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THE IPSWICH TOUCH TEST (IPTT) HAS THE SENSITIVITY AND SPECIFICITY EQUIVALENT TO THE MONOFILAMENT TEST FOR THE DETECTION OF DIABETIC SENSORY NEUROPATHY

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ABSTRACT
The most common complication of diabetes is neuropathy. Diabetic foot screening includes secondary prevention efforts against further complications from diabetes. The need for practitioners to have practical, simple, and affordable sensory neuropathy screening techniques that can be independently is a demand in today's health services. A study aimed to assess the sensitivity and specificity of the ipswich touch test (IPTT) to the 10g monofilament test in the early detection of diabetic neuropathy. Methods: This quantitative observational research design used a cross-sectional method with 61 respondents who had diabetes mellitus for more than one year in the working area of the Pasar Ikan Health Center, Bengkulu City. Samples were taken by consecutive sampling. The researcher conducted an ipswich touch test (IPTT) first and then an examination with a monofilament test of 10g as the gold standard. The data is processed and analyzed with a computer application to see the sensitivity and specificity values. Ipswich touch test (IPTT) had a sensitivity value of 91.3%, specificity of 92.1%, positive predictive value of 87.5%, negative predictive value of 94.59%, positive probability ratio of 11.55, negative probability ratio of 0.09 and AUC value of 91%. The ipswich touch test (IPTT) has the same sensitivity, specificity, and accuracy as the monofilament test.

Keywords: diabetes mellitus; ipswich touch test; monofilament test; screening; sensory neuropathy

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INTRODUCTION

Diabetes mellitus is often referred to as a silent killer (Ahuja & Gupta, 2020). According to the International Diabetes Federation (IDF), there are at least 537 million diabetics worldwide between the ages of 20 and 79. This number is expected to increase to 643 million in 2030 and 783 million in 2045 (IDF, 2022). Indonesia is the country with the fifth highest prevalence of diabetes in the world and the third highest in Southeast Asia, reaching 19.47 million people (IDF, 2022; Kemenkes, 2022). There were 3,087 cases of diabetes mellitus in Bengkulu City in 2022 (Bengkulu City Health Department et al., 2022). Diabetes mellitus is at risk of causing complications in the body's blood vessels and innervations progressively (WHO, 2022). The most common complication of diabetes is neuropathy. Almost all diabetics (90%) have neuropathy (Rahman et al., 2021). There are three types of neuropathy: motor neuropathy, sensory neuropathy, and autonomic neuropathy (Fitria et al., 2017). Patients with type 2 diabetes have a 50% chance of developing sensory neuropathy, which is a consequence of microvascular disorders (Mawaddah et al., 2022).

Sensory neuropathy is a nerve disorder that transmits touch, temperature, or pain signals (Sophausvaporn et al., 2023). This disorder can cause symptoms including numbness, paresthesia, discomfort, and numbness in the legs (Chuesawai & Suwat Srisuwannanukorn, 2023). The impact of delayed prevention of sensory neuropathy can increase the likelihood of diabetic wounds ending in amputation (Mawaddah et al., 2022). Therefore, it is necessary to screen the risk of neuropathy complications in the legs of people with diabetes (Idramsyah et al., 2024). Screening is expected to be practical, affordable, and effective.

Diabetic foot screening includes efforts to prevent further complications from diabetes. Neuropathy screening is the most efficient way to reduce the increase in neuropathy symptoms (Pamugkas & Usman, 2021). It is known that the method used to test sensation is using a 128Hz tuning fork or a 10gr monofilament tool (Ilham et al., 2021). 10g monofilament is more straightforward, objective, and comfortable to carry than a 128Hz tuning fork tool (Zhao et al., 2021). Monofilament tests have become the gold standard for diagnosing diabetic neuropathy (Ilham et al., 2021). However, not all health service units provide this service, so this technique is considered less practical and less affordable because it requires special tools (Suyanto & Astuti, 2020).

An alternative to the sensory neuropathy test is the ipswich touch technique (IPTT). IPTT is a more straightforward method of identifying sensory neuropathy (Zhao et al., 2021). IPTT techniques are novel, easy to use, and do not require special tools. The examiner only examines by gently touching the six points on their feet (Ilham et al., 2021). The patient's family can also do IPTT technical examinations at home for free and independently (Handayani et al., 2022). However, there are doubts among some practitioners regarding the effectiveness of IPTT techniques. The need for practitioners to have the availability of practical, simple, and affordable screening techniques, which can even be done independently, is a demand for services today. This phenomenon needs to be addressed, so the research team conducted a study to assess the sensitivity and specificity of IPTT to the 10g monofilament test in the early detection of diabetic neuropathy.

