



Review Paper: Rehabilitation Interventions for Gait Problems in Patients With Diabetic Peripheral Neuropathy: A Scoping Review



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ABSTRACT

Background and Objectives: Gait and balance disturbances are challenging conditions in patients with Diabetic Peripheral Neuropathy (DPN). The overall literary consensus is that rehabilitation interventions are effective in improving gait performance in this patient group. This review sought to highlight and assess the literature and provide a scoping review on the current knowledge gaps in the rehabilitation interventions for the gait problems of patients with DPN.

Methods: An electronic databases search was done between 2001 and May 2020. Besides, a hand-search method was used for grey literature. Two experts reviewed the results and screened them based on the subject's diagnosis with DPN and gait problems.

Results: Of 87 studies obtained, nine met the inclusion criteria. The frequent components of the rehabilitation interventions included exercise therapy, dual-task intervention, and the use of assistive devices. The outcomes utilized most frequently included changes in balance and stability, muscle strength, proprioception, function, and gait parameters.

Conclusion: Evidence was formed as a scoping review to guide rehabilitation for DPN patients with gait problems. Rigorous comparative studies with clearly defined interventions are needed.

Keywords: Rehabilitation, Gait, Diabetic peripheral neuropathy



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↑ *What is “already known” in this topic:*

Rehabilitation interventions are effective in improving gait performance in patients with diabetic peripheral neuropathy.

→ *What this article adds:*

Findings highlight small sample sizes, current knowledge gaps in the rehabilitation interventions for the gait problems of patients with diabetic peripheral neuropathy, and the need for rigor in the methodology of future studies.

1. Introduction

D iabetic peripheral neuropathy (DPN) is considered as one of the associated complications of type 2 diabetes mellitus and has rapidly increased in developing countries [1, 2]. Its prevalence ranged from 13% to 68% in the diabetic population, in 2009 [3]. Some patients experience painful symptoms, while others may be asymptomatic [1]. The DPN affects the lower extremities (motor, sensory, and autonomic) nerves to variable degrees and it progresses gradually and symmetrically from distal to proximal [4-6]. The complications of DPN include the loss of vibration sense, reduced tactile sensitivity, proprioception deficiency, decreased muscle strength, and changes in balance and gait patterns [4-7].

Gait and balance disturbances are challenging conditions in the diabetic patient as they result in reduced performance. Previous research has reported changes in gait parameters, such as speed, step length, the number of steps per minute, articular position, and ground reaction forces in DPN patients, compared with healthy individuals [4-8]. As a result of these changes, patients adopt less demanding functional gait variations. In a closed-loop chain, less activity results in a reduced Range Of Motion (ROM), reduced muscle strength, and the deterioration of the gait biomechanics and balance [9, 10]. A consequence is the gradual adoption of a hip prominent strategy because of reduced ankle plantar flexor strength, which is known as a “slowness strategy” [11, 12].

The management of the diabetic patients’ symptoms follows various recommendations as presented within public health guidelines [13]. One of these is an exercise program involving a minimum of 30 minutes per day, six times per week, to maintain gait security and balance [13]. Additionally, some evidence indicates that both physiotherapy and exercise therapy positively af-

fect muscle strength, proprioception improvement, and balance and gait recovery in peripheral neuropathy patients, including those with type 2 diabetes [14, 15]. A further consideration is the psychological and cognitive-behavioral factors involved in the management of diabetic patients, particularly those with gait alternations. Intervention provided by the therapists should encourage a reduction in fall risk and include treatment plans that consequently improve the performance and safety of patients’ gait. This will increase patients’ self-confidence to an acceptable level, where they can perform these gait patterns as an integral part of the activity of daily living [16]. The overall literary consensus is that rehabilitation interventions effectively improve gait performance in diabetic neuropathy patients [17, 18].

Scoping review is an increasingly recognized literature review methodology, especially in health-care studies. According to Mays et al. (2001), scoping studies allow a specific line of research to propose rapidly and strongly the key concepts underpinning a line of research for relevant literature, with broad questions that enable the findings to be summarized, and subsequently provide the existing knowledge gaps for future research [19, 20]. Later, in 2005, Arksey and O’Malley [19] developed a methodological framework that expanded the Mays et al. (2001) definition [20].

