

The Impact of Diabetic Neuropathy on Activities of Daily Living, Postural Balance and Risk of Falls - A Systematic Review

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Abstract

Objective: The objective of this review is to discuss a compilation of the currently available literature regarding the impact of diabetic neuropathy (DN) on activities of daily living (ADL), postural stability, and risk of falls.

Methods: A systematic electronic search strategy was conducted on PubMed/MEDLINE database, Cochrane Library, and Embase in March 2020. This narrative review included clinical cross-sectional studies assessing ADL, postural balance, and falls in adults with DN. All studies underwent a quality assessment based on the Newcastle Ottawa scale developed to assess cross-sectional studies.

Results: Forty-two studies were identified. A total of 37 studies evaluated postural stability in DN, 10 studies assessed fall accidents, and three studies assessed ADL in individuals with DN. Seven studies assessed both postural stability and fall accidents, and one study assessed postural stability and ADL. Each of the studied outcome variables was assessed separately. Based on a quality assessment, eight studies were excluded resulting in an evaluation of 34 studies.

Conclusions: Diabetic neuropathy has a negative impact on postural balance and gait kinematics combined with an increased fall risk. Because of the few number of studies available, we were unable to evaluate the impact of DN on ADL. Our findings are in concordance with previous reviews, supporting the evidence for DN as a critical measure negatively impacting postural stability and fall risk in individuals with diabetes. Further clinical investigative studies are needed.

Keywords

activities of daily living, diabetic neuropathy, falls, postural stability

Introduction

Journal of Diabetes Science and Technology's special section on Diabetic Neuropathy.

Diabetic neuropathy (DN) is a common complication of diabetes that may negatively affect physical activity and independence.¹ DN has been reported to lead to postural instability, increased risk of falling, and inability to perform activities of daily living (ADL). Several studies have assessed ADL, postural stability, and fall risk in individuals with DN. Because of large variabilities in the study populations and designs, outcome measures, and definitions of DN, there is a substantial lack of knowledge and evidence. No previous review has comprehensively assessed these factors.

Therefore, in our review, we will present and discuss an updated compilation of the currently available literature on the impact of DN on activities of daily living, postural stability, and risk of falls.

Methods and Design

Our methodology for the systematic literature search aimed to identify studies that assessed individuals with DN regarding fall accidents, postural balance, or activities of daily living. Two independent reviewers assessed the inclusion and exclusion criteria (KSK, HA). Only investigational clinical studies concerning humans with DN written in English were included. We applied the PRISMA guidelines for this review (Supplementary Material). The defined PICO-statements

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were defined as follows: Population (P): Adults (age >18 y) with diabetes mellitus; Phenomenon of Interest (I): Impact of Diabetic neuropathy; Context (C): in diabetic neuropathy; Outcome (O): The outcome variables were accidental falls, postural balance, and activities of daily living.

Exclusion criteria: Studies reported as abstracts only. Abstracts that did not mention the inclusion of individuals with diabetic neuropathy. Abstracts that did not include any of the outcome measures, studies that enrolled less than 10 individuals with DN included neuropathies due to other causes than diabetes, intervention trials on drugs, study protocols, case reports, other reviews, studies that included treatment interventions, or studies used to validate assessment instruments were excluded. Studies were excluded if they did not specify how DN was diagnosed or only included subgroups of DN (e.g. painful DN).

Search Strategy

An electronic search was conducted on PubMed/MEDLINE database, Cochrane Library, and Embase in March 2020. The search had no set start date criteria. The reviewers assessed the inclusion and exclusion criteria. The search strategy on PubMed/MEDLINE was as follows and was modified for other search databases: Search ((((((“Diabetic Neuropathies”[Mesh]) OR “Diabetic Neuropathies”) OR “Diabetic Neuropathy”) OR “Diabetic Polyneuropathies”) OR “Diabetic Polyneuropathy”)) AND (((((((((((“Postural Balance”[Mesh]) OR “Postural Balance”) OR “Postural Balances”) OR “Body Equilibrium”) OR “Accidental Falls”[Mesh]) OR “Accidental Falls”) OR “Accidental Fall”) OR “Falling”) OR “Activities of Daily Living”[Mesh]) OR “Activities of Daily Living”) OR “Activity of Daily Living”) OR “Daily Life Activities”) OR “Daily Life Activity”) Filters: Humans

Data Collection and Selection of Studies

Collection and selection of studies were performed through an online reference management system (Mendeley) to assess database hits and remove duplicates. First articles were screened by abstract and title, and full-text articles were screened only if the inclusion criteria for the review were met or if the eligibility could not be assessed based on the abstract or title.

