



O-10

PHYSICAL EXERCISE IN PATIENTS WITH DIABETIC PERIPHERAL NEUROPATHY: A CASE STUDY

Riani Dwiastuti¹, Farid Rahman²

¹Student of Profession Physiotherapy, Universitas Muhammadiyah Surakarta, Indonesia

²Faculty of Health Sciences, Universitas Muhammadiyah Surakarta, Indonesia

*Corresponding author: Riani Dwiastuti, Email: rianidwiastuti4@gmail.com

Abstract

Introduction: Diabetic peripheral neuropathy (DPN) is a common complication of long-term diabetes mellitus (DM) and is a progressive and irreversible disease. DPN occurs in 40%-59% of the total DM population, in general the estimated prevalence of DPN is 15.3-72.3/100,000 person-years, and in developing countries the prevalence of DPN is around 25-50%. Symptoms of DPN include paresthesias, hyperesthesia, and dysesthesias, and some patients experience neuropathic symptoms (such as burning and tingling) while others may have no signs or symptoms. Many disorders of the lower extremities and feet such as deformity, decreased range of motion, impaired balance coordination, and muscle weakness can be caused by DM. Physical therapy can improve the overall quality of life of DPN patients, and can relieve symptoms of diabetic neuropathy. It can also improve muscle strength, joint mobility, balance, coordination and physical function, when done regularly can reduce neuropathic pain and can help control blood sugar levels.

Case Presentation: A 60-year-old woman with Diabetes Mellitus (DM) since 6 years ago (2015). Having complaints of numbness in both legs, these complaints more or less appeared in the last one year. Complaints get worse, especially when used to sit for a long time and stand for a long time, and complaints decrease when resting and walking at home.

Management and Outcome: The physiotherapy program provided is in the form of stretching exercises for the lower extremities, balance (One leg stance, Side Lunges), gait training (Walking Exercise) and strengthening (Ankle theraband). Evaluation was carried out by measuring the value of numbness using NRS, measuring muscle strength in the lower extremities with the Five Time Sit to Stand Test, measuring static balance with MCTSIB and dynamically using the Time Up and Go Test.

Discussion: Skeletal muscle stretching can help a person to control or lower blood glucose, this movement effectively has the benefit of exercising without physical stress. Gait and balance exercises with function-oriented strengthening programs are directed to simultaneously improve balance and gait in diabetic patients, exercise can improve macro and microvascular factors in diabetes. Strengthening exercises are important to reduce lower extremity weakness, which is a risk factor for falls in patients with DPN.

Conclusion: The physiotherapy program which was conducted three times with stretching, balance, gait training and strengthening exercises was able to reduce the value of numbness in both legs.

Keyword: Diabetic peripheral neuropathy (DPN), Physical Exercise, Stretching, Balance, Strengthening.



Introduction

Diabetes Mellitus (DM) is a metabolic disorder with various etiologies characterized by hyperglycemia and impaired carbohydrate, fat and protein metabolism due to defects in insulin secretion, insulin action or both. Long-term diabetes can cause various complications such as retinopathy, nephropathy, neuropathy, arteriosclerosis and others [1]. One of several complications of DM is diabetic peripheral neuropathy (DPN), DPN occurs in 40% -59% of the total DM population. As many as 27%-57% of the total population of DPN are between the ages of 50-60 years, and it increases to 50%-100% when the age is over 70 years [2]. In general, the estimated prevalence of DPN is 15.3-72.3/100,000 people per year, and in developing countries the prevalence of DPN is around 25-50% [3].

DPN is a common complication of long-term DM and is a progressive and irreversible disease. Polyneuropathy is characterized by damage to peripheral nerves (sensory, motor and autonomic) [4]. Symptoms of DPN include paresthesias, hyperesthesia, and dysesthesias, and some patients experience neuropathic symptoms (such as burning and tingling) while others may have no signs and symptoms [5]. Many disorders of the lower extremities and legs such as deformities, decreased range of motion, impaired balance coordination, and muscle weakness can be caused by DM [6]. DPN is associated with complications related to activities of daily living such as sleeping, climbing stairs, walking, and working. In addition, people with DPN have a greater risk of falling, slower gait and reactions, and altered postural control and difficulty in ADLs as the disease progresses [7]. Michigan neuropathy screening instrument (MNSI) was used to diagnose DPN, the MNSI physical examination included examination of the feet, evaluated for deformity, dry skin, callus, infection, fissures, and ulcers. Vibration (using a 128 Hz tuning fork) and monofilament (using 5.07/10 gm) were assessed on the dorsum of the big toe just proximal to the nail bed, while the Achilles reflex was assessed using a reflex hammer. The maximum score for the MNSI physical examination is 5 points for each leg, so the total maximum score is 10 points. It says DPN if the total score is more than 2, if the score is less than 2 it is only a Suspect Diabetic Peripheral Neuropathy [8].