This study aimed to use such a scoping review to highlight the current knowledge gaps in the rehabilitation interventions for the gait problems of patients with DPN.

Evidence acquisition: This scoping review followed a recognized methodological framework [19] that includes five stages: 1. Identifying the research questions; 2. Identifying relevant studies; 3. Study selection; 4. Charting the data; and 5. Collating, summarizing, and reporting the results. Ethics committee approval is not required for the scoping review studies.

Identifying the research questions

To answer the research objective, the authors framed the research questions according to the PICO (T) elements of patient, intervention, outcome, comparison, and time. The PICO (T) approach is an evidence-based model that includes a process of creating a question, identifying its location, evaluating, and repeating as needed [21]. We identified the research question as “What are the effective rehabilitation interventions that improve the functional gait of patients with diabetic neuropathy?” Also, the study objectives were as follows:

- To identify existing rehabilitation interventions for DPN patients with gait problems,
- To identify the literature gaps in gait and balance rehabilitation especially for patients with diabetes neuropathy,
- And to illustrate an evidence map and provide an evidence database on the scoping review results.

Identifying relevant studies

We conducted a preliminary search in PubMed, ScienceDirect, OTseeker, the Cochrane library, and Google Scholar search engine. The Medical Subject Heading terms and keywords included “diabetic neuropathy” AND “rehabilitation” AND/OR “gait” OR “posture” OR “stability” OR “lower limb” OR “interventions” OR “physical therapy” OR “occupational therapy”. The search period was from 2001 till May 2020. We also searched each reference list from the relevant articles to identify any related articles, including potential grey literature.

Study selection (screening)

Two experts reviewed the results and screened them based on the following inclusion/exclusion criteria. The inclusion criteria for the title were the subject’s diagnosis with DPN and gait problems, with or without the implementation of rehabilitation interventions. Besides, the exclusion criteria were non-English articles, the unavailability of full text, and ineffective interventions. Then, the reviewers screened the relevancy of the selected papers.

Charting the data

“Charting” is the process of charting the key topics of information from the primary studies included in the final analysis. Charting results in a frame or picture of them that are derived from the literature [19]. A copy

of the defined articles was provided to the same two reviewers; they separately reviewed the articles and charted the data. The research team conducted the data abstraction for all articles and sorted the obtained data into four broad elements or themes (in a paired approach of two reviewers per article, with a decision provided by a third reviewer in case of a split decision). Preliminary data abstraction elements were as follows:

- Subject characteristics (the type of diabetes, age, and gender),
- Type of rehabilitation intervention (physical therapy, occupational therapy, etc),
- Timing of interventions,
- And the type of outcomes (e.g., physical, mental, functional, etc).

Collating, summarizing, and reporting the data

Considering the aims of a scoping review to overview and present a large amount of data with high attention in summarized format [19], we used maps and tables to summarize the results.

2. Results

Out of 87 papers identified in our search (electronic and hand-search), nine studies had met the inclusion criteria and were entered in this review (Figure 1). Table 1 summarizes the characteristics of the included studies. The selected studies were conducted across eight countries and published between 2001 and 2020. Six randomized control trials met our inclusion criteria [22-27]. Four studies examined patients with diabetes type 2 [24, 26-28], and three studies included both diabetes types 1 and 2 [23, 25, 29]. Also, the duration of the interventions ranged from 2 to 12 weeks. All studies examined a rehabilitation intervention, however, no comparative reports were presented about the two different rehabilitation interventions in patients. Paul et al. evaluated the effect of a cognitive-motor task on the gait variables of healthy and neuropathic subjects [30]. However, the studies significantly differed in terms of the intervention components, the difficulty of the rehabilitation program, the types of treatment providers, and the amount of details noticed in the study. Table 2 provides the results of the intervention components used in each study.

