Acta Medica Ruha
International Journal of Medicine and Health Sciences
E-ISSN: 2980-1184

REVIEWARTICLE
Volume:3 Issue:4 Year:2025
https://doi.org/10.5281/zenodo.17917191

Effects of Non-pharmacological and Complementary Interventions on Foot Function in Painful and Non-painful Diabetic Peripheral Neuropathy

Fatmaz Zehra Küçük[1]

[1]Harran University Vocational School of Health Services, Podology Program, Sanliurfa, Türkiye

ABSTRACT

Diabetic peripheral neuropathy (DPN) is a major determinant of diabetic foot disease and lower-limb amputation, affecting not only pain but also foot function, gait, balance, and ulcer risk. While non-pharmacological and complementary interventions are increasingly used as adjuncts to pharmacotherapy in both painful and non-painful DPN, the extent to which these approaches influence foot-related outcomes remains unclear. This review synthesises current evidence on the effects of non-pharmacological (e.g. foot–ankle exercise, physical therapy, insoles and orthoses, educational and web-based programmes) and complementary interventions (e.g. reflexology, acupuncture, Reiki, foot massage) on foot function in individuals with DPN. Across randomized and controlled trials, foot–ankle–focused exercise programmes consistently improved intrinsic foot muscle strength, plantar pressure distribution, ankle–foot kinematics, balance, and gait performance, and reduced mechanical risk factors associated with ulceration. Insoles and orthoses with various materials and designs were shown to lower peak plantar pressures and pressure–time integrals and redistribute load away from high-risk metatarsal head regions, supporting their role as effective off-loading strategies. Complementary therapies demonstrated beneficial effects on neuropathic pain and overall quality of life; however, foot function-specific outcomes (e.g. plantar pressure, deformity progression, ulcer incidence, foot-related quality of life) were rarely assessed and were typically reported only as secondary, limited endpoints. Overall, the evidence supports integrating structured exercise and podiatric off-loading strategies into DPN management, while highlighting the need for methodologically robust trials that systematically evaluate foot-centred outcomes to clarify the true podiatric impact of complementary interventions.

Keywords: Diabetic Peripheral Neuropathy, Diabetic Foot, Foot Function, Non-Pharmacological İnterventions, Complementary Therapies.

INTRODUCTION

Diabetic peripheral neuropathy (DPN) is one of the most common chronic microvascular and neurodegenerative complications in individuals with diabetes, and is characterized by progressive damage to peripheral sensory, motor, and autonomic nerve fibers, predominantly involving thinly myelinated and unmyelinated sensory fibers (1,2). Recent epidemiological studies indicate that the prevalence of DPN in the adult diabetic population ranges between approximately 25% and 50%, depending on the diagnostic criteria used and the characteristics of the study sample, and that, on average, one in three individuals with diabetes has neuropathy (3,4). Furthermore, the high frequency of mild and subclinical cases, the insufficiency of screening programs, and the non-specific nature of symptoms result in a substantial proportion of patients with DPN remaining undiagnosed for prolonged periods, thereby increasing the risk of developing severe complications such as diabetic foot ulcers and lower extremity amputations (3,5,6).

From a clinical perspective, DPN can be broadly classified into two main forms: painful and non-painful. Patients with painful DPN typically present with neuropathic pain described as burning, stabbing, or electric-shock-like sensations, along with paresthesia and allodynia, whereas in non-painful DPN, protective sensory loss—particularly on the plantar surface of the feet—predominates in the absence of prominent subjective complaints (1,3). In cases of non-painful DPN with loss of protective sensation, the patient's lack of "pain perception" leads to unrecognized and repetitive minor trauma, excessive mechanical loading, and unperceived thermal or mechanical injuries. Consequently, increased plantar pressure in specific regions, disruption of skin integrity, callus formation, and ultimately the

Corresponding Author: Fatmaz Zehra Küçük, e-mail: zehraklc2015@gmail.com
Received: 24.10.2025, Accepted: 12.12.2025, Published Online: 20.12.2025
Cited: Küçük F.Z. Effects of Non-pharmacological and Complementary Interventions on Foot Function in Painful and Non-painful Diabetic Peripheral Neuropathy. Acta Medica Ruha. 2025;3(4):193-198. https://doi.org/10.5281/zenodo.17917191
The journal is licensed under a Attribution 4.0 International (CC BY 4.0)

development of diabetic foot ulcers may occur (7,8). Therefore, the early detection of asymptomatic sensory loss is as critical as the recognition of painful symptoms for the prevention of diabetic foot complications (1,8).

