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APPLICATIONS OF DIABETIC FOOT EXERCISE TO INCREASE FOOT SENSITIVITY IN ELDERLY WITH TYPE 2 DIABETES MELLITUS

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Research Report

ABSTRACT

Introduction: *Diabetes Mellitus is one of the global health emergencies. Approximately 40-59% of all people with diabetes mellitus will experience diabetic peripheral neuropathy with decreased foot sensitivity. Diabetic foot exercise can improve blood circulation, especially in the legs or lower limbs. This case study was aimed to determine the increased foot sensitivity in elderly with Type 2 Diabetes Mellitus after diabetic foot exercise.* ***Methods:*** *This case study design used a descriptive method with a family nursing care approach. The case study will be carried out at Sendangmulyo, Semarang in June 2023. There were 3 clients in the family developmental stage of the elderly with Type 2 Diabetes Mellitus who were selected using a purposive sampling technique. Inclusion criteria in this study were type 2 diabetics aged ≥ 60 years, female, diagnosed of diabetes > 5 years, and having controlled OADs. While the exclusion criteria were type 2 diabetics with diabetic ulcers. Clients are given foot exercises for 7 days with a duration of 30-45 minutes each. The case study instrument was 10g Retractable Monofilament with a diameter of 0.4 mm.* ***Results:*** *After 7 days of intervention, there was an increased foot sensitivity, with a mean increased score on right and left foot of 0,43 and 0,33.* ***Conclusions:*** *Diabetic foot exercise for 7 days with a duration of 30-45 minutes can increase foot sensitivity in elderly with Type 2 Diabetes Mellitus. Increased foot sensitivity is due to peripheral blood vessel vasodilation. Diabetic foot exercise can be applied as an independent measure to prevent diabetic peripheral neuropathy.*

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INTRODUCTION

Diabetes Mellitus is one of the fastest growing global health emergencies in the 21st century (International Diabetes Federation, 2021). International Diabetes Federation estimated that 10.5% of the worlds adult population living with diabetes in 2021 (International Diabetes Federation, 2021). This number is predicted to reach 11.3% by 2030 and 12.2% by 2045. Indonesia is a developing country that ranks 5th in the worlds with the highest diabetes cases of 19.5 million people in 2021 (International Diabetes Federation, 2021).

According to Riset Kesehatan Dasar data, the prevalence of diabetes reached 6.9% in 2013 and increased to 8.5% in 2018 (Riskesdas, 2018). The number of people with diabetes in Central Java reached 9.12% in 2021 and increased to 10% in 2022 (Dinas Kesehatan Provinsi Jawa Tengah, 2022). The incidence of diabetes was relatively high based on the distribution of non-communicable disease (NCD) cases in public health centers in Semarang City, there were 6581 people with insulin-dependent of diabetes and there were 32,318 people with non-insulin-dependent of diabetes in 2019 (Dinas Kesehatan Kota Semarang, 2019). Based on the random blood sugar screening at RW 9, Kelurahan Sendangmulyo, there were 52.63% of the elderly had random blood sugar above 125 mg/dL.

Type 2 Diabetes Mellitus is the most common type of diabetes, it accounts for more than 90% of all diabetes cases in the worldwide (International Diabetes Federation, 2021). Chronic hyperglycemia with inappropriate management can caused vascular complications such as neuropathy (Yulita et al., 2019). The risk of developing neuropathy increases with the aging process and the duration of diabetes diagnosed (Sembiring et al., 2018). Neuropathy occurs in 40-59% of all diabetics. 27-57% of the diabetics with neuropathy is between 50-60 years old and increase to 50-100% when over 70 years old (Dwiastuti & Rahman, 2021).

Neuropathy is a disease that attacks the nervous system, including sensory, motor, and autonomic nerves. Neuropathy is more common in the peripheral nerves and is known as diabetic peripheral neuropathy (Rosyid & Angraini, 2022). Peripheral neuropathy occurs in the distal nerves, especially the nerves of the lower extremities (Dwiastuti & Rahman, 2021). Inappropriate management of diabetic peripheral neuropathy can caused loss of sensation in the lower extremities and can significantly caused complications such as foot injuries and ulcerations which resulted in amputation of the lower extremities (Graciella & Prabawati, 2020).