The frequent components of the rehabilitation interventions included exercise therapy and physical activity (n =

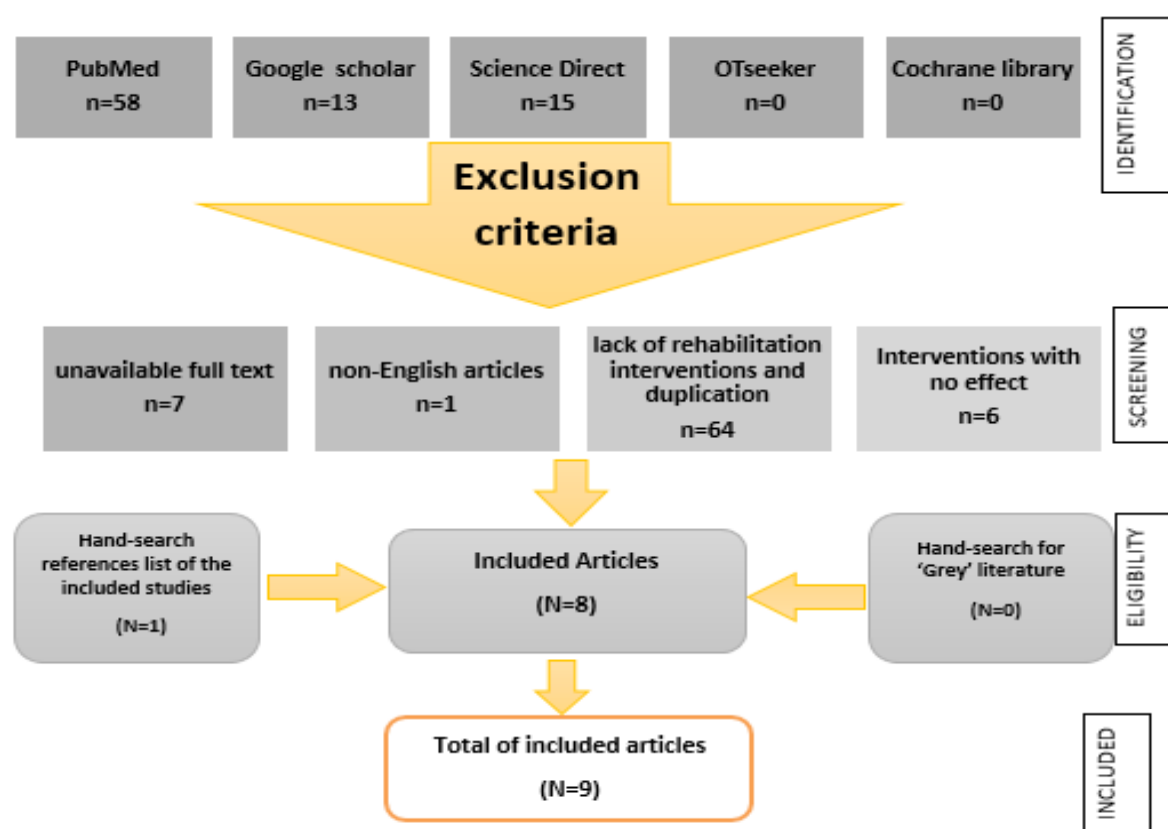


Figure 1. Overview of Study Identification and Selection

5) [22-25, 27], dual-task intervention (n = 2) [26, 30], and the use of assistive devices (n = 2) [28, 29]. A randomized control trial did not provide any information about the intervention providers [22]. In the remaining studies, the rehabilitation services were provided by physical therapists (n = 5), nurses (n = 1), a biomedical engineer (n = 1), and orthotics and prosthetics specialists (n = 1). Variable rehabilitation outcomes were obtained during the studies. The most frequently utilized outcomes included the assessment of changes in balance and stability [22, 30]; muscle strength [22]; proprioception [23]; function [23, 25-27]; gait parameters, such as speed, cadence, step time, and ankle joint ROM [24]; lower limb muscle coordination [26]; falls risk reduction [27]; conservative gait pattern [30]; and neuropathic symptoms [28].

