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The Relationship Between Clinical And Anthropometric Factors And Diabetic Neuropathy In Type 2 Diabetes Mellitus Patients At Primary Healthcare Facilities

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Abstract

Background: Diabetic neuropathy is a chronic complication commonly occurring in type 2 diabetes mellitus patients and serves as the primary cause of foot ulcers and amputations. In primary healthcare facilities, early detection of neuropathy faces limitations in resources and diagnostic tools. Therefore, identifying easily measurable clinical and anthropometric factors is crucial to support initial screening in at-risk populations.
Aims and Scope of the Paper: This study aims to analyze the relationship between clinical factors and anthropometric parameters with the incidence of diabetic neuropathy in patients with type 2 diabetes mellitus at primary healthcare facilities. The scope of the study includes the evaluation of variables such as age, gender, duration of diabetes, random blood glucose levels, blood pressure, and body mass index (BMI).
Methods: This study employed an analytic observational design with a cross-sectional approach. A total of 120 patients with type 2 diabetes mellitus were recruited using purposive sampling. Diabetic neuropathy was assessed using the monofilament test. Independent variables included body mass index (BMI), duration of diabetes, and hypertension status. Data analysis was performed using the chi-square test with calculation of prevalence ratios (PRs) and 95% confidence intervals (CIs).
Results: Of the 120 respondents, 78 (65.0%) were diagnosed with diabetic neuropathy. Overweight/obese BMI was significantly associated with neuropathy (PR = 4.39; 95% CI: 2.17–8.89; $p < 0.001$). Diabetes duration of more than 5 years also demonstrated a significant association (PR = 2.27; 95% CI: 1.35–3.83; $p = 0.002$). Hypertension was significantly associated with diabetic neuropathy (PR = 2.91; 95% CI: 1.58–5.36; $p < 0.001$).
Conclusion: Overweight/obese BMI, longer duration of diabetes, and hypertension were significantly associated with diabetic neuropathy in patients with type 2 diabetes mellitus at primary healthcare facilities. These simple clinical and anthropometric parameters can be utilized as a basis for risk screening in the early detection of diabetic neuropathy in primary care settings.

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INTRODUCTION

The prevalence of Type 2 Diabetes Mellitus (T2DM) has risen substantially on both global and national scales, marking it as a critical chronic metabolic disorder. Prolonged hyperglycemia

associated with T2DM frequently leads to diverse vascular complications, with diabetic neuropathy emerging as the most prevalent micro vascular issue that severely diminishes patient well being (Apriliany et al., 2022). Diabetic peripheral neuropathy develops progressively due to prolonged hyperglycemia, leading to oxidative stress, endothelial dysfunction, and micro vascular damage to neural tissue (Zhu et al., 2024).

Clinically, this condition may present with symptoms such as paresthesia, numbness, neuropathic pain, and sensory disturbances that increase the risk of foot ulcers and amputation. Jensen et al. (2023) emphasized that diabetic neuropathy is frequently underdiagnosed in its early stages, particularly in primary care settings, due to the limited routine screening and insufficient clinical awareness. In Indonesia, chronic complications of T2DM remain a major challenge within the primary healthcare settings. Therefore, the identification of risk factors that are easily measurable and applicable in daily clinical practice is essential to support the early detection of diabetic neuropathy.

Research from the last five years indicates that the development of diabetic neuropathy is driven by a complex interplay of various elements. Specifically, inadequate management of blood glucose levels and an extended history of diabetes have been identified as primary determinants frequently linked to the onset of peripheral neuropathy. Luo et al. (2024) reported that an extended history of T2DM serves as a primary driver in elevating the risk of peripheral nerve damage. Similar findings were reported by Pfannkuche et al. (2020). Research has established a strong correlation between suboptimal glycemic management and the advancement of neuropathy among individuals recently diagnosed with T2DM. Beyond these clinical indicators, physical measures like Body Mass Index (BMI) are also recognized as contributing factors to the underlying development of nerve damage.

