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Physical training and activity in people with diabetic peripheral neuropathy: A case report

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Abstract

Background: Diabetes mellitus (DM) is the most common endocrine disorder affecting more than 100 million people worldwide, around 6% of the population. This matter characterized by hyperglycemia (high glucose levels in blood) caused by a lack or ineffective production of insulin by the pancreas which results in an increase or decrease in the concentration of glucose in the blood. *Diabetic peripheral neuropathy* (DPN) or what is called diabetic peripheral neuropathy is the most common complication in cases of diabetes mellitus. DPN is a disease of loss of motor, sensory and autonomic nerve function, which can affect the peripheral nervous system. Sensorimotor training is considered a technique that can improve balance. This emphasizes the function of the sensorimotor system as a unit that works to increase sensory input and motor recruitment patterns in maintaining joint stability and regulating movement through the central nervous system (CNS). Aerobic exercise is a type of physical activity that can prevent and reduce DPN. Aerobic exercise such as *treadmill* can train balance. Balance training shows a high positive effect on improving motor and sensory symptoms in peripheral neuropathy
Purpose: To examine the effects of sensorimotor training and lower limb muscle activity in DPN patients using *treadmill*.
Method: The research uses a case study design, namely a research method that uses various data sources that can be used as research material, describing and explaining comprehensively various aspects of an individual, group, program, organization or event systematically. Participants in this study were patients aged 64 years, female, diagnosed *diabetes mellitus* type 2 (T2DM) for 10 years by a doctor. This research uses an aspect identification questionnaire instrument. DPN is screened using *Michigan Neuropathy Screening Instrument* (MNSI). Static balance is determined by *romberg test* and for dynamic balance it is measured by *timed up and go test*. Functional lower limb muscle strength is checked using tests *Five Time Sit to Stand* (5xSST).
Results: The data for the respondent is a housewife aged 64 years, last education is junior high school with status as a housewife. The patient suffered from T2DM for 10 years with a hemoglobin 1AC level of 6.8 mg/dl, was overweight as indicated by the patient's BMI of 26 kg/m^2. Often feels pain in both legs, when the patient walks and does strenuous activities with a score of 9, and the pain decreases when resting with a score of 3. Apart from that, the patient also has vision problems with a score of 20/40, meaning the patient can only see letters. at a distance of 20 feet. Even though normally letters can be seen clearly, namely 40 feet, this visual disturbance can cause the patient's balance to be disturbed. Providing treatment for 6 weeks can significantly improve the patient's quality of life as seen from the initial WHO QoL score of 58 to 86.
Conclusion: Providing treadmill training for 6 weeks carried out 3 times a week showed significant results in reducing hemoglobin levels and DPN scores in T2DM patients.

Keywords: Diabetes Mellitus (DM); Diabetic Peripheral Neuropathy; Treadmills.

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INTRODUCTION

Diabetes mellitus (DM) is the most common endocrine disorder affecting more than 100 million people worldwide, approximately 6% of the population. This matter characterized by hyperglycemia (high levels of glucose in the blood) caused by a lack or ineffective production of insulin by the pancreas which results in an increase or decrease in the concentration of glucose in the blood. So it was found that there was a lot of damage to the body's systems, especially the blood vessels, eyes, kidneys, heart and nerves (Ismail, & Yaheya, 2009; Piero, Nzaro, & Njagi, 2015).

Insulin is a hormone produced by pancreatic β cells to control blood glucose through regulation glucose use and storage (Asmat, Abad, & Ismail, 2016).The main cause of insulin deficiency is because there is damage to the pancreatic β cells which function to produce insulin (Baynes, 2015). Additionally, DMs can jIt is also caused by insulin resistance which is a reduced ability of insulin to stimulate insulin use of glucose or decreased response of target cells, such as muscle, tissue and liver to physiological insulin levels
(Baynes, 2015). This disease is known to have existed for a long time and was recorded in Egyptian manuscripts around 1500 BC (Allen, & Gupta, 2019).

