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Physical Activity to Reduce Pain Scale in Diabetic Neuropathy Patients: A Scoping Review

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Purpose: This study aims to identify physical activity that can reduce pain scales in diabetic neuropathy patients.

Patients and Methods: The scoping review method was used in this research using three databases and one search engine, namely PubMed, CINAHL, Sage Journal, and Google Scholar. Inclusion criteria include full-text articles and publications in English and Indonesian between 2012–2022 with a minimal quasi-experimental design. Critical Appraisal was used to assess the article's bias.

Results: Research found 12 articles discussing the effectiveness of activity training in reducing the pain scale in diabetic neuropathy patients from the results of a scoping review of 12 studies, articles were found that used pain scales such as the Visual Analog Scale (VAS), Numeric Rating Scale (NRS), Foot Health Status Questionnaire Pain Score (FHSQ), and Leeds Assessment of Neuropathic symptoms and signs Scale for pain assessment, in measuring pain intensity. Some variations of physical activity include aerobic exercise, resistance exercise, vibration, and a combination of aerobic and resistance training. 30 minutes each session for 8 weeks with a frequency of 6 days/week. These studies used various designs, namely RCT, Experiment, and Quasi-experimental Pre test-post test with control group design Physical activity improves blood circulation and minimizes peripheral nerve damage so that pain intensity can decrease.

Conclusion: Conclusion: Physical activity intervention is effective in reducing pain scales in diabetic neuropathy patients and can be a supportive therapy for diabetic neuropathy patients who experience pain.

Keywords: physical activity, pain, diabetes, diabetic neuropathy, review

Introduction

According to 2021 International Diabetes Federation (IDF) data, as many as 537 million people in the world aged 20–79 years live with diabetes. This number increased by around 16% compared to 2019 which reached 463 million people, expected to increase by 51% to 700 million in 2045. It will impact chronic complications that will arise from DM. Hyperglycemia or hypoglycemia may result from ineffective management of glycaemia.[1,2] The failure to control these conditions can result in multiple health complications. The most common chronic complication of DM is diabetic neuropathy, with a prevalence of 54%.[3] Diabetic neuropathy will affect peripheral somatosensory disturbances or neuropathic pain. Approximately 16–33% of patients with type II DM experience diabetic neuropathic pain, of which 39% are not treated.[4] Diabetic peripheral neuropathy (DPN) often occurs in the distal part of the nerve fibers. Initial symptoms of paresthesia or increased sensitivity, especially at night when pain is also felt in the lower extremities.[5]

In addition, the pain in the limbs radiates in the proximal direction. The pain is felt like burning, stinging, electric shock, and tearing, and does not go away just by changing the position of the joint. Pain is more felt while walking, especially barefoot. Pain worsens at rest after activity and often increases at night, which makes it very uncomfortable and disturbing. Several studies have shown that diabetic neuropathic pain can adversely affect the quality of life, limiting activities of daily living, self-care skills, work, and interpersonal relationships.[6] Unfortunately, neuropathic pain remains

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an unresolved problem in patients with diabetes. Several aspects such as support, benefits, and self-care agencies are needed to achieve diabetes patients' resilience.[7] Type II DM patients must have self-care skills to change their lifestyle.[8]

One of the treatments for diabetic neuropathy is physical activity.[9] Physical activity increases metabolic factors that prevent peripheral nerve damage by affecting nerve health and microvascular function. For instance, limb muscles are estimated to have a three-fold increase in blood flow from resting muscles. An increase in peripheral blood circulation can minimize peripheral nerve damage, decreasing pain intensity.[10]

Pain is the most common symptom experienced in diabetic neuropathy patients. Untreated neuropathic pain adversely affects the quality of life, limits daily activities, and self-care abilities, and increases pain levels. Pain symptoms reduce with physical activity. According to AlKhotani et al 2023,[11] there is a significant association between neuropathy and physical activity, body mass index, duration of diabetes mellitus, and HbA1c level. In addition, physical activity can boost metabolism, affecting nerve function and relieve pain. Several literature studies on pain management in peripheral neuropathy patients have been conducted, such as research on non-pharmacological general interventions in peripheral neuropathy patients, including reducing pain and improving quality of life.[12] According to in the Journal of Pain Research conducted a randomized controlled trial which showed that a physical exercise program could improve quality of life and reduce pain in diabetic neuropathy patients. These findings support the importance of physical activity as a component in pain management strategies[13] in Clinical Diabetes and Endocrinology assessed evidence from clinical trials showing the role of physical activity in the management of neuropathic pain. Their results suggest that physical activity may be a useful intervention in managing neuropathy symptoms. In their study published in Diabetes Research and Clinical Practice reported that physical activity can improve functional outcomes and reduce pain in patients with diabetic neuropathy. This study suggests that physical activity interventions may be an effective adjunct in the management of neuropathic pain. Management of diabetic neuropathic pain can be divided into pharmacological therapy and non-pharmacological therapy. Non-pharmacological therapy is a companion therapy, one of the non-pharmacological therapies is physical activity with the aim of reducing side effects of drugs: Non-pharmacological therapy can reduce the need for drugs, thereby reducing the risk of side effects or drug dependence. The authors have not yet found a literature study that examines physical activity to reduce pain in DPN patients. Based on these concerns, the authors are interested in conducting a scoping review to reveal physical activity that has the potential to reduce pain in peripheral neuropathy patients.

