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ORIGINAL ARTICLE

Prediction of Diabetes by Measuring the Cross-Sectional Area of Median and Tibial Nerves. Is It a Good Predictor?

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Abstract

Objective: To evaluate the sonography of median and tibial nerve in diabetic and non-diabetic individuals.

Method: In this Case-Control study 90 individuals divided into 45 diabetics and 45 non-diabetics were examined. The study was performed at Sehat Medical Complex Hanjarwal Lahore. Independent sample T test was used to compare the two groups.

Result: 90 individuals were recruited for this study. 52 (57.8%) were female and 38(42.2%) were male. The average age of individuals was 42.17 ±14.75. The average size of the median nerve in diabetic patients was 12.1 ±2.1 mm^2 and in non-diabetics was 6.88 ±1.3mm^2. The average size of the tibial nerve in diabetic patients was 15.06 ± 3.0mm^2 and in non-diabetics was 8.3 ±2.4mm^2. There was a significant difference $p<0.005$. In the tibial nerve, females (Mean = 12.0 ± 4.2 mm) exhibited a slightly larger size compared to males (Mean = 11.2 ± 4.5 mm). In terms of the Median Nerve, males had a mean size of 9.44 ± 2.8 mm, while females had a slightly larger mean of 9.6 ± 3.4 mm.

Conclusion: According to this research, the vast majority of diabetic patients who underwent ultrasonography had a significant increase in the cross-sectional area of nerves in diabetic patients as compared to healthy control individuals. Moreover, these results suggested that sonographic examinations could be useful in the early diagnosis of diabetic neuropathy.

Keywords: Diabetes mellitus, Diabetic peripheral neuropathy, High resolution ultrasound, Cross sectional area.

INTRODUCTION

According to the World Health Organization, about 220 million individuals have diabetes mellitus (DM) all over the world [1, 2]. Currently, Pakistan has an 11.77% prevalence of type 2 diabetes. 9.19% of women and 11.20% of men experience this incidence [3]. One in five Diabetic peripheral neuropathies (DPNs) might be asymptomatic. Serious consequences, such as diabetic foot ulcers and gangrene, can result from recently formed DPN [4, 5]. About half of patients develop neuropathy at some point in the illness. A significant risk factor for diabetic neuropathy may be poorly controlled glycaemia. Hyperglycemia can cause peripheral nerve damage, enhanced transformation of glucose to sorbitol by aldose reductase which can result in the beginning of neuropathy, as well as enlargement of nerves along with myelin sheath and axon impairment [6, 7]. Symptoms of diabetes mainly include tingling, numbness and needle sensation [8].

High-resolution ultrasound (HRU) has been used to assess peripheral nerve morphology that is not characterized by nerve conduction tests, in particular localized nerve entrapments, and is being used more frequently to assess peripheral neuropathy [9,10]. Time-consuming and minimally invasive nerve conduction studies are carried out by neurologists to diagnose peripheral neuropathy [7, 11, 12, 13]. Modern high-resolution ultrasound has grown in popularity over the past ten years for use in diagnosing illnesses of the peripheral nervous system. The most often used measurement for determining the size of a particular nerve at this time is its cross-sectional area (CSA), with a higher CSA indicating disease [14]. Specifically, in diabetic patients, the median and tibial nerve's cross-sectional area become increased as compared to non-diabetic individuals. See Figure 1(a) and 2 (a).

The median nerve is located next to the axillary artery inside the arm in a lateral location. At the medial aspect of the arm, lateral to the brachial artery, beyond the axillary artery, the median nerve is located. The median nerve travels anterior and then medially to the brachial artery, passing via the brachialis muscle at the level of the coracobrachialis insertion in the center of the arm. In the cubital fossa, which is situated close to the bicipital aponeurosis, the median nerve descends from this place [15]. Figure 1 (b). The posterior tibial nerve (PTN), which originates in the upper point of the popliteal fossa, is the sciatic nerve's terminal branch just beneath the medial malleolus. Figure 2 (b). The tibial nerve is situated just below the posterior tibial artery, which one may feel [16]. The ability of the peripheral nerve to adapt to changes in the size of its bed brought by limb movement [17].