Pre-diabetes is a metabolic disorder characterized by low blood glucose levels between normal and diabetic. Pre-diabetes has characteristics such as fasting glucose levels (6.1–6.9 mmol/L), tolerance glucose levels (7.8 –11.0 mmol/L), and glycated hemoglobin levels or hemoglobin bound to glucose (HbA1C) 6.0–6.4% (Punthakee, Goldenberg, & Katz, 2018). Symptoms of pre-diabetes can progress to diabetes, however Most will return to normal conditions. This does not rule out the possibility that people with pre-diabetes can increase the risk of suffering from cardiovascular disease and disorders of the nervous system (Bergman, Buysschaert, Schwarz, Albright, Narayan, & Yach, 2012).

In general, DM is grouped into 4 types, namely Type 1 DM (DMT1), Type 2 DM (2DMT), gestational, and other specified diabetes (Olokoba, Obateru, & Olokoba, 2012; Punthakee *et al.,* 2018). T2DM is a type that is common in every country and is a chronic disease, and the prevalence can continue to increase significantly due to economic development and urbanization which causes lifestyle changes characterized by unhealthy lifestyles and obesity (Kusnadi, Murbawani, & Fitranti, 2017).

International Diabetes Federation (IDF) estimates that the number of diabetes sufferers in Indonesia will reach 28.57 million people in 2045. This number has increased by 47% compared to 2021 which was 19.47 million people. Diabetes mellitus has two complications, namely macrovascular and microvascular. According to a 2018 study by Corina, the most common chronic complications in T2DM patients were microvascular complications (57%), most of which were diabetic neuropathy (45.6%) and diabetic nephropathy (33.7%), and diabetic retinopathy (20.7%). While macrovascular complications were 43%, the most common complications were peripheral neuropathy (29.9%), coronary artery disease (27.8%) and cerebrovascular disease (19.4%) (Corina, 2018).

Diabetic peripheral neuropathy (DPN) or called diabetic peripheral neuropathy is the most common complication in cases of diabetes mellitus, DPN is a disease of loss of motor, sensory and autonomic nerve function, which can affect the peripheral nervous system (Davies, Brophy, Williams, & Taylor, 2006). Diabetic peripheral neuropathy is associated with complications, one of which is changes in weight distribution on the legs which can cause balance problems (Meijer, Van Sonderen, Blaauwwiekel, Smit, Groothoff, Eisma, & Links, 2000). Poor balance can coexist with sensorimotor disorders which can increase the risk of falls. So it can reduce the patient's quality of life. Sensory disturbances include, loss of sensation or sensitivity, pain, tingling, burning, allodynia or hyperalgesia (Juster-Switlyk, & Smith, 2016). Patients with DPN will experience a decrease in muscle activation, especially when standing and walking due to somatosensory nerve disorders, especially in the cutaneous nerves in the skin (Rusnani, 2014). A decrease in the cutaneous nerve in detecting sensation results in a decreased ability of the proprioceptor to provide information to the brain about *velocity* motion, joint pressure, joint movement, and direction of joint movement.

Sensorimotor training is considered a technique that can improve balance. This emphasizes the function of the sensorimotor system as a unit that

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works to increase sensory input and motor recruitment patterns in maintaining joint stability and regulating movement through the central nervous system (CNS) (Page, 2006). Any imbalance in the muscles responsible for postural control causes movement disorders and ultimately alters the motor program in the CNS. In correcting this disorder, sensorimotor training first facilitates sensory input (proprioceptive and somatosensory structures), then corrects muscle imbalances and finally facilitates correct motor programming. Balance exercises as part of sensorimotor training have also been shown to improve trunk proprioception in DPN patients (Song, Petrofsky, Lee, Lee, & Yim, 2011).

Aerobic exercise is a type of physical activity that can prevent and reduce DPN. Aerobic exercise such as *treadmill* can train balance. Balance training shows a high positive effect on improving motor and sensory symptoms in peripheral neuropathy. Balance training is the most effective type of physical activity in DPN patients. Physical therapy, if done regularly and regularly, can help control blood sugar levels, reduce neuropathic pain, improve muscle strength, balance and joint mobility, and can improve the quality of life of DPN patients (Majeedkutty, Jabbar, & Sreenivasulu, 2019). Additionally, previous research suggests that simple exercise such as brisk walking can modify the natural history of DPN (Balducci, Lacobellis, Parisi, Di Biase, Calandriello, Leonetti, & Fallucca, 2006). However, in this research there is still a lack of knowledge showing the effects of sensorimotor training on neuromuscular function. So this study aims to test the effects of sensorimotor training and muscle activity on the lower limbs in DPN patients using *treadmill*.