Quality evaluation of included studies. All studies included were assessed for quality by the Newcastle-Ottawa Quality Assessment Scale (NOAS) for cross-sectional studies.² This scale consists of three major components: (1) selection, (2) comparability, (3) outcome and encompasses eight criteria. Study quality is scored on a scale from 0 to 10, a higher score indicating higher methodological quality. To be included in our narrative review, studies had to have a score of ≥ 5 . Studies were assessed separately for the three outcomes: postural

balance, fall accidents, and ADLs. If a study assessed two or more variables, the study was reassessed for each variable within each category.

Diabetic neuropathy. Only studies including clinical assessment of individuals with diabetes and DN were included. If a study was based solely on questionnaires or registry data, the study was not included.

Postural balance. Several factors can affect balance in DN, including impairment of the sensory system, muscle weakness, impaired mobility, and structural and functional alterations of the foot.³ Both static and dynamic postural stability has been shown to be impaired in DN. In individuals with DN the gait is characterized by longer stance phases, shorter steps,⁴ and slower gait velocity. Several different tools have been identified and used for the measurement of balance. All clinical studies were included in this review, assessing both static and dynamic postural stability by the use of computer-assisted tools such as posturography or kinematic gait analysis tools or clinical tests.

Accidental falls. All clinical studies evaluating individuals with DN and the frequency or risk of falling prospectively and/or retrospectively and or by registry data were included. Several recently published studies have assessed falling based on a risk estimation using the Berg Balance Scale or other clinical assessment. However, as actual falling was not assessed, these studies were not included.

Activities of daily living. “Activities of daily living” are defined as activities in the performance of the basic activities of self-care, such as feeding, dressing, toileting, washing, and ambulation. Other more extensive tasks are included within the definition, such as the use of public transportation, shopping for groceries, meal preparation, and doing household chores. Only studies that included an actual assessment of ADL were included.

Results

Our systematic search identified 1247 articles. After removing duplicates, titles and abstracts were screened, resulting in 54 full-text articles. These articles were assessed for eligibility, out of which 42 were included (Figure 1, Table S1). After quality assessment of the cross-sectional studies according to the NOAS (Table S2.), further eight studies were excluded due to poor quality. One study described postural stability and ADL in DN.⁵ Seven studies assessed both fall accidents and postural stability in individuals with DN; however, one of these studies was included for the postural stability assessment but did not fulfill the criteria for risk of falls description.³ None of the included studies assessed all three outcome variables of interest.

