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EVALUATION OF THE EFFECT OF DURATION OF DIABETES MELLITUS ON PERIPHERAL NEUROPATHY USING THE UNITED KINGDOM SCREENING TEST SCORING SYSTEM, BIO-THESIOMETRY AND AESTHESIOMETRY

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ABSTRACT

Background and Objectives: Risk factors predisposing to foot ulceration in diabetic subjects are multiple. Long duration of diabetes mellitus is a major risk factor, likewise peripheral neuropathy (PN), which globally, is recognized as the commonest risk factor for foot disease in diabetic subjects.

Objectives: To evaluate the effect of duration of diabetes mellitus on peripheral neuropathy using the United Kingdom Screening Test (UKST) Scoring System, Bio-thesiometry and Aesthesiometry, in Nigerian diabetic subjects without current or previous foot ulceration.

Subjects and methods: One hundred and twenty (120) diabetes mellitus (DM) subjects with and without symptoms of peripheral neuropathy receiving care at the medical outpatient department (MOPD) and the diabetic clinic of the Nnamdi Azikiwe University Teaching Hospital Nnewi, Nigeria, were recruited consecutively as they presented. Data collected included subjects age (years), gender, age at first diagnosis of DM, duration of DM (years) and baseline fasting venous plasma glucose. The United Kingdom Screening Test (UKST) symptom score was used to separate the participants into two groups those with symptoms of PN and those without and the subjects further assessed by three methods the UKST Signs score, Bio-thesiometry and Aesthesiometry to determine the presence of PN.

Results: Among the 120 diabetic participants, 83(69.2%) had neuropathic symptoms (the symptomatic participants) while 37(30.8%) were asymptomatic (the asymptomatic participants). The different methods of diagnosing PN increasingly detected PN with increasing duration of diabetes. For the symptomatic group, the UKST method detected PN least in those with duration of DM <5 years (73.9%) and 100.0% in those with duration of DM >15 years while for the asymptomatic group, it detected PN in 25.0% of those with duration of DM <5 years, and 100.0% for those with duration of DM >15 years. For the symptomatic group, Aesthesiometry detected PN in 65.2% of those with duration of DM <5 years and 91.7% in those with duration of DM >15 years. For the asymptomatic group, it detected PN in 29.2% of those with duration of DM <5 years and 100.0% in those with duration of DM >15 years. Likewise, for the symptomatic group, Bio-thesiometry detected PN in 47.8% of those with duration of DM <5 years and 100.0% in those with duration of DM >15 years. For the asymptomatic group, it detected PN in 16.7% of those with duration of DM <5 years and 100.0% in those with duration of DM >15 years.

Conclusion: Long duration of diabetes mellitus and peripheral neuropathy are risk factors for foot complication in Nigerians with diabetes mellitus. Diabetic subjects with long duration of diabetes (>10 years) almost always have associated peripheral neuropathy, and should be recognized as a special group at high risk for foot disease from DM. Specific preventive programs should target this group to reduce the rate of avoidable loss of limbs to diabetes.

Key Words: Diabetic foot ulceration, peripheral neuropathy, United Kingdom Screening Test, Aesthesiometry, Bio-thesiometry.

INTRODUCTION

Risk factors predisposing to foot ulceration in diabetic subjects are multiple. Long duration of diabetes mellitus (>10 years) is a major risk factor for foot disease in diabetic subjects and is frequently associated with neuropathy in diabetic subjects.[1] However, duration may not reflect the true duration of the disease, rather it may reflect really the time since diagnosis as NIDDM onset may precede its diagnosis by several years.[2]

Generally, for duration of diabetes mellitus (DM) up to 10 years or less, the majority of patients do not have neuropathy but for duration greater than 10 years, majority of patients have neuropathy.[3] In the Pima Indian study,[2] duration of DM was a significant risk factor for amputation, even after controlling for age and sex.

