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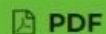
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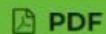
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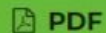
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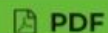## The Peripheral Vascular Status in Individuals with Type 2 Diabetes Mellitus

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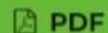
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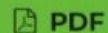
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The Peripheral Vascular Status in Individuals with Type 2 Diabetes Mellitus

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ARTICLE INFORMATION

A B S T R A C T

Poor vascularization in individuals with diabetes will worsen blood circulation due to high glucose in the blood. One of the risk factors leading to diabetic foot ulcers (DFU) is peripheral vascular disease. This study aims to identify the peripheral vascular status in individuals with type 2 diabetes mellitus (T2DM) at Kebonsari Public Health Centre, Surabaya. The research design in this study used a quantitative descriptive approach. There were 40 respondents with an accidental sampling. The data collection was carried out for four weeks, from May to June 2020. The research instrument was an observation sheet to record the Dorsalis Pedis artery pulse and ankle-brachial index (ABI). In addition, a digital sphygmomanometer was used to measure the Dorsalis Pedis artery pulse. Most respondents had the normal Dorsalis Pedis artery pulse in the right legs (80%), 20% had bradycardia, and none had tachycardia (0%). In addition, they had the normal Dorsalis Pedis artery pulse in the left legs (70%), 20% had bradycardia, and none had tachycardia (0%). Furthermore, they had the normal ABI values in the right legs (55%), 45% had borderline ABI values, and none had ischemic and critical ischemic (0%). In addition, they had the normal ABI values in the right legs (52%), 47% had borderline ABI values, and none had ischemic and critical ischemic (0%). Most individuals with T2DM at the Kebonsari Public Health Center, Surabaya, had normal peripheral vascular status. However, few respondents had bradycardia in the Dorsalis Pedis artery pulses, and almost half had borderline ABI values.

INTRODUCTION

Degenerative non-communicable diseases (NCDs) are a global and local public health problem. The World Health Organization (WHO) in 2010 reported that Diabetes Mellitus (DM) is one of the non-communicable diseases with an increasing number of sufferers. It has attracted a lot of attention because of the expanding number of sufferers and the growing complications of diabetes, such as vascular disorders or angiopathy in the diabetic foot (Bistara *et al.*, 2020).

Poor vascularization in individuals with diabetes will worsen blood circulation due to high glucose in the blood. It results in narrowing, blockage, and poor blood circulation (Bistara *et al.*, 2022). This condition, coupled with advanced age and comorbidities (cardiovascular), can worsen blood circulation. Further, poor management of diabetic foot angiopathy can become diabetic foot ulcers (DFU). In conclusion, one of the risk factors leading to diabetic foot ulcers is peripheral vascular disease (Embuai, 2019). Thus, examining peripheral vascular status is essential to prevent DFU.

Research conducted by Norman, Davis, and Bruce in America (2016) explained the incidence of Peripheral Artery Disease (PAD) was 13.6% of the 1,294 samples. In addition, the PAD incidence in individuals with diabetes was 3.7% per year. Furthermore, a study revealed that patients with diabetes were four times more likely to lead peripheral arterial insufficiency caused by atherosclerosis (Bill and

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Letter, 2019). World Health Organization (WHO) estimates there will be 21.3 million individuals with DM in Indonesia in 2030. In addition, 15% of them will experience complications of diabetic ulcers, especially DFU. Furthermore, the Surabaya District Department of Health Office in 2018 reported that 199,104 individuals with DM registered with health providers in the southern city of Surabaya (Huda and Widayanti, 2019). The preliminary study at the Kebonsari Public Health Center in Surabaya found that 5 of 7 individuals with type 2 diabetes mellitus (T2DM) had foot ischemia.