Materials and Methods

Design Study

This study uses a descriptive scoping review method. The scoping review aims to analyze the literature to answer research questions by using several sources to search for literature.[14] This sampling method has been applied in many studies.[15–17] The article search strategy was based on Arksey and O'Malley's systematic review framework. The results of the study were reported using PRISMA-ScR.

Eligibility Criteria

The strategy used in determining the study's feasibility involved using the PICO question framework. It focuses on physical activity intervention for diabetic neuropathy patients with no other intervention Comparison. The primary outcome of the study must reveal diabetic pain. The inclusion criteria of this study included full-text articles published from 2012–2022, focusing on physical activity to reduce pain scales in diabetic neuropathy patients. In contrast, the type of review research was excluded.

Search Strategy

The search strategy of the article was performed systematically based on scientific papers selected through the database and search engine, namely PubMed, CINAHL, Sage Journal, and Google Scholar. The keywords and Boolean operators were used to identify scientific articles. Those were "physical activity" OR "exercise" OR "physical exercise" OR

Table 1 Quality Assessment of Articles

No	Researcher (Year)	Study Design	Score		Mean
			Reviewer 1	Reviewer 2	
1	Cox, Gajanand Burton, Coombes & Coombes (2020)[18]	RCT	80%	85%	82,5%
2	Win, M. M. T. M., Fukai et al (2020)[19]	RCT	82%	78%	80%
3	Stambolieva, K., Petrova, D., and Irikeva, M. (2017)[20]	Quasi experiment	60%	60%	60%
4	Dixit et al (2014)[21]	RCT	67%	78%	72,5%
5	Kluding, P. M., (2012)[10]	Quasi experiment	90%	90%	90%
6	Pratiwi (2018)[22]	Quasi experiment	82%	84%	83%
7	Sari & Faizah (2020)[23]	Quasi experiment	77%	87%	82%
8	Kessler, N. J., Lockard, M. M., and Fischer, J (2020)[24]	Experiment	90%	88%	89%
9	Ahn and Song (2012)[25]	Experiment	85%	85%	85%
10	Monteiro (2020)[26]	Experiment	85%	87%	86%
11	Hamed (2014)[17]	RCT	90%	87%	88,5%
12	Margiyanti (2015)[27]	Quasi Experiment	85%	82%	83,5%

"exercise training" AND "pain" OR "burning pain" AND "diabetic peripheral" OR "diabetic peripheral neuropathy" OR "diabetic neuropathy" OR "DPN".

Study Risk of Bias Assessment

The bias appraisal used Critical Appraisal to assess articles that met the inclusion criteria as seen in Table 1. The risk of bias of articles in this study was assessed using the assessment component of the JBI Critical appraisal for Randomized Controlled Trial Instruments containing thirteen assessments and a Quasi Experiment containing nine assessment criteria. Each criterion was scored as "Yes", "No", "Unclear", and "Not Applicable", and each standard rated "Yes" was awarded one point. Screening, article quality assessment, and article preparation were carried out by three researchers (SP, BA, and TE).

Data Collection and Analysis

The study selection process was completed using the PRISMA flow chart: (1) Duplicate screening; (2) Screening of topics, titles, and abstracts; and (3) identification of full-text and language availability as seen in Figure 1. Then, data extraction and documentation were displayed using the tabulation method, which included identified items: author, year of publication, design, research sample, instruments, type of intervention, follow-up and results. The descriptive analysis technique was used in this study.