3. Discussion

This study was conducted to present the rehabilitation interventions for gait problems in patients with DPN. The included studies considerably differed in terms of the measured indices, sample size, the method of implementation, etc. The studies provided preliminary support that rehabilitation interventions can improve gait parameters, balance, and function in people with DPN. The results of this scoping review fill an existing knowledge gap and

provide findings for researchers, clinicians, and knowledge users concerned with diabetic rehabilitation. This scoping review also identified evidence on diabetic gait rehabilitation, however, related published studies were scarce in this regard. The reviewed studies presented different and scattered reports of rehabilitation interventions. Most of the research in rehabilitation programs was based on exercise therapy and physical activity; none considered the psychological and psychosocial aspects. Furthermore, the effectiveness of rehabilitation interventions on the activity of daily living was not investigated.

Over one-third of the papers discussed Impaired balance and decreased muscle strength as common problems in patients with diabetic neuropathy [4]. The majority of the included studies investigated the effect of interventions and gait training in chronic diabetic participants [2] and demonstrated positive findings. The results of this review also demonstrated that rehabilitation interventions play an effective role in improving balance and proprioception, increasing the coordination of the lower limb muscles, and improving muscle strength. These findings are consistent with the results of a previous study that reviewed rehabilitation interventions [32].

Table 1. Characteristics of the selected studies

Title, Year, Country	Purpose	Participants	Intervention	Main Rehabilitation Findings
Investigating the role of backward walking therapy in alleviating plantar pressure of patients With DPN; 2014, China [22]	To investigate the effect of a combination therapy of backward walking training and alpha-lipoic acid treatment on the distribution of plantar pressure in patients with DPN.	Patients with DPN (N = 60), mean age: 52.7 years	12 weeks (3 times per week), backward walking exercises with lipoic acid for the test group, and lipoic acid treatment for the control group	Positive effect on balance ability and muscle strength
Sensorimotor and gait training improves proprioception, nerve function, and muscular activation in patients with DPN: A randomized control trial, 2019, India [23]	To examine the effect of sensorimotor and gait training on proprioception, nerve function, and muscle activation in DPN patients.	Patients with DPN, type 1 or 2 diabetes for at least 7 years (N = 38), mean age: 58.78 years BMI: 18.5	8 weeks (3 times per week), sensorimotor and gait training plus foot care education for the test group, and foot care education for the control group	Improvement of proprioception and nerve function
Efficacy of exercise rehabilitation program in improving gait of Diabetic Neuropathy Patients, 2014, Egypt [24]	To evaluate the effect of a rehabilitation program on the gait of DPN patients.	Patients with DPN, type2 diabetes for at least 7 years (N= 30), mean age = 57.2 years BMI = 30.6	8 weeks (3 times per week); an exercise program, including ROM, muscle strengthening, balance, and gait training for the test group; and usual medical care for the control group.	Improvement in gait speed, cadence, step time, and ankle joint ROM
Effects of strengthening, stretching and functional training in patients with Diabetic Neuropathy: Results of a randomized controlled trial, 2014, Brazil [25]	To investigate the effects of strengthening, stretching, and functional training on the foot rollover process during gait.	Patients with DPN, type 1 or 2 diabetes for at least 7 years (N = 55), mean age = 59.5 years BMI = 28.5	12 weeks (twice a week), exercises for foot-ankle and gait training for the test group, and standard medical care for the control group	Better functional condition of the foot-ankle complex
Effect of exercise with rhythmic auditory stimulation on muscle coordination and gait stability in patients with Diabetic Peripheral Neuropathy: A randomized controlled trial, 2019, Japan [26]	To determine whether rhythmic auditory stimulation affected the gait performance of patients with DPN.	Patients with DPN, type 2 diabetes for 6.35 years (N = 40), mean age = 59.1 years BMI = 26.3	2 weeks as an inpatient, walking twice a day for each group, RAS group participants walked in time with a metronome set at a self-chosen and comfortable rate.	Improvement in the lower limb muscle coordination and gait function
Effect of ankle proprioceptive training on gait and risk of fall in patients with Diabetic Neuropathy: A randomized controlled Trial, 2019, Egypt [27]	To investigate the effect of ankle proprioceptive training on gait and the risk of falling in patients with diabetic neuropathy.	Patients with DPN, type 2 diabetes for at least 7 years (N = 30), mean age = 58.36 years BMI = 26.98	8 weeks (3 times per week), ankle proprioceptive training in addition to traditional physical therapy for the test group, and traditional physical therapy exercises for the control group	Improvement in gait and reduction of the risk of falls
The Effect of a cognitive or motor task on the gait parameters of those With Diabetes, with and without Neuropathy, 2008, UK [30]	To compare the gait parameters of older people with diabetes and people with diabetes and DPN and investigate the effect of a secondary motor or cognitive task on their gait.	Patients with DPN or DM with 14.5 years duration, (N = 30), mean age = 66.8 years	Subjects undertook 4 walking exercises under normal walking conditions (single task), 4 times, while simultaneously undertaking an additional motor task (dual-task), 4 times undertaking a cognitive dual-task. There was no control group.	All subjects had a more conservative pattern.