Obesity contributes to insulin resistance and chronic systemic inflammation, which may accelerate peripheral nerve damage (Davalos et al., 2025). Contesa et al. (2024) found that overweight and obesity were significantly associated with an increased incidence of peripheral neuropathy in diabetic patients. Another study by Callaghan et al, (2020) demonstrated a correlation between metabolic and anthropometric parameters and changes in nerve conduction. Hypertension has also been reported as a comorbid factor that exacerbates diabetic neuropathy through mechanisms of micro vascular dysfunction and impaired nerve perfusion (Sethi et al., 2022). However, the simultaneous relationship between clinical and anthropometric factors in the context of primary healthcare has not been comprehensively studied.

Although various studies have identified risk factors for diabetic neuropathy, the majority of research has been conducted in referral hospitals or tertiary centers utilizing advanced laboratory examinations such as HbA1c or nerve conduction studies. Research based in primary healthcare settings, which utilizes simple clinical parameters such as random blood glucose levels, blood pressure, and BMI, remains limited. Furthermore, several studies have demonstrated inconsistent findings regarding the role of BMI in diabetic neuropathy, thereby necessitating additional research to clarify this relationship in different populations (Sun et al., 2024). The primary care context in Indonesia, characterized by limited diagnostic resources, requires an approach based on simple variables that are easily implementable. This gap highlights the need for research that specifically analyzes the relationship between clinical and anthropometric factors and diabetic neuropathy in T2DM patients at primary healthcare facilities.

Based on the aforementioned gap, this study is grounded in the assumption that simple and readily obtainable clinical and anthropometric factors at primary healthcare facilities may be associated with the incidence of diabetic neuropathy. Variables such as BMI, blood pressure, random blood glucose levels, and duration of diabetes are parameters routinely assessed in primary care settings and have the potential to be utilized to enhance awareness of neuropathic complications. By understanding the relationship between these factors, healthcare professionals in primary care settings can perform earlier screening and plan preventive interventions tailored to individual patient conditions.

The objective of this research is to investigate the association between clinical indicators and anthropometric measures with the occurrence of diabetic neuropathy among T2DM patients at primary health centers. The hypothesis of this study is that there is a relationship between Body

Mass Index (BMI), duration of diabetes, blood pressure, and random blood glucose levels with the incidence of diabetic neuropathy.

METHODS

Research Design

A quantitative, cross-sectional observational design was utilized in this research. This specific methodology was chosen to examine the correlations between clinical and anthropometric variables and the occurrence of diabetic neuropathy in T2DM patients at a single point in time. Such an approach allows for a comprehensive analysis of variable relationships simultaneously, without the need for experimental intervention.

Participant

The participants in this study were patients with T2DM who were undergoing routine follow-up at primary healthcare facilities. Respondents were selected based on predetermined inclusion and exclusion criteria. The study population was selected based on specific eligibility criteria, where participants were required to have a confirmed diagnosis of T2DM, be at least 30 years of age, and demonstrated a willingness to participate by signing an informed consent form. Conversely, individuals with a pre-existing history of neurological disorders or those who were experiencing acute medical conditions that could potentially interfere with the clinical examination process were excluded from the study.

Population and Sampling Methods

The study population consisted of all T2DM patients registered and receiving treatment at the designated primary healthcare centers during the data collection phase. A purposive sampling strategy was implemented to select participants based on specific criteria aligned with the research goals. This method was utilized because certain patients did not meet the eligibility requirements for clinical parameter measurements or neuropathy assessments. Consequently, a total of 120 respondents were successfully enrolled in this study.

Instrumentation

Data collection was performed using a combination of observation sheets and direct clinical examinations.

1. Anthropometric Variables

Body Mass Index (BMI) was determined by dividing body weight in kilograms by the square of height in meters. Weight was recorded using a calibrated digital scale, while a microtoise was employed for height measurements. The resulting BMI values were then classified in accordance with the World Health Organization (WHO) standard criteria.