DPN can damage the somatosensory and motor control systems, this results in instability in gait and static posture, which previously stemmed from muscle weakness [9]. Lower extremity muscle strengthening exercises are given to patients with DPN because someone with DPN has a risk of decreasing muscle strength by around 30-50% in the upper and lower limbs [10]. Exercise has a good effect on glucose control, cardiovascular risk factors, and lipid metabolism in DM patients [5]. U.S. The Department of Health and Human Services physical activity guidelines recommend low-intensity aerobic exercise, namely walking exercise to have a good effect on DPN sufferers [11]. Physical therapy can improve the overall quality of life of DPN patients, and can relieve symptoms of diabetic neuropathy. It can also improve muscle strength, joint mobility, balance,

coordination and physical function, when done regularly, can reduce neuropathic pain and can help control blood sugar levels [10].

Case Presentation

A 60-year-old woman comes to the clinic complaining of numbness in both legs. Complaints arose more or less in the last year, where the patient was diagnosed by a doctor with Diabetes Mellitus (DM) since 6 years ago (in 2015). Complaints get worse, especially when used to sit for a long time and stand for a long time, and complaints decrease when resting and walking at home. After suffering from DM, the patient routinely checks with the doctor and takes medication regularly, where the patient's sugar level is maintained. The drugs that the patient is taking include amlodipine 10 mg, glimepiride 1 mg, and metformin 500 mg. It is known that the patient has been to physiotherapy in the past month but with an irregular schedule, and complaints of numbness in both legs still occur frequently. The patient has a history of comorbidities, namely hypertension, and the patient's parents have a history of the same disease, namely DM.

The therapist checked the vital signs which can be seen in table 1, as well as the MNSI examination. A total score of 3 was obtained where the patient included Diabetic Peripheral Neuropathy (DPN) because the total score was more than 2. Both patient's feet looked dry (dry skin), ulcers appeared on the right foot, and vibration perception and examination with monofilament obtained normal results.

Table 1. Vital Sign and Laboratory

Vital Sign	Laboratory
Blood pressure : 150/80 mmHg (Hypertension)	Gula darah puasa : 116 mg/dL (normal)
Pulse rate : 83 x/minute (normal)	Total cholesterol : 134 mg/dL(normal)
Respiration rate : 20x/minute (normal)	Gout : 4,0 mg/dL (normal)

Examination of the value of numbness in both feet, measured using the Numerical Rating Scale (NRS) which has an 11-point scale from 0-10, where 0 means no pain/numbness to 10 means unbearable pain/numbness. The NRS value was 7, which means moderate on both legs.

Table 2. Physical Examination Results

Pemeriksaan	Hasil	Keterangan
NRS	7	Moderate
<i>Five Time Sit to Stand Test</i>	12,47 secon	Decreased muscle strength
<i>Time Up and Go Test</i>	14,34 secon	Fall Risk
MCTSIB	0.925	Normal

Examination of muscle strength in the lower extremities using the Five Time Sit to Stand Test. This test measures the functional strength of the lower extremities and identifies the movements the patient uses to complete transitional movements. The patient is asked to sit to standing 5 times,



then the therapist calculates with a stopwatch how long it will take. From the examination of the Five Time Sit to Stand Test, the results were 12.47 seconds, where the patient had a decrease in lower extremity muscle strength.

Examination of the patient's dynamic balance was measured using the Time Up and Go test. From a sitting position, the patient is asked to stand up and then walk around through the 3 meter long cone and then sit back down to the chair. The therapist calculates using a stopwatch how long it will take the patient. After the Time Up and Go test, the result is 14.34 seconds, where the patient has a risk of falling.

