Darussalam Nutrition Journal, November 2024, 8(2):167-177 *P- ISSN 2579-8588*
DOI: 10.21111/dnj.v8i2.11492 *E-ISSN 2579-8618*

ANKLE-BRACHIAL INDEX, FASTING BLOOD GLUCOSE, AND BMI SCORES AS PREVENTION AND MANAGEMENT OF THE RISK OF DIABETES MELLITUS COMPLICATIONS

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ABSTRACT

Background*: Diabetes has become an important health problem in the world, with prevalence rates increasing throughout the world. Uncontrolled diabetes can have various negative impacts, mainly increasing risk of complications as well as neuropathy and circulation disorders, which can cause various health problems, including diabetic foot wounds and the risk of amputation. Controlling blood sugar levels is one strategy to prevent the risk of complications. Health screening and monitoring can help in preventing and managing complications of uncontrolled diabetes.* ***Purpose****: The aim of this study was to determine the ankle-brachial index (ABI), spontaneous blood sugar levels (GDS), and body mass index (BMI) scores to prevent complications risk of Diabetes Mellitus in people through a health screening program.* ***Method****: This research was a cross-sectional approach with an observational design. It was conducted in June 2023 at Posbindu Ngrame, Tamantirto subdistrict, Kasihan district, Bantul regency, Yogyakarta province. The number of respondents in the study were 75 people who were taken by accidental sampling technique. Instruments used for data collection includes ABI questionare, microtoice and body scale for measure IMT, and glucose meter for GDS.* ***Results:*** *This study showed that (90.7%) of respondents were female, in the elderly category (41.3%), had primary school education (40%), and were housewives (50.7%). GDS levels were mostly normal (78.7%), BMI category 1 (41.3%), and ABI values were normal category (89.3%).* ***Conclusion****: The description of the risks and complications of DM based on GDS and ABI values is mostly normal, while based on BMI values, most are in the 1st-degree obese category.*

Key words : Screening, prevention, blood sugar, ABI, diabetes

INTRODUCTION

Diabetes mellitus (DM) is a disease with metabolic disorder characterized by hyperglycemia (high glucose level in the blood) due to secretion disorders of insulin, insulin resistance, or both. Diabetes is a global health problem, with prevalence rates increasing throughout the world. Approximately 463 million of diabetes in adults in 2019. In 2045 diabetes case is expected to increase until 700 million (IDF, 2019). Based on Riskesdas 2018, prevalence of diabetes mellitus in Indonesia reach in 37 thousand (10,9 %) (Balitbangkes, 2018).

Diabetes mellitus can cause various complications that have a negative effect including decreased quality of life of diabetic patients and families. These complications can affect organ systems such as the eyes disorder, kidneys, nervous system, heart, and disorder of the blood circulation system. Uncontrolled diabetes can also cause the risk of complications such as neuropathy, retinopathy, nephropathy, cardiovascular disease, ect (Teli, Thato and Rias, 2023) (Saputri et al., 2019).

Complications of diabetes with neuropathy and circulation disorders can cause various health problems, including risk of amputation since of diabetic foot wounds. Untreated diabetic foot wounds can develop into more serious infections and lead to the risk of amputation. Most amputation cases in diabetic patients were the lower legs that can cause decreased quality of life, limited mobility, and increased risk of death (Armstrong et al., 2017).

The risk of complications and worse effects in diabetes patients can be prevented by controlling sugar levels in blood circulation. Regulating sugar levels in blood circulation in diabetes patients can be done through healthy eating patterns, regular exercise, and the use of medication prescribed by a doctor, as well as education and monitoring to increase knowledge and attitudes as well as compliance in controlling blood sugar levels (Prayoga, Sulistyarini and Kristanti, 2018).

Prevention and management of complications in diabetes patients is important. Screening, monitoring and health education can help to prevent and treat diabetes complications. Diabetes screening is a method for early detection of the presence of diabetes in people who do not have symptoms of diabetes. Screening can be done using a simple blood test to measure blood glucose levels. Diabetes screening is important to identify cases of DM at an early stage. It is intended that immediate treatment and prevention of complications can be carried out. In addition, for patients who have been diagnosed with DM, screening is carried out to prevent complications, such as diabetic foot ulcers.

