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The effect of exercise on peripheral function in people with diabetic neuropathy (a review study)

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Abstract

Background and goal: Diabetic neuropathy is a serious complication of diabetes that can lead to a range of debilitating symptoms, including neuropathic ulcers, loss of sensation in the legs, impaired coordination and balance, chronic pain, and potential issues with heart and digestive function. This condition significantly impacts the quality of life for individuals affected by diabetes and requires ongoing management and treatment to minimize its effects.

Method: The current study was of a type of traumatic study. Searched articles were used from 2022 to 2023 on Google Scholar, Scopus, WOS, Pub Med, Science Direct, MDPI, and Wiley. was used. 91 articles were selected based on entry and exit criteria. After careful review, 71 articles that lacked selection criteria were deleted and 20 articles were selected for final analysis.

Findings: Current research findings have shown that exercise has numerous benefits, including improving nerve transmission speed, managing nerve pain, and improving foot movement spectrum and performance strength.

Conclusion: Results show that regular physical activity can improve symptoms and overall health of the patient. It is important to continue to study the specific types and intensities of exercise that are most effective, as well as the underlying mechanism for these benefits. Understanding the role of exercise in managing diabetes neuropathy can improve treatment strategies and outcomes for patients.

Keywords: Diabetic neuropathy, Exercise Therapy , Diabetes Neuropathies

Introduction

The global prevalence of Type 2 diabetes is on the rise, with an estimated 700 million adults expected to be affected by 2045. This widespread health issue represents a significant challenge for public health systems worldwide [1]. Around half of the patients are impacted by the various types of neuropathies [2, 3]. The most significant symptoms of diabetic peripheral neuropathy (DPN) are the substantial decline in foot functionality and its associated neuromechanical properties [4]. Diabetic neuropathy (DN) can lead to complications such as infections, foot blisters, and ulcers. DN is categorized as either acute or chronic neuropathy. The acute form is linked to significant weight loss and can result in intense pain with or without sensory impairment. It does not exhibit motor symptoms, reflex loss, or nerve degeneration. With proper management, it can completely resolve within six months [5]. Chronic DN leads to nerve inflammation and demyelination. It is identified by sensory loss in a stocking-and-glove pattern affecting the feet and legs first, then progressing to the hands and arms. Common signs and symptoms of chronic DN encompass numbness, temperature fluctuations, tingling or burning sensations, muscle weakness, heightened sensitivity to touch, and mild walking difficulties. These symptoms tend to worsen during nighttime [6]. Engaging in regular physical activity can help prevent DN by various means, such as regulating blood glucose levels, enhancing blood flow to the nerves, supporting the renewal of axons, increasing neurotransmitter levels, and promoting the function of Na/K-ATPase, which is essential for nerve conduction speed [7]. Previous research has demonstrated that exercise training can effectively prevent and delay the onset of T2DM while also aiding in the regulation of blood sugar levels. As a result, physical activity and exercise have long been regarded as critical components of diabetes care and treatment, offering a cost-effective and non-pharmacological approach that enhances its therapeutic benefits [8]. Therefore, it is necessary to obtain sufficient and new information in order to improve this neurological damage by examining previous studies in the field of the impact of exercise on environmental performance in individuals with diabetic neuropathy. For this reason, the aim of the present study was to review the effects of exercise on environmental performance in individuals with diabetic neuropathy.

Materials And Methods

The study was of a systematic type. Searched for articles from all articles featured in 2022 and 2023 on Google Scholar, Scopus, WOS, Pub Med, Science Direct, MDPI, and Wiley. Articles were extracted from the keywords

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Diabetic neuropathy pain, Diabetes Neuropathies, Exercise Therapy, Nerve Conduction and Transitional Movements.The entry criteria for the study may include: All articles in the field of exercise were for people with diabetic neuropathy. Articles whose trials had problems with diabetic neuropathy. New articles are used from articles of the last two years. The full text of the articles is available. Subjects who had other diseases or had a history of surgery were excluded from the study. In the end, the title of the article was searched only based on the keywords used. After careful review of the quality of articles and articles titles, 20 Bacchevite article titles were selected in relation to the effect of exercise on diabetic neuropathy, and were reviewed and analyzed by researchers. Figure 1 also shows the selection of current study articles.