RESEARCH METHOD

This research uses a case study design, namely a research method that uses various data sources that can be used as research material, describing and explaining comprehensively various aspects of an individual, group, program, organization or event systematically. This case study is a study for tested the effects of sensorimotor training and lower limb muscle activity in DPN patients using *treadmill*.

Participants in this study were patients aged 64 years, female, diagnosed *diabetes mellitus* type 2 (T2DM) for 10 years by a doctor.

The patient has a hemoglobin 1Ac level of 6.8%, has no neurological or cardiac complications, no cerebral ataxia, and can walk without assistive devices. The patient can understand verbal commands very well, but experiences complaints of pain and numbness in both legs. The pain spreads like an electric current when the patient stands for a long time, so he cannot walk for more than 15 minutes. At night sufferers often cramp up to 2-3 times. The patient experienced some limitations in participating in several social activities around his house because he could not sit on the floor in community meetings because he felt sick and numb. So, the patient is told to sit in a chair. This condition makes him uncomfortable.

This research uses an aspect identification questionnaire instrument. DPN is screened using *Michigan Neuropathy Screening Instrument* (MNSI) and the patient has a score of 3.5. The MNSI is reported to have good to moderate sensitivity and specificity of 61% and 79%, respectively, for clinical neuropathy assessment scores *cut-off* 2. Meanwhile, neuropathic pain such as burning, numbness, cramps and numbness are measured using *numeric rating scale* with a score of 0-10.

Next, a visual acuity test is carried out using *snellen eye chart test*. The patient is asked to sit in front *chart* about 3 meters and asked to read the letters on it *chart,* if the score ≥ 75 is considered normal visual acuity. Static balance is determined by *romberg test* and for dynamic balance it is measured by *timed up and go test*. *Romberg test* used to identify proprioceptive dysfunction and specific goals of intervention. *Romberg test* It is said to have failed if the patient lifts the heel and opens the leg. This test is carried out with the eyes open and closed for 30 seconds each. The patient can complete with eyes open for 25.62 seconds and with eyes closed for 8.63 seconds, meaning the patient does not have good static balance control.

Time up go test is a test used to measure functional balance. The patient is asked to sit then stand, then walk 3 meters and sit again calmly. *Time up go test* had a sensitivity and specificity of 80% and 56% respectively for predicting falls. If the travel time is more than 13.5 seconds then it is categorized as having a high risk of falling.

Functional lower limb muscle strength is checked using tests *Five Time Sit to Stand* (5xSST). A score

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below 13 seconds is a score recommended as normal lower limb functional muscle strength and a low fall risk category. 5xSST had a sensitivity of 66% and a specificity of 67%. The patient was identified as having low lower leg muscle strength, namely with a result of 15.32 seconds.

Physical fitness in patients is evaluated using the 6-minute walk test or *Six Minute Walking Test* (6MWT). The patient can stop if he feels tired, but the time continues for up to 6 minutes. After 6 minutes, calculate how far the patient can travel. *Falls-efficacy* (FE) is the patient's sense of confidence in his body balance which is examined using *kuesioner Activity Balance Performance* Indonesian version which consists of 26 question items (ABC-16 Ina). This questionnaire contains 16 items with a 10 point ordinal scale. Scores range from 0-100. The ABC scale has an internal consistency value (*Cronbachs Alpha*) which is very good at 0.96. A score greater than or equal to 67 indicates a high fall risk.

This research uses *Geriatric Depression Scale* Indonesian version to record anxiety levels. This tool was reported to have moderate to high sensitivity and specificity of 87.6% and 71.8%, respectively, with a clear cut score of 5.5.