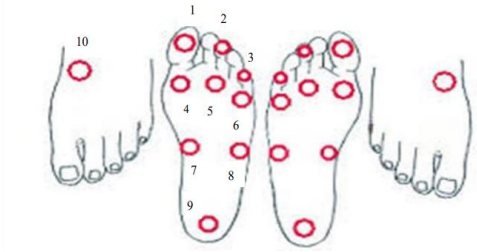
Physical exercise such as diabetic foot exercise can be an alternative prevention the severity of diabetic peripheral neuropathy (Qurotulnguyun et al., 2018). Diabetic foot exercise is the muscles and joints of foot movement to increase the calf and thigh muscles strengthness, improve blood circulation, prevent foot deformities, and improve the limitations of joints motion (Graciella & Prabawati, 2020). Study conducted by Rosyid & Angraini (2022) stated that there was an increased foot sensitivity after diabetic foot exercise for 7 days. Another study conducted by Sukartini et al. (2019) showed that there was an increased foot sensitivity after diabetic foot exercise.

This case study was aimed to determine the application of diabetic foot exercise to increase foot sensitivity in the elderly with Type 2 Diabetes Mellitus.

MATERIALS AND METHODS

This case study design used a descriptive method with a family nursing care approach which includes assessment, nursing diagnose, intervention, implementation, and evaluation after diabetic foot exercises for 7 days. Respondent in this case study were 3 clients in the family developmental stage of the elderly with Type 2 Diabetes Mellitus who were selected using a purposive sampling technique (Nursalam, 2020). Inclusion criteria in this case study were type 2 diabetics aged ≥ 60 years, female, diagnosed of diabetes > 5 years, and having controlled OADs (Akter et al., 2019; Suharni et al., 2022). While the exclusion criteria were type 2 diabetics with diabetic ulcers (Suharni et al., 2022). Inclusion criteria in this case study was female based on data Riskesdas, (2018) which stated that the prevalence of Type 2 Diabetes Mellitus was higher in female by 1.78%. The case study was carried out at Sendangmulyo, Semarang in June 2023.

The instrument in this case study used a 10 g Retractable Monofilament with a diameter of 0.4 mm which was pressed at 10 sites on the client's foot. The client's inability to feel the monofilament test sensation will be recorded with a score of 0 and normal is recorded with a score of 1. Sensitivity measurements were carried out before and after the diabetic foot exercise intervention.



Monofilament Test Examination Location
Source: Nothern Devon Healthcare, (2020)

Based on the figure, there are 10 sites for the monofilament test, including: 1) Plantar aspect of first toe (great toe); 2) Plantar aspect of third toe; 3) Plantar aspect of fifth toe; 4) Plantar aspect of first metatarsal head; 5) Plantar aspect of third metatarsal head; 6) Plantar aspect of fifth metatarsal head; 7) Plantar aspect of the midpoint of the medial longitudinal arch; 8) Plantar aspect of fifth metatarsal tuberosity; 9) Plantar aspect of calcaneal tuberosity (heel); 10) Dorsal aspect of mid-foot (dorsal) (Northern Devon Healthcare, 2020).

Table 1. Monofilament Test Examination Interpretation

	Interpretation
Low risk	Able to feel touch or sensation at less than 8 sites and palpable pulse
Moderate risk	Not feeling the touch at more than 8 sites, absent pulses or other risk factors (poor footwear, social circumstances, poor diabetes control)
High risk	Not feeling the touch at more than 8 check points, absent pulses plus foot deformity or skin changes/thickening (erythema, callous/corn previous ulcer or amputation)
Emergency condition	New Ulceration, Swelling Spreading cellulitis discolouration

Source: Nothern Devon Healthcare, (2020)

Diabetic foot exercise includes: 1) The subject sits upright on a chair with foot placed on the floor; 2) Putting the heels on the floor by straightening and gripping the toes for 10 movements; 3) Putting the heel on the floor with the sole of the foot lifted up followed by placing the toe and lifting the heel up for 10 movements; 4) Putting the heel on the floor by lifting and rotating the front of the foot for 10 movements; 5) Putting toes on the floor by lifting and rotating

heels for 10 movements; 6) Lifting the foot by straightening the knee and rotating the ankle for 10 movements; 7) Lifting the foot by straightening the knee and bending and straightening the ankle for 10 movements; 8) Squeezing the newspaper by forming a ball using both foot (Az Zahra, 2022).