Title, Year, Country	Purpose	Participants	Intervention	Main Rehabilitation Findings
The effect of daily use of plantar mechanical stimulation through micro-mobile foot compression device installed in shoe insoles on vibration perception, gait, and balance in people with DPN, 2019, USA [28]	To investigate the therapeutic effectiveness of mechanical stimulation through a wearable foot compression device equipped in the shoes inner soles on vibration perception, balance control, and gait performance in people with DPN.	Patients with DPN, type 2 diabetes (N = 30), mean age = 68.1 years BMI = 33.4	A single-arm 4-week intervention, an FDA cleared micro-mobile foot compression device was installed in the shoes inner soles. There was no control group.	Useful for reducing neuropathic symptoms and enhancing motor performance
Gait stability of diabetic patients is altered with the rigid rocker shoes, 2019, Iran [29]	To investigate if rigid-rocker shoes influence diabetic gait stability.	Patients with DPN, type 1 or 2 of diabetes (N = 60), mean age = 48.3 years BMI = 25.2	Using experimental shoes; A: R10 (rocker angle: 10°, apex position: 60%, apex angle: 80°), B: R15 (rocker angle: 15°, apex position: 55%, apex angle: 95°), and C: R20 (rocker angle: 20°, apex position: 60%, apex angle: 95°).	Increased gait stability

Moreover, diabetic ulcers in diabetic patients are a determinant factor in their gait disorders and must be considered in the management and prevention programs. The changes in plantar pressure distribution increase ulcer formation [33], however, this was only mentioned in two studies [22, 25]. Interestingly, a few interventions were performed by healthcare providers separately from the rehabilitation specialists, including nurses and biomedical engineers [28, 30].

Due to the variable characters of DPN patients and the negative effects gait can cause, rehabilitation specialists and researchers should consider several combined multidisciplinary aspects of interventions to attain the desired outcomes based on each patient's profile. Every person with

DPN and their health providers have their own set of needs, concerns, and preferences for managing their gait problems. Also, the personal and environmental factors should be considered during treatment decision-making [14].

To facilitate the descriptive comparisons between the studies with different designs, most of the interventions in this study were extracted from pre-post intervention studies and unique studies with specific outcome measurements. With this procedure, the results are at render of overestimating the effect of the intervention and bias; this can be considered as the weakness of this study. Consequently, these interventions must be interpreted cautiously. Furthermore, the majority of the included stud-

Table 2. Intervention Components

Authors	Assistive Device	Education	Physical Activity	ROM Exercise	Dual-Task	Strength Training	Medical Care
Xingguang Zhang et al., 2014 [22]	-	-	*	-	-	-	*
Irshad Ahmad et al., 2019 [23]	-	*	*	-	-	-	*
Basant Hamidy El-refay et al., 2014 [24]	-	-	*	*	-	*	*
Isabel CN Sacco et al., 2014 [31]	-	-	*	-	-	*	*
Keisuke Suzuki et al., 2019 [26]	-	-	*	-	*	-	-
Nagwa Ibrahim Rehab et al., 2019 [27]	-	-	*	-	-	*	-
Paul, L and et al., 2008 [30]	-	-	*	-	*	-	-
Gu Eon Kang et al., 2019 [28]	*	-	-	-	-	-	-
Banafshe Ghomian et al., 2019 [29]	*	-	-	-	-	-	-

ies had relatively small sample sizes ($N < 40$), which may have limited the power of their analysis and findings.