Results

Study Selection

Initial search results identified 815,103 articles from PubMed (n= 20,883), CINAHL (n= 279), Sage Journal (n=776,891), and Google Scholar (n= 17,100). The researcher then screened the articles based on the title, year, full text, and title research method and disseminated 92,700 articles because the title did not match the inclusion criteria. A total of 112 articles were checked based on the abstract and obtained 12 articles which would then be assessed for eligibility as seen in the PRISMA flow chart.

Study Characteristics

The total sample of the study was 597 DPN patients. The study design was RCT (n=4), experimental (n=5), and quasi-experimental (n=4). The feasibility of the study was assessed using critical appraisal tools (JBI), and article publications ranged from 2012–2022. The research locations are spread across countries, such as Australia (n=1), America (n=2),

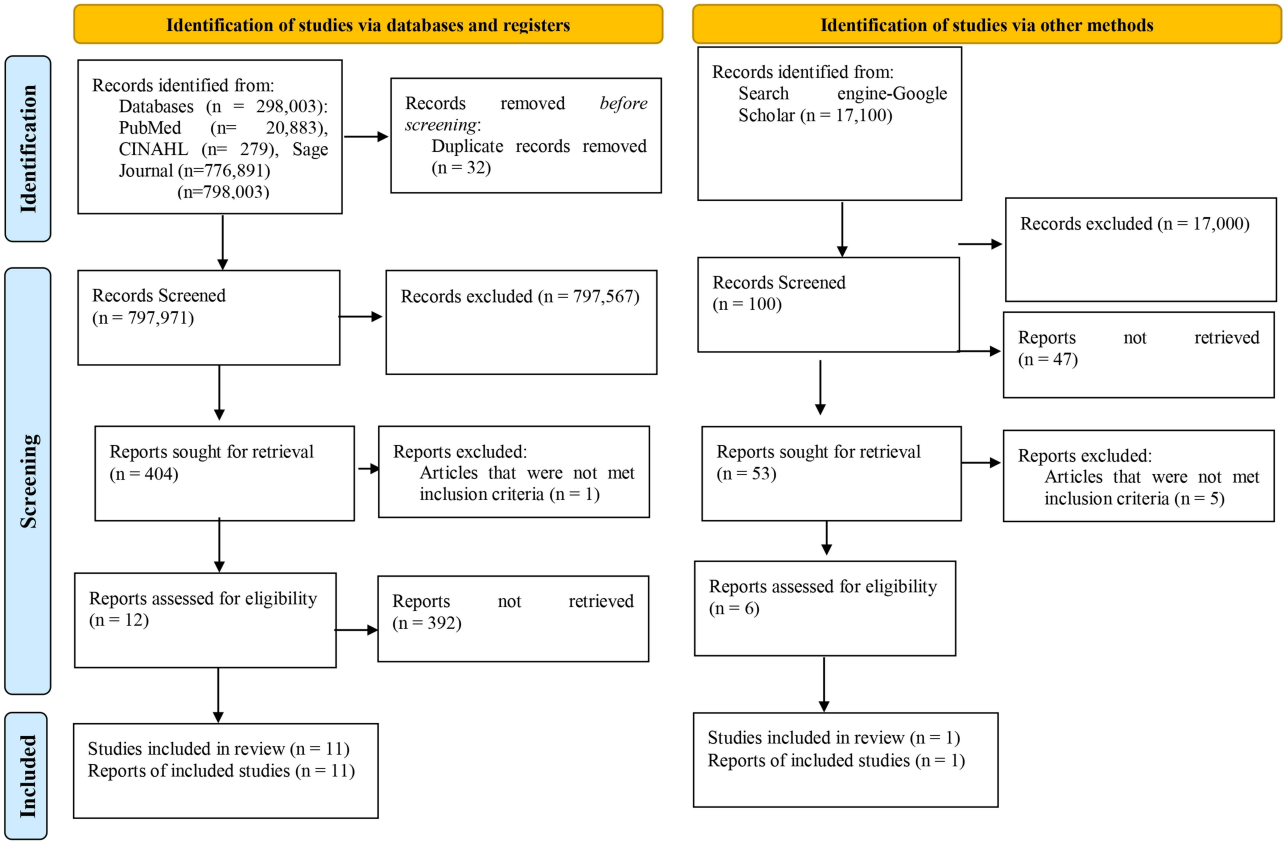

Figure 1 PRISMA Flow Diagram for the Selection of Studies in the Scoping Review.
Notes: PRISMA Flow Diagram illustrating the study selection process for the systematic review. It details the number of records identified through database searches and other methods, the screening process, and the number of studies included in the review.