To evaluate lesions and other morphological diseases, it is now feasible to evaluate the tibial nerve, the median nerve, and their surrounding tissues. Ultrasound can be used as sensitive tool to determine the peripheral nerves' typical appearance as early as possible [4, 18]. Normal nerves have a distinct architecture on an ultrasound picture, consisting of a fascicle and an epineurium around it. The (echogenic) outer membrane, which encircles the nerve bundle, the (hypoechoic) on the transverse axis to creates a structure resembling a honeycomb with a 5–15 MHz linear array transducer [19, 20]. The nerves on the longitudinal axis are thin and the area between both the low and high echo lines makes a linear structure that is parallel to that structure [4].

The nerve is more echogenic in comparison to the muscle, which has hypoechoic muscle fiber bundles with surrounding echogenic perineurium. There is a small cluster of echogenic fibrils in the tendon which is more echogenic than the nerve. The nerves slide across the muscles and tendons when examined dynamically [21, 22, 23, 24]. The main traits listed below can be used to distinguish nerves from other structures. First, because of epineurial connective tissue, nerves have a hyperechoic border around them. Compared to muscles and tendons, they are more anisotropic which means that, in contrast to nerves, tilting the transducer will noticeably alter the echo intensity of these other tissues. Using ultrasound, each nerve was detected, and the transducer's angle was changed until it was perpendicular to the nerve to produce the smallest cross-sectional image possible. Thirdly, they lack pulsatile movement and Doppler flow, making them, unlike blood arteries [25, 26, 27].

According to several studies, DPN patients' median nerve cross-sectional areas are bigger than those of healthy controls and are correlated with NCS. Additionally, it seems that people with diabetes mellitus (DM) and a decreased motor nerve conduction velocity (MCV) had a considerably larger percentage of peripheral nerves with hypoechoic areas and increased CSA. Nerve expansion and an increase in the proportion of hypoechoic areas might point to degenerative changes in median and tibial nerves [1]. The demyelinating pattern tends to be more visible in areas of change. In comparison to healthy individuals, there were noticeably more peripheral nerves displaying elevated CSA in probable DPN instances with normal NCS [9]. According to the study, patients who had type 2 DM exhibited peripheral nerves with greater size and more hypoechoic patterns when compared to healthy individuals [28, 29]. Since the majority of people in our nation cannot afford expensive diagnostic procedures, ultrasonography is a modality that is most widely used.

Patients with diabetes and those without diabetes can be examined with an easy and non-invasive technique of ultrasound for peripheral nerves without any discomfort as in NCS. Moreover, an ultrasound study is useful to compare the findings between diabetes (the case group) and non-diabetic individuals by correlating the CSA and echogenicity of the tibial and median nerves (control group).

MATERIAL AND METHOD

This analytical case-control study was performed at Sehat Medical Complex Hanjarwal Lahore. In this study, 90 individuals were examined. 45 were diabetics and 45 were non-diabetics. Individuals of all age groups, both genders and diabetics were included. Any abnormality other than diabetes was excluded. The sampling technique was convenient. Mindray and Toshiba (5 – 18 MHz) ultrasound machines were used to perform the study. Quantitative variables i.e., age, cross-sectional area of median and tibial nerves. Qualitative variables include gender and echogenicity. The sample size was calculated at a 99 % level of significance and 95 % power of test. The ratio for sample size (diabetic / non-diabetic) is 1. Data were evaluated and analyzed by statistical software for social sciences SPSS25.0. Frequencies and Percentages were calculated for qualitative data. Mean ± SD were calculated for quantative data. Independent sample t-test was applied to check the association between diabetes and Median/Tibial nerve. P-value less than 0.05 was considered significant.