The presence of DPN is regarded as a major determinant and key risk factor for diabetes-related foot disease and the development of diabetic foot ulcers (DFU) (9). Large cohort studies and consensus reports have demonstrated that DPN, in conjunction with sensory loss, foot deformities, and elevated plantar pressure, plays a central role in the pathogenesis of diabetic foot ulcers, whereas the risk of ulceration is significantly lower among individuals with diabetes who do not have neuropathy (3,7,9). The lifetime risk of developing a DFU in individuals with diabetes has been reported to be approximately 19–34%, and most of these ulcers precede both major and minor lower extremity amputations attributable to diabetes (7,8). Accordingly, the early diagnosis and effective management of DPN are considered fundamental targets in the prevention of diabetic foot ulcers and the associated amputations (7,9).

In recent years, large multicenter observational studies have shown that the prevalence of active diabetic foot ulcers among patients with diabetes presenting to hospital ranges from approximately 15% to 25%, and that in the majority of cases ulceration coexists with peripheral neuropathy and peripheral arterial disease at the time of presentation (10,11). These findings support the central pathophysiological role of the synergistic interaction between sensory loss–related repetitive trauma and ischemia in the development of diabetic foot ulcers (10). In its guidelines on the prevention and management of diabetes-related foot disease, the International Working Group on the Diabetic Foot (IWGDF) recommends regular neuropathy screening, systematic assessment of increased plantar pressure and foot deformities, and the use of appropriate footwear and effective off-loading strategies (such as therapeutic footwear, custom insoles, total contact casts, and similar methods) in at-risk individuals as core components of care (7,12). These recommendations emphasize that early detection of DPN and reduction of mechanical loading constitute a central strategy for preventing diabetic foot ulcers and amputations (7,12). In this context, DPN represents a critical clinical problem not only in terms of pain, but also with respect to foot function, gait, balance, and ulcer risk.

The large- and small-fiber sensory damage that develops in DPN, together with concomitant motor and proprioceptive impairments, affects lower extremity biomechanics in a multidimensional manner. Sensory loss and muscle weakness, particularly involving the intrinsic muscles of the foot, lead to atrophy and the emergence of structural deformities such as claw toes, pes cavus, and hallux valgus, while simultaneously causing a reduction in the range of motion at the ankle and metatarsophalangeal joints (13–15). As a result of these structural and functional alterations, plantar load distribution becomes abnormal, and repetitive high peak pressure areas develop especially under the forefoot and metatarsal heads. This, in turn, promotes callus formation, disruption of skin integrity, and the creation of a mechanical risk substrate for diabetic foot ulceration (16–18). Thus, in the management of DPN, the therapeutic focus should extend beyond the relief of neuropathic pain to include the preservation and restoration of foot function.

In the first-line pharmacological treatment of painful DPN, gabapentinoids, tricyclic antidepressants, serotonin–noradrenaline reuptake inhibitors, topical capsaicin preparations, and agents such as alpha-lipoic acid are commonly recommended (3,19,20). However, randomized controlled trials and clinical guidelines indicate that the analgesic efficacy of these drugs in neuropathic pain is often only moderate, that clinically meaningful pain relief is achieved in only a subset of patients, and that treatment is frequently discontinued or dose escalation is limited due to adverse effects such as sedation, dizziness, weight gain, orthostatic hypotension, and gastrointestinal symptoms (20–22). This adverse-effect profile and the limited analgesic response highlight that pharmacological therapy alone is insufficient in the

management of painful DPN, and underscore the need to integrate non-pharmacological and complementary approaches into the treatment plan (20,22).