RESULTS

Assessment

Based on the studies that have been carried out, characteristics of the three case study subjects were obtained as follows:

Table 2. Characteristics of Case Study Subjects at Semarang, June 2023

Subject	Gender	Age	Long Diagnosed of Diabetes Mellitus	Oral Anti-Diabetes Mellitus Drugs (OADs)
1	Female	62	7	Gliquidon 30 mg
2	Female	66	6	Glimepiride 1 mg
3	Female	66	9	Glimepiride 1 mg
Mean		64,7	7,3	

Results of the study that was carried out showed that three subjects were female, had a mean age of 64.7 years, had a mean duration of Diabetes Mellitus diagnosed 7.3 years, and controlled OADs such as gliquidone 30 mg and glimepiride 1 mg. Three subjects were at the family developmental stage of elderly and two of them had a hereditary disease of Diabetes Mellitus. The mean random blood sugar level is 210 mg/dl. The mean score foot sensitivity on the right and left foot is 2 and 2.67. Three subjects had symptoms such as tingling, numbness, and thickness on the foot and admitted that they did not understand the Diabetes Mellitus. This statement was proven by poor diabetes management such as lack of physical activity. Family care functions assesment found that the subjects' family members said that they did not know diabetes. Their family said that they had not been able to carry out treatment for the subjects to reduce these symptoms.

Nursing Diagnose

The main nursing diagnose in this case study was ineffective family health management (D.0115) (PPNI, 2016a). Assessment data results that subject and their families do not know about diabetes treatments with decreased foot sensitivity.

Intervention

Nursing interventions in this case study subjects is physical exercise education (I.12389) (PPNI, 2016b). Planned physical exercise education is diabetic foot exercise which consists of observation (identification the diabetic peripheral neuropathy symptoms and foot sensitivity score), therapeutic (sitting position and giving diabetic foot exercise), education (educate the function of foot exercise, frequency and duration of implementation). Diabetic foot exercise intervention was carried out for 7 days with a duration of 30-45 minutes.

Implementation

Nursing implementation was carried out for 13 days in this case study. The first day visit carried out an assessment, determine of a nursing diagnose, and educate the diabetes disease process. On the second day visit, education of diabetes was carried out including the definition, etiology, symptoms, and normal random blood glucose level. The third day visit was education about complications and prevention of diabetes complications. On the fourth day visit, education was conducted regarding diabetic foot exercises including the definition, purpose, and diabetic foot exercise procedures. On the fifth day visit, educate the diabetics foot treatments. On the sixth day visit, education was carried out regarding the diet diabetics including the types of food that must be limited and avoided for diabetics. On the seventh day to the thirteenth day visit, diabetic foot exercise was carried out for 7 days with a duration of 30-45 minutes and measurement of foot sensitivity using a monofilament test pre post intervention.

Evaluation

After diabetic foot exercises for 7 days with a duration of 30-45 minutes, the results of measuring foot sensitivity were obtained as follows:

Table 3. Mean Foot Sensitivity Increased of the Subjects

Subject	Right foot		Left Foot		Mean Increased	
	Pre	Post	Pre	Post	Right foot	Left Foot
1	4.14	4.57	3.43	3.71	0.43	0.28
2	3.57	4	4.29	4.71	0.43	0.42
3	1.86	2.29	2.43	2.71	0.43	0.28
Average	3.19	3.62	3.38	3.71		
Increased	0.43		0.33			

Based on table, shows that the subjects experienced a decrease in protective sensation before the intervention, as proven by the client being able to feel touch at <8 sites and included in the low risk category of experiencing diabetic peripheral neuropathy. After 7 days of intervention, it was shown that there was an increased foot sensitivity in the subjects. The mean increased foot sensitivity of the subjects on the right and left foot was 0.43 and 0.33.

DISCUSSION

Assessment

Diabetes Mellitus is a long-term metabolic disease that occurs when raised levels of blood glucose occur because the body cannot produce any or enough of the hormone insulin or cannot effectively use the insulin it produces (International Diabetes Federation, 2021). Three subjects in this case study was diagnosed Diabetes Mellitus more than 40 years old because in line with the aging process there is a decreased body's ability to metabolize blood glucose resulting in a decrease in insulin secretion from pancreatic β cells (Paojah & Yoyoh, 2019). Type 2 diabetes is characterized by hyperglycemia due to the inability of the body's cells to respond fully to insulin, a condition termed insulin resistance (International Diabetes Federation, 2021). Along with long-term hyperglycemia conditions, there is an accumulation of glucitol and fructose and a myo-inositol decreased which can cause neuropathy (Embuai et al., 2019). Peripheral neuropathy is caused by the use of the polyol pathway for glucose metabolism, causing an increase in reactive oxygen and oxidative stress which causes neuronal damage and decreased perfusion (Rosiani et al., 2018).