Myanmar (n=1), Bulgaria (n=1), India (n=1), Indonesia (n=3), Saudi Arabia (n=1), South Korea (n=1), and Brazil (n=1). The whole summary of findings describes in Table 2 as follows.

Search Result

Aerobic Exercise

Aerobic exercise is the most common exercise identified in this review. This exercise engages the large muscles by performing a movement rhythmically over a long period (eg walking, jogging, cycling, and dynamic). Aerobic exercise can improve fitness. The type of intervention aerobic exercise that is carried out is by doing High-Intensity Interval Training for 15 weeks,[18] a combination of aerobic exercise and resistance or strengthening components for 8–10 weeks,[10,21] and moderate-intensity aerobics during eight weeks.[26]

In addition to the scale of reducing pain levels, aerobic exercise affects controlling hyperglycemia and decreases waist circumference,[17] improves the quality of life, decreases HbA1C, and increases the number of neurons in the proximal part.[10]

Mobility and Functional Movement

Mobility and functional movement exercises are discussed in 2 articles with two different types of activities. The first type of exercise only focuses on leg muscle strength. The other is an exercise consisting of simple hand, finger, and foot movements.

A 12-week therapeutic exercise program strengthen the muscles and improves the functionality of the foot-ankle complex. The results showed significantly improved toes strength, and contact time during gait and DPN symptoms, and peak forefoot pressures increased over time.[19]

Table 2 Summary of Findings (17–29)

No	Author (Year)	Design	Study Location and Sample	Research Instrument	Intervention	Duration of Intervention	Research Result
1.	Cox, Gajanand Burton, Coombes & Coombes (2020)[18]	RCT	Australia Sample: 32 inactive adults aged 18–80 years were diagnosed with type 2 diabetes with an HbA1c level of 6.0%.	Nordic Musculoskeletal Questionnaire (NMQ)	Mild and high intensity aerobic	8 weeks of exercise: High-intensity aerobics 4 days/week Duration 210 minutes/week. High intensity aerobics, 3 days/week Duration 78 minutes/week	A combination of high-intensity exercise and resistance training is effective in reducing pain scales in DM patients with diabetic neuropathy (p value = 0.04).
2.	Win, Fukai, Nyunt, and Linn (2020)[19]	RCT	Myanmar Sample: 104 type 2 DM patients with diabetic neuropathy without stroke, tuberculosis, and patients with amputation of hands and feet.	Visual analog scale (VAS)	Mobility and functional movement	10 minutes/session, 2–3 days/week, 8-week duration	Hand and foot movement exercises significantly improved motor score and specific activities of daily living, such as climbing stairs and performing work or chores. However, it does not look effective in reducing pain in DM patients with diabetic neuropathy (p value > 0.05).
3.	Dixit, Maiya, and Shastry (2014)[20]	RCT	India Sample: 87 respondents with diabetic neuropathy. A total of 47 respondents were included in the control group and 40 participants in the intervention group.	Michigan diabetic neuropathy score (MDS)	Aerobic	150 minutes/weeks, 5–6 days/weeks, with 150 minutes minimum and 360 minutes maximum of exercise	Aerobic exercise is effective in reducing pain scales in diabetic neuropathy patients (p value = 0.01).

(*Continued*)

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Table 2 (Continued).

No	Author (Year)	Design	Study Location and Sample	Research Instrument	Intervention	Duration of Intervention	Research Result
4.	Hamed & Raoof (2020)[21]	RCT	Saudi Arabia Sample: 80 T2DM with polyneuropathy	Leeds Assessment of Neuropathic symptoms and signs Scale for pain assessment	Aerobic	50 minutes each session for 15 weeks with a frequency 3 days/week	Movement exercises reduce pain scores in DPN patients (p value ≤ 0.0001)
5.	Kluding et al (2012).[10]	Experimental	America Sample: 17 respondents consisting of 8 men and 9 women, aged 40–70 years with diabetic neuropathy	Visual analog scale	Aerobic	30–50 minutes each session for 10 weeks with a frequency 3–4 days/week	There was a decrease in pain scores in diabetic neuropathy patients after ten weeks of aerobic exercise (p value = 0.05).
6.	Pratiwi (2018)[22]	Quasi experiment Pre test-post test with control group design	Indonesia Sample: 60 T2DM patients experienced FRONT with MSNI score ≥ 7.	Visual analog scale (VAS).	Resistance exercise	±30 minutes each session for 4 weeks with a frequency 3 days/ week	Foot and resistance exercise have a significant effect on reducing pain scores in DPN patients (p value < 0.05).
7.	Stambolieva, Petrova, and Irikeva (2017)[23]	Quasi experiment	Bulgaria Sample: 12 patients consisted of 6 men and 6 women. Age range 40–70 years, DM patients with diabetic neuropathy without orthopedic complaints, no cardiovascular problems.	Visual analog scale (VAS)	Vibration	30 minutes each session for 8 weeks with a frequency 6 days/week	The pain scale was significantly reduced after being given a plantar vibration intervention for 5 weeks (p value < 0.05).
8.	Sari & Faizah (2020)[23]	Quasi experiment	Indonesia Sample: 60 people in the intervention group and 60 people in the control group. Age range 26–65 years consisting of 44 males and 76 females	Michigan Neuropathy Screening Instrument (MNSI)	Resistance exercise	30 minutes each session for 4 weeks	Resistance exercise Effective in reducing pain scores in DPN patients (p value < 0.05).
9.	Kessler, N. J., Lockard, M. M., and Fischer, J (2020)[24]	Experimental	America Sample: 60 DPN patients, consisting of 9 males and 11 females.	Visual analog scale (VAS)	Whole body vibration	12 minutes each session for 4 weeks with a frequency 3 days/week	Whole body vibration is effective in reducing pain scale in DPN patients after 2–4 weeks of treatment (p value = 0.033).