These limitations have markedly increased interest in, and utilization of, non-pharmacological (e.g., exercise, physical therapy and rehabilitation approaches, transcutaneous electrical nerve stimulation, insoles and orthoses, educational programs) and complementary interventions (such as reflexology, acupuncture, Reiki, and massage) as adjuncts to pharmacological treatment in both painful and non-painful DPN (20,24). Systematic reviews and meta-analyses published in recent years have reported that complementary and alternative medicine interventions can reduce neuropathic pain intensity and improve overall quality of life in diabetic neuropathy; moreover, modalities such as acupuncture, reflexology, and foot massage may provide superior pain control compared with placebo or pharmacological treatment alone when added to standard care (23,24). Nonetheless, in the majority of existing clinical studies and systematic reviews, the primary outcome has been pain, whereas foot function–related specific outcomes—such as plantar pressure and loading parameters, ankle–foot kinematics, muscle strength, balance, gait performance, ulcer occurrence and ulcer risk factors, and foot-related quality of life—have either not been assessed or have only been reported as secondary and limited outcomes. This situation leaves an important gap in understanding the true podiatric contribution of non-pharmacological and complementary interventions in DPN (20–24).

Conversely, there has been a notable increase in the number of randomized controlled trials demonstrating the beneficial effects of foot–ankle–focused exercise programs on foot function in individuals with DPN. Home-based or center-based foot–ankle exercise protocols of approximately 8–12 weeks' duration have been reported to increase intrinsic foot muscle strength, improve functional balance and gait speed, and, additionally, promote a more homogeneous plantar pressure distribution by reducing peak pressures particularly in the forefoot region, while also yielding significant improvements in ankle–foot kinematics and gait kinetics (25–28). These studies further suggest that such exercise programs may be associated with improvements in DPN severity and sensory test results (e.g., monofilament testing and vibration perception) and that web-based interventions targeting plantar pressure parameters, which are among the key ulcer risk factors, may constitute clinically feasible and cost-effective options (29,30). Similarly, randomized or controlled trials employing insoles and orthoses with different materials and design characteristics have shown that these devices can significantly reduce mechanical loading indices such as peak plantar pressure and pressure–time integrals in individuals with DPN, redistributing load away from high-risk metatarsal head regions toward a broader plantar surface and thereby providing an important off-loading strategy for the prevention of diabetic foot ulcers (30–32).

In the context of complementary interventions, randomized controlled trials focusing particularly on foot reflexology have demonstrated reductions in neuropathic pain symptoms in individuals with DPN, and some studies have also reported improvements in ankle–brachial index (ABI) values, reflecting peripheral circulation, as well as favorable changes in peripheral hemodynamic parameters (25,33). Furthermore, randomized or quasi-experimental studies have shown that acupuncture, Reiki, foot massage, and similar complementary modalities can provide beneficial effects on pain intensity and overall quality of life in patients with diabetic neuropathy (34–37). However, most of these studies have primarily focused on pain and general quality of life as their main outcomes, and have not systematically evaluated podiatric outcomes such as foot function, plantar pressure and loading patterns, deformity progression, ulcer incidence, or foot-specific quality of life, or have reported them only in a limited and secondary manner (25,35,37). This highlights a substantial knowledge gap regarding the true impact of complementary interventions on foot health and podiatric risk in DPN.

Overall, while the existing literature includes numerous clinical studies and reviews focusing on the effects of non-pharmacological and complementary interventions on pain in DPN, there appears to be a

lack of studies that comprehensively and systematically evaluate foot function–centered outcomes—such as plantar pressure and loading parameters, ankle–foot kinematics, muscle strength, balance and gait performance, ulcer occurrence and ulcer risk factors, and foot-related quality of life—in both painful and non-painful DPN. This gap hampers a holistic understanding, by clinicians and researchers, of non-pharmacological and complementary strategies aimed at preserving foot health and mitigating podiatric complications in DPN.

CONCLUSION

Diabetic peripheral neuropathy is a key determinant of diabetic foot disease and lower extremity amputation, exerting substantial effects not only on pain but also on foot function, gait, balance, and ulcer risk. In this review, the effects of non-pharmacological and complementary interventions on foot function in individuals with painful and non-painful DPN were examined from a podiatric perspective.

The available evidence indicates that foot–ankle–focused exercise programs and insole/orthotic-based interventions can improve plantar pressure distribution, ankle–foot kinematics, muscle strength, balance, and gait performance, and can attenuate mechanical risk factors for ulceration. Complementary approaches such as reflexology, acupuncture, Reiki, and foot massage appear to reduce pain and enhance overall quality of life; however, the number of studies that adequately and systematically report foot function–specific outcomes remains limited.