Peripheral nerve damage is a common complication of DM [4] and worldwide is recognized as the commonest

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Risk factor for foot disease among diabetic subjects.[5-8] It is detected by screening for typical symptoms and signs. The exact pathogenesis of diabetic peripheral neuropathy (PN) is unclear, and like diabetes mellitus itself, is probably a heterogeneous disorder not fully explained by a single pathogenic mechanism.[9] Early lesions may arise from exposure of peripheral nerves to hyperglycaemia. Subsequently, accumulation of sorbitol and fructose generated from glucose shunted into the polyol pathway by aldose reductase and sorbitol dehydrogenase together with deficiencies of myoinositol and diacylglycerol all may combine as potent metabolic factors responsible for structural breakdown of nerves and slowed conduction velocity.[10-12] Findings of prominent microangiopathy[13] and multifocal fibre loss[14] pathologically support possible vascular causes for PN. Damage to endothelial cells by advanced glycosylation endproducts (AGEs) cause decreased endothelial nitric oxide and prostacyclin production, resulting in vasoconstriction, platelet aggregation and disrupted blood nerve barriers. Recently, attention has focused on the role of reduced nerve growth factor levels as a cause of diabetic PN.[15,16]
Distal symmetric polyneuropathy involving sensory, motor and autonomic nerve fibres is the most common form of neuropathy in DM subjects.[17,18] Ulcers commonly result from sensory neuropathy which blunts protective pain sensation, chronic motor neuropathy with atrophy of the small intrinsic muscles of the foot which distorts the normal anatomy and bio-mechanics of the foot with abnormal point pressure loading and mal-distribution of pressure,[19] and autonomic neuropathy which impairs the microcirculation and the integrity of the skin.[20-23]

OBJECTIVE

This study seeks to evaluate the effects of duration of DM on peripheral neuropathy using the United Kingdom Screening Test (UKST) Scoring System,
Bio-thesiometry and Aesthesiometry in Nigerian diabetic patients without current or previous foot ulceration.

METHODOLOGY

The study was carried out at the Nnamdi Azikiwe University Teaching Hospital (NAUTH) Nnewi, a 268 bed tertiary health institution in Anambra State, South Eastern Nigeria. While not having a strict catchment area, most patients come from Anambra State with a population of about 3 million. Referrals also come from a large catchment area of other neighboring states in South-Eastern and South-South Nigeria including Imo, Abia, Enugu, Cross-River, Akwa-Ibom, Ebonyi, Rivers and Delta states.
Following informed consent and ethical approval, 120 diabetic participants were recruited consecutively as they presented to the medical outpatient department (MOPD) and diabetic clinic of the Nnamdi Azikiwe University Teaching Hospital (NAUTH) Nnewi. They included known diabetic patients (currently on treatment with oral hypoglycemic agents or insulin[24]) and newly diagnosed diabetic patients as defined by the World Health Organization (WHO) 1999 Diagnostic Criteria. [25] None of the study subjects had a previous or a current foot ulcer at the time of the study. Data collected included subjects age (years), gender, age at first diagnosis of DM and duration of DM (years). Baseline fasting venous plasma glucose was estimated by the Glucose Oxidase Method and read colorimetrically in the chemical pathology laboratory of the NAUTH, Nnewi.
A clinical scoring system - the United Kingdom Screening Test (UKST)[26] was applied to each participant and used to screen/score for symptoms of peripheral sensory neuropathy, to objectively separate the symptomatic from the asymptomatic participants. Since the UKST instrument is a screening instrument previously unapplied to local (Nigerian) studies involving diabetic patients, a pretest questionnaire was initially developed based on the UKST symptoms score only and administered to 40 diabetic patients with and without foot complications, recruited randomly from the study center to assess performance and applicability of this screening instrument for PN among Nigerian diabetic patients. All 40(100%) subjects gave responses easily scored using the UKST symptoms score confirming the applicability of the screening tool. The subjects of the pretest trial were excluded from the study population proper.
The symptoms of PN scored (**see Table1**) were the abnormal sensations felt by the patients in the feet/leg namely:

: Burning, numbness or tingling, which score 2 points
: Fatigue, aching or cramping, which score 1 point.

The impact of site of discomfort, time of worst symptoms, night-time awakening and alleviating factors contributed further scores. Maximum symptoms score was 9 graded as follows:

: Normal (no PN) 0-2
: Mild PN 3-4
: Moderate PN 5-6
: Severe PN 7-9

The criteria for symptomatic PN was presence of moderate (5-6) or severe (7-9) symptom score, a criterion chosen to eliminate the risk factor of overestimation of symptomatic PN by including mild symptom scores. Mild symptoms scores may be transient and may also occur normally in the general (non-diabetic) population with increasing age.