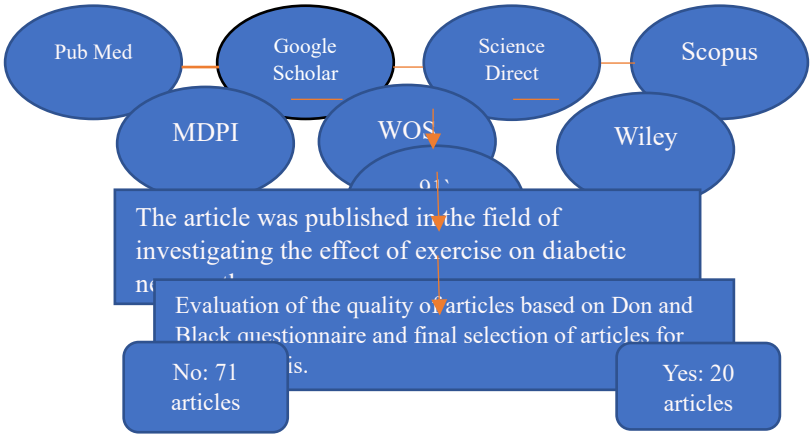

Figure 1. The process of searching, reviewing and selecting articles.

Results

Revised studies show that sports exercises cause nerve repetition during exercise, change foot AROM, increase performance and reduce symptoms, increase foot flexor movement and balance in walking and improve face ROM, as well as neuropathic pain management, preventative role, improve neural conduction speed in the sensitive urogenital nerve and hypothetical motor nerve function, improve leg and functional spectrum, increase central stability and reconstruction, improve blood pressure and environmental diseases in diabetics, improve lower urinary state, increase powder strength extensors and flexors and motor performAny discrepancies in the evaluation of studies using the Downs and Black questionnaires were examined separately by the researchers, and cases where researchers had disagreements were evaluated after consultation and discussion to minimize errors in the assessment of studies. ance in addition to these non-invasive methods of exercise to reduce neural pain.

Table of 1. Examining the Effects of Sports Exercise on People with Diabetic Neuropathy.

Conclusion	The variable under consideration	Structure of the study	year of publication and journal	names
Aerobic training can improve the relationship between vastus lateralis activities and vertical loading rate amplitudes in men with DN.	Aerobic exercises	In this double blinded, randomized, controlled clinical trial, participants were 40 men with DN (20 in the training group: age= 54.9±7.3 years, body mass index= 28.4±5.4 kg/m2; and 20 in the control group: age= 54.1±7.3 years, body mass index=28.5±5.1kg/m2), who were selected by a	[2023] The Scientific Journal of Rehabilitation Medicine	Jafarnezhadgero et al. **[9]**

		convenience sampling method.		
Overall, the studies included in this systematic review showed that exercises could have a positive effect in increasing ankle AROM and reducing forefoot PPPs. However, methodological flaws, heterogeneity of study designs and lack of a gold standard of physical therapy intervention or treatment protocol meant that firm conclusions are not easy to reach.	Systematic review and meta-analysis of the effects of foot and ankle physical therapy	Databases included MEDLINE (including PubMed), EBSCO (including AMED and CINHAL), Cochrane Database of Systematic Reviews, Joanna Briggs Institute Database of Systematic Reviews and PROSPERO. The search of grey literature was undertaken in EThOS, Web of Science and Google Scholar. Searches included manual searches of reference lists within articles.	[2023] Diabetes/Metabolism Research and Reviews	Lepesis et al. **[10]**
The quality of evidence suggesting that exercise therapy provides short-term benefits in neuropathic symptoms, signs, and physical function in patients with DN is very low. Furthermore, there were no effects found on psychosocial aspects.	Exercise therapy on diabetic neuropathy: a systematic review and meta-analysis	A search was performed in PubMed, Web of Science, Physiotherapy Evidence (PEDro) and Cochrane databases from start to date invalid NaN. Randomized clinical trials (RCTs) in patients with DN that compared exercise therapy with a control group were selected.	[2023] Physiotherapy Theory and Practice	Hernando-Garijo et al. **[11]**
Although many of the changes noted were insignificant, the trends indicated an improvement in the intervention group over the 10-week intervention period. These improvements can be considered clinically important.	Isometric exercise	Recruitment was strictly voluntary, and participants had the right to withdraw without penalty. Before signing the consent form, volunteers were assured that they had the right to withdraw from the study at any time without any penalties. The final study sample consisted of 14 participants, aged 18–80 years.	[2023] International Journal of Diabetes in Developing Countries	du Plessis et al. **[12]**
We conclude that photobiomodulation therapy is an effective, non-invasive, and	Efficacy of photobiomodulation treatment	We conducted a systematic review (PubMed, Web of Science, CINAHL, and Cochrane) to	[2023] Current diabetes reviews	Korada et al. **[13]**