Strengths and limitations of this study

To the best of our knowledge, this is the first scoping review that identifies and summarizes the available literature on rehabilitation and intervention characteristics for gait problems in patients with DPN.

Despite intending to do a comprehensive search and finding grey literature sources, there is the possibility of missing some related studies. We did our best to consider the most important results in the literature. However, due to the limited word number, it was impossible to provide a detailed discussion considering all aspects of rehabilitation interventions effects, such as participation, objective, benefits, user satisfaction, and barriers to adoption and use. This review excluded non-English studies that may lead to incomplete data composition.

Implications for future research

Our review did not find any evidence on the best rehabilitation practice for DPN patients with gait abnormalities. Based on this scoping review, the priorities and inquiries for future research should be considered as follows:

- Evaluating rehabilitation interventions for DPN patients with gait problems in all countries;
- Identifying the limitations and barriers in performing rehabilitation interventions for DPN patients;
- Performing a systematic review of rehabilitation interventions for patients with DPN and gait problems;
- And the investigation of rehabilitation interventions that aim to resolve activity restriction and participation barriers, not only impairments, in this population.

Additionally, larger sample sizes and detailed methods are required for evaluating the effectiveness of rehabilitation interventions in DPN to further strengthen the findings for or against the various modalities adoption and utilization for gait rehabilitation. Unfortunately, it is unclear whether these types of rehabilitation interventions would be applied, effective, or cost-effective in different settings (e.g. inpatient, outpatient, community, or home). These are also important questions to be explored in future studies.

4. Conclusion

A variety of studies with different rehabilitation interventions and outcome measurements have been conducted on gait abnormalities in DPN patients. The effectiveness of these rehabilitation programs in the improvement of gait abnormalities is sparse and inconclusive. It appears that more trials with appropriate control and detailed descriptions of rehabilitation interventions are needed to determine the most relevant interventions for this patient group.

Ethical Considerations

Compliance with ethical guidelines

This is an scoping review and for such manuscript there is no need to Ethical code.

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Authors' contributions

Conceptualization, supervision: Hamidreza Mokhtarinia, Charl Philip Gabel; Methodology: Chals Philip Gabel; Investigation, writing – review & editing: All authors; Writing – original draft: Zahra Hasani.

Conflict of interest

The authors declare no competing interests.

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مداخلات توانبخشی برای مشکلات راه رفتن در بیماران دیابتی با نوروپاتی محیطی: مطالعه مروری

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چکیده

مقدمه: مشکلات تعادل و راه رفتن از وضعیت‌های چالش برانگیز در بیماران مبتلا به نوروپاتی محیطی دیابت (DPN) است. اتفاق نظر کلی این است که مداخلات توانبخشی در بهبود عملکرد راه رفتن در این گروه بیماران موثر است. هدف از مطالعه حاضر مروری بر مداخلات توانبخشی برای مشکلات راه رفتن در بیماران DPN می باشد.

مواد و روش‌ها: جستجوی جامع در پایگاه‌های اطلاعاتی الکترونیکی و جستجوی دستی در بازه زمانی ۲۰۰۱ تا ۲۰۲۰ انجام شد. دو متخصص توانبخشی مقالات را بر اساس تشخیص DPN و مشکلات راه رفتن مورد ارزیابی قرار دادند.

یافته‌ها: از بین ۸۷ مطالعه، ۹ مقاله دارای معیارهای ورود بودند. مداخلات توانبخشی پرتکرار در مقالات شامل تمرین درمانی، مداخلات چند وظیفه‌ای و استفاده از تجهیزات کمکی بود. نتایج این مداخلات بهبود تعادل و ثبات، قدرت عضلانی، حس عمقی، عملکرد و پارامترهای راه رفتن را شامل می‌شد.

نتیجه‌گیری: شواهد در قالب یک مطالعه مروری بر مداخلات توانبخشی برای مشکلات راه رفتن بیماران DPN جمع آوری شد. مطالعات مقایسه‌ای دقیق‌تر در آینده مورد نیاز است.

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توانبخشی، راه رفتن، نوروپاتی محیطی دیابتی

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