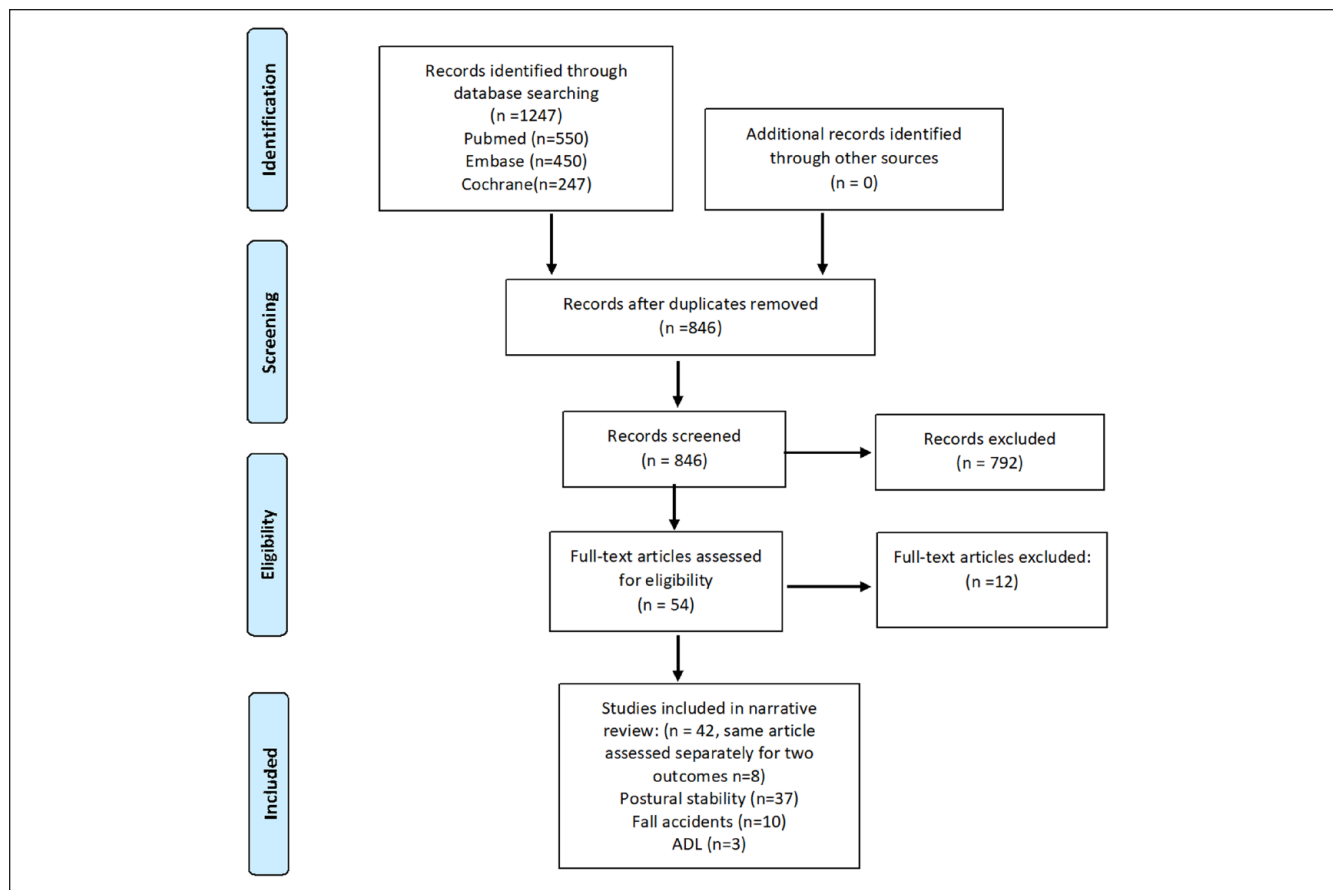


Figure 1. PRISMA flow chart for study selection.

A total of 37 studies examining the impact of DN on postural stability were identified. After quality assessment, eight studies were excluded and 29 studies, of which 14 studies, were good quality studies. Several of the included studies described a correlation between postural instability and altered gait kinematics in individuals with DN.^{3,6-16} Two studies described the correlation between poor postural stability and the severity of DN.^{17,18} Additionally, two studies accentuated the finding by also performing nerve conduction velocities.^{19,20} Slower walking speed^{8,21} and altered gait pattern^{10,22} reduced muscle strength, and/or reduced joint torques of the lower limbs while walking in DN, were described in several studies.²³⁻²⁶ However, three studies suggested that DN may not be the only cause of postural instability reported in this population, suggesting diabetes may itself negatively affect postural control²⁷ through impaired neurocognitive functions²⁸ or poor glycemic control.¹³

Ten studies evaluating fall accidents in DN were identified, of which, one study had to be excluded due to an unsatisfactory score. This resulted in inclusion of nine studies with a satisfactory score. However, none of the studies included qualified for a “good” or “very good” category.

Out of the nine studies assessing falls in DN, six studies showed an increased frequency of falling in the DN population,^{13,16,26,28,29} whereas one study showed no difference between the reporting of falls between individuals with and without DN. Cavanaugh described that individuals with DN had a 15 times increased risk of suffering from a fall-related injury.³⁰ However, this study did not only evaluate fall accidents as other injuries such as fall-related fractures, sprains, and cuts were also included within the same category.

Only three studies were identified evaluating ADL in DN, all of which were qualified as “good” or “very good.” All three studies found a correlation between decreased ADL and DN. Vileikyte et al. suggested ADL restrictions in DN were associated with depressive symptoms and neuropathic pain.³¹

Discussion

Based on the results of the present systematic review of 34 studies, it can be concluded that individuals with DN suffer from postural instability, impaired gait, and report an increased incidence of falling. Only three studies assessed activities of daily living, and therefore, we can only infer that

impaired balance and decreased gait kinematics in DN can increase the incidence of falling and impact ADL.

Diabetic Neuropathy and Postural Stability

Based on literature search, the majority of the studies identified reported DN to impair postural stability and alter gait kinematics (gait velocity, stride length, forefoot displacement, plantarflexion, and the proprioceptive threshold of the ankle). Several of the studies were of high quality; however, most studies included a convenience sample, and only two studies included a random sample of individuals with DN/and or diabetes representing the average diabetes population.^{13,32}

Three of the studies describing postural stability included a power sample size calculation.^{13,17,32} Most of the studies included, compared, and described the results in a control group, and 15 studies compared the results to individuals without DN and healthy controls, adjusting for the impact of diabetes per se. All studies included a clinical evaluation of postural stability. Only four studies described the use of an objective and validated instrument for the evaluation of postural stability.^{14,22,28,33} By not using validated evaluation methods, other studies might have inaccurately evaluated postural instability. Several of the studies described postural stability based on functional reach test (FRT), or the one-legged stand test.^{11,16,32,34} Although these tests are validated, they are not objective as compared to computer-assisted posturography. Compensatory movements during the test such as truncal shift, are not taken into account in FRT, which may influence the test to a higher degree than the displacement of center of pressure, which is evaluated during computer-assisted posturography.³⁵

Several of the studies of postural stability did not adjust for confounders such as age and gender, which might have skewed the findings,^{10,12,18,23,27,36} as older age is known to be associated with postural instability. Based on our review of the currently existing literature, we found an association between DN and postural instability as 29 studies confirmed the association, and only three studies disproved it.