2. Clinical Variables

- Random blood glucose levels were measured using a digital glucometer at the time of the patient's visit.
- Blood pressure was measured using a digital sphygmomanometer in a sitting position after the respondent rested for a minimum of 5 minutes.
- Duration of diabetes was obtained through structured interviews and confirmation from medical records, then categorized into ≤5 years and >5 years.

3. Diabetic Neuropathy

Diabetic neuropathy status was assessed using a neuropathy screening instrument, namely the monofilament test. Scoring was performed based on standard examination procedures: respondents were considered to have neuropathy if a reduction in sensation was detected at the examination points. The examination instruments utilized have demonstrated adequate clinical validity and reliability based on previous literature and are recommended for screening in primary care settings.

Procedures and Time Frame

Data collection was conducted following the receipt of ethical approval from the Health Research Ethics Committee with reference number No. 207/EA/F.XXIII.38/2025 and authorization from the local healthcare facilities. The research procedures were carried out through several stages, including socialization of the study to eligible patients with diabetes mellitus, completion of informed consent forms by respondents, collection of demographic data and duration of diabetes through structured interviews, measurement of blood pressure, body weight, height, and examination of random blood glucose levels. Neuropathy examination was performed using a neuropathy screening instrument and the monofilament test. The entire data collection process was conducted from November 2024 to February 2025 at Puskesmas Kagok, Semarang City.

Analysis Plan

Data were processed using statistical software through a two-stage analysis, beginning with univariate techniques to determine the frequency distribution and proportions of all variables including age, gender, BMI, blood pressure, random blood glucose, diabetes duration, and neuropathy status followed by bivariate analysis using the chi-square test to evaluate the relationship between clinical and anthropometric independent variables and the incidence of diabetic neuropathy, with a p-value of < 0.05 established as the threshold for statistical significance

Scope and Limitations of the Methodology

The primary objective of this research is to evaluate the correlation between anthropometric and clinical variables and the occurrence of diabetic neuropathy among T2DM patients. The scope of the investigation was specifically restricted to parameters that are feasible and practical for measurement within a primary healthcare environment.

The limitations of this study include:

1. The cross-sectional design does not allow for the determination of causal relationships.
2. The use of purposive sampling technique may limit the generalizability of the study findings.
3. Neuropathy examination was performed using a screening method with the monofilament test, rather than advanced neurological examinations such as electromyography.
4. Multivariate analysis was not performed to control for confounding factors.

Nevertheless, this study provides relevant empirical evidence for screening practices in primary healthcare settings.

RESULTS AND DISCUSSION

Results

Table 1. Characteristics of Respondents (n = 120)

Variable	Kategori	N	%
Gender	Male	40	33.3
	Female	80	66.7
Body Mass Index (BMI)	Normal	30	25.0
	Overweight/Obese	90	75.0
Blood Pressure	Normotension	50	41.7
	Hypertension	70	58.3
Duration of Diabetes	≤ 5 Years	30	25.0
	> 5 Years	90	75.0
Diabetic Neuropathy	Yes	78	65.0
	No	42	35.0

Based on Table 1, a total of 120 respondents diagnosed with T2DM participated in this study. Based on the distribution of respondent characteristics presented in Table 1, the majority of respondents were female, accounting for 80 individuals (66.7%), while male respondents numbered 40 individuals (33.3%). This finding regarding the proportion of sex is consistent with

several epidemiological reports demonstrating a higher prevalence of diabetes among females in certain Southeast Asian populations (Suyanto et al., 2022). Based on anthropometric status, the majority of respondents had a Body Mass Index (BMI) in the overweight/obese category, accounting for 90 individuals (75.0%), while respondents with normal BMI numbered 30 individuals (25.0%). These findings reflect the high burden of obesity in the population of patients with T2DM, which has also been reported in observational studies across various countries, where obesity is associated with insulin resistance and chronic complications of diabetes such as neuropathy (Gao et al., 2021).