Scanning Technique:

Depth, gain, and dynamic range were optimized to achieve optimal differentiation between the nerves and adjacent soft tissue structures. Images were captured with the subject in a prone position, and the transducer was placed perpendicularly during the acquisition of the tibial nerve cross-sectional area (CSA). To prevent deformation of the underlying soft tissue structures, the transducer on the skin surface applied minimal pressure. Previous research has indicated the utilization of standard imaging and write-zoom magnification techniques for CSA measurement. In this study, the standard imaging method was employed. The measurement of the cross-sectional area of the tibial nerve was conducted at specific positions: level I, situated 1 cm below the point where the sciatic nerve bifurcates into the tibial and common peroneal nerves, and level II, positioned 1 cm superior and posterior to the medial malleolus.

RESULTS

90 individuals were recruited for this study. 52 (57.8%) were female and 38 (42.2%) were male. The average age of individuals was 42.17 ±14.75 (Table 1). Mean age of diabetics was 52.1±10.2 years and non-diabetics was 32.2±11.5 years (Table 2). The largest size of the median nerve was 20mm^2 with a mean of 9.53 ± 3.20mm^2 and the tibial nerve was 26mm^2 with a mean of 11.688 mm^2 ± 4.38. The average size of the median nerve in diabetic patients was 12.1 ±2.1 mm^2 and in non-diabetics was 6.88 ±1.3mm^2. The average size of the tibial nerve in diabetic patients was 15.06 ± 3.0mm^2 and in non-diabetics was 8.3 ±2.4mm^2 (Table 3). An independent-sample-test was performed to compare the median and tibial nerve in non-diabetic conditions. There was a significant difference p<0.005 (Table 4). For the tibial nerve, females (Mean = 12.0 ± 4.2 mm) exhibit a slightly larger size compared to males (Mean = 11.2 ± 4.5 mm). In terms of the Median Nerve, males had a mean size of 9.44 ± 2.8 mm, while females had a slightly larger mean of 9.6 ± 3.4 mm (Table 5).

Table 1: Descriptive statistics

Variables	Frequencies (%)
Age	42.1 ± 14.7
Gender	Female 52 (57.8%) Male 38 (42.2%)
Status of Diabetes	Diabetic 45 (50%) Non-Diabetic 45 (50%)
Median Nerve size (mm)	Hypoechoic 42 (46.7%) Normal 48 (53.3%)
Tibial Nerve size (mm)	Hypoechoic 41 (45.6%) Normal 49 (54.4%)
Median Nerve Echogenicity	9.5 ± 3.2
Tibial Nerve Echogenicity	11.6 ± 4.3