Therefore, in clinical practice, management strategies for DPN should not rely solely on pharmacological pain control, but should also incorporate structured exercise programs and off-loading podiatric strategies as integral components of care. Future research should focus on high-quality randomized controlled trials that:

- differentiate between painful and non-painful DPN subgroups,
- employ standardized, foot function–specific outcome measures (e.g., plantar pressure indices, kinematic analysis, muscle strength, and foot-related quality of life), and
- are methodologically robust with sufficient sample sizes and follow-up durations.

Such studies are essential to define the true role of non-pharmacological and complementary interventions in preserving foot health, reducing podiatric risk, and informing evidence-based, multidisciplinary care models for individuals living with DPN.

DESCRIPTIONS

No financial support.

No conflict of interest.

Acknowledgements and Presentation Information: This study has not been previously presented in any form or on any platform.

REFERENCES

1. Feldman EL, Callaghan BC, Pop-Busui R, et al. Diabetic neuropathy. Nat Rev Dis Primers. 2019;5(1):41.

2. Callaghan BC, Cheng HT, Stables CL, Smith AL, Feldman EL. Diabetic neuropathy: clinical manifestations and current treatments. Lancet Neurol. 2012;11(6):521-534.

3. Pop-Busui R, Boulton AJ, Feldman EL, et al. Diabetic Neuropathy: A Position Statement by the American Diabetes Association. Diabetes Care. 2017;40(1):136-154. doi:10.2337/dc16-2042

4. Hicks CW, Selvin E. Epidemiology of peripheral neuropathy and lower extremity disease in diabetes. Curr Diab Rep. 2019;19(10):86.

5. Yang Y, Zhao B, Wang Y, et al. Diabetic neuropathy: cutting-edge research and future directions. Signal Transduct Target Ther. 2025;10(1):132.

6. Selvarajah D, Kar D, Khunti K, et al. Diabetic peripheral neuropathy: advances in diagnosis and strategies for screening and early intervention. Lancet Diabetes Endocrinol. 2019;7(12):938-948.

7. Bus SA, Armstrong DG, Gooday C, et al. IWGDF guideline on offloading foot ulcers in persons with diabetes: part of the 2019 IWGDF guidelines on the prevention and management of diabetic foot disease. 2019.

8. Boulton AJM, Armstrong DG, Kirsner RS, et al. Diagnosis and management of diabetic foot complications. Arlington (VA): American Diabetes Association; 2018.

9. Armstrong DG, Boulton AJM, Bus SA. Diabetic foot ulcers and their recurrence. N Engl J Med. 2017;376(24):2367-2375.

10. Zhang P, Lu J, Jing Y, Tang S, Zhu D, Bi Y. Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis. Ann Med. 2017;49(2):106-116.

11. Yazdanpanah L, Shahbazian H, Nazari I, et al. Incidence and risk factors of diabetic foot ulcer: a population-based diabetic foot cohort (ADFC study)—two-year follow-up study. Int J Endocrinol. 2018;2018:7631659.

12. Schaper NC, van Netten JJ, Apelqvist J, et al. Practical guidelines on the prevention and management of diabetic foot disease (IWGDF 2019 update). Diabetes Metab Res Rev. 2020;36(S1):e3266.

13. Tesfaye S, Boulton AJM, Dyck PJ, et al. Diabetic neuropathies: update on definitions, diagnostic criteria, estimation of severity, and treatments. Diabetes Care. 2010;33(10):2285-2293.

14. Allen MD, Doherty TJ, Rice CL, Kimpinski K. Physiology in Medicine: neuromuscular consequences of diabetic neuropathy. J Appl Physiol (1985). 2016;121(1):1-6.

15. Kumar CS, Rajagopal KV, Hande HM, Maiya AG, Mayya SS. Intrinsic foot muscle and plantar tissue changes in type 2 diabetes mellitus: 2型糖尿病患者足部内在肌与足底组织的变化. J Diabetes. 2015;7(6):850-857.

16. Fernando ME, Crowther RG, Lazzarini PA, et al. Plantar pressures are higher in cases with diabetic foot ulcers compared to controls despite a longer stance phase duration. BMC Endocr Disord. 2016;16(1):51.

17. Lockhart M, Dinneen SF, O'Keeffe DT. Plantar pressure measurement in diabetic foot disease: A scoping review. J Diabetes Investig. 2024;15(8):990-999. doi:10.1111/jdi.14215

18. Kimura T, Thorhauer ED, Kindig MW, et al. Neuropathy, claw toes, intrinsic muscle volume, and plantar aponeurosis thickness in diabetic feet. BMC Musculoskelet Disord. 2020;21(1):485.