Regarding blood pressure, 70 respondents (58.3%) had hypertension, while 50 respondents (41.7%) were in the normotensive category. This finding is consistent with the pattern of clinical comorbidities in patients with type 2 diabetes who frequently experience hypertension, which plays a role in exacerbating the burden of micro vascular complications (Shillah et al., 2024). The majority of respondents had been diagnosed with diabetes mellitus for more than five years, accounting for 90 individuals (75.0%), while 30 respondents (25.0%) had a disease duration of ≤5 years. Duration of diabetes was a factor consistently associated with the progression of complications such as diabetic neuropathy, due to prolonged exposure to chronic hyperglycemia (Nistiandani et al., 2020).

The results of neuropathy examination using a monofilament test revealed that 78 respondents (65.0%) had diabetic neuropathy, while 42 respondents (35.0%) did not show signs of neuropathy. This prevalence of neuropathy is higher than that reported in several previous studies, yet remains within the range reported in primary diabetes populations with longer disease duration (Ray et al., 2021). Descriptively, respondent characteristics of respondents demonstrated a predominance of metabolic and vascular risk factors, particularly obesity, hypertension, and longer duration of diabetes, which are clinically known to contribute to the development of diabetic neuropathy complications.

The finding that the proportion of patients with diabetic neuropathy reached 65% reinforces previous reports that peripheral neuropathy is one of the chronic complications with a high prevalence in patients with T2DM, particularly in those with longer disease duration and suboptimal glycemic control (Kusnadi et al., 2022). The predominance of overweight/obese BMI in this population reflects the important role of obesity in the pathogenesis of diabetic neuropathy.

According to Rohm et al. (2022), obesity not only exacerbates insulin resistance but also triggers systemic inflammation that accelerates micro vascular damage, including peripheral nerves. This suggests a strong relationship between anthropometric status and the incidence of neuropathy in patients with type 2 diabetes. Furthermore, the relatively high proportion of hypertension among respondents is consistent with evidence that hypertension is a comorbidity that frequently accompanies diabetes and may worsen tissue perfusion while accelerating peripheral nerve damage in diabetic neuropathy (Nistiandani et al., 2020). The combination of hypertension and hyperglycemia has a synergistic effect on micro vascular damage. A diabetes duration of more than five years also demonstrates a strong tendency toward the occurrence of neuropathy. Longer disease duration implies prolonged exposure to elevated blood glucose levels, which can chronically lead to the accumulation of advanced glycation end-products (AGEs) and endothelial dysfunction mechanisms that have been well-described in the pathophysiology of diabetic neuropathy (Kaur et al., 2023).

Table 2. The Relationship Between Clinical and Anthropometric Factors and Diabetic Neuropathy (n = 120)

Variable	Neuropathy (+) n (%)	Neuropathy (-) n (%)	PR (95% CI)	p-value
Body Mass Index (BMI)				
Overweight/Obese (n=90)	71 (78.9%)	19 (21.1%)	4.39 (2.17–8.89)	<0.001
Normal (n=30)	7 (23.3%)	23 (76.7%)	1 (reference)	
Duration of Diabetes				
>5 Years (n=90)	68 (75.6%)	22 (24.4%)	2.27 (1.35–3.83)	0.002
≤5 Years (n=30)	10 (33.3%)	20 (66.7%)	1 (reference)	
Hypertension				
Yes (n=70)	56 (80.0%)	14 (20.0%)	2.91 (1.58–5.36)	<0.001
No (n=30)	10 (33.3%)	20 (66.7%)	1 (reference)	

Bivariate analysis revealed that overweight/obese BMI was significantly associated with diabetic neuropathy ($p < 0.001$). Respondents with overweight/obese BMI had a 4.39 times higher risk of developing neuropathy compared to respondents with normal BMI. A duration of diabetes of more than five years also demonstrated a significant association ($p = 0.002$), with a 2.27 times higher risk of neuropathy compared to patients with a duration of ≤5 years. Hypertension was significantly associated with neuropathy ($p < 0.001$), with an almost threefold higher risk compared to patients without hypertension.