10.	Ahn and Song (2012)[25]	Experimental	South Korea Sample: 39 DPN patient, consisting of 20 males and 19 females.	QOL score	Thai chi	60 minutes each session for 12 weeks with a frequency 2 days/week	Tai chi is effective in reducing pain scale in DPN patients (p value = 0.009)
11.	Chagas, Bonfim, Turi, Brondino, and Monteiro (2020)[26]	Experimental	Brazil Sample: 30 DPN patients	FHSQ pain score	Mobility and functional movement	50 minutes each session for 12 weeks with a frequency 2 days/week	Movement exercises reduce pain in DPN patients (p value < 0.05)
12.	Margiyanti, Lavisa, and Ivon (2015)[27]	Quasi experimental	Indonesia Sample: 16 DPN patients	NRS (Numerical Rating Scale)	Foot exercise	15 minutes every day for 4 days	Foot exercises reduce pain scores effectively in DPN patients (p value = 0.01)

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Eight weeks of simple hand, finger, and foot exercises did not show a significant effect on the pain scale in DPN patients. However, the research showed significantly more significant improvements in the motor score and specific activities of daily living, such as climbing stairs and performing work or chores.[20]

Vibration

The vibration exercise intervention is divided into two types: plantar vibration and whole-body vibration. An 8-week low-frequency (30 minutes a day) plantar vibration increases the conductive nerve velocity of the foot nerves, increases postural stability, and cause the disappearance of the pain and tingling ($p<0.005$).[24]

Insole vibration produced sub-threshold noise that improved signal processing of pressure information from the mechanoreceptors and caused increased postural stability by providing more accurate and more reliable sensory feedback that would be integrated for better stability.[24] Vibrating platform forces progressed from 0.5 g up to 1.0 g at a frequency of 25 hz, which were palpable and audible to the participant. There was a chronic decrease in pain following 2–4 weeks of whole-body vibration therapy ($p<0.05$).[27]

Foot and Resistance Exercise

Foot exercise is a diversion of attention to the pain felt by the patient. It relaxes the body so that the production of endorphins in the body increases. Endorphin hormones block the P-substance, which acts as a pain stimulus so that the transmission of pain impulses in the spinal cord can be inhibited, and the intensity of DPN in the extremities decreases.[23]

Resistance exercise aims to increase peripheral tissue circulation, flexibility, and muscle strength.[23] During exercise, muscles that are actively moving increase the glucose demand, but insulin levels do not increase. Muscles that move during exercise will increase blood flow, thereby opening capillary nets. The opening of capillary nets will have an impact on increasing the availability of insulin receptors, and the receptors will become more active.[22]

Resistance exercise and foot exercise significantly improve neuropathy improvement in DPN patients.[22,23,28] In addition, resistance exercise increases the ABI score.[28]

Tai Chi

Tai Chi (TC) has been introduced as a moderate-intensity aerobic exercise. The TC for diabetes (TCD) program is based on a standardized form of 21 movements from the combined Yang and Sun style of Tai Chi. The exercise was completed in 1-hour sessions twice weekly for 12 weeks.