This case study showed that mean age of the subjects was 64.7 years. Elderly are a high risk population of experiencing peripheral neuropathy due to complications of diabetes which is a long-term impact of hyperglycemia, with the result that neuropathy is most commonly found in older diabetics (Mawaddah et al., 2022). In line with research conducted by Rahmawati & Hargono, (2018) that peripheral neuropathy is most commonly in the age group of 61-70 years as much as 41.7%. With increasing age, the accumulation of cellular and molecular damage increases as a result of long-term hyperglycemia which causes nerve demyelination or axonal damage resulting in an increased risk of sensory peripheral neuropathy (Mawaddah et al., 2022).

Three subjects in the case study were female according to the data Riskesdas, (2018) which stated that the prevalence of Type 2 Diabetes Mellitus was higher in female by 1.78% compared to male by 1.21%. This is in line with the research conducted by Graciella & Prabawati, (2020) which shows that peripheral neuropathy is most commonly in diabetics with female by 66.7%. Female are high risk of experiencing diabetic peripheral neuropathy because the large amount of the estrogen hormone in women can interfere with the absorption of iodine which plays a role in nerve myelination which triggers sensory peripheral neuropathy (Mawaddah et al., 2022).

The results of the study showed that the subjects had diagnosed diabetes for more than 5 years with symptoms such as tingling, numbness and thickness on the foot. The duration of diabetes diagnosed and these symptoms causes a decreased foot sensitivity, with the result that they are a high risk of experiencing complications of peripheral neuropathy (Rahmawati & Hargono, 2018). Hyperglycemia that occurs in the long term can caused non-enzymatic glycosylation reactions between reducing sugars and proteins amino. Decreased protein glycosylation can trigger the formation of advanced glycation end products (AGEs) which cause peripheral nerve damage and decrease neuronal vasodilation resulting in peripheral neuropathy (Suharni et al., 2022). In addition, the length of time a people diagnosed diabetes triggers changes in the blood vessels, capillary membranes and thickening of the endothelial cells, causing a decrease in oxygen tension and hypoxia. This process underlies the occurrence of endoneural ischemia, causing sensory peripheral neuropathy (Mawaddah et al., 2022)

Three subjects in this case study regularly consume OADs such as Gliquidone 30 mg and Glimepiride 1 mg which are the second choice drugs for Type 2 diabetes which work by inducing the scretion of insulin hormone from pancreatic β cells (Hardianto, 2020; Sola et al., 2018). Based on research conducted by Akter et al., (2019) stated that the worse the glucose control in diabetics, increased the risk of experiencing severe neuropathy. Insulin and oral anti-diabetic drugs (OADs) controlled can reduce the probability of peripheral neuropathy by 3.93 times compared to the uncontrolled drugs (Azmiardi et al., 2019).

The subjects had symptoms such as tingling, numbness, and thickness on the foot. Common symptoms of neuropathy include paresthesia (tingling or prickling feeling), numbness, decreased sensitivity of touch, pain, and temperature (International Diabetes Federation, 2021). The mean foot sensitivity scores of the subject showed results on the right and left feet of 2 and 2.67. Based on the foot sensitivity score, subjects experienced decreased protective sensation because they can only feel touch at < 8 sites and are included in the low risk category of experiencing diabetic peripheral neuropathy (Northern Devon Healthcare, 2020).

Nursing Diagnosis

The main symptoms of the subjects were felt tingling, numb, thick on the foot and their family said that they had not been able to treat the subjects to reduce these symptoms so that there was a foot sensitivity decreased. Based on the assessment that was carried out on the subjects, it was found that the nursing diagnosis was ineffective family health management (PPNI, 2016a). Decreasing foot sensitivity can increase the risk of diabetic peripheral neuropathy which can significantly cause complications such as foot injuries and ulcerations which result in amputation of the lower extremities (Graciella & Prabawati, 2020).

Intervention

Diabetes Mellitus can be handled in four main pillars including providing health education, nutritional therapy, pharmacological therapy, and physical exercise (Perkumpulan Endokrinologi Indonesia (PERKENI), 2021). Physical exercises such as diabetic foot exercises can be an alternative prevention the severity of diabetic peripheral neuropathy (Qurotulnguyun et al., 2018). The intervention applied to the subjects was physical exercise education (PPNI, 2016b). The planned physical exercise education is diabetic foot exercise consisting of observation (identification of diabetic peripheral neuropathy symptoms and foot sensitivity level), therapeutic (sitting position and giving diabetic foot exercise), education (educate the function of foot exercise, frequency and duration of its implementation). Diabetic foot exercise is a physical exercise to help improve blood circulation in the leg and prevent foot deformities (Rosyid & Angraini, 2022; Sukartini et al., 2019). In this case study, diabetic foot exercises will be administered for 7 days with a duration of 30-45 minutes (PERKENI, 2021; Rosyid & Angraini, 2022).