One of the parameters to prevent the risk of DM complications can be done by ankle-brachial index (ABI) examination. Assessing the risk of DM complications using the ABI has several advantages, such as the measurements carried out are non-invasive, so they do not cause pain. Apart from that, the ABI examination procedure is relatively simple and fast, and the level of accuracy is high enough to detect circulation disorders or peripheral diseases in patients (Babaei *et al.*, 2020),(Sartore *et al.*, 2023).

Therefore, The aim of this activity is to provide an overview of the ABI score of diabetic patients that exist in Posbindu Ngrame, Tamantirto sub district, Kasihan district, Bantul regency, Yogyakarta province. This activity was purpose to overcome the

problems by carrying out health screening therefore the complications risk of DM can be prevented and resolved properly.

METHOD

This research uses a descriptive study approach. A descriptive approach was used to describe respondents' characteristic preferences and the results of diabetes mellitus risk screening. The purpose of this study is to determine the risk of DM complications in people through a health screening program. Data collection was carried out at Posbindu Ngrame, Tamantirto sub district, Kasihan district, Bantul regency, Yogyakarta province in June 2023. The population in this study consisted of all members of Posbindu Ngrame in Kelurahan Tamantirto, Kasihan District, Bantul Regency, totaling 92 individuals. The number of respondents in this research were 75 people taken by accidental sampling technique. The inclusion criteria for this study included individuals who attended the Posbindu Ngrame, were aged 18 years and above, and were willing to participate in the diabetes risk screening program. The exclusion criteria in the study included pregnant women and individuals who were unwilling to give consent to participate as respondents. The data collection process was carried out directly involving students and RSUP Dr Sardjito hospital practitioners. The research instruments used were ABI questionnaires, digital blood pressure meters (OMRON), electronic personal scale (GEA) microtoise (GEA) and glucometers (Easytouch). Standard criteria for IMT based on Asian Pacific Standard; described in table 1. Data analysis uses descriptive statistics with tables of frequency distribution.

Table 1. Diagnostic Criteria of ABI, GDS, and IMT

No	Criteria	value	Interpretation
1	Ankle Brachial Index(ABI)[1]	1.00-1.40	Normal
		0.91-0.99	Borderline
			Perform exercise ankle brachial index testing if indicated
		< 0.90	Abnormal-peripheral artery disease
		> 1.40	Non-compressible vessel
			Obtain toe-brachial index to diagnose peripheral artery disease
2	GDS[2]	>=126	Diabetes
		100-125	Prediabetes
		70-99	Normal
3	Body Mass Index[3]	< 18.5	Underweight
		18,5-22,9	Normal
		23-24.9	Overweight with risk
		25-29,9	Obesitas
		>= 30	Obesitas II

Note: 1. Standard of ABI based on (Aboyans *et al.*, 2012)
2. Standard of GDS based on (Soelistijo, 2021)
3. Standard of BMI based on Asia Pacific Standard (Lim *et al.*, 2017)

RESULTS AND DISCUSSION

Table 2 presents data on respondent characteristics. Most of the respondents were female, namely 68 respondents (90.7%). Most of the respondents' age categories were elderly, namely 31 respondents (41.3%). The type of work that most housewives do is 38 respondents (50.7%). The education level of most of the respondents was an elementary school (SD) or Madrasah Ibtidaiyah (MI) level, namely 30 respondents (40%). The majority of respondents did not have a history of smoking, namely 72 respondents (96%).