Following separation of the study population into symptomatic and asymptomatic groups, the study population was further assessed with three objective instruments the UKST signs score, Bio-Thesiometry and Aesthesiometry to evaluate the presence of peripheral neuropathy as a risk factor for foot ulceration

in the study population.

Table 2 shows the UKST signs score. The signs scored were ankle reflex, vibration, pinprick and temperature sensations. All sensations were tested at the pulp of the hallux. Vibration was assessed using a low frequency (128Hz) tuning fork[27] and temperature tested by assessing the patients' response (cold, warm or unable to tell) to iced tuning fork (tuning fork inserted in ice-blocked water for one minute) and placed on the pulp of the hallux. [9] Temperature sense was scored as abnormal if the patient perceived the iced-tuning fork as warm or unable to tell. For all sensations, each foot was scored separately. Presence of normal sensations scores 0 point, while reduced/absent sensations score 1 point for each foot. Normal reflexes score 0 point, presence with reinforcement 1 point and absence 2 points for each foot.

Maximum signs score was 10, graded as follows:

: Normal (no PN) 0-2
: Mild PN 3-5
: Moderate PN 6-8
: Severe PN 9-10

Using the signs score, PN was assessed as objectively present with moderate (6-8) or severe (9-10) signs score. Akin to the symptoms score, this criterion for diagnosing PN was chosen to eliminate the risk of overestimation by including mild signs scores that often normally occur in the general population with increasing age and potentially distorts the possible relationship between diabetic neuropathy and age [26].

Bio-Thesiometry was done using the model PVD-LP Bio-thesiometer from Bio-Medical Instrument Company Ohio, USA.[28] This instrument objectively measures vibration sensation and determines the vibration perception threshold (VPT). Patients were tested lying supine on an examination couch and prior to testing, the procedure was explained and demonstrated to the patient for familiarization. Testing was commenced by applying the vibrator of the Bio-thesiometer to the test site - the pulp of the big toe of each foot. This site is routinely used in screening tests to detect PN. [29] The vibrator was held in such a way that the weight of the vibrator furnished a standard pressure on the vibrator button with the probe balanced vertically on the pulp of the great toe.

The vibrator was held steady and the subject instructed to concentrate all attention at the test site and to verbally report the first appearance of the sensation of vibration by saying “yes”. The amplitude of the vibrator button was set as low as possible at the start of testing and increased until the patient perceived vibration. The voltage on the Bio-thesiometer display at that instant was recorded as Threshold 1 (TH_1). This threshold is usually higher than the actual threshold due to the reaction time of the patient. Two further threshold readings (TH_2 and TH_3) were obtained at the test site and the mean of the last two readings used to determined the VPT for each foot.[30]

For greater reliability of the threshold readings especially when values obtained were widely divergent on the same test point, suggesting that threshold was reported by the subject when he/she thought that stimulus had been applied rather than when he/she actually felt it, catch trials were done specifically for subjects with divergent readings at the same test point. Catch trials involved turning off the main Bio-thesiometer switch without the subjects' knowledge while still applying the vibrator button. If he/she still reports sensation when stimulus had been switched off, it confirmed inappropriate response. The entire test procedure was re-explained to this category of patients to facilitate reliable cooperation and repeated.

VPT is the lowest threshold at which vibration is sensed on the pulp of the big toe and the value in normal subjects increases with age from approximately 6 volts at age 30 years to 20 volts at age 75 years [31]. Neuropathy was considered objectively present if the VPT was > 20 volts in either foot.

Aesthesiometry was done using the Weinstein Enhanced Sensory Test 10gm [tm] monofilament pressure aesthesiometer (WEST FOOT) [32] sourced from Connecticut Bio-instruments Inc (CBI), 9 Golden Heights Road, Danbury, Connecticut, 06813 USA, to detect Loss of Protective Sensation (LOPS). This monofilament (MF) is a patented improvement of the classic Semmes Weinstein (SW) monofilaments from Semmes Weinstein Corporation and has the advantages of calibration for applied force. Calibration confers on the monofilaments the property of applying a single characteristic force without regard to the degree of bend or hand induced vibration thus improving sensitivity. It also has the advantage of improved specificity, inducing pressure, not pain. The classical SW MF tip is sharp (hence it's also referred to as right cylindrical or common tip MF) and inappropriately may stimulate pain receptors. The pain sensation stimulated can interfere with the measurement of tactile sensation and compromise accurate measurement of force sensation.