Table 2: Descriptive statistics of Diabetes

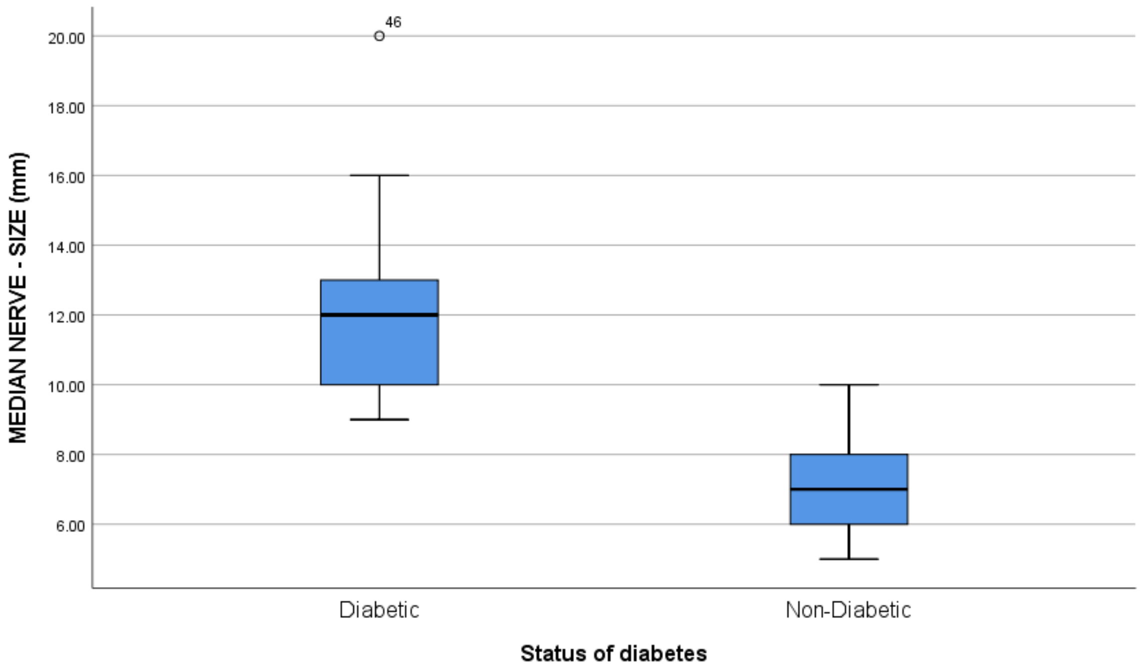
	Diabetes		P-value
	Yes (n=45)	No (n=45)	
Age	52.1 ± 10.2	32.2 ± 11.5	0.000
Gender	Male (20) Female (25)	Male (18) Female (27)	N.A
Median Nerve Echogenicity	Hypoechoic (42) Normal (3)	Hypoechoic (0) Normal (45)	0.000
Tibial Nerve Echogenicity	Hypoechoic (41) Normal (4)	Hypoechoic (0) Normal (45)	0.000

Table 3: Mean comparison between median/tibial nerve and status of diabetes.

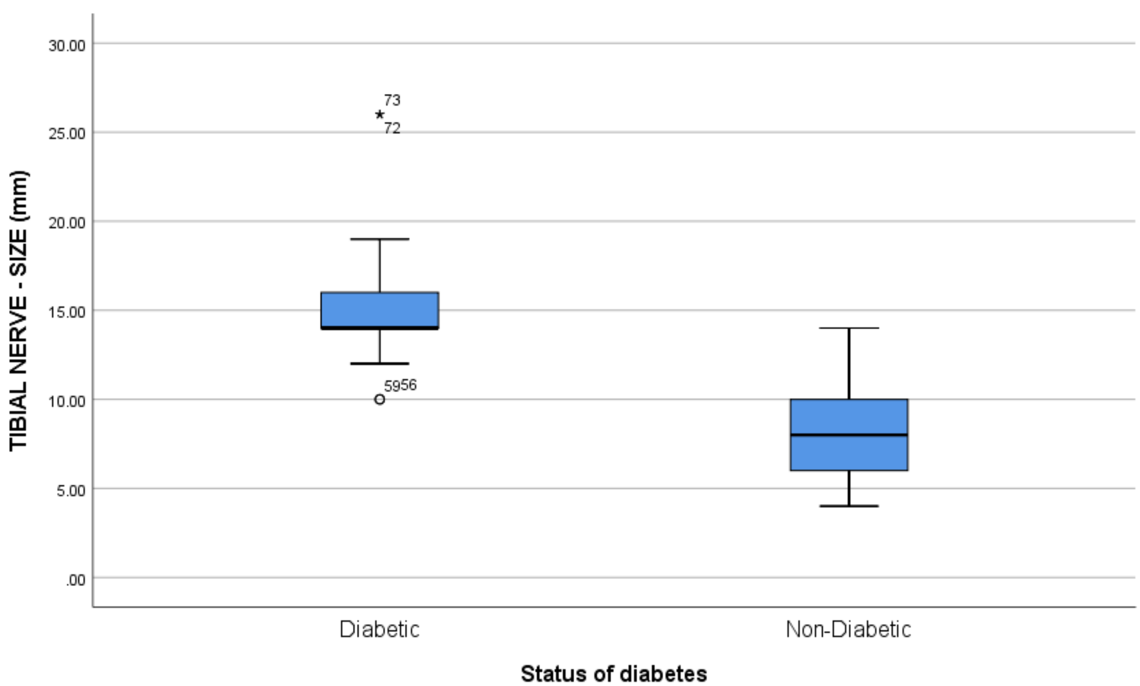
	Diabetes	N	Mean	Std. Deviation	Std. Error Mean
Median Nerve - Size (mm)	No	45	6.8889	1.36885	.20406
	Yes	45	12.1778	2.14570	.31986
Tibial Nerve - Size (mm)	No	45	8.3111	2.45711	.36628
	Yes	45	15.0667	3.08516	.45991