METHOD

The design of this quantitative observational research uses a cross-sectional method. There is a population of 492 people with type 2 diabetes mellitus and a sample of 61 respondents who have had diabetes mellitus for more than one year in the working area of the Bengkulu City Pasar Ikan Health Center. Samples were collected using consecutive sampling techniques. The instruments used in this study are questionnaires, IPTT observation sheets, observation sheets, and 10g monofilament tools. All respondents received the same treatment: the researcher conducted an ipswich touch test (IPTT) examination first and then an examination with a monofilament test of 10g as the gold standard. The data was processed and analyzed with a computer application to see the sensitivity value and specificity of sensitivity, specificity, positive predictive value (NPP), negative predictive value (NPN), positive likelihood ratio (RKP), and negative likelihood ratio (RKN).

RESULTS

Overview of Characteristics of Diabetics

The characteristics of the respondents included age, length of diabetes, blood glucose levels, gender, and the type of diabetes therapy undergone.

Table 1.
Description of Respondent Characteristics Based on Age, Length of DM, GDS Level, Gender, and Type of DM Therapy Undergone (n=61)

Characteristic Variables	Value
Age	
Mean	66,147
Min	44
Max	83
SD	8,306
CI 95%	64,020-68,274
Long Time Holding DM	
Mean	56,131
Min	13
Max	288
SD	49,786
CI 95%	43,480-68,881
GDS Levels	
Mean	212,8525
Min	147
Max	416
SD	50,090
CI 95%	200,023-225,681
	Frequency (people)
Gender	
Woman	38 (62,3%)
Man	23 (37,7%)
Type of DM Therapy Undertaken	
OHO	54 (88,5%)
Insulin	5 (8,2%)
Combination	2 (3,3%)

Table 1 illustrates the average age of respondents, who were 66.14 years old. Their average DM duration was 56.13 months, and their average GDS level was 212.85 mg/dL. Most respondents were female (62.3%), and the most widely used type of therapy was OHO therapy (88.5%).

Overview of Sensory Neuropathy Screening Results with Ipswich Touch Test (IPTT)

Table 2.
Distribution of Frequency of IPTT Screening Results and Monofilament Test in People With Diabetes Mellitus (n=61)

IPTT	f	%
Negative	37	60,7
Positive	24	39,3
Total	61	100
Monofilament Test		
Negative	38	62,3
Positive	23	37,7
Total	61	100

Table 2 shows the results of the IPTT examination: 24 people (39.3%) were detected to have sensory neuropathy, and 23 people (37.7%) were detected to have sensory neuropathy based on the monofilament test results.

Ipswich Touch Test (IPTT) Sensitivity and Specificity Values

Table 3.
Cross-tabulation of Ipswich Touch Test (IPTT) & Monofilament Test in Sensory Neuropathy Screening in Patients With DM (n=61)

Result in IPTT		*Monofilament Test*		Total
		Positive	Negative	
Positive	f	21	3	24
	%	87,5	12,5	100
Negative	f	2	35	37
	%	5,4	94,6	100
Total	f	23	38	61
	%	37,7	62,3	100

Based on the cross-tabulation above, it can be seen that of the 24 people who at the time of positive IPTT results, it turned out that at the time of the monofilament test, 21 people (87.5%) remained positive, and three people (12.5%) were negative. In 37 respondents whose IPTT scores were negative, it turned out that after being confirmed by the monofilament test, 35 people (94.6%) remained negative, while two people (5.4%) were positive. Based on the cross-table results, sensitivity values, specificity, positive prediction values (NPP), negative prediction values (NPN), positive likelihood ratios (RKP), and negative likelihood ratios (RKN) can be calculated.

Table 4.
Sensitivity and Specificity of IPTT in Sensory Neuropathy Screening in People With Diabetes Mellitus

Diagnostic Value	Formula	%
Sensitivity	21 : (21+2)*100%	91,3
Specificity	35 : (3+35)*100%	92,1

Table 4 provides information that the IPTT examination has a sensitivity value of 91.3% to determine whether diabetic mellitus patients who experience sensory neuropathy are sick. The analysis showed that 92.1% of the ipswich touch test (IPTT) is perfect for identifying people with diabetes who do not experience sensory neuropathy and declaring them harmful.