Disorders of blood vessels in type 2 diabetes can occur in macrovascular (macroangiopathy) & microvascular (microangiopathy). Macroangiopathic disorders are associated with atherosclerosis causing the narrowing of large and medium arteries in the lower legs and feet (Ainiyah *et al.*, 2022). In addition, hypertriglyceridemia and hypercholesterolemia play a role in atherogenesis. Individuals with diabetes mellitus are the potential to have narrowing of the tibial and personal arteries between the knee and ankle. Then, the decreased supply of oxygen and nutrients causes an ischemic foot. Ischemic foot is characterized by rest pain; reduced pulse rate in the Dorsalis Pedis, tibial and popliteal arteries; and cold feet and thickened nails. Furthermore, tissue necrosis and ulcers usually begin from the tip of the foot or leg (Hikmat Permana, 2018).

In addition, microangiopathy leads to capillary thrombosis, so blood vessels become stiff (reduced relaxation). Then, the condition makes it difficult for erythrocytes to pass due to the thickening of the basement membrane. As a result, there is capillary obstruction so that the tissue becomes ischemic. Eventually, the tissue becomes necrotic and causes diabetic ulcers (Chaidir, Wahyuni, and Furkhani, 2017).

The ankle-brachial index (ABI) measurement can determine peripheral vascular disorders (Husin, Hudaja, and Kristianto, 2016). It is a non-invasive examination often used in individuals with DM and PAD to determine peripheral vascular status. Furthermore, it can assess the prognosis of the diabetic foot and follow up with appropriate wound management. An investigation conducted in China by Xu et al. showed a high specificity (83.3-99.0%) and high accuracy (72.1-89.2%) on the ABI (Ante Brachial Index) $\leq$ 0.90 in detecting vessels stenosis $\geq$50% (Pebrianti, Nugraha and Platini, 2018). In addition, research reported that the sensitivity rate of ABI measurement was 95%, and its specificity was almost 100% (Hijriana and Sahara, 2020). The ABI measurement method is a simple and non-invasive procedure that makes patients feel comfortable. In addition, it only takes less than 15 minutes. Moreover, the cost is affordable. This study aims to identify the peripheral vascular status in individuals with type 2 diabetes mellitus (T2DM) at Kebonsari Public Health Centre, Surabaya.

METHOD

The research design in this study used a quantitative descriptive approach. There were 40 respondents with an accidental sampling. Inclusion criteria were individuals with T2DM treated at Kebonsari Health Center Surabaya and taking diabetic medication. The exclusion criteria were individuals with foot ulcers. The data collection was carried out for four weeks, from May to June 2020. The research instrument was an observation sheet to record the Dorsalis Pedis artery pulse and ankle-brachial index. In addition, a digital sphygmomanometer was used to measure the Dorsalis Pedis artery pulse. The classification of Dorsalis Pedis artery pulse is tachycardia (pulse rate >100x/minute), bradycardia (pulse rate <60x/minute), and normal (pulse rate 60-100x/minute). The ankle-brachial index (ABI) test was measured by counting the right and left Dorsal Pedis arteries' systolic divided by the right and left brachial arteries' systolic. The interpretation of ABI is critical ischemia (score <0.4), severe ischemia (score <0.5), borderline (score 0.6 –0.8), and normal (score $\geq 0.9 - 1.3$). The ethical clearance of this research was carried out at Sekolah Tinggi Ilmu Kesehatan Hang Tuah Surabaya with certificate number PE/30/VI/2020/KEPK/SHT.

RESULT

Most respondents were female (55%), 49-55 years old (47.5%), and housewives (40%). In addition, they graduated from Senior High School (50%). Furthermore, they did regular checkups with healthcare providers (77.5%) and performed foot care and diabetic foot exercise (75%) (Table 1).

Table 1 Characteristics of Respondents in Individuals with Type 2 DM at the Kebonsari Public Health Surabaya from May to June 2020 (n=40)

Characteristics of Respondent		Total	Percentage
Sex	Male	18	45 %
	Female	22	55 %
Age	49 – 55 years	10	47.5 %
	56 – 61 years	23	40 %
	62 – 67 years	12	12.5 %
Education	Elementary School	11	13 %
	Junior High School	7	30 %
	Senior High School	21	50 %
	University	2	5 %
Occupation	Labor	7	17.5%
	Housewife	16	40%
	Government Employees	3	7.5%
	Retired	1	2.5%
	Private Employees	13	32.5%
Regular checkups with healthcare providers	Yes	31	77.5 %
	No	9	22.5%
Foot care and diabetic foot exercises	Yes	30	75 %
	No	10	25 %

Table 2 shows that of 40 respondents, most have the normal Dorsalis Pedis artery pulse in the right legs (80%), 20% have bradycardia, and none have tachycardia (0%). In addition, most respondents have the normal Dorsalis Pedis artery pulse in the left leg (70%), 20% have bradycardia, and none have tachycardia (0%).