Table 2. Characteristics of Posbindu Respondents

Respondent Characteristics	Frequency	Percentage (%)
Gender		
Man	7	9,3
Woman	68	90,7
Age		
Young adults	9	12,0
Late adulthood	13	17,3
Elderly	31	41,3
Late elderly	22	29,3
Type of work		
Farmer	7	9,3
civil servants	1	1,3
Private	13	17,3
Pension	3	4,0
RT's mother	38	50,7
Others	13	17,3
Level of education		
No School	11	14,7
SD/MI	30	40,0
Middle/Junior High School	11	14,7
SMA/MA	17	22,7
PT	6	8,0
Smoking history		
Of	3	4,0
No	72	96,0
Total	**75**	**100**

Several studies show a correlation between the age of the respondent and diabetes mellitus incidence. Research conducted in elderly people at the Balaraja Health Center, Tangerang Regency found that there was a correlation of gender and type 2 diabetes mellitus incidence (Rosita *et al.*, 2022), (Rahmawati, 2021). Similar result found the relationship between age, gender, and level of education and diabetes mellitus incidence. Low level of education causes difficulty absorbing information received from socialization provided by health authorities. (Resti Arania, Tusy Triwahyuni, Toni Prasetya, 2021).

Diabetes mellitus is the eight cause of death in both men and women, also the fifth cause of death in women. According to 2018 Riskesdas data, there was DM in women than in men, with a 1.78% ratio value. (Kemenkes RI, 2018). Higher risk of suffering from DM in women than men is caused by higher leptin and adiponectin levels in

women. Reducing of sex hormone-binding globulin (SHBG) also increases the risk of diabetes in women (Ciarambino *et al.*, 2022).

There were decreased function of the pancreas and insulin resistance with increasing age (Widiastuti, 2019). In elderly women aged 58-65 years, there are risk factors that influence the occurrence of insulin resistance, such as obesity, family history of diabetes mellitus, and socio-economic factors (Imelda, 2019). Another study found that instead of age and gender, level education was correlated with the incidence of diabetes mellitus at Central Mardi Waluyo Clinic in 2020 (Arania *et al.*, 2021).

Some types of work will be related to a person's physical activity. Risk of suffering DM was increased at work that requires low physical activity or sitting for long periods. Meanwhile, jobs that require high levels of physical activity can help reduce the risk of suffering from diabetes mellitus (Resti Arania, Tusy Triwahyuni, Toni Prasetya, 2021). Instead of physical activity, other factors which contribute to increasing the risk of suffering from diabetes mellitus are unhealthy lifestyles, such as an unbalanced diet, lack of, and smoking habits (Muna Lubis *et al.*, 2023). Smoking is associated with microvascular complications and contribute to the pathogenesis of type 2 diabetes (Sliwinska-Mosson and Milnerowicz, 2017). Numerous investigations conducted on animals have indicated that nicotine could impact the growth of pancreatic cells and play a role in the onset of diabetes. Pancreatic islets and β cells have nicotinic receptors, and nicotine may, at least partially, impair the function of these cells. Therefore, the mechanism of nicotine's harmful influence on β cells that secrete insulin may account for the existence of neuronal nicotinic receptors responsive to nicotine in pancreatic cells. Numerous investigations have demonstrated that in animal models exposed to nicotine, nicotine can enhance the apoptosis of islet β cells (Sliwinska-Mosson and Milnerowicz, 2017).

Table 3. Screening Results for Risk and Complication Detection of Diabetes Mellitus

Variable	Frequency	Percentage (%)
Kategori GDS		
Normal	59	78,7
Risk	13	17,3
Hyperglycemia	3	4,0
Body mass index (BMI) categories		
Less	3	4,0
Normal	19	25,3
Risk	12	16,0
Obese 1	31	41,3
Obese 2	10	13,3
Ankle-brachial index (ABI) category		
Abnormal	3	4,0
Borderline	3	4,0
Normal	67	89,3
Height	2	2,7
Total	**75**	**100**

Based on Table 3, it can be seen that most of the respondents had normal sugar level in blood circulation (GDS), namely 59 respondents (78.7%). Results on the body mass index (BMI) category, the majority of respondents were obese, namely 31 respondents (41.3%). Meanwhile, in *the brachial index* (ABI) category, most were in the normal, namely 67 respondents (89.3%).

Table 3 shows the results of screening to detect risks and complications of Diabetes Mellitus (DM). Range of blood sugar level for the category of respondents at risk of DM between 140-199 mg/dl, namely 13 subjects (17.3%). Meanwhile, the category of respondents with hyperglycemia whose blood sugar levels ≥ 200 mg/dl, namely 3 respondents (4%).