Positive Predictive Value (PPV) and Negative Predictive Value (NPV) Ipswich Touch Test (IPTT)

Table 5.
Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of IPTT in Sensory Neuropathy Screening in People With Diabetes Mellitus

Diagnostic Value	Formula	%
Positive Predictive Value	21 : (21+3)*100%	87,5
Negative Predictive Value	35 : (2+35)*100%	94,59

Table 5 presents the results of the positive predictive value (PPV) analysis of people with diabetes mellitus who are positive (87.5%) for positive sensory neuropathy based on the ipswich touch test (IPTT) examination. In IPTT, an optimistic prediction value of 87.5% is considered very high. This proves that in patients who experience sensory neuropathy, IPTT can identify early cases of the condition up to 87.5%. In this study, the ipswich touch test (IPTT) had a high negative predictive value of 94.59%. These results prove that in the future, ipswich touch test (IPTT) results in individuals with diabetes mellitus will show a high incidence of sensory neuropathy, with a very low probability of false negatives due to the accuracy of the test approaching 100%.

Positive Likelihood Ratio (LR+) and Negative Likelihood Ratio (LR-) Ipswich Touch Test (IPTT)

Table 6.
Positive Likelihood Ratio (LR+) and Negative Likelihood Ratio (LR-) of IPTT in Sensory Neuropathy Screening in People With Diabetes Mellitus

Diagnostic Value	Formula	%
Positive Possibility Ratio	0,913 : (1-0,921)	11,55
Negative Possibility Ratio	(1-0,913) : 0,921	0,09

The ipswich touch test (IPTT) has a positive probability ratio (LR+) value of 11.55 or more than 10, which indicates an excellent diagnostic value. A very positive diagnostic test result results in a probability ratio value much higher than 1. The result of the negative probability ratio (LR-) analysis was 0.09. A robust negative test result will give a probability ratio value close to 0, whereas this study shows a negative probability ratio of 0.09.

ROC Curve Overview

Table 7.
Analysis of IPTT's Receiver Operating Curve (ROC) in Sensory Neuropathy Screening in People With Diabetes Mellitus

Positive	Negative	AUC	P-Value	OR 95% CI
24	37	91	0,000	82,2-99,9

Based on the data in table 7 above, 24 respondents suffered from sensory neuropathy, and 37 did not. An AUC value of 91 indicates that the value is in the range of >90%–100%, which means that IPTT has extreme accuracy and is included in the excellent category with a population confidence level between 82.2% and 99.9%. In addition, a p-value of 0.000 was obtained, which indicates that the test results are significant.

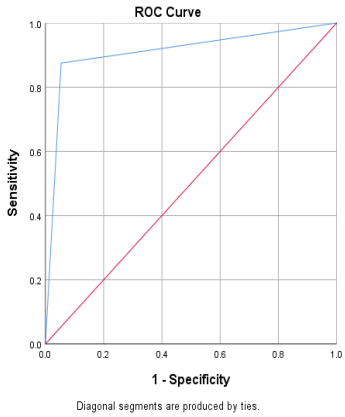

Image 1. Receiver Operating Characteristic (ROC) Curve

From image one above, it can be seen that the ROC curve shows that IPTT has an excellent diagnostic value because it exceeds 50% and is close to 100%.

DISCUSSION

The results showed that the average age of the respondents was 66.14 years, with the lowest age range of 44 years and the highest age of 83 years. According to Abdissa (2020), the majority of diabetic neuropathy patients are over 40 years old. This is because diabetic neuropathy is a chronic diabetes complication caused by hyperglycemia, which takes time to develop and is more common in elderly diabetic patients. The nervous system is more susceptible to ongoing metabolic stress and the physiological effects of degenerative processes as we age. In the long term of DM, it was found that the average respondent had diabetes for 56.13 months. The results of this study are in line with Mildawati's (2020)

research; a person who has suffered from diabetes mellitus for more than a year can also experience nerve-related complications such as sensory neuropathy. Diabetic neuropathy is more common and has a higher risk of complications if a person has diabetes for a longer time.