Table 2 Dorsalis Pedis artery pulse in Individuals with Type 2 DM at the Kebonsari Public Health Surabaya from May to June 2020 (n=40)

Pulse Rate	Right Leg		Left Leg	
	Frequency	Percentage	Frequency	Percentage
Normal (60-100)	32	80%	28	70%
bradycardia (<60)	8	20%	12	30%
Tachycardia (>100)	0	0%	0	0%
Total	40	100%	40	100%

Table 3 indicates that of 40 respondents, most have the normal ankle-brachial index in the right legs (55%), 45% have borderline ABI values, and none have ischemic and critical ischemic (0%). In addition, most respondents have the normal ankle-brachial index in the right legs (52%), 47% have borderline ABI values, and none have ischemic and critical ischemic (0%).

Table 3. Ankle Brachial Index in Individuals with Type 2 DM at the Kebonsari Public Health Surabaya from May to June 2020 (n=40)

Ankle Brachial Index	Right Leg		Left Leg	
	Total	Percentage	Total	Percentage
Normal	22	55%	21	52%
Borderline	18	45%	19	47%
Ischemic	0	0%	0	0%
Critical Ischemic	0	0%	0	0%
Total	40	100%	40	100%

DISCUSSION

This study found that most respondents had normal Dorsalis Pedis artery pulses in the right and left legs (Table 2). It may be because most of them did regular checkups with healthcare providers and performed foot care and diabetic foot exercises (Table 1). Foot care and diabetic foot exercises can help increase sensitivity and improve glycemic control by increasing pressure in the arteries. It can cause the widening of the arterial walls and pressure of peripheral blood vessels in the vascular channels of the feet (Santosa and Widi Rusmono, 2016). In addition, it reduces the plaques in the blood vessels due to atherosclerosis or others. So that blood circulation becomes smoother and the Dorsalis Pedis pulse becomes stronger (Arif, 2018). A previous study showed that foot exercise could increase the Dorsalis Pedis pulse in individuals with type 2 diabetes. The study indicated that the mean pulse rate before the intervention was 72,058 times/minute and 79,647 times/minute after the intervention (Arif, 2018). Furthermore, regular checkups help control the pulse frequency within the normal range. It includes pulse frequency, blood

pressure, blood sugar examinations, and other tests for individuals with diabetes. Furthermore, it can early detect diabetes complications (Bistara, Zahroh and Wardani, 2019).

However, few respondents had bradycardia in the Dorsalis Pedis artery pulses in the right and left legs (Table 2). It may be because a few did not do foot care and diabetic foot exercises (Table 1). Individuals with diabetes who do not perform foot care and diabetic foot exercise potentially decrease blood flow to the legs due to continuous hyperglycemia. As a result, hyperglycemia can damage blood vessels and nerves. In addition, it can thicken the blood flows in blood vessels, resulting in decreased blood flow to the feet' skin and nerves (D. d. A. Y. Handaya, 2016). Bradycardia in uncontrolled diabetes can lead to diabetic retinopathy, heart disease, and nerve damage. It also can cause diabetic foot ulcers. Furthermore, 15% of diabetes incidences develop into diabetic foot ulcers within five years (Huda, 2017).

Almost half respondents in this paper were 49-55 years (Table.1). According to the Ministry of Health Republic of Indonesia, the age is classified as early elderly. As age increases, the recurrence rate of diabetic foot ulcers increases by 70%. It is because insulin resistance increases with advancing age. Insulin resistance contributes to decreased muscle mass (sarcopenia), overweight, reduced physical activity, and decreased pancreas function (Sujana, 2019).