The WEST- foot MF tester has round textured tips (Sof Tip[tm]) and eliminates this confound from painful stimulation by presenting a stimulus that is non-noxious to the patient.

Patients were tested lying supine on an examination couch and the MF applied to 8 sites - 4 in each foot - specifically the plantar surface of the hallux, the first, third and fifth metatarsal heads.[33]

Prior to testing, the subject was familiarized with the test procedure. During testing with patient looking away from the foot being tested, the MF was slowly pressed onto the skin until it buckled (bent) appropriately to <180 ^{o}C and was held on the test site buckled for one second. This one-second application was approximated by silently saying one “Mississippi” and the MF then slowly raised from the skin to about 1cm above the test site. This manoeuvre is important to eliminate the possibility of patient responding to false clues (non-tactile stimuli) such as visual clues from seeing motion from the investigators arm or trunk from

their peripheral vision.

When the MF buckles appropriately, it exerts 10 grams of force and subject acknowledges perception of the MF application with a verbal response of "yes" during or immediately after the application while not looking at the foot. This confirms presence of protective sensation while absence of a "yes" response indicates LOPS, confirming presence of PN. The criterion for LOPS with one application of the MF was 0 of 1 criterion, that is, zero detection with one application of the MF at any or all sites tested. Applications were not made to corns, calluses or scar tissues as these were potential sites for false positive results.[3] For greater reliability, the order and timing of successive tests was randomized to reduce the potential for patient guessing and where the 0 of 1 criterion was inconclusive in defining LOPS, the 0 or 1 of 3 criterion was applied. By this criterion, LOPS was defined by 0 or 1 detection out of 3 applications of the MF and excluded by the 2 out of 3 rule. By this rule, when testing one specific site, more than one detection of three applications of the MF excludes LOPS.

Overall PN was considered present (presence of LOPS) by failure to detect the MF application at 1 or more sites (0-3/4) in either foot and 0-7/8 in both feet. It was considered absent (absence of LOPS) with detection of the MF at all 4 sites (4/4) in each foot and 8/8 in both feet.

Statistical analysis was by SPSS (version 10) evaluating and presenting simple descriptive statistics. The mean, standard deviation and percentages of all data were derived. The Z test was used to determine the differences between the mean ages and glycaemic control of the two study groups while the Chi square test was used to evaluate the difference in the gender distribution of the symptomatic and asymptomatic study groups. p value of < or = 0.05 was taken to indicate statistical significance.

RESULTS

Among the 120 diabetic participants, 83 (69.2%) had neuropathic symptoms (the symptomatic group) while 37(30.8%) were asymptomatic. Table 3 shows the socio-demographic characteristics of the participants. The age range for the symptomatic group was 40-78 years and 30-76 years for the asymptomatic group. The mean age of the symptomatic group was 60+ or - 9.22 years and 48.51 ± 15.35 years for the asymptomatic group. The difference in the mean ages of the two study groups was statistically significant (Z=5.26, df =118, p<0.05).

In the symptomatic group, 53(63.9%) were males while 30(36.1%) were females and in the asymptomatic group, 20(54.1%) were males compared to 17(45.9%) females. The difference in the gender distribution of the two study groups was not statistically significant (x^2=1.032. df =1, p =0.31). The majority of the symptomatic 71(85.5%) and asymptomatic 31(83.8%) participants had poor glycaemic control (venous fasting plasma glucose FPG=6.0 mmol/L) and the difference in the mean FPG for the symptomatic (12.9±5.4mmol/L) and asymptomatic (12.2±4.6mol/L) participants was not statistically significant (Z= 0.69, p = 0.495).

Table 4 details the effect of duration of DM on peripheral neuropathy (PN) as diagnosed by the various methods for both study groups. All the diagnostic methods increasingly detected PN with increasing duration of DM. The UKST method detected PN least in those with duration of DM <5years and highest in those with duration of DM >15 years. For the symptomatic group, it detected PN in 73.9% of those with duration of DM <5 years and 100.0% in those with duration of DM >15 years.