costefficient means to improve neuropathic pain and altered plantar pressure distribution in diabetic peripheral neuropathy.		summarise the evidence on photobiomodulation therapy for Diabetic Peripheral Neuropathy with type 2 diabetes mellitus. Randomized and non-randomized studies were included in the review.		
In conclusion, the present study provides evidence that a 12-week-long sand training intervention that has a multifaceted effect would be a useful therapy in case of DPN, by improving plantar flexor peak torque, balance, walking speed, and ankle sagittal ROM both in plantar- and dorsiflexion without the occurrence of any adverse events.	Effects of a 12-week sand training program	Seven (female, n = 4, male, n = 3) DPN patients with neuropathy (age = 62.7 ± 9.7 years; body mass = 96.04 ± 25.5 kg; height = 172.57 ± 9.5 cm) participated in the study. Patient information on health status and physical activity was obtained by verbal questioning.	[2023] International Journal of Environmental Research and Public Health	Prókai et al. **[14]**
Neurodynamic exercises were effective in managing diabetic peripheral neuropathy pain. Neurodynamics techniques for Peripheral Nerve can reduce the diabetes associated peripheral neuropathy symptoms in upper limb.	Effects of neurodynamic exercises	It was a series of cases. In this study, 40 patients with type 2 diabetes with peripheral neuropathic pain were selected. Sequential sampling method was used. Standard neurodynamic sliding techniques were applied to the radial, ulnar and median nerves in the appropriate position by a qualified physiotherapist for 10 seconds with 2 seconds rest and 10 repetitions. TENS (80 Hz and 150 μs) was applied for 20 minutes.	[2023] Physiotherapy Quarterly	Ali et al. **[15]**
Most participants reported low physical activity (65.7%), and the prevalence of DN in this study was	Relationship between physical activity and peripheral neuropathy in diabetic patients	A total of 204 diabetic patients participated in this multicenter, cross-sectional study. A validated self-administered	[2023] Cureus	AlKhotani et al. **[16]**

56.3%. There is a significant association between neuropathy and physical activity, BMI, duration of DM, and HbA1c levels. It is recommended to raise the awareness of diabetic patients about the benefits of exercise in the prevention and management of neuropathy.		questionnaire was distributed electronically to patients on-site during follow-up. Physical activity and diabetic neuropathy (DN) were assessed using the validated International Physical Activity Questionnaire (IPAQ) and the validated Diabetic Neuropathy Score (DNS), respectively.		
In this study, 10 weeks of aerobic exercise combined with unilateral lower extremity training improved nerve conduction velocity in the sural sensory nerve and also improved peroneal motor nerve function in diabetic men and women with neuropathy. Additionally, a significant decrease in glycosylated haemoglobin A1c was observed in patients with peripheral neuropathy.	The Effects of a 10-Week Aerobic and Resistance Training Program	28 participants for this study were selected from the patients referred to the Endocrine and Metabolism Research Institute of Iran University of Medical Sciences (men and women) diagnosed with type 2 diabetes with peripheral neuropathy in the age range of 30 to 60 years. 20 people (11 women and 9 men) completed the intervention.	[2023] Journal of Human Kinetics	Beigi et al. **[17]**
The increases in hip moment at push-off and hallux surface contact area suggest an improvement in the propulsion phase with greater participation of the toes in foot rollover after 12 weeks of a group-based foot-ankle exercises program for people with DPN. Individual face-to-face, longer-term, and more intensive interventions may	Ankle exercise on foot and ankle kinematics, plantar pressure and walking kinetics	Sixty-six participants with DPN were randomly allocated into a control group (CG; n = 31), which received usual care, and an intervention group (IG; n = 35), which received usual care plus a 12-week group-based foot-ankle exercise program. Outcomes were assessed at baseline and 12 weeks by an assessor blinded to group allocation.	[2023] Brazilian Journal of Physical Therapy	Monteiro et al. **[18]**