Respondents who experience the risk category have the potential to become DM in the future, or known as prediabetes. Prediabetes is a blood sugar tolerance disorder or can be simplified as a transitional condition between normal blood sugar conditions and diabetes mellitus (Fermín-Martínez *et al.*, 2024). In 2018, the prevalence of people with prediabetes in Indonesia is still quite high, namely 26.35% (Kemenkes, 2018), (Riskesdas, 2018). The excess risk for progression from pre-diabetes to diabetes is multifactorial, which should be considered for preventive strategies (Beulens *et al.*, 2019).

The primary consequences of this condition include impaired insulin secretion due to dysfunction of pancreatic beta cells, as well as reduced insulin action resulting from insulin resistance. When insulin resistance is predominant, the beta cell mass adapts and increases insulin production to compensate for the excessive and abnormal demand. In other words, plasma insulin levels are elevated during both fasting and feeding states.

Fasting blood glucose reflects insulin sensitivity and pancreatic function. In type 2 diabetes, the body becomes resistant to insulin, leading to elevated blood glucose levels. Studies show that lifestyle interventions, including diet and exercise, can significantly lower fasting blood glucose levels and improve insulin sensitivity in individuals with prediabetes and type 2 diabetes. Regular monitoring of fasting blood glucose is crucial for diabetes management. It helps assess how well diabetes is controlled and can guide treatment adjustments.

According research Ridwanto *et al* (2020) A relationship was observed between fasting blood glucose levels and BMI (P=0.02), smoking habits (P=0.04), and potassium intake (P=0.02) in patients with T2DM, while psychological stress (P=0.85) showed no correlation with fasting blood glucose levels. Smoking can damage beta pancreatic cells, which disrupts insulin production. Moreover, nicotine from cigarettes inhibits insulin secretion by interacting with the NAchR receptor and activating mTOR pathways.

Other studies indicate The prevalence of uncontrolled fasting blood sugar is notably high among individuals with type 2 diabetes mellitus. Factors that contribute to uncontrolled fasting blood sugar include older age, male gender, low literacy, employment status, longer disease duration, hypertension, smoking, and obesity. To achieve better blood sugar control in diabetics, it is advisable to manage blood pressure and body weight, as well as to avoid smoking (Guo et al., 2017).

Weight management is crucial for preventing diabetes mellitus (DM). Numerous studies have established a link between DM and obesity, particularly abdominal obesity. It is thought that obesity reduces insulin sensitivity by damaging insulin receptors in the membranes of peripheral target cells, ultimately leading to impaired function of pancreatic β-cells . This study detailed the relationship between BMI and fasting blood glucose (FBG), showing that an increase in BMI could raise FBG levels in non-diabetic individuals. Conversely, we found that a rise in waist circumference (WC) adversely affected FBG levels in DM patients. Even with weight loss, abdominal fat accumulation continued to elevate FBG in these individuals. Therefore, it is recommended that those with normal FBG focus on controlling their BMI, while DM patients should concentrate on managing their WC (Riaz et al., 2021).

Based on Table 3, it is found that the most of respondents in the obese category are degree 1, namely 31 respondents (41.3%). The range of body mass index (BMI) values in grade 1 obesity is 25-29.9. This result means that the prevalence of obesity in Yogyakarta is quite high. Data by (Riskesdas, 2018), found that obesity at the age of 18 years and over reaches 28.7% of prevalence (BMI ≥ 25), while the prevalence of overweight is 13.5% (Kemenkes RI, 2018). The prevalence rate of obesity among teenagers in cities is greater than in rural areas. Several risk factors contributing to obesity include unhealthy eating patterns, an inactive lifestyle, and excessive fast food consumption (Mahdiah, Hadi and Susetyowati, 2023)

Several previous studies have shown between BMI and the incidence of DM had a significant relationship (Hartono and Fitriani, 2019). A high BMI can increase the risk of suffering DM, a condition where insulin does not respond well, so blood sugar levels become high (Putri, Nugroho and Adi, 2022). A high BMI can also cause chronic inflammation in the body, and increased blood pressure and cholesterol levels, which can also increase the risk of developing diabetes mellitus (Azizah, 2020), (Nine Luthansa, 2017).