After the 12-week TCD program, fasting blood glucose (FBS), HbA1C, and balance control were significantly controlled ($p<0.05$). In addition, there was an increase in the quality of life in 5 domains, namely the physical functioning domain, bodily pain, physical role limitation, emotional role limitation, and social functioning ($p <0.05$).[29]

Discussion

This review found several types of physical activity that can reduce pain scale in DPN patients, namely aerobic exercise, resistance exercise, vibration, a combination of aerobics with resistance exercise, tai chi, and foot exercises. Moderate-intensity aerobic exercise was done with a certain intensity, duration, and frequency.

Based on studies, it was found that aerobic exercise carried out at moderate intensity with an average duration of 30–50 minutes per day for 5–12 weeks was effective in reducing the pain scale in DPN patients.[20,21] Aerobic exercise can improve the work and function of the heart, lungs and blood vessels, characterized by decreased resting pulse rate, reduced lactic acid buildup, increased HDL cholesterol, and reduced atherosclerosis. Exercise is part of structured physical activity to maintain fitness and improve body functions.

Physical activity has decreased the risk of all cardiovascular outcomes and diabetes mellitus incidence.[29] Actively moving muscles increase blood flow to open more capillaries. Muscle contractions can also affect insulin permeability and increase the sensitivity of body cells to insulin. As a result of increased cell sensitivity to insulin, blood glucose is controlled and can be converted into energy. Controlled blood glucose then activates the polyol pathway. KPC and AGES synthesis can be inhibited as an antidote to free radicals to improve vascular vasodilation and transduction of nerve tissue, so that blood flow to the periphery becomes uninhibited.[28] Exercise potentially strengthens atrophic muscles in DPN, especially the dorsal/plantar ankle flexors and knee extensors/flexors.

Increased muscle strength around the ankle joint can provide more foot control for individuals with diabetic peripheral neuropathy and increase ankle muscle mobility during the heel strike phase, ultimately improving motor function for these patients.[17]

The decrease in the pain scale is related to the effect of glycemic control. Moderate to high-intensity exercise increases circulating glucocorticoids which facilitate analgesia. Aerobic exercise delays the onset of diabetic neuropathic pain by attenuating changes in Ca2+ channel tension in small-diameter dorsal root ganglion neurons by altering opioidergic tone.[17] The quality of life in patients with PDN can be decreased due to pain catastrophizing. In addition, the perceived decline in physical activity mediated the association between catastrophizing and disability and quality of life.[30]

Moreover, the previous study shows that the intervention of resistance exercise and aerobic exercise in DPN patients for ten weeks with a duration of 10 minutes per session can improve neuropathic symptoms and reduce pain scores in DPN patients.[10] Resistance exercise has an effect on sensory and autonomic responses which reduces pain symptoms in DPN patients.[28] Furthermore, plantar vibration effectively reduces pain in DPN patients.[24,27] The vibration in this study used a low frequency, carried out for eight weeks with 30 minutes per session duration. Glucose absorption can be affected by direct vibration, affecting the Peroneus longus (PL) muscle in the foot, which is delivered by tendons through the sole. Therefore, it directly interacts with the vibration source to improve glucose absorption in the blood.[31]

In addition to reducing pain, physical activity affects blood sugar control and decreases abdominal levels. Exercise generally increases muscle strength and pulls the internal viscera back into the pleural cavity, thereby reducing waist circumference.[17] Exercise may increase the body's response to intrinsic insulin by multiple mechanisms, including increasing the number of glucose transporters into the muscle cells, increasing insulin receptor substrates, and increasing muscle mass. The fatty acids released from adipose tissue, concentrating inside the myocytes, reduce the glucose transportation onto the cell membrane. However, exercise will reduce the fatty acid accumulation within the myocytes by oxidizing them to reduce HbA1C levels and hyperglycemic conditions in diabetic patients. However, intrinsic aspects that support behavior are needed to increase the success of reducing pain in DPN patients. Patients with type II DM require knowledge, attitudes, and beliefs that support behavior to prevent complications due to their disease.[32]

DPN patients must get support and motivation from family and closest people to comply with a healthy lifestyle and adequate health education from health workers, especially nurses. Exercise compliance and maintenance influence a better outcome. In addition to exercise considerations, maintaining diet, supportive psychological conditions, and medication adherence will further improve the quality of life of DPN patients.

Conclusion

Various types of exercise effectively reduce pain scales in DPN patients, including aerobic exercise interventions, resistance exercise, vibration, a combination of aerobics with resistance exercise, tai chi, and foot exercises. Applying this type of exercise to DPN patients can be adjusted to the preferences and age of the patient. In addition, patient preferences can consider the patient's weight, ability to exercise inside/outside the home, availability of equipment, and the patient's physical ability to follow the exercise.