be needed to positively influence foot-ankle biomechanics and pressure parameters in other plantar areas.				
Kinesio tapping is effective when added to the traditional exercise therapy for polyneuropathy diabetic patients.	Aerobic exercises	Sixty adult diabetic patients who were diag-nosed with peripheral polyneuropathy of both sexes (28 male and 32 female) participated in this study. Their age ranged between 50-60 years. The partic-ipants were selectedfrom The National Institute of Diabetes and Endocrinology in Cairo, Egypt.	[2022] Pakistan Journal of Medical & Health Sciences	Naimat-Ullah et al **[19]**
Findings show that eight weeks of core stability training can be used in the process of physical rehabilitation of patients with diabetic neuropathy.	Effect of eight weeks of selected core stability exercises	30 patients with neuropathy (mean ± standard deviation, 55.1±2.6 years of age, 154.9±2.7 height, 74.1±8 weight and history of neuropathy 11.8±3.4) in a targeted and accessible manner were chosen. Then they were randomly divided into two groups of experimental (n = 15) and control (n = 15). The experimental group performed selected 20-minute core stability exercises for eight weeks each week and the control group followed their normal treatment process.	[2022] Journal of Exercise and Health Science	Arabie et al. **[20]**

Tree type of exercise especially resistance training can increase the value of ABI. the results of the present study demonstrated that each exercise training is effective in improving blood flow that caused improve blood pressure and peripheral vascular disease in diabetic men, reinforcing the positive role of this approach in improve glycemic indexes.	The effect of 12 weeks aerobic, resistance and combined trainings	44 men with type 2 diabetes were randomly divided into four groups of aerobic, resistance, combined and control. Intensity of aerobic exercise was 70–75 percent of maximum heart rate for 25–45 min, Resistance training consists of two to three sets with 8–12 repetitions and combined training consists of both aerobic and resistance training, three times a week for 12 weeks	[2022] Obesity Medicine	Alni et al. **[21]**
Patients with type 2 Diabetes Mellitus can applicate foot exercises to change lower extremity sensory status and blood glucose level.	The effect of foot exercise	The design in this study was pre-experimental with a one group preposttest design approach, this study sought the effect of foot exercise on the status of lower extremity sensory neuropathy and changes in blood glucose levels in patients with type 2 diabetes mellitus at Tanjunganom Public Health Center, Nganjuk Regency, in this study involved 30 respondents with purposive sampling technique. This research was conducted on October 14-21, 2022	[2022] Journal of Scientific Health	Rosyid et al. **[22]**
Exercises on the mini-trampoline and ankle therapeutic exercises at home can be effective in improving patients' quality of life as a simple, affordable, low-risk and quick-improvement treatment program that focuses on the	Effects of Weight-bearing Exercise on a Mini-trampoline, and Foot-ankle	The present research is a clinical trial study th at has been conducted using two intervention groups and one control group. The statistical population of this study includes 48 women with type 2 diabetes and moderate or severe neuropathy living in Tehran.	[2022] Physical Treatments-Specific Physical Therapy Journal	Ansari et al. **[23]**