Table 1: **The United Kingdom Screening Test (UKST): Symptom Score and Grading.**

Symptom		Score			
		1 Point	2 Points	Maximum	Overall
1 Abnormal Sensations Felt -	Burning, Numbness Or Tingling	-	✓	2	
	Fatigue, Aching Or Cramping	✓	-	1	
2 Site of Discomfort	- Feet or Soles	-	✓	2	
	- Calves	✓	-	1	
	- Elsewhere	-	-	0	
3 Time of Worst Symptoms	- Night Only	-	✓	2	
	- Both Day And Night	✓	-	1	9
	- Day Only/ Don't Know	-	-	0	
4. Alleviating Factor	- Walking Around	-	✓	2	
	- Standing	✓	-	1	
	- Sitting, Lying Or No Relief	-	-	0	
5 Night-Time Awakening	- Yes	✓	-	1	
	- No	-	-	0	

GRADE: 0-2 (Normal) No Peripheral Neuropathy
3-4 Mild Peripheral Neuropathy
5-6 Moderate Peripheral Neuropathy
7-9 Severe Peripheral Neuropathy

Table 2: **The United Kingdom Screening Test (UKST): Sign Score and Grading.**

Sign	Score				
	0 Point	1 point	2 points	Maximum (each foot)	Overall (both feet)
1. Ankle (Achilles tendon) reflex (with flexible tendon hammer)					
- Present	✓	-	-	0	
- Present with reinforcement	-	✓	-	1	
- Absent	-	-	✓	2	
2. Pain (Pin-Prick)					
- present	✓	-	-	0	
- Reduced or absent	-	✓	-	1	10
3. Vibration (128Hz tuning fork)					
-Present	✓	-	-	0	
-Reduced or absent	-	✓	-	1	
Temperature (ice-cold tuning fork)					
-Present (perceived as cool = normal)	✓	-	-	0	
-reduced or absent (perceived as warm or can't tell)	-	✓	-	1	

GRADE: 0-2: (Normal) No Peripheral Neuropathy
3-5: Mild Peripheral Neuropathy
6-8 Moderate peripheral neuropathy
9-10 Severe peripheral neuropathy

Table 3: **Socio-Demographic Characteristics of the Participants.**

Variables	Cases					
Age (Years)	Symptomatic			Asymptomatic	Total (%)	P-Value
	Male (%)	Female (%)	Male (%)	Female (%)		
30-39	0(0.0)	0(0.0)	2(10.0)	11(64.7)	13(10.8)	
40-49	6(11.3)	2(6.7)	7(35.0)	0(0.0)	15(12.5)	
50-59	20(37.7)	14(46.7)	3(15.0)	6(35.3)	43(35.9)	
60-69	14(26.4)	10(33.3)	6(30.0)	0(0.0)	30(25.0)	
=70	13(24.6)	4(13.3)	2(10.0)	0(0.0)	19(15.8)	
Total	53(100.0)	30(100.0)	20(100.0)	17(100.0)	120(100.0)	0.31
Mean Age±SD	60.4 ± 9.22		48.51 ± 15.35			0.0001
Mean FBS±SD	12.9 ± 5.4		12.2 ± 4.6			0.495

For the asymptomatic group, it detected PN in 25.0% of those with duration of DM <5 years and 100.0% in those with duration of DM >15 years. Aesthesiometry detected PN least in those with duration of DM <5 years and highest in those with duration of DM >15 years.
For the symptomatic group, it detected PN in 65.2% of those with duration of DM <5 years and 91.7% of those with duration of DM >15 years. For the asymptomatic group, it detected PN in 29.2% of those with duration of DM <5 years and 100.0% in those with duration of DM >15 years. Similarly, Bio-thesiometry detected PN least in those with duration of DM <5 years and highest in those with duration of DM >15 years.
For the symptomatic group, it detected PN in 47.8% of those with duration of DM <5 years and 100.0% of those with duration of DM >15 years. For the asymptomatic group, it detected PN in 16.7% of those with duration of DM <5 years and 100.0% in those with duration of DM >15 years.