Table 4: Independent sample t-test for median/tibial nerve and diabetes.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Median Nerve-Size(mm)	Equal variances assumed	5.404	.022	13.940	88	.000	5.28889	.37941	4.53489	6.04288
	Equal variances not assumed			13.940	74.725	.000	5.28889	.37941	4.53302	4.53302
Tibial Nerve-Size(mm)	Equal variances assumed	.002	.962	11.490	88	.000	6.75556	.58794	5.58714	7.92397
	Equal variances not assumed			11.490	83.804	.000	6.75556	.58794	5.58632	7.92479 ,



Plot 1: Box-Plot shows the comparison between Median nerve and diabetes.



Plot 2: Box-Plot shows the comparison between tibial nerve and diabetes.

Table 5: Mean comparison of tibial/median nerve with gender.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Tibial Nerve - Size (mm)	Male	38	11.2	4.5	0.7
	Female	52	12.0	4.2	0.5
Median Nerve - Size (mm)	Male	38	9.44	2.8	0.45
	Female	52	9.6	3.4	0.48

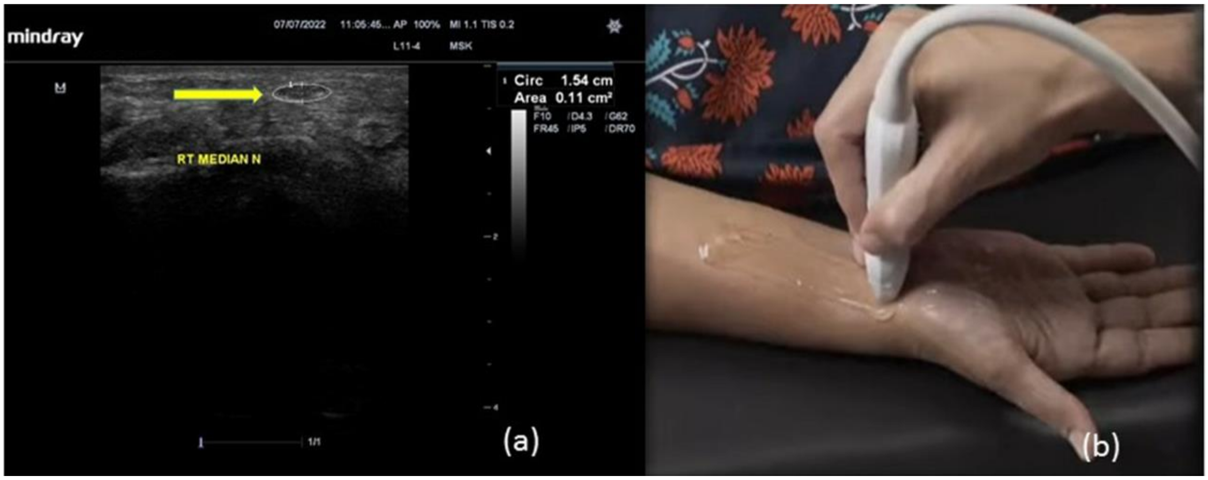


Figure 1(a) shows the increase cross sectional area of right median nerve of 58-year-old male diabetic patient (b) show the position of median nerve at the carpel tunnel (wrist).