use of segmental exercises for foot functionality.				
Among the exercise-based solutions, aerobic training improves neural structure and function and ameliorates neuropathic signs and symptoms. Resistance training induces marked improvement of muscle performance and may alleviate neuropathic pain. A combination of aerobic and resistance training (i.e., combined training) restores small sensory nerve damage, reduces symptoms, and improves muscle function. The evidence so far suggests that exercise training is highly beneficial and should be included in the standard care for DPN patients	Neuromuscular dysfunction and exercise training	A detailed search of PubMed, EMBASE, Scopus and Web of Science databases was conducted from their inception to March 2021 for the following key terms: 'diabetic neuropathies' OR 'diabetic peripheral neuropathy' OR 'diabetes' AND 'muscle' OR 'peripheral nerves' OR 'neuromuscular system' AND 'exercise training' OR 'aerobic training' OR 'resistance training' or 'combined training'. The systematic reviews and original research papers were selected according to their scientific relevance.	[2022] Diabetes Research and Clinical Practice	Orlando et al. **[24]**
Through thematic synthesis, this systematic review provides evidence in support of physical exercise as an ameliorative treatment of T2D DSPN, one that can readily be incorporated into care plans at no cost. However, exercise treatment efficacy may be limited by DSPN severity and only improve some signs or symptoms. Other evidence suggests that exercise may	Physical Exercise as Treatment for Type 2 Diabetes A Systematic Review of Randomized and Controlled Studies	systematic review searches can optimize result inclusivity by utilizing a combination of Embase, MEDLINE, Google Scholar, and Web of Science databases. Since Web of Science was inaccessible, searches were conducted (without snowballing references) using Embase, MEDLINE, and Google Scholar to collect articles published in English within the last eight years from January 1, 2012 to April 20, 2020.	[2022] Journal of Diabetes Mellitus	Zampogna **[25]**

even delay or altogether prevent DSPN onset.				
PRT improved muscle strength of the knee extensors and flexors and motor function in individuals with type 2 diabetic polyneuropathy at levels comparable with those seen in individuals with diabetes without DPN and healthy control individuals, while no effects were observed in IENFD.	Effects of progressive resistance training	This was an assessor-blinded trial conducted at the Neurology department, Aarhus University Hospital. Adults with type 2 diabetes, with and without DPN and healthy control participants were randomised to either supervised PRT or non-PRT for 12 weeks.	[2022] Diabetologia	Khan et al. **[26]**
Among various studies in this review, the results were conflicting, as the set mode, intensity, frequency and duration varied in different studies	various exercise protocols	An extensive search of literature was conducted on August 2, 2021 in Scopus, Web of Science, PubMed, Science direct and ProQuest.	[2022] Clinical Research & Reviews	Tatikola et al. **[27]**
Kinesio tapping is effective when added to the traditional exercise therapy for polyneuropathy diabetic patients.	Effects of Kinesio Tapping on Diabetic Peripheral Neuropathy.	Sixty adult diabetic patients who were diag-nosed with peripheral polyneuropathy of both sexes (28 male and 32 female) participated in this study. Their age ranged between 50-60 years. The partic-ipants were selectedfrom The National Institute of Diabetes and Endocrinology in Cairo, Egypt.	[2022] The Medical Journal of Cairo University	Nesreen et al. **[28]**

Modified Downs and Black checklist for randomized and non-randomized studies.

Authors	Jafarnezhadgero et al.[9]	Lepsis et al.] 10 [	Hernando-Garijo et al.	du Plessis et al.[12]	Korada et al.[13]	Prókai et al.[14]	Ali et al.[15]	Al Khotani et al.[16]	Begi et al.[17]	Monteiro et al.[18]	Naimat-Ullah et al [19]	Arabie et al.[20]	Alnie et al.[21]	Rosyid et al.[22]	Ansari et al.[23]	Orlando et al.[24]	Zampogna [25]	Khan et al.[26]	Tatikola et al.[27]	Nesreen et al.[28]