RESEARCH RESULTS

The respondent data is a 64 year old housewife, last education is junior high school with status as a housewife. The patient suffered from T2DM for 10 years with a hemoglobin 1AC level of 6.8 mg/dl, was overweight as indicated by the patient's BMI of 26 kg/m^2. Often feels pain in both legs, when the patient walks and does strenuous activities with a score of 9, and the pain decreases when resting with a score of 3. Apart from that, the patient also has vision problems with a score of 20/40, meaning the patient can only see letters. at a distance of 20 feet. Even though normally letters can be seen clearly, namely 40 feet, this visual disturbance can cause the patient's balance to be disturbed.

Interventions are carried out on patients by following a physical therapy program in the form of *treadmill* 3 times every week for 6 weeks, with a duration of 30 minutes for each treadmill exercise. To avoid leg cramps and painful sensations, the patient stretches the calf muscles slowly and continuously on both legs in each session for 30 seconds, 2 sets and 6-8 repetitions. During the treadmill, saturation is measured with oximetry and always asked about feelings of fatigue, nausea, feeling like vomiting, blurred vision, cold sweat as signs of unconsciousness. Blood pressure checks are carried out before and after exercise. Assessments for all measurements were carried out pre (before starting therapy), every week (6 weeks) and then the patient did not receive therapy for 2 weeks. Follow-up measurements were carried out every 2 weeks for 1 month.

Giving treatment for 6 weeks resulted in a reduction in DPN symptoms with the MNSI score dropping drastically from 3.5 to 1.5. Reduced hemoglobin 1Ac levels (mg/dl) from 6.8 to 6.3. Reduces pain when resting, standing, walking and doing heavy activities, but the pain condition decreases significantly, namely when standing with an initial score of 7 to 2. Significantly improves balance, both static and dynamic balance. Improved static balance is seen with *romberg test* eyes open with an initial score of 25.62 to 30.00, while with eyes closed the initial score was 8.63 to 17.68. Improved dynamic balance can be seen with *TUG test* with the initial score the results were 15.38 to 10.76. There was a significant increase in lower leg muscle strength with an initial score of 15.32 to 10.38. There was a significant increase in physical fitness with an initial score of 318 to 390. Providing treatment for 6 weeks also increased the patient's self-confidence with an initial score of 55 to 75. Improved patient sleep quality with an initial score of 5 to 7, as well as a significant increase in the patient's social participation. with an initial score of 32 to 17. So providing treatment for 6 weeks can significantly improve the patient's quality of life as seen from the initial WHO QoL score of 58 to 86.

DISCUSSION

Research results of T2DM patients with DPN after being given intervention *treadmill* with frequency, intensity, time, type (FITT) 3 times a week for 6 weeks with a duration of 30 minutes and a moderate intensity of 40-60% MHR (Mirtha, & Permatahati, 2018).The results showed improvements in motor and sensory skills in the legs resulting in a decrease in hemoglobin 1Ac levels (mg/dl) and a decrease in DPN symptoms. A decrease in DPN symptoms can increase lower leg

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muscle strength resulting in improved balance, both static and dynamic (Streckmann, Zopf, Lehmann, May, Rizza, Zimmer, & Baumann, 2014).

Previous research carried out aerobic exercise with high-intensity interval training and moderate-intensity continuous training. Exercise using a treadmill is carried out for 40 minutes consisting of 5 minutes of warm-up, 30 minutes of exercise (which consists of 5 x 3 sets of exercises) and 5 minutes of cool-down. The patient did the exercise without using handrails on the treadmill. It was found that the results showed a decrease in blood glucose during the treadmill walking intervention *high-intensity interval training* (HIIT) and *medium intensity continuous training* (MICT) which is compared with *a control session of rest* (CON), p<0.001. The effect of HIIT was greater compared to MICT (p = 0.017) (Mendes, Sousa, Themudo-Barata, & Reis, 2019).HIIT walking on a treadmill is safer and more effective for acute glycemic control than MICT in middle-aged and elderly patients on medication (Rahmadiya, & Dahlia, 2022).