The blood glucose levels of the study participants are currently, on average, at 212.85 mg/dL. Untreated high blood glucose levels have been linked to decreased peripheral blood circulation, impaired vascular function, and reduced delivery of oxygen and nutrients to cells and nerves. This aligns with Sari's (2021) research, which showed that prolonged increases in blood glucose levels trigger the glycosylation process. Glycosylation degradation, which chemically damages nerves and interferes with the normal functioning of sensory nerves, is a cause of peripheral neuropathy and nerve damage processes associated with high blood glucose concentrations. As many as 62.3% of the total research respondents are women. This is in line with Mawaddah's (2022) research, which shows that women are more likely to experience diabetic neuropathy than men. In women, they are twice as likely to experience complications than men. Hormonally, estrogen increases the likelihood of neuropathy in women by blocking the ability of the intestines to absorb iodine, thereby stopping the development of nerve myelin. Because of the hormone testosterone, men are less likely to develop type 2 diabetes mellitus than women. Oral hypoglycemic drug therapy (OHO) was used to treat diabetes mellitus in almost all study participants (88.5%). Trisna et al. (2016) reported that insulin therapy, compared to oral antidiabetic treatment or OHO, lowered the risk of diabetic neuropathy in type 2 diabetic patients. Based on these findings, it can be said that insulin therapy can reduce the incidence of diabetic neuropathy in people with type 2 diabetes.

The majority of respondents in this study were 37 people, or 60.7% of the sample, who did not suffer from sensory neuropathy based on the examination results using the ipswich touch test (IPTT). Meanwhile, as many as 24 respondents, or 39.3%, reported suffering from sensory neuropathy. This is by the examination's findings using the monofilament test, obtained from 38 respondents, or 62.3% of the sample, who did not suffer from sensory neuropathy, and 23 respondents, or 37.7% of the sample, who suffered from sensory neuropathy. The results of the cross-tabulation showed an overview that based on the screening ipswich touch test (IPTT) and monofilament test, respondents were obtained with the results of the examination being entirely negative (true negative) as many as 35 people (94.6%), meaning that the respondents did not experience sensory neuropathy in the legs by using two examinations, namely IPTT as the index and monofilament test as the gold standard. Respondents with positive screening results experienced sensory neuropathy with the two examinations of as many as 21 people (87.5%). Respondents with false-positive screening results were three people (12.5%), and false negatives were two people (5.4%). The most popular noninvasive test for identifying sensory neuropathy is the monofilament test. According to the American Diabetes Association (2020), it is the gold standard for determining whether a diabetic mellitus patient has lost protective sensation in his legs. It has been widely reported that 10g monofilaments can be used to identify diabetic sensory neuropathy. Monofilaments are helpful and easy to identify the loss of protective feelings. However, this examination requires specific instruments and practitioners trained to carry it out. Of course, this presents challenges in medical facilities where 10g monofilament devices still need to be made available. Therefore, a more straightforward and less specialized examination with the same goal is required.

An alternative assessment for sensory neuropathy in people with diabetes comparable to a monofilament test but does not require special equipment is the ipswich touch test (IPTT). To prevent foot problems in patients with diabetes mellitus, Gerry Rayman of The Ipswich Hospital NHS Trust and Prasanth Vas of Kings College Hospital London initially developed IPTT in 2012. Research on the usefulness of the ipswich touch test (IPTT) in the early stages of diagnosis of diabetic sensory neuropathy is still lacking. It has never been done in Indonesia, so more efforts must be made in this field. Gerry Rayman created IPTT for the first time in 2012 as an effort to protect the feet of diabetic mellitus patients from complications. The IPTT's "Touch The Toes Test" is a method now accepted by Diabetes UK for evaluating sensory abnormalities of the legs (Diabetes UK, 2012). This study's findings align with Setyoko's (2021) research on clinical neurological examination (CNE) scores and the diagnostic usefulness of monofilament tests in diabetic polyneuropathy. The monofilament test had good sensitivity (80.6%) for the diagnosis of diabetic polyneuropathy in a real-world clinical setting, according to the results of a study involving 96 respondents.

This monofilament test research is in line with the ipswich touch test (IPTT) research conducted in Saudi Arabia on 351 respondents by Madanat et al. (2019), showing that IPTT has proven to be a fast, easy, affordable, and reliable method to determine the risk of people with diabetes developing foot ulcers. Because the procedures for the ipswich touch test (IPTT) and monofilament test are almost the same, the description of the test results in this study shows the similarity of the examination results. The discovery of evidence of sensory neuropathy in the legs of diabetics is the goal of these two tests. The ipswich touch test (IPTT) had a sensitivity value of 91.3%, a specificity of 92.1%, an optimistic prediction value of 87.5%, a negative prediction value of 94.59%, a positive probability ratio of 11.55, a negative probability ratio of 0.09, and an AUC value of 91% according to the results of the diagnostic test analysis in this study. Therefore, it can be concluded that the monofilament and the ipswich touch test (IPTT) are beneficial for detecting sensory neuropathy in people with diabetes mellitus. It is rare to find a perfect diagnostic test that gives a negative result in healthy subjects and a positive result in all sick subjects. Almost all diagnostic tests have the risk of producing false-negative results in sick subjects and positive results in healthy subjects (false positives). Many factors, especially the degree and prevalence of the disease at the time the diagnostic test is performed, affect the interpretation of the test results.