			[11]																	
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	0
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	0
8	1	1	0	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0	0
9	0	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1
10	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1
11	1	1	1	**UTD**	1	1	1	1	1	1	**UTD**	**1**	1	1	**UTD**	1	1	1	1	1
12	1	**1**	1	1	0	0	1	1	1	1	1	0	1	0	1	**UTD**	1	1	1	0
13	1	1	1	1	1	1	1	0	**UTD**	0	1	1	1	0	1	1	**UTD**	1	1	1
14	0	0	1	0	1	0	0	0	0	1	0	0	1	0	0	**UTD**	1	1	0	**UTD**
15	0	1	0	1	1	1	0	**UTD**	1	0	1	1	0	1	0	1	1	**UTD**	1	1
16	1	1	0	1	0	**UTD**	0	1	0	0	0	0	1	1	1	0	1	0	**UTD**	0
17	**UTD**	1	0	0	0	**UTD**	1	0	1	1	**UTD**	1	**UTD**	0	1	1	0	1	0	**UTD**
18	1	1	1	1	**UTD**	1	1	1	1	1	1	0	1	**UTD**	0	1	1	1	1	1
19	1	1	1	1	1	0	0	1	0	0	1	1	0	1	1	0	0	0	0	0
20	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0
21	1	1	1	1	1	1	1	0	1	1	0	0	1	1	1	1	1	0	0	1
22	1	1	1	**UTD**	0	1	1	1	1	1	1	1	**UTD**	1	1	0	1	1	1	0
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
24	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	1	1	0	1	0
25	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
26	0	1	1	1	0	1	1	1	1	0	1	**UTD**	1	1	1	1	1	1	0	1
27	**UTD**	1	1	1	1	1	1	1	1	1	1	1	1	0	**UTD**	0	0	1	0	**UTD**
Total	18	24	23	22	19	19	21	21	22	21	20	19	18	17	17	18	20	19	16	14

Risk of Bias Assessment (No: score-0; Yes: score-1, UTD-Unable to determine).

Discussion

Therefore, the aim of this study was to investigate the effect of various types of exercise on people with diabetic neuropathy. High-intensity training has been proven to be more effective than low-intensity training in building

muscle strength [29]. Therefore, it is not unexpected that the majority of previous research on individuals with DPN participating in low-load and low-frequency training interventions have reported insignificant findings [30]. into non-specific strength or natural movement patterns reflected by functional tests. Compound resistance exercises that target the largest muscle groups can lead to increased lean body mass and result in enhancements in natural movement patterns that may impact the ability to walk [31]. The study assessed the impact of age on balance improvement after sensorimotor exercise intervention. Unsurprisingly, the ≥60-year-old group had longer DDs and more severe DSPN compared to the <60-year-old group. Both age groups showed significant improvement in OLS/UST times, with the older group showing even greater improvement. This could be attributed to the potential partial restoration of LNF function or differences in muscle strength between age groups. Regular exercise may also play a role in enhancing muscle mass and fiber recruitment, leading to improved balance regardless of age [32]. The study's results highlight the positive effects of exercise training on diabetic neuropathy in individuals with diabetes. Our findings are in line with previous research indicating that exercise can improve nerve function and alleviate neuropathy symptoms in diabetic patients. The underlying mechanisms are believed to include better nerve blood flow, decreased inflammation, and enhanced nerve regeneration [33]. The latest research also indicates that both aerobic and resistance training can effectively enhance nerve function and alleviate neuropathic symptoms. This is significant as it offers individuals with diabetes a range of exercise choices to select from, enabling them to discover a fitness routine that aligns with their requirements and preferences. Furthermore, our study demonstrated that exercise training was well-received by participants and did not intensify their neuropathic symptoms, suggesting that it can be safely integrated into the treatment of diabetic neuropathy [34]. To sum up, the findings of our study support the idea that exercise can have a positive impact on diabetic neuropathy. It is important for healthcare professionals to include exercise as part of the treatment plan for individuals with diabetes and neuropathy. Further research should aim to determine the most effective type and duration of exercise for this particular patient group, as well as to understand the mechanisms through which exercise improves neuropathy. This will ultimately help to optimize the management of diabetic neuropathy and improve the quality of life for those affected by this condition.

Conclusion

In summary, our research has shed light on the potential advantages of exercise training in the treatment of diabetic neuropathy. The data indicates that regular physical activity can have a beneficial impact on neuropathic symptoms and the overall well-being of patients with diabetic neuropathy. These results emphasize the significance of integrating exercise into the comprehensive management of diabetes and neuropathy. Further studies should focus on exploring the specific types, intensities, and durations of exercise that are most effective in relieving neuropathic symptoms, as well as the underlying mechanisms responsible for these benefits. By gaining a better understanding of the role of exercise in managing diabetic neuropathy, healthcare professionals can enhance treatment strategies and enhance the outcomes for individuals coping with this challenging condition.

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