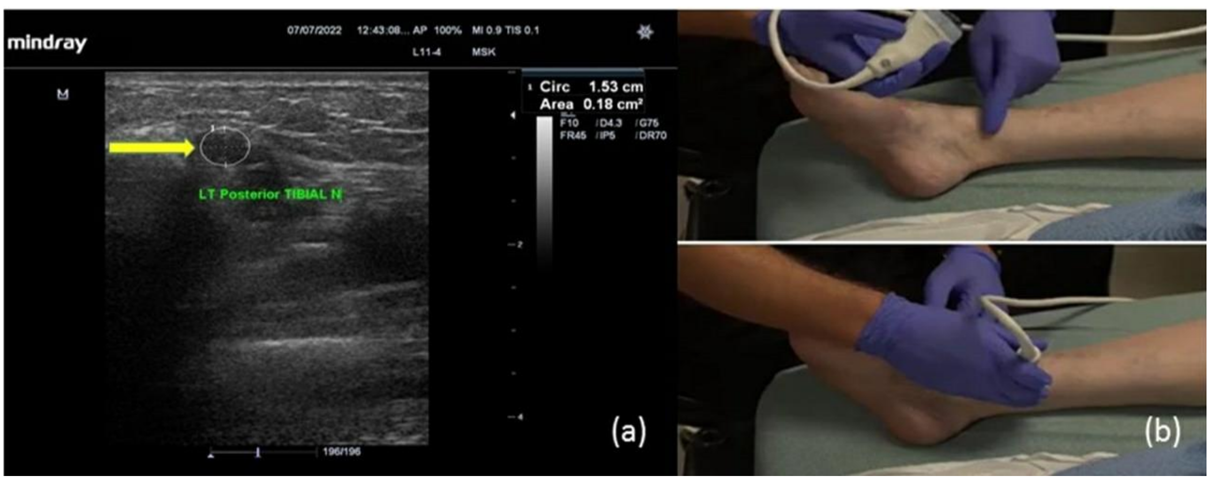


Figure 2 (a) shows the increase cross sectional area of the posterior tibial nerve of 45 year old female diabetic patient (b) show the position of posterior tibial nerve at medial malleolus site

DISCUSSION

The study was conducted at Sehat Medical complex Hanjarwal Lahore in 2022. We recruited 90 individuals aged 18-75. Out of the 90 individuals 45 were diabetics and 45 were non-diabetics with a mean age of 42.17±14.7 years. The median nerve's mean size in healthy individuals was 6.88±1.3 $mm^2$and in diabetic patients was 12.17 ± 2.1 mm^2. In diabetic individuals, the tibial nerve's CSA was 15.06±3.0mm^2, but in non-diabetics, it was 8.3±2.4mm^2. The Independent Sample test revealed the statistical difference between the average CSA of the median nerve in healthy and diabetic individuals ($p<0.005$). Our research revealed a considerable difference in the median nerve's CSA in healthy and diabetic individuals. The median nerve CSA in diabetic patients was larger than it was in the control group.

Based on the results of the independent samples t-tests, there was a statistically significant difference in the mean size of the median nerve between diabetic and non-diabetic participants ($t(88)=13.940$, $p<0.001$), as well as a significant difference in the mean size of the tibial nerve between diabetic and non-diabetic participants ($t(88)=11.490$, $p<0.001$). These findings are consistent with previous research that has also found that individuals with diabetes have larger nerve sizes compared to non-diabetic individuals [30]. A study by Aslan et al. [35] found that the tibial nerve size was significantly larger in diabetic patients as compared to non-diabetic patients ($p<0.001$), which is consistent with the findings of the present study. Similarly, a study by Kim et al. [36] also reported significantly larger tibial nerve size in diabetic patients as compared to non-diabetic patients ($p=0.011$). In this study, the diabetic group had significantly smaller median and tibial nerves than the non-diabetic group. This suggests that diabetes may have contributed to the differences observed in this study.