Implementation

The implementation of diabetic foot exercise which was carried out for 7 days with a duration of 30-45 minutes showed an increase in foot sensitivity in the subjects who were measured pre and post intervention foot exercise. The mean foot sensitivity increased in the subjects on the right and left foot was 0.43 and 0.33. Subjects experienced an foot sensitivity increased after the application of diabetic foot exercises, the results in this case study were in line with the study conducted by Embuai et al., (2019) states that diabetic foot exercises can increase foot sensitivity.

Routinely foot exercise can improve microvascular function and neurotrophic factors. Increasing Neurotrophin-3 (NT-3) which is stimulated during foot exercises is associated with an increase in peripheral nerve conduction and a reduction in neuropathic pain. Neurotrophin-3 (NT-3) plays a role in the process of neuronal differentiation to encourage the growth of new synapses and neurons (Sukartini et al., 2019).

Evaluation

The results of this case study showed that all three subjects experienced increased foot sensitivity. This is in line with other studies conducted by Sanjaya et al., (2019) which states that foot exercise can increase foot sensitivity in diabetics. Foot exercise is considered to reduce sorbitol levels in the body so that it can prevent a decrease in blood flow in endoneural blood flow. In addition, the application of foot exercises can produce action potentials resulting in depolarization which triggers an increase in Na+/K+ ATP activity and an increase axonal transport resulting in sensory sensation increased (Sukartini et al., 2019).

Another study conducted by Graciella & Prabawati, (2020) stated that was in line with this case study, there was a mean peripheral neuropathy score decreased after foot exercise. During diabetic foot exercises, there is an oxygen decreased which causes dilatation of the muscle arterioles. Muscles use oxygen rapidly during foot

exercises, reducing the amount of oxygen in the tissues. In the absence of oxygen, the walls of the arterioles cannot continue to contract and are deprived of oxygen, causing the release of vasodilators. This triggers local arteriolar vasodilation so that all capillaries open and blood flow increases. Blood flow can transport oxygen and nutrients to the tissues and nerve cells and affects the metabolic processes of Schwann cells so that axon function is maintained (Sukartini et al., 2019).

The movement of the foot while doing diabetic foot exercises triggers stretching of the foot muscles and compression of the veins around the muscles, this mechanism can encourage blood flow towards the heart and cause venous pressure to decrease which is known as the venous pump mechanism (Rosyid & Angraini, 2022). During this mechanism, it can improve blood circulation, prevent foot deformities, and overcome joint limitations (Graciella & Prabawati, 2020). Smooth blood circulation can inhibit the process of tearing the myelin sheath on neurons which has the potential to damage axons. If the neuron cells are in good condition, the process of transmitting impulses to sensory, motor, and autonomic cells will also provide adequate protection (Rosyid & Angraini, 2022).

Foot exercise is considered to have an effect on the status of peripheral neuropathy in Type 2 diabetics because during foot exercises there is active movement of the foot muscles (Oktorina et al., 2021). The foot muscles movement during exercise can compress the blood vessels thereby triggering the release of nitrite oxytocin (NO) which is produced from the conversion of amino acids (L arginine to L citrulline) with the help of the enzyme nitrite oxytocin synthase by endothelial cells (Yulita et al., 2019). When there is relaxation of the smooth muscle of blood vessels, it triggers vasodilation of peripheral blood vessels. When peripheral blood vessel vasodilation occurs, the nerve cells in the periphery receive oxygen and nutrients so that they can convey transmission, and trigger an sensitivity increased in peripheral sensory nerve cells (Sukartini et al., 2019; Yulita et al., 2019).

In this case study, researchers implemented diabetic foot exercise in the elderly who experienced symptoms of peripheral neuropathy in accordance with existing theories and journals. Diabetic foot exercise was carried out routinely for 7 days with a duration of 30-45 minutes. During the implementation process, researchers did not find any obstacles and got the expected results. These are supported by other supporting factors such as the use of Oral Anti-Diabetes Mellitus Drugs (OADs) and controlled blood sugar.

CONCLUSIONS

Diabetic foot exercise for 7 days with a duration of 30-45 minutes can increase foot sensitivity in elderly with Type 2 Diabetes Mellitus. Increased foot sensitivity is due to peripheral blood vessel vasodilation. Diabetic foot exercise can be applied as an independent measure to prevent diabetic peripheral neuropathy.

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