Discussion

The prevalence of diabetic neuropathy (65%) in this study indicates that microvascular complications remain a significant clinical problem at the primary care level. This high proportion is likely associated with the predominance of metabolic risk factors in the study population, particularly obesity and longer disease duration. The strong relationship between BMI and diabetic neuropathy confirms the role of obesity in the pathogenesis of peripheral nerve damage. Obesity contributes to chronic systemic inflammation, increased oxidative stress, and endothelial dysfunction, which cumulatively accelerate impairment of nerve microcirculation. This is consistent with the recommendations of the American Diabetes Association (2024), which emphasizes the importance of weight management as a preventive strategy for microvascular complications.

Evidence suggests that a duration of diabetes exceeding five years substantially elevates the risk of developing neuropathy. Long-term exposure to chronic hyperglycemia triggers several pathological mechanisms, including the accumulation of advanced glycation end-products (AGEs), activation of the polyol pathway, and subsequent structural degradation of nerve fibers, as documented in *Diabetes Care* (Sunartini et al., 2023). It was explained that the progression of neuropathy is greatly influenced by the duration of uncontrolled metabolic exposure.

In addition to metabolic factors, hypertension also plays a role in increasing the risk of neuropathy. Microcirculatory disturbances caused by elevated blood pressure can worsen peripheral nerve ischemia and accelerate axonal degeneration. Evidence indicates that vascular comorbidities substantially exacerbate the risk of neuropathy in individuals with T2DM. Ultimately, these results confirm that diabetic neuropathy arises from an intricate interplay between metabolic and vascular determinants. In primary healthcare settings, the assessment of accessible risk factors including Body Mass Index (BMI), diabetes duration, and blood pressure status offers a feasible and economical strategy for the early identification of this complication (Amelia et al., 2021).

1. **Anthropometric Relationship and Diabetic Neuropathy**

The notable correlation between elevated BMI (overweight or obese) and the occurrence of diabetic neuropathy in this research underscores obesity as a critical risk factor for microvascular complications in T2DM. Mechanistically, obesity contributes to heightened insulin resistance, persistent systemic inflammation, and endothelial dysfunction, all of which progressively impair peripheral nerve perfusion.

This finding is consistent with the study by Joni et al. (2025), which demonstrated that the metabolic risk index has a significant relationship with peripheral neuropathy in T2DM patients. Furthermore, Nashtahosseini et al. (2025) reported that components of metabolic syndrome, including obesity, are associated with an increased incidence of neuropathic complications in diabetic patients. Mechanistically, obesity triggers an increase in pro-inflammatory cytokines such as TNF-α and IL-6, which contribute to oxidative stress and nerve fiber damage. Cho (2023) explained that metabolic disturbances in obesity accelerate axonal degeneration through inflammatory pathways and microcirculatory impairment. Furthermore, in the latest guidelines from the American Diabetes Association (2024), weight management is recommended as an integral part of the strategy for preventing microvascular complications, including neuropathy. Therefore, the findings of this study are consistent with international clinical recommendations that position obesity as a primary intervention target.

2. **Glycemic Control and Diabetic Neuropathy**

The finding that uncontrolled blood glucose was associated with diabetic neuropathy is aligned with the pathophysiological concept of neuropathy resulting from chronic hyperglycemia. Prolonged hyperglycemia triggers the activation of the polyol pathway, formation of advanced glycation end-products (AGEs), and increased oxidative stress, which cause microvascular damage and peripheral nerve dysfunction. In a publication in *Diabetes Care*, Carmichael et al. (2021) confirmed that poor glycemic control is the primary determinant of the progression of diabetic neuropathy. The study also emphasized that neuropathy frequently develops gradually and remains undetected in its early stages, thereby necessitating routine screening.