Static balance measurements were performed using the Modified Clinical Test of Sensory Interaction in Balance (MCTSIB). The aim of this test was to evaluate the effect of sensory interactions on postural stability in the standing position in DPN patients.

Table 3. MCTSIB Examination

MCTSIB	Time (s)	Result
Propioceptive, vestibular dan visual	30	
Propioceptive dan vestibular	30	
Vestibular dan visual	27,5	
Vestibular	23,5	
Total	111 / 120	0.925

The MCTSIB result value is 0.925 which means normal, where if the result is less than 0.75 then there is a decrease in function between receptors, namely propioceptive, vestibular and visual.

Management and Outcome

The process of physiotherapy is carried out on patients in a physiotherapy clinic. The goals of the intervention are to reduce numbness in both legs, increase muscle strength in the lower extremities, improve balance and optimize the patient's functional ability. The physiotherapy interventions carried out are as shown in the following table:

Table 4. Management Physiotherapy

Intervention	Dosis
Stretching : Stretching the upper and lower limbs, such as the m. trapezius, m. biceps brachii, m. triceps brachii, m. pectoralis major and m. quadriceps, m. hamstrings, m. calf muscles, and each gluteus muscle.	3 times a week, 3 sets and each movement held for 30 seconds, stretching until the patient feels stretched in each muscle that is targeted.
Balance : <ul style="list-style-type: none">• One leg stance• Side Lunges	3 times a week, 3 sets of repetitions 10 times each movement One leg stance : hold 30 seconds.
Gait training : <ul style="list-style-type: none">• Walking Exercise : walking, walking backwards and walking on tiptoes	3 times a week, duration of exercise 10 - 20 minutes, including low intensity



Strengthening :

- Ankle theraband

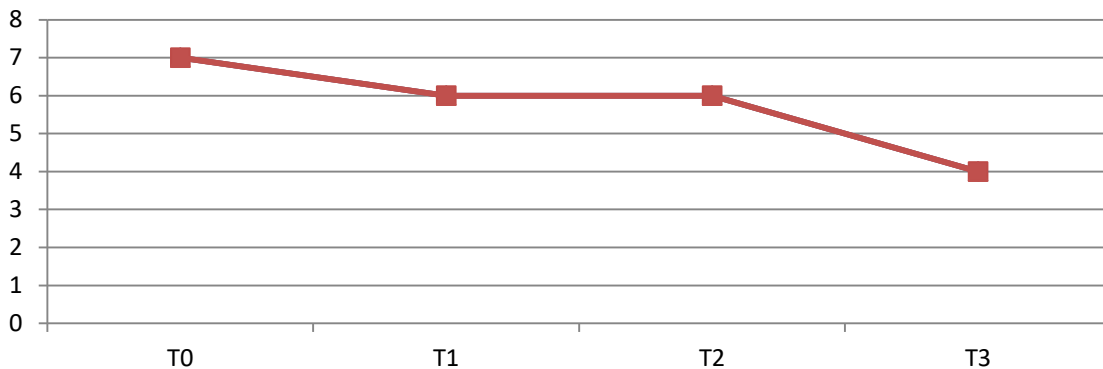
3 times a week, 3 sets, 10 times each movement, using the red theraband

After the patient received three physiotherapy sessions, the measurement of numbness was evaluated using the NRS, the measurement of muscle strength in the lower extremities with the Five Time Sit to Stand Test, measurement of static balance with the MCTSIB and dynamic measurement with the Time Up and Go Test.

The results of measuring the value of numbness with NRS

The measurement of the numbness value using the NRS was carried out before the intervention was given and evaluated after the intervention was given, the results of the measurement of the numbness value with the NRS were as follows:

Table 5. NRS Measurement Results



The graph above shows a decrease in the value of numbness on both legs from T0-T3. Exercises in the form of stretching, balance, gait training and strengthening can reduce the frequency of numbness in the patient's legs at T0: 7, T1: 6, T2: 6, and T3: 4 which are still in the moderate range.

The results of measuring muscle strength in the lower extremities with the Five Time Sit to Stand Test

Examination of lower extremity muscle strength was carried out before the intervention was given and evaluated at the third meeting, the following results were obtained:

Table 6. Lower Extremity Muscle Strength Test Results

	T0	T3
<i>Five Time Sit to Stand Test</i>	12,47	11,65

The results of measuring lower leg muscle strength using the Five Time Sit to Stand Test showed a decrease in time from T0-T3 from 12.47 seconds to 11.65 seconds, where there was a slight increase in muscle strength in the lower extremities.