Diabetic Neuropathy and Falls

Only few included studies assessed the frequency of falling in DN, most of which were of low quality. In most studies, the results were compared to a control group and result concerning non-responders were presented. Four studies assessed falling prospectively,^{28-30,37} whereas the other studies were retrospective using recall assessment of falling based on different time frames (3, 6, or 12 mo). Assessing fall accidents during different time frames limits the ability to compare the results from the different studies, as longer time frames might introduce recall bias, whereas shorter time frames have to take seasonal changes into account. Assessment of fall accidents is challenging as multiple factors such as external forces and seasonal changes can impact

the frequency. In this review, we evaluated if other risk factors were taken into consideration, such as age and gender. However, we did not grade the studies according to the adjustment of other factors that may affect the risk of falls and or postural stability. Maintenance of postural balance and the ability to recover from a fall depends on several factors, including the normal function of; visual, vestibular, somatosensory, and the musculoskeletal system, all of which can be impaired in diabetes. Other factors, such as decreased cognitive functions, depression, orthostatic hypotension, and hypoglycemic episodes, have also shown to increase fall risk. Several of the studies included did not incorporate a multifactorial assessment for fall risk with little or no evaluation of confounding factors, not allowing for an accurate assessment of the impact of DN on falls. Furthermore, most studies identified did not consist of a random sample, were lacking a clear definition of falling, or provided little or no explanation of the time frame used for fall assessment. Only one study included a random sample of individuals with sample size calculation.¹³

In spite of several weaknesses, all of the included studies, except one, described an association between increased fall risk and DN. Therefore we conclude that there is an increased risk of falls in DN.

Diabetic Neuropathy and Activities of Daily Living

Four studies assessed both postural stability and falling in individuals with DN,^{13,15,28} and one of these studies³ was excluded due to low quality under the fall outcome category assessment; however, this study was included in the postural stability assessment.

As balance and gait can have a great impact on activities of daily living, multiple studies suggest an association. Remarkably, only few studies assessed the impact of DN on activities of daily living using scales or questionnaires. Therefore, we may conclude that the impact of DN on ADL remains unknown and future clinical studies should include tools assessing ADL.

Technology

Studies included in our search were based on individuals with DN. However, the technologies used in the assessment of DN differed in the included studies basing the diagnosis of DN on: vibration perception thresholds, monofilament testing, nerve conductive studies and different clinical scales such as: Toronto Clinical Neuropathy Score, Utah Early Neuropathy Scale, modified Neuropathy Disability Score, Diabetic Neuropathy Examination Score, and Michigan Neuropathy Screening Instrument. In the past, clinical testing and diagnosis of DN have been challenging because of low reproducibility and a lack of consensus concerning the definition of DN. However, over the past decades, multiple clinical scales, questionnaires, and scoring systems have been developed and

validated to aid in recognition of clinical manifestations and complaints in DN. This has led to recommendations of performing more than one test, with more than one abnormality to confirm the diagnosis of DN. In 2009, the criteria were defined and described by Tesfaye et al. on behalf of the Toronto Diabetic Neuropathy Expert Group.³⁸ Studies included in this review were not differentiated or excluded based on the diagnostic criteria of DN (Table S1). However, studies were included pending inclusion of a description and evaluation of DN. This may be a weakness due to the uncertainty to what degree individuals suffered from DN. Only six studies included in our review performed both clinical assessment and nerve conductive studies, which are included in the Toronto criteria of confirmed DN.

There is a clear need for clinical studies assessing the causation of falling in diabetes by applying a multifactorial assessment and including DN, which has a great impact on postural stability, fall risk, and may lead to impaired activities of daily living. In individuals with DN, clinicians should consider examination of postural stability and fall risk as part of fall prevention programs to improve ADL and ultimately quality of life.

Conclusions

Based on this review we conclude that DN has a negative impact on postural balance. Furthermore, DN causes impaired gait and leads to an increased fall risk. Because of a very few number of studies, it was not possible to assess the impact of DN on ADL. Our findings are in concordance with previous reviews, supporting the evidence for DN as a critical measure negatively impacting fall risk, postural instability in individuals with diabetes. There is a clear need for high quality controlled clinical studies focusing on the functional consequences of DN.

Abbreviations

ADL, activities of daily living; DN, diabetic neuropathy; NOAS, Newcastle-Ottawa Quality Assessment Scale.

Author contributions

Khan KS: Study design, data collection, interpretation of data and writing of first manuscript draft.

Andersen H: Study design, data collection, interpretation of data, writing and revision of manuscript.

Both authors approved the final manuscript.

Declaration of Conflicting Interests

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Supplemental Material

Supplemental material for this article is available online.

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