According to Eva Decroli (2019), the duration of diabetes mellitus predisposes blood circulation disorders (angiopathy). It occurs because individuals who have had diabetes for years' experience narrowing or blockage of blood vessels, especially in the lower extremities, because of blood viscosity due to high blood glucose levels. Hyperglycemia affects the flexibility of red blood cells to release oxygen so that there is decreased oxygen supply. As a result, peripheral hypoxia causes ineffective peripheral tissue perfusion. Inadequate peripheral tissue perfusion can be characterized by weak pulse, changes in motor function, differences in skin characteristics, CRT filling time > 3 seconds, the presence of extremity edema, pain, tingling, and changes in skin color to pale or cyanosis (Huda, 2017; Huda and Widayanti, 2019).

Our findings also showed that half of the respondents had a normal ankle-brachial index in the right and left legs (Table 3). It may be because most of them did regular checkups with healthcare providers and performed foot care and diabetic foot exercises (Table 1). The Kebonsari Public Health Centre has programs to prevent diabetic foot in individuals with diabetes. Normal ankle-brachial index means that blood is circulating well without any significant obstruction to the peripheral blood vessels. Thus, blood circulation adequately meets nutritional and oxygen supplies in the lower extremities. ABI evaluates foot vascularization in individuals to detect chronic complications of diabetes, one of which is diabetic foot ulcers (DFU). Furthermore, neurological abnormalities, vascular disorders, or peripheral artery disease (PAD) can cause DFU. Vascular disorders in the form of blockages in peripheral arteries can cause foot ulcers. Thus, diabetic foot ulcers are often associated with the ankle-brachial index (Dahlia *et al.*, 2019).

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Diabetic foot exercise can improve circulation, especially in the foot area (Guirguis-Blake *et al.*, 2018). Foot movements performed during diabetic foot exercises are like a foot massage. The movements apply pressure and can increase endorphin secretion. The hormone reduces pain and blood vessel vasodilatation, resulting in a decrease in blood pressure, especially brachial systolic pressure, which is directly related to the ankle-brachial index (Bozkurt *et al.*, 2011). A prior investigation revealed that most respondents (71.4%) who performed diabetic foot exercises had normal ABI values (0.9 - 1) (Megawati, Utami and Jundiah, 2020). Guyton & Hall explain that foot exercise contains movements in the legs, so they can tense up the leg muscles and compress the veins around the leg muscles. The foot exercise pushes blood toward the heart and decreases venous pressure, a mechanism known as a venous pump. The mechanism will improve blood circulation in the legs (Wahyuni, 2013).

However, almost half of the individuals with T2DM in this study had a borderline value of ABI (0.6 to 0.8) (Table 3). It means perfusion changes in blood vessel walls that affect the transport of oxygen and nutrients to tissues. The intima layer thickens due to cellular proliferation and fibrosis. In addition, the fibers in the media layer are calcified, thin, and cut. So, the collagen accumulates in the intima and media layers. These changes cause blood vessel stiffness, resulting in increased peripheral vascular pressure and impaired blood flow (Aulia *et al.*, 2019).

Patients with diabetes often experience changes in the elasticity of the capillaries of blood vessels, thickening of blood vessel walls, and the formation of plaques or thrombi that cause impaired peripheral vascularization. Thus, the Ankle-Brachial Index in individuals with diabetes tends to have lower ABI values than normal (Y. Handaya, 2016). Peripheral blood flow disorders, especially in the legs, are marked by a decrease in the ABI value. It is due to atherosclerosis and lack of physical exercise (Wahyuni, 2013).

CONCLUSION

Most individuals with type 2 diabetes mellitus (T2DM) at the Kebonsari Public Health Center, Surabaya, had normal peripheral vascular status. However, few respondents had bradycardia in the Dorsalis Pedis artery pulses, and almost half had borderline ABI values. Thus, preventing peripheral blood flow disorders in the lower extremities in individuals with T2DM is crucial to prevent diabetic foot ulcers.

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Imroatul Farida - The Peripheral Vascular Status in Individuals with Type 2 Diabetes Mellitus

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- Author Name: Full name without title, name of institution (Study Program, Faculty and University) and email address.
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