Static and dynamic balance measurement results

Examination of static and dynamic balance was carried out before the intervention was established or T0, and evaluated at the third meeting or T3, the results were as follows:

Table 7. Balance Measurement Results

Balance	T0	T3
Statis (MCTSIB)	0,925	0,958
Dinamis (<i>Time Up and Go Test</i>)	14,34	13,53

In the results of static balance measurements with MCTSIB, there was no significant improvement, from 0.925 to 0.958. Meanwhile, in dynamic balance with time up and go test, the time decreased from 14.34 seconds to 13.53 seconds.

Discussion

Stretching

Stretching skeletal muscles can help a person to control or lower blood glucose, both active and passive stretching. However, passive stretching is better than active stretching in lowering blood sugar levels, passive stretching can also be used as an alternative for elderly patients who are not physically active, obese patients, rheumatism, neurological patients that affect balance and coordination [12]. Passive stretching will cause sustained tension in the muscles through the external force applied, resulting in an increase in muscle length thereby increasing muscle metabolic activity. This movement effectively has the benefit of exercising without physical stress [13].

Balance and Gait training

Decreased balance ability is most likely related to loss of strength in the lower extremities and decreased sensorimotor function [14]. Weakness in the distal body occurs late in the natural history of DPN. Instability in these muscles causes difficulty in maintaining balance and ultimately affects gait. Both static and dynamic balance are affected in DPN. Various factors that affect balance in this population are the result of significant sensory disturbances, impaired proprioception, impaired movement control, structural biomechanical disturbances, and disorientation. The literature reports significant improvements in balance and gait speed after multisensory training, as well as proper and safe balance training, and has the potential to improve balance and gait [10].

Gait and balance exercises with function-oriented strengthening programs are directed to simultaneously improve balance and gait in diabetic patients, exercise can improve macro and microvascular factors in diabetes. Therefore, vascular adaptation caused by exercise can improve blood flow to peripheral nerves, and can even improve gait function [3]. Walking backwards can



increase the stretching of the hamstring muscle group during stride, and exercise proprioceptive control or balance during the activity. During walking forward and backward there is a strengthening of m. rectus femoris, m. biceps femoris short head, and m. posterior tibial. However, the strengthening of m. A good iliacus is only achieved during backward walking. Activation of the tibialis anterior when walking backwards can maintain stability and balance [15].

Strengthening

Strengthening exercises are important for reducing lower extremity weakness, which is a modifiable risk factor for falls. People with DPN have decreased lower leg muscle strength and greater muscle mass over time compared with people of the same age with type 2 DM without DPN, therefore the added weakness puts them at a higher risk of falling [16]. Ankle strengthening and mobilization exercises using theraband can increase ankle dorsiflexion ROM, because ankle dorsiflexion is significantly decreased in diabetic patients compared to healthy people. Increased ankle mobility has been associated with a decrease in peak plantar pressure and with the potential to prevent foot ulceration, as well as being a means of improving balance [17].

Conclusion

The physiotherapy program which was conducted three times with stretching, balance, gait training and strengthening exercises was able to reduce the value of numbness in both legs.

References

- [1] I. Ahmad, E. Hussain, D. Singla, S. Verma, and K. Ali, “JSM Diabetology and Management Balance Training in Diabetic Peripheral Neuropathy: A Narrative Review,” *JSM Diabetol Manag*, vol. 2, no. 1, pp. 1–9, 2017.
- [2] I. Ahmad, M. M. Noohu, S. Verma, D. Singla, and M. E. Hussain, “Effect of sensorimotor training on balance measures and proprioception among middle and older age adults with diabetic peripheral neuropathy,” *Gait Posture*, vol. 74, no. August, pp. 114–120, 2019.
- [3] H. Melese, A. Alamer, M. H. Temesgen, and G. Kahsay, “Effectiveness of exercise therapy on gait function in diabetic peripheral neuropathy patients: A systematic review of randomized controlled trials,” *Diabetes, Metab. Syndr. Obes. Targets Ther.*, vol. 13, pp. 2753–2764, 2020.
- [4] H. H. M. Battasha, G. M. Ahmed, H. A. Amer, A. M. El Gohary, and W. M. Ragab, “Effect of core stability exercises and desensitisation therapy on limit of stability in diabetic peripheral neuropathy patients,” *Int. J. Ther. Rehabil.*, vol. 25, no. 3, pp. 128–134, 2018.
- [5] F. Gholami, S. Nikookheslat, Y. Salekzamani, N. Boule, and A. Jafari, “Effect of aerobic training on nerve conduction in men with type 2 diabetes and peripheral neuropathy: A randomized controlled trial,” *Neurophysiol. Clin.*, vol. 48, no. 4, pp. 195–202, 2018.