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Disclosure

The authors declare no conflicts of interest in this study.

References

1. International Diabetes Federation (IDF). IDF diabetes atlas 9th edition western pacific. 2020:1–150. Available from: www.diabetesatlas.org. Accessed October 22, 2024.
2. Lopes ROP, Barbosa GDS, Leite KR, Mercês CAMF, Santana RF, Brandão MAG. Risk factors for hyperglycemia and hypoglycemia in adults with pharmacologically treated type 2 diabetes mellitus: a quantitative systematic review protocol. *JBI Evidence Synth*. 2020;19(1):163–169. doi:10.11124/jbisrir-d-19-00295
3. Kementrian Kesehatan RI. Laporan Nasional Riskesdas 2018. In Laporan Nasional Riskesdas 2018. 2018.
4. Aslam A, Singh J, Rajbhandari S. Pathogenesis of painful diabetic neuropathy. *Pain Res Treat*. 2014;2014:1–7. doi:10.1155/2014/412041
5. 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. doi:10.2337/dc10-1303
6. Motilal S, Maharaj RG. Nutmeg extracts for painful diabetic neuropathy: a randomized, double-blind, controlled study. *J Altern Complement Med*. 2013;19(4):347–352. doi:10.1089/acm.2012.0016
7. Kusnanto K, Arifin H, Widyawati IY. A qualitative study exploring diabetes resilience among adults with regulated type 2 diabetes mellitus. *Diabetes Metab Syndr*. 2020;14(6):1681–1687. doi:10.1016/j.dsx.2020.08.035
8. Kusnanto K, Kurniawati ND, Bakar A, Wahyuni ED, Arifin H, Pradipta RO. Spiritual-based motivational self-diabetic management on the self-efficacy, self-care, and HbA1c of type 2 diabetes mellitus. *Syst Rev Pharm*. 2020;11(7):304–308.
9. Balducci S, Sacchetti M, Haxhi J, et al. Physical exercise as therapy for type II diabetes. *Diabetes/Metab Res Rev*. 2014;32(30):13–23. doi:10.1002/dmrr
10. Kluding PM, Pasnoor M, Singh R, et al. The effect of exercise on neuropathic symptoms, nerve function, and cutaneous innervation in people with diabetic peripheral neuropathy. *J Diabetes Complications*. 2012a;26(5):424–429. doi:10.1016/j.jdiacomp.2012.05.007
11. AlKhotani RY, Al-Dubai SA, Almeshaly MS, et al. The association between physical activity and peripheral neuropathy in diabetic patients: a cross-sectional multicenter study from Saudi Arabia. *Cureus*. 2023;15(2).
12. Amato Nesbit S, Sharma R, Waldfogel JM, et al. Non-pharmacologic treatments for symptoms of diabetic peripheral neuropathy: a systematic review. *Curr Med Res Opin*. 2019;35(1):15–25. doi:10.1080/03007995.2018.1497958
13. Kioskli K, Scott W, Winkley K, Kylakos S, McCracken LM. Psychosocial factors in painful diabetic neuropathy: a systematic review of treatment trials and survey studies. *Pain Med*. 2019;20:1756–1773. doi:10.1093/pm/pnz071
14. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Method*. 2018;18(1):1–7. doi:10.1186/s12874-018-0611-x
15. Fitri SYR, Nasution SK, Nurhidayah I, Maryam NNA. Massage therapy as a non-pharmacological analgesia for procedural pain in neonates: a scoping review. *Complement Ther Med*. 2021;59:102735. doi:10.1016/j.ctim.2021.102735
16. Moreira CB, Dahinten VS, Howard AF, Fernandes AFC, Schirmer J. Factors related to mammography adherence among women in Brazil: a scoping review. *Nurs Open*. 2020;8(5):2035–2049. doi:10.1002/nop2.706
17. Susilaningsih FS, Komariah M, Mediawati AS, Lumbantobing VBM. Quality of work-life among lecturers during online learning in COVID-19 pandemic period: a scoping review. *Malaysian J Med Health Sci*. 2021;17(SUPP4):163–166.
18. Hamed NS, Raoof NALA. Effect of high intensity interval training on diabetic obese women with polyneuropathy: a randomized controlled clinical trial. *Phys Ther Rehabil*. 2014;1(1):4. doi:10.7243/2055-2386-1-4