19. Finnerup NB, Attal N, Haroutounian S, et al. Pharmacotherapy for neuropathic pain in adults: a systematic review and meta-analysis. Lancet Neurol. 2015;14(2):162-173.

20. Jang HN, Oh TJ. Pharmacological and nonpharmacological treatments for painful diabetic peripheral neuropathy. Diabetes Metab J. 2023;47(6):743-756.

21. Pop-Busui R, Ang L, Boulton AJM, et al. Diagnosis and treatment of painful diabetic peripheral neuropathy. 2022.

22. Moisset X. Neuropathic pain: evidence-based recommendations. Presse Med. 2024;53(2):104232.

23. Tesfaye S, Kempler P. Conventional management and current guidelines for painful diabetic neuropathy. Diabetes Res Clin Pract. 2023;206:110765.

24. Syahriyani S, Yusuf S, Syam Y. The effectiveness of complementary and alternative medicine therapy in reducing pain in diabetic neuropathy: a systematic review. Public Health Indones. 2021;7(1):31-40.

25. Cicek SC, Demir S, Yilmaz D, Yildiz S. Effect of reflexology on ankle brachial index, diabetic peripheral neuropathy, and glycemic control in older adults with diabetes: a randomized controlled trial. Complement Ther Clin Pract. 2021;44:101437.

26. Silva EQ, Veríssimo JL, Ferreira JS, et al. Effects of a home-based foot-ankle exercise program with educational booklet for foot dysfunctions in people with diabetic neuropathy: results of the FOCA-II randomized controlled clinical trial. Appl Sci (Basel). 2023;13(3):1423.

27. Monteiro RL, Ferreira JS, Silva EQ, et al. Effects of foot-ankle exercises on foot-ankle kinematics, plantar pressure, and gait kinetics in people with diabetic neuropathy: secondary outcomes from a randomized controlled trial. Braz J Phys Ther. 2023;27(3):100517.

28. Monteiro RL, Ferreira JS, Silva EQ, et al. Foot–ankle therapeutic exercise program can improve gait speed in people with diabetic neuropathy: a randomized controlled trial. Sci Rep. 2022;12(1):7561.

29. Actis RL, Ventura LB, Lott DJ, et al. Multi-plug insole design to reduce peak plantar pressure on the diabetic foot during walking. Med Biol Eng Comput. 2008;46(4):363-371.

30. Collings R, Freeman J, Latour JM, Paton J. Footwear and insole design features for offloading the diabetic at risk foot—a systematic review and meta-analyses. Endocrinol Diabetes Metab. 2021;4(1):e00132.

31. Elgohary HM, Allam I, Tolba AM, et al. Effect of foot insole on plantar pressure distribution in patients with neuropathic diabetic foot ulcer: a prospective, randomized, double-blinded, controlled clinical trial. Medicina (Kaunas). 2024;60(12):2066.

32. Tang UH, Zügner R, Lisovskaja V, Karlsson J, Hagberg K, Tranberg R. Comparison of plantar pressure in three types of insole given to patients with diabetes at risk of developing foot ulcers: a two-year, randomized trial. J Clin Transl Endocrinol. 2014;1(4):121-132.

33. Shawky Gomaa W, Gaber Mohammed H, Saied Taha A, Mahmoud Abo El-Fadl N. Effect of foot reflexology technique on diabetic neuropathy patients' health outcomes. J Nurs Sci Benha Univ. 2022;3(2):873-887.

34. Safitri RM, Mahyuvi T. Effect of massage, foot massage, and warm blanket combination on ankle brachial index in diabetic ulcer risk. J Nurs Pract. 2025;8(2):237-246.

35. Dietzel J, Habermann IV, Hörder S, et al. Acupuncture in patients with diabetic peripheral neuropathy-related complaints: a randomized controlled clinical trial. J Clin Med. 2023;12(6):2103.

36. Chao MT, Schillinger D, Nguyen U, et al. A randomized clinical trial of group acupuncture for painful diabetic neuropathy among diverse safety net patients. Pain Med. 2019;20(11):2292-2302.

37. Lee MS, Pittler MH, Ernst E. Effects of reiki in clinical practice: a systematic review of randomised clinical trials. Int J Clin Pract. 2008;62(6):947-954.