T2DM patients with DPN were then given no treatment for 2 weeks and then visited every 2 weeks for 1 month. The results obtained were an increase in hemoglobin 1Ac levels (mg/dl) and an increase in DPN symptoms. An increase in DPN symptoms causes an increase in pain, resulting in a decrease in lower leg muscle strength which can cause a decrease in balance and physical fitness (Meijer*et al.,* 2000). Decreased physical fitness can affect the quality of sleep and social participation and thus affect the patient's quality of life (Van Acker, Bouhassira, De Bacquer, Weiss, Matthys, Raemen, & Colin, 2009).

Providing treadmill exercise is very important because it can reduce hemoglobin 1Ac levels (mg/dl). A decrease in blood sugar levels in T2DM patients can occur after physical activity. When doing physical activity, the muscles will contract, triggering increased release of GLUT-4 (glucose transporter) to take up glucose in the muscles (Suryati, 2021).In addition, the muscles that contract during physical activity will increase blood flow so that more capillaries will open (Anggriawan, 2015).When more capillaries open, it can trigger more insulin receptors and the receptors become more active, therefore blood glucose levels will decrease by themselves. In addition to reducing blood sugar levels, physical activity using a treadmill can also increase muscle strength, especially lower leg muscles (Istiqamah, & Julia, 2022).

In line with previous research that Physical activity is closely related to metabolic disease because if someone does not do physical activity 30 minutes per day or 3 times a week, this will happen fat buildup in the body and insufficient insulin to convert glucose into energy which results the occurrence of T2DM with increased blood glucose (Subiyanto, 2018). This is also supported by the results that physical activities such as daily activities and regular physical exercise carried out 3-4 times a week for approximately 30 minutes is one of the steps in managing T2DM (Putra, & Berawi, 2015).

Results in other studies also show this *rexistence exercise* which is done regularly is proven to improve glycemic control, reduce the degree of neuropathic, where *resistance exercise* This can be done by increasing the training load, either using weights or increasing resistance during training. Implementation *resistance exercise* What is recommended is 2-3 times a week with a duration of approximately 30 minutes in each training session, each movement is repeated 10-12 times for both extremities top or bottom. The recommended rest interval for repetitions is 30-60 seconds between each exercise and 3-5 minutes before the next training session. After completing the training session, it is recommended to cool down for 5-10 minutes. The impact of training will appear after a minimum of 24 times training. Resistance exercise in DM patients requires supervision both from the patient himself and from other people (family or health workers) in case monitoring blood sugar before and after activity and monitoring the possibility of injury during exercise (Suryawan, Dahlia, Yona, & Kurnia, 2022).

Resistance training has the potential to increase muscle mass and adipose tissue, namely adiponectin which is an anti-inflammatory protein that increases insulin sensitivity, increases glucose transport to skeletal muscle via the GLUT4 protein (*Glucose Transporter*), as well as increased mitochondrial function and content (Reusch, Regensteiner, Stewart, & Veves, 2017). It was stated in previous research that, combination *aerobic* and *resistance training* carried out with appropriate frequency, duration, intensity and repetition can improve glycemic control in DM patients with

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indicators of blood sugar stability and HbA1c (Suryawan, Dahlia, & Kurnia, 2022).

The results of this study showed that hemoglobin levels decreased during 6 weeks of exercise *treadmill* resulting in a reduction in DPN symptoms. Apart from that, providing training *treadmill* for 6 weeks showed a decrease in pain, both when resting, standing, walking and doing heavy activities. A decrease in pain can result in an increase in lower leg muscle strength so that it can improve static and dynamic balance in T2DM patients with DPN. Good patient balance can improve physical fitness so that the patient's sleep quality and self-confidence improves, as well as an increase in social participation which can influence the improvement of the patient's quality of life.

In addition, the results showed changes in T2DM patients with DPN when they were not given exercise *treadmill* for 2 weeks. The patient's hemoglobin level increases so that the symptoms of DPN also increase. When no treatment is given for 2 weeks, the pain experienced by the patient will increase as a result of which the muscle strength in the lower limbs will decrease which can cause the patient's balance to also decrease. Decreased balance will result in a decrease in physical fitness, which will affect the quality of sleep and even the patient's quality of life.

CONCLUSION

Providing treadmill training for 6 weeks carried out 3 times a week showed significant results in reducing hemoglobin levels and DPN scores in T2DM patients.

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