19. Chagas EFB, Bonfim MR, Turi BC, Brondino NCM, Monteiro HL. Effect of moderate-intensity exercise on inflammatory markers among postmenopausal women. *J Phys Act Health*. 2017;14(6):479–485. doi:10.1123/jpah.2016-0319
20. Win MMTM, Fukai K, Nyunt HH, Linn KZ. Hand and foot exercises for diabetic peripheral neuropathy: a randomized controlled trial. *Nurs Health Sci*. 2020;22(2):416–426. doi:10.1111/nhs.12676
21. Cox ER, Gajanand T, Burton NW, Coombes JS, Coombes BK. Effect of different exercise training intensities on musculoskeletal and neuropathic pain in inactive individuals with type 2 diabetes-preliminary randomised controlled trial. *Diabetes Res Clin Pract*. 2020;164:108168. doi:10.1016/j.diabres.2020.108168
22. Yunita Sari R, Faizah I. Resistance exercise affects the improvement of diabetic neuropathy in type 2 DM patients [Resistance Exercise Berpengaruh Terhadap Perbaikan Neuropati Diabetikum Pada Penderita Dm Tipe 2]. *Jurnal Ilmiah Permas Jurnal Ilmiah Stikes Kendal*. 2020;10(3):395–406.
23. Margiyanti I, Lavisa H, Ivon N. The effect of diabetic foot exercises on the intensity of diabetic neuropathy pain in patients with type 2 diabetes mellitus [Pengaruh Senam Kaki Diabetik Terhadap Intensitas Nyeri Neuropati Diabetik Pada Penderita Diabetes Melitus Tipe 2]. 2015. Available from: http://ejournal.stikestelogorejo.ac.id/index.php/jikk/article/view/384. Accessed October 22, 2024.
24. Stambolieva K, Petrova D, Irikeva M. Positive effects of plantar vibration training for the treatment of diabetic peripheral neuropathy: a pilot study. *Somatosens Mot Res*. 2017;34(2):129–133. doi:10.1080/08990220.2017.1332585
25. Ahn S, Song R. Effects of tai chi exercise on glucose control, neuropathy scores, balance, and quality of life in patients with type 2 diabetes and neuropathy. *J Altern Complement Med*. 2012;18(12):1172–1178. doi:10.1089/acm.2011.0690
26. Dixit S, Maiya A, Shastry B. Effect of aerobic exercise on quality of life in population with diabetic peripheral neuropathy in type 2 diabetes: a single blind, randomized controlled trial. *Qual Life Res*. 2014;23(5):1629–1640. doi:10.1007/s11136-013-0602-7
27. Kessler NJ, Lockard MM, Fischer J. Whole body vibration improves symptoms of diabetic peripheral neuropathy. *J Bodyw Mov Ther*. 2020;24(2):1–3. doi:10.1016/j.jbmt.2020.01.004
28. Pratiwi RM. The effect of resistance exercise on the improvement of diabetic neuropathy, ankle brachial index and blood sugar levels in type 2 diabetes mellitus patients [Pengaruh Resistance Exercise Terhadap Perbaikan Neuropati Diabetikum, Ankle Brachial Index dan Kadar Gula Darah Pada Pasien Diabetes Mellitus Tipe 2]. Universitas Airlangga; 2018:13–277. Available from: https://repository.unair.ac.id/77521/2/TKP43_18Prap.pdf. Accessed October 22, 2024.

29. Wahid A, Manek N, Nichols M, et al. Quantifying the association between physical activity and cardiovascular disease and diabetes: a systematic review and meta-analysis. *J Am Heart Assoc*. 2016;5(9). doi:10.1161/jaha.115.002495
30. Geelen CC, Kindermans HP, van den Bergh JP, Verbunt JA. Perceived physical activity decline as a mediator in the relationship between pain catastrophizing, disability, and quality of life in patients with painful diabetic neuropathy. *Pain Pract*. 2016;17(3):320–328. doi:10.1111/papr.12449
31. Ravanbod R, Eslami N, Ashtiani MN. Immediate effects of footwear with vibration applied to the swing phase of the gait cycle on dynamic balance in patients with diabetic peripheral neuropathy. *J Biomech*. 2021;128:110710. doi:10.1016/j.jbiomech.2021.110710
32. Johnson CAH, Pitta NC, Dessotte CAM, Dantas RAS, Rossi LA. Knowledge, attitudes, and beliefs about acute coronary syndrome among patients with type 2 diabetes. *Revista Latino-Americana de Enfermagem*. 2021;29. doi:10.1590/1518-8345.5435.3503