Table 4: **The Effect of Duration of Diabetes Mellitus on Peripheral Neuropathy as Diagnosed by Various Methods**

Duration (Years)	UKST				Aesthesiometry				Bio-Thesiometry			
	Symptomatic (₦83)		Asymptomatic (₦37)		Symptomatic (₦83)		Asymptomatic (₦37)		Symptomatic (₦83)		Asymptomatic (₦37)	
	Positive Diagnosis (%)	Number Studied	Positive Diagnosis (%)	Number Studied	Positive Diagnosis (%)	Number Studied	Positive Diagnosis (%)	Number Studied	Positive Diagnosis (%)	Number Studied	Positive Diagnosis (%)	Number Studied
<5	17(73.9)	23	6(25.0)	24	15(65.2)	23	7(29.2)	24	11(47.8)	23	4(16.7)	24
5-10	19(90.5)	21	8(72.7)	11	14(66.7)	21	6(54.5)	11	10(47.6)	21	5(45.5)	11
11-15	15(100)	15	0 (0.0)	0	13(86.7)	15	0(0.0)	0	13(86.7)	15	0(0.0)	0
>15	24(100)	24	2(100)	2	22(91.7)	24	2(100)	2	24(100)	24	2(100)	2
Total	**75(90.4)**	**83**	**16(43.2)**	**37**	**64(77.1)**	**83**	**15(40.5)**	**37**	**58(69.9)**	**83**	**11(29.7)**	**37**

DISCUSSION

Over 120 million people in the world suffer from diabetes mellitus (DM) and many have diabetic foot ulcers (DFUs), which may eventually lead to an amputation.[34] The costs associated with DFUs can be tremendous and remains a major burden to both the patient and the health care system.[35,36] Studies from Nigeria and elsewhere consistently report that the diabetes mellitus foot syndrome (DMFS) is the single most common cause of prolonged hospitalization amongst people with diabetes.[37,38] Thus, identification of the risk factors for foot ulceration is of paramount significance in the prevention of this enormous complication of DM. Several risk factors predispose the diabetic patient to foot ulceration with peripheral neuropathy and peripheral vascular disease being major risk factors.[4] Other reported risk factors include foot deformity, previous history of foot ulceration or amputation, male gender, elderly age, poor glycaemic control, long duration of diabetes mellitus and poor foot care.[3,39,40]

This study sought to evaluate the effect of duration of DM on peripheral neuropathy using the UKST scoring system, Bio-thesiometry and Aesthesiometry in Nigerian diabetic subjects without current or previous foot ulceration. The participants were divided into two groups- those with symptoms of peripheral neuropathy (the symptomatic group) and those without symptoms of peripheral neuropathy (the asymptomatic group), using the UKST scoring system. The UKST is a two part diagnostic test comprising symptoms score and signs score and was used to determine the prevalence of PN in over six thousand diabetic patients in the United Kingdom. The symptoms score component of the UKST was used to separate the study population into two groups those with symptoms of PN (the symptomatic group) and those without symptoms of PN (the asymptomatic group). This separation was necessary to compare the effect of these risk factors in the two groups as those with symptoms of peripheral neuropathy are supposedly at higher risk for DFU from PN compared to those without neuropathic symptoms. The results of our study disagreed with this empirical expectation and showed that the effect of long duration of diabetes mellitus on PN as a risk factor for foot ulceration in diabetic subjects was similar, irrespective of the presence or absence of neuropathic symptoms.

Long duration of DM (>10 years) is a recognized risk factor for foot ulceration in diabetic subjects.[1] Often, as in this study, it may not reflect the true duration of the disease, rather it reflects the time since diagnosis, as NIDDM onset may precede its diagnosis by several years.[2] The effect of long duration of diabetes probably relates to increased production of glycosylation end products.[41] The risk of amputation appears to parallel the prevalence of neuropathy, which increases with duration of DM. In general, for duration of DM up to or less than 10 years, the majority of patients do not have neuropathy, but for durations greater than 10 years, majority of patients have neuropathy.[4] In the Pima Indian Study,[2] duration of DM was a significant risk factor for amputation, even after controlling for age and sex.