- [6] N. J. Akbari, M. Hosseinifar, and S. S. Naimi, “The efficacy of physiotherapy interventions in mitigating the symptoms and complications of diabetic peripheral neuropathy: A systematic review,” 2020.
- [7] M. M. T. M. Win, K. Fukai, H. H. Nyunt, and K. Z. Linn, “Hand and foot exercises for diabetic peripheral neuropathy: A randomized controlled trial,” *Nurs. Heal. Sci.*, vol. 22, no. 2, pp. 416–426, 2020.
- [8] N. Khan, I. Ahmad, and M. M. Noohu, “Association of disease duration and sensorimotor function in type 2 diabetes mellitus: beyond diabetic peripheral neuropathy,” *Somatosens. Mot. Res.*, vol. 37, no. 4, pp. 326–333, 2020.
- [9] K. Suzuki, M. Niitsu, T. Kamo, S. Otake, and Y. Nishida, “Effect of Exercise with Rhythmic Auditory Stimulation on Muscle Coordination and Gait Stability in Patients with Diabetic Peripheral Neuropathy: A Randomized Controlled Trial,” *Open J. Ther. Rehabil.*, vol. 07, no. 03, pp. 79–91, 2019.
- [10] N. A. Majeedkuty, M. A. Jabbar, and S. Sreenivasulu, “Physical therapy for diabetic peripheral neuropathy: A narrative review,” *Disabil. CBR Incl. Dev.*, vol. 30, no. 1, pp. 112–125, 2019.
- [11] C. Johnson and J. K. Takemoto, “A review of beneficial low-intensity exercises in diabetic peripheral neuropathy patients,” *J. Pharm. Pharm. Sci.*, vol. 22, no. Figure 1, pp. 22–27, 2019.
- [12] S. Solomen, R. Shakya, K. Agarwal, and P. Aaron, “Passive stretching versus active stretching on immediate blood glucose in subjects with type II diabetes mellitus-A pilot study,” ~ 146 ~ *Int. J. Phys. Educ. Sport. Heal.*, vol. 2, no. 1, pp. 146–149, 2015.
- [13] P. Gurudut and A. P. Rajan, “Immediate effect of passive static stretching versus resistance exercises on postprandial blood sugar levels in type 2 diabetes mellitus: A randomized clinical trial,” *J. Exerc. Rehabil.*, vol. 13, no. 5, pp. 581–587, 2017.
- [14] S. Dixit, A. Maiya, B. A. Shastri, and V. Guddattu, “Analysis of postural control during quiet standing in a population with diabetic peripheral neuropathy undergoing moderate intensity aerobic exercise training: A single blind, randomized controlled trial,” *Am. J. Phys. Med. Rehabil.*, vol. 95, no. 7, pp. 516–524, 2016.
- [15] X. Zhang *et al.*, “Investigating the role of backward walking therapy in alleviating plantar pressure of patients with diabetic peripheral neuropathy,” *Arch. Phys. Med. Rehabil.*, vol. 95, no. 5, pp. 832–839, 2014.
- [16] Y. Gu and S. M. Dennis, “Are falls prevention programs effective at reducing the risk factors for falls in people with type-2 diabetes mellitus and peripheral neuropathy: A systematic review with narrative synthesis,” *J. Diabetes Complications*, vol. 31, no. 2, pp. 504–516, 2017.
- [17] K. Lindberg, B. S. Møller, K. Kirketerp-Møller, and M. T. Kristensen, “An exercise program for people with severe peripheral neuropathy and diabetic foot ulcers—a case series on feasibility and safety,” *Disabil. Rehabil.*, vol. 42, no. 2, pp. 183–189, 2020.