Furthermore, (Strand et al., 2024) stated that metabolic dysfunction resulting from chronic hyperglycemia can cause impairment of sensory and autonomic nerve transmission. Sartika (2023) also demonstrated that a high glycemic index is associated with an increased risk of peripheral neuropathy. These findings reinforce the importance of blood glucose level management as a primary preventive strategy in reducing the progression of diabetic neuropathy, particularly in primary care settings.

3. **Duration of Diabetes as a Risk Factor for Neuropathy**

The significant correlation between a diabetes duration of more than five years and the incidence of neuropathy in this study is consistent with various previous studies. A longer disease duration reflects prolonged exposure to chronic hyperglycemia, which contributes to the accumulation of microvascular and structural damage to the peripheral nerves. (Sriyati, 2024) reported that diabetes duration is a strong predictor of peripheral neuropathy in T2DM patients. Similarly Husna et al. (2024) demonstrated that the duration of the disease is significantly associated with an increase in neuropathic complications.

Faiqotunnuriyah (2021) in a systematic review emphasized that diabetes duration is among the primary determinants of peripheral neuropathy, particularly when combined with poor glycemic control and vascular comorbidities. Pathophysiologically, long-term exposure to hyperglycemia causes structural changes in nerve fibers through mechanisms of oxidative stress, chronic inflammation, and impaired microvascular blood flow. Therefore, the longer an individual lives with diabetes, the higher the risk of developing neuropathy.

Implications

The results of this study underscore that easily accessible variables in primary healthcare settings such as BMI, random blood glucose, and diabetes duration can serve as early risk indicators for diabetic neuropathy. This pragmatic approach is crucial, given that advanced neurological diagnostic tests are often unavailable in primary care facilities. Consequently, primary healthcare

providers should be motivated to conduct regular monitoring of these parameters rather than focusing solely on glucose control.

Research Contribution

This study enriches the existing literature by:

1. Simultaneously examining the correlation between clinical and anthropometric factors within the Indonesian primary care setting.
2. Utilizing practical and easily measurable variables for screening neuropathy risks.
3. Providing empirical evidence that can serve as a foundation for complication prevention strategies in primary care facilities.

These findings support simple yet effective early detection strategies for neuropathy in resource-limited environments.

Limitations

1. Due to the cross-sectional design, causal relationships cannot be determined.
2. The purposive sampling technique limits the generalizability of the findings.
3. The diagnosis of neuropathy was performed using clinical screening rather than advanced neurophysiological examinations.
4. Multivariate analysis was not conducted to control for other potential confounding factors.

Suggestions

Future research is recommended to:

1. Utilize longitudinal designs to evaluate causal relationships between variables.
2. Incorporate standard neurophysiological examinations for the diagnosis of neuropathy.
3. Apply multivariate analysis to identify independent risk factors.
4. Develop score-based risk screening models that can be implemented in primary care settings.

CONCLUSION

This study demonstrates that an overweight/obese Body Mass Index (BMI), a diabetes duration of more than five years, and hypertension are significant associated with diabetic neuropathy in T2DM patients within primary healthcare facilities. These results align with the study's objective to identify simple clinical and anthropometric factors that can serve as risk indicators for neuropathy.

These findings confirm that parameters easily obtained in daily clinical practice can be utilized as a basis for risk stratification and the reinforcement of early screening in primary care. Moving forward, longitudinal research involving multivariate analysis is required to develop a more comprehensive and applicable neuropathy risk prediction model.

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AUTHOR CONTRIBUTION STATEMENT

MS contributed to the conceptualization of the study, research design, data collection, data analysis, and manuscript writing. EAN contributed to data collection and field data validation. KPH contributed to statistical analysis and interpretation of results. MDPS contributed to the literature review and revision of the scientific substance. GT contributed to research supervision and final review of the manuscript. All authors have read and approved the final version of the manuscript.

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