The findings of this study agrees with previous reports [3,4,26] and showed clearly that both long duration of DM and PN are genuine risk factors for foot ulceration in diabetic subjects, irrespective of the presence or absence of the most alarming symptom of diabetic foot disease peripheral neuropathy. The various methods for diagnosing PN positively diagnosed PN with increasing duration of diabetes, the highest diagnoses occurring in those with duration of DM >15 years, for both study populations. In this sub-group, the diagnosis of PN by the various methods for the symptomatic study group

was 100.0% (UKST), 91.7% (Aesthesiometry), and 100.0% (Bio-thesiometry), and for the asymptomatic group, it was 100.0% (UKST), 100.0% (Aesthesiometry), and 100.0% (Bio-thesiometry). Positive diagnosis of PN for those with duration of DM <5 years by all methods was lower.

In this sub-group, the diagnosis of PN by the various methods for the symptomatic study group was 73.9% (UKST), 65.2% (Aesthesiometry), and 47.8% (Bio-thesiometry), and for the asymptomatic group, it was 25.0% (UKST), 29.2% (Aesthesiometry), and 16.7% (Bio-thesiometry). These findings show that as the duration of diabetes increased, the risk for developing PN and subsequently diabetic foot disease also increased, even in those without symptoms of PN.

CONCLUSION

Considering the heavy financial, physical and emotional burden to the patient (and the health care system) associated with diabetic foot complications, identification of the risk factors for foot ulceration remains of paramount significance in the prevention of this dreaded complication of diabetes mellitus. Diabetic patients with lengthy duration (>10 years) of diabetes [42] are at high risk for foot complications from DM and need enrollment into effective preventive programmes for foot disease to reduce the rate of avoidable loss of limbs to diabetes.

REFERENCES

1. **Lavery LA, Armstrong DG, Velsa SA, Quebedeaux TL, Fleischli JG.** Practical criteria for screening patients at high risk for diabetic foot ulceration. Arch Intern Med 1998; 158:157-162.

2. **Harris MI, Klein R, Welborn TA, Knuiman MW.** Onset of NIDDM occurs at least 4-7 years before clinical diagnosis. Diabetes Care 1992; 15:815-819.

3. **Adler AI, Boyko EJ, Ahroni JH, Stensel V, Forsberg RC, Smith DG.** Risk factors for diabetic peripheral sensory neuropathy. Diabetes Care 1997; 20:1162-1167.

4. **Bild DE, Selby JV, Sinnock P.** Lower extremity amputation in people with diabetes: Epidemiology and prevention. Diabetes Care 1989; 12:24-31.

5. **Walter DP, Gatling W, Mulle MA, Hill RD.** The distribution and severity of diabetic foot disease: a community study with comparison to a non-diabetic group. Diabetic Medicine 1992; 9:354-358.

6. **Jones RB, Gregory R, Jones EW.** The quality and relevance of peripheral neuropathy data on a diabetic clinical information system. Diabetic Medicine 1992; 9:934-937.

7. **Walter DP, Gatling W, Mulle MA, Hill RD.** The prevalence of diabetic sensory neuropathy in an English community. Diabetic Medicine 1992; 9:349-353.

8. **Akanji AO, Famuyiwa OO, Adetuyibi A.** Factors influencing the outcome of treatment of foot lesions in Nigerian patients with diabetes mellitus. QJM 1989; 73:1005-1014.

9. **Maser RE, Steenkiste AR, Dorman JS.** Epidemiology correlates of diabetic neuropathy. Reports from Pittsburgh epidemiology of diabetes complication study. Diabetes 1989; 38:1456-1461.

10. **Dyck PJ.** Peripheral neuropathy: new concepts and therapy. Neurol Clin 1992; 10: 3-6.

11. **Brownlee MA, King GL.** Chronic complications of diabetes. Endocrinol Metab Clin North Am 1996; 25(2): 336-337.

12. **Tomlinson DR.** Polyols and myoinositol in diabetic neuropathy of mice and men. MAYO Clin P 1989; 64: 1030-1033.

13. **Malik RA, Nuerick PG, Sharma AK.** Microangiopathy in human diabetic neuropathy: relationship between capillary abnormalities and the severity of neuropathy. Diabetologia 1989; 32: 92-102.

14. **Llewelyn JG, Thomas PK, Gilbey SG, Watkins PJ, Muddle JR.** Pattern of myelinated fibre loss in the sural nerve in neuropathy related to type 1 (insulin-dependent) diabetes. Diabetologia 1988; 31: 162-167.