On the other hand, some studies have reported contradictory findings regarding the association between nerve size and diabetes. For instance, a study by Ahn et al. [37] found that the tibial nerve size did not differ significantly between diabetic and non-diabetic patients ($p=0.324$), which contradicts the findings of the present study. Similarly, a study by Kerasnoudis et al. [38] reported no significant difference in median nerve size between diabetic and non-diabetic patients ($p=0.401$).

Gender differences may also play a role in nerve size differences between the two groups. Previous studies have shown that there are gender differences in median and tibial nerve size, with males having larger nerves than females [31, 32]. The results showed no statistically significant difference in the mean size of the median or tibial nerve between males and females ($p>0.05$). This is consistent with the findings of other studies that have also failed to find significant gender differences in nerve size [33, 34]. One study we found indicated significant differences in nerve conduction parameters between males and females for various nerves, including the median and tibial [39].

Overall, the findings from this study suggest that diabetes is associated with larger nerve sizes, which may have implications for the diagnosis and management of diabetic neuropathy. Implementing nerve cross-sectional area measurements in routine screenings may enable early detection of diabetes and diabetic neuropathy. Continued research could lead to the development of more advanced diagnostic tools and treatment strategies for diabetes-related complications.

CONCLUSION

This study concluded that the majority of diabetic patients who underwent ultrasonography had a much larger cross-sectional area of median and tibial nerves than healthy control subjects. Moreover, the findings imply that sonography investigations could help in the early evaluation of diabetic neuropathy.

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Conflict of interest: The authors declared no conflicts of interest.

Ethical approval: Study was conducted after the approval from Research ethical committee, The University of Lahore.

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التنبؤ بالسكري عن طريق قياس مساحة المقطع العرضي للأعصاب الوسطى والسمنية. هل هو متنبئ جيد؟

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الملخص

الخلفية والاهداف : تقييم تصوير الأعصاب السينية والمشطية في الأشخاص الذين يعانون من مرض السكري وغيرهم من غير المصابين بالسكري. الطريقة: في هذه الدراسة نوع الحالة – الضابطة، تم فحص 90 فرداً تم تقسيمهم إلى 45 مصاباً بالسكري و 45 غير مصابين بالسكري. تم إجراء الدراسة في مجمع سيحات الطبي هنجرول لاهور. تم استخدام اختبار t للعينة المستقلة لمقارنتها بين المجموعتين.

منهجية الدراسة : تم استقطاب 90 فرداً خلال دراستنا، بينهم 52 (57.8٪) إناث و 38 (42.2٪) ذكور. كان متوسط عمر الأفراد 42.17 ± 14.75. كان متوسط حجم العصب السيني في المصابين بالسكري 12.1 ± 2.1 مم مربع وفي غير المصابين بالسكري 6.88 ± 1.3 مم مربع. كان متوسط حجم العصب المشطي في المصابين بالسكري 15.06 ± 3.0 مم مربع وفي غير المصابين بالسكري 8.3 ± 2.4 مم مربع.

النتائج : كان هناك فارق كبير بينهما ($p<0.005$). بالنسبة للعصب المشطي، تعرضت الإناث (المتوسط = 12.0 ± 4.2 مم) لحجم أكبر قليلاً مقارنة بالذكور (المتوسط = 11.2 ± 4.5 مم). فيما يتعلق بالعصب السيني، كان للذكور حجم متوسطي قدره 9.44 ± 2.8 مم، بينما كان للإناث متوسط أكبر قليلاً بحجم 9.6 ± 3.4 مم.

الاستنتاج: وفقًا لبحثنا، كان لدى الغالبية العظمى من المصابين بالسكري الذين خضعوا للتصوير بالأمواج فوق الصوتية زيادة كبيرة في المنطقة الشعاعية المستعرضة للأعصاب في المصابين بالسكري مقارنة بالأفراد الأصحاء. علاوة على ذلك، تشير هذه النتائج إلى أن

الكلمات الدالة: مرض السكري، العصبونية السكرية الطرفية، الموجات فوق الصوتية عالية الدقة، المنطقة المستعرضة. ترجمتها إلى العربية.