications in patients with diabetes mellitus who have DPN (Monteiro et al., 2022). Scientific evidence supports the view that leg exercises are a safe, practical, and effective nonpharmacological strategy for improving patients' quality of life in evidence-based nursing practice (Khurshid et al., 2025). Therefore, incorporating a foot exercise program into the comprehensive management of patients with DPN may be considered as part of efforts to prevent long-term complications and promote functional rehabilitation in these patients (Junior et al., 2024).

CONCLUSION

Evidence from the reviewed studies suggests that diabetic foot exercise interventions provide substantial benefits in enhancing peripheral circulation, sensory function, intrinsic foot muscle performance, range of motion, balance, and gait ability among individuals with DPN. These improvements may contribute to a lower risk of diabetes-related foot complications through enhanced biomechanical function and more effective plantar pressure redistribution.

Furthermore, both home-based and digitally delivered foot exercise programs have been shown to support rehabilitation and promote better quality of life outcomes in patients with DPN. Despite differences in exercise protocols, intervention intensity, and program duration across studies, the overall findings consistently demonstrate favorable physiological and functional effects. Therefore, diabetic foot exercises should be considered a valuable non-pharmacological nursing intervention for preventing diabetic foot complications and improving patient outcomes in individuals with DPN.

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