Values of ankle-brachial index (ABI) in Table 3 show that the majority are in the normal category, namely 67 respondents (89.3%), while the others show borderline borderline and abnormal, namely 3 respondents (4%) each. Normal ABI values range from 1-1.4, borderline 0.91-0.99, and abnormal ≤ 0.9, which indicates peripheral vascular disorders. ABI testing also helps to detect problems in blood circulation, such as peripheral artery disease, which can cause narrowing or blockage of blood vessels. ABI measures the ratio of blood pressure at the wrist (brachial artery) and ankle (ankle artery). Several studies show that diabetes mellitus patients have lower ABI values compared to people who do not have diabetes (Kartikadewi *et al.*, 2022).

Research underscores the importance of the ankle-brachial index as a vital tool in the assessment and management of peripheral artery disease, particularly in populations at risk, such as individuals with diabetes. Regular screening and monitoring can help prevent complications and improve patient outcomes.

Overall, ABI is a valuable marker for assessing cardiovascular risk and peripheral artery disease in diabetic patients. Regular monitoring of ABI can help identify individuals at higher risk

and guide interventions to improve outcomes. Poor glycemic control in diabetic patients can lead to vascular damage, which may manifest as reduced ABI values. Better management of blood glucose levels is associated with improved ABI results.

The longer a person has diabetes, the higher the risk of vascular complications, including PAD. Prolonged exposure to high blood sugar can lead to cumulative damage to blood vessels. High levels of insulin resistance, common in type 2 diabetes, can negatively affect blood flow and may correlate with lower ABI values, indicating compromised vascular health. Higher BMI and abdominal obesity are linked to increased inflammation and vascular damage, which can lead to lower ABI readings. Weight management is critical for improving ABI.

Low ABI values in diabetes patients indicate impaired blood flow to the feet or ankles. This can occur because of blockage or narrowing of the blood vessels caused by atherosclerosis. Atherosclerosis is a complication that often occurs in diabetes patients over a long period (Cahyono and Purwanti, 2019). High blood sugar levels cause bad effects on damage of blood vessel walls and cause atherosclerotic plaque formation. This plaque can block or narrow blood vessels so blood flow to the feet and ankles is disrupted. This disruption in blood flow can cause various complications, such as wounds that are difficult to heal, infections, and gangrene (Cahyono and Purwanti, 2019). Other research also shows a relationship between increasing ABI values and insulin sensitivity in type 2 diabetes mellitus patients (Artikaria and Machmudah, 2022).

ABI is a tool to detect the risk of peripheral artery disease, including diabetic ulcers. Therefore diabetic patients with an ABI value <0.9 need to take precautions risk of diabetic ulcer by implementing healthy lifestyle patterns such as eating behavior and physical activity (Soelistijo, 2021).

This research has a weakness, especially limited population coverage, therefore the suggestion for further research is to implement ABI measurements to provide wider benefits in a wider area.

CONCLUSIONS

Description of the risk of DM in the community at Posbindu Ngrame, Tamantirto sub district, Kasihan district, Bantul regency, based on blood sugar levels, most of them are in the normal category (78.7%). The description of the risk of diabetes based on body mass index was mostly in the obese category 1 (41.3%), while the report of the risk of diabetes complications based on the value of ankle-brachial index (ABI) was mostly in the normal category.

SUGGESTIONS

It is hoped that risk factors that can contribute to diabetes can be prevented and controlled to reduce the risk of diabetes prevalence and complications.

THANK-YOU NOTE

The researchers would like to thank the Research and Community Service Institute (LPPM) of Respati University, Yogyakarta, which has provided funds through the internal research grant scheme for the 2023 fiscal year. The research contract agreement letter is 01/Pen/Hibah.Int/PPPM/V/2023.

Researchers also express their gratitude to the cadres of Posbindu Ngrame Tamantirto, Kec. Kasihan, Kapanewon Bantul, DI Yogyakarta, for the assistance and permission given to

this activity and enumerator friends who have helped collect research data.

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