A high-sensitivity diagnostic test is needed to determine if there is a disease. Diagnostic tests with high sensitivity can identify more cases. Diagnostic tests with high specificity are used to determine if a disease exists. Diagnostic tests that have high specificity will likely exclude healthy individuals. Screening is done as part of diagnostic testing to help confirm the most likely diagnosis. Generally, screening is done to find diseases in subjects that meet the risk criteria, allowing for additional testing and the possibility of early diagnosis. Because diabetic neuropathy is the most common complication of type 2 diabetes mellitus with an incidence rate of up to 50%, early detection of this condition is very important for people with diabetes mellitus. Peripheral neuropathy screening is a meaningful way to detect the early risk of diabetic foot. Simple measures such as early diagnosis of neuropathy, awareness of diabetic foot prevention, regular foot check-ups, and proper footwear use can prevent leg ulceration and amputation in 80% of cases. Early detection of diabetic neuropathy can change the course of the disease and avoid complications in the form of diabetic ulcers. IPTT is one method to assess the sensitivity level of DM patients. It is sensitive, effective, and specific, easy to do without cost or tools, does not pose a danger to patients and examiners, and can be done by anyone (Ilham et al., 2021). The ipswich touch test (IPTT) is a new, straightforward, and instrument-free technique for neurosensory assessment in diabetic feet. Any medical facility

can perform this examination. When screening sensory neuropathy in individuals with diabetes mellitus, the ipswich touch test works best because it has a sensitivity of 91.3% and a specificity of 92.1%. In other words, the accuracy of the IPTT test in identifying individuals with diabetes mellitus who do not have sensory neuropathy is 60.7%. In comparison, the accuracy in detecting the presence of sensory neuropathy in patients with the disease is 39.3%. The ipswich touch test (IPTT), which has a high specificity value (92.1%) and a good sensitivity value (91.3%), can be used to screen for diabetic sensory neuropathy. People with diabetes mellitus and their families can use IPTT with basic written instructions at home. The findings of this study are consistent with previous research by Rayman et al. (2012) in the UK, The Ipswich Touch Test: A Simple and New Method To Identify Hospitalized Patients With Diabetes At Risk Of Foot Ulcers, which involved 265 respondents. The IPTT method has a sensitivity value of 77%, a specificity of 90%, an optimistic prediction value of 91%, and a negative prediction value of 77%. It is fast, easy to teach, and does not require tools. Nurses and doctors can complete this method.

This study is corroborated by a literature review by Kusumaningrum (2020), which seeks to summarize, collect, and analyze the findings of previous IPTT research and conclude that IPTT is considered a simple approach for early identification and risk assessment of foot ulcers. Health workers can use the IPTT method at home or in health services. At its establishment, IPTT was considered suitable for non-professionals because it did not require special instruments, required little training, and had straightforward written instructions with a sensitivity score of 78.3% and specificity of 93.9%. These results are the conclusion of another study by Sharma et al. (2021) on 331 people with diabetes mellitus. The ipswich touch test (IPTT), analyzed by the researchers, is a valuable screening tool for diabetic sensory neuropathy because it can provide an overview of a person's sensory perception by lightly touching the tip of the toe. Humans rely on sensory inputs to interpret and shape their perception of the world. One type of sensory stimulus that can tell if a person has a sensory impairment or not is light touch, especially in people with diabetes mellitus.

CONCLUSION

The average age of respondents with diabetes mellitus was 66.14 years old. The majority of the gender is female. The average respondent had diabetes for 56.13 months. The average respondent had a GDS level of 212.85 mg/dl. Almost all respondents used OHO therapy as their primary treatment. The ipswich touch test (IPTT) has a sensitivity value of 91.3%, specificity of 92.1%, positive predictive value of 87.5%, negative predictive value of 94.59%, positive probability ratio of 11.55 and negative probability ratio of 0.09. An AUC value of 91% shows that the AUC is in the range of >90%-100%. As a result, IPTT is categorized as having extreme accuracy and is rated very well, with a level of population confidence between 82.2% and 99.9%. In addition, it was found that the p-value was 0.000; this value was less than 0.05, proving that the test results were statistically significant. The ROC curve shows that IPTT has an excellent diagnostic value because it exceeds 50% and is close to 100%.

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