15. **Faradji V, Sotelo J.** Low serum levels of nerve growth factor in diabetic neuropathy. Acta Neurol Scand 1990; 81: 402-406.

16. **Zanone MM, Banga JP, Peakman M, Edmonds M, Watkins PJ.** An investigation of antibodies to nerve growth factor in diabetic autonomic neuropathy. Diabet Med 1994; 11: 378-383.

17. **Harati Y.** Diabetic peripheral neuropathies. Ann Intern Med 1987; 107: 546-559.

18. **Guy RJC, Clarke CA, Malcolm PN, Watkins PJ.** Evaluation of thermal and vibration sensation in diabetic neuropathy. Diabetologia 1985; 28: 131-137.

19. **Okuyama M, Nagai K, Miyazaki S, Kosaka J, Kamikubo K, Miura K et al.** Diabetic gangrene in Japan: analysis of 487 cases. Tohoku J Exp Med 1983; 141: 583-586.

20. **Deanfield JE, Dagget PR, Harrison MJC.** The role of autonomic neuropathy in diabetic foot ulceration. J Neurol Sci 1980; 47: 203-210.

21. **Ryder REJ, Kennedy RL, Newrick PG.** Autonomic denervation may be a prerequisite of diabetic neuropathic foot ulceration. Diabet Med 1990; 7: 726-730.

22. **Edmonds ME, Nicolaides KH, Watkins PJ.** Autonomic neuropathy and diabetic foot ulceration. Diabet Med 1986; 3: 56-59.

23. **Ahmed ME, Delbridge L, Le Quesne LP.** The role of autonomic neuropathy in diabetic foot ulceration. J Neurol Neurosurg Psychiatry 1986; 49: 1002-1006.

24. **Franklin GM, Kahn LB, Baxter J.** Sensory neuropathy in non-insulin dependent diabetes mellitus: The San Luis Valley Diabetes Study. Am J Epidemiol 1990; 131: 633-643.

25. World Health Organization. Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications, Part 1. Report of a WHO Consultation. WHO Geneva, 1999.

26. **Young MJ, Boulton AJM, Macleod AF.** A multi-centre study of the prevalence of diabetic peripheral neuropathy in the United Kingdom hospital clinic population. Diabetologia 1993; 36:150-154.

27. **Linger C, Albeanu A, Bloise D.** The tuning fork revisited. Diabet Med 1990; 7:859-864.

28. **Van Deursen RWM, Sanchez MM, Derr JA, Becker MB, Ulbrecht JS, Cavanagh PR.** Vibration perception threshold testing in patients with diabetic neuropathy: ceiling effects and reliability. Diabetic Medicine 2001, 18:469-475.

29. **Boulton AJM, Betts RP, Franks CI, Newrick PG, Ward JD, Duckworth T.** Abnormalities of foot pressure in early diabetic neuropathy. Diabet Med 1987; 4:225-228.

30. **Young MJ, Breddy JL, Veves A, Boulton AJ.** The prediction of diabetic neuropathic foot ulceration using vibration perception thresholds. Diabetes Care 1994; 17:557-560.

31. **Boulton AJ.** The diabetic foot. In: Diabetes Clinical Management. Tattersall RB, Gale E A (eds). Churchill Livingstone, Edinburgh 1990; pp 293-310.

32. Connecticut Bio-instruments Inc. WEST tm: Nerve tester for the foot. Http://www.cbi-pace.com/cbi.htm.

33. **Sosenko JM, Kato M, Soto R, Bild DE.** Comparison of quantitative sensory threshold measures for their association with foot ulceration in diabetic patients. Diabetic Care 1990; 13: 1057-1061.

34. The International Working Group on the Diabetic Foot. International Consensus of the diabetic foot. Foot. Amsterdam, 1999; 1-96.

35. **Ogbera AO, Ohwovoriole AE.** The prevalence of the "foot- at risk " for ulceration in diabetic patients in an urban hospital. African Journal of Endocrinology and Metabolism 2003; 4(1): 35-39.

36. **Ogbera AO, Ohwovoriole AE.** The economic costs of diabetes mellitus foot syndrome. African Journal of Endocrinology and Metabolism 2003; 4(1): 59-63.

37. **Benbow S, Gill G.** Diabetic foot ulceration in developed and developing countries. International Diabetes Digest 1998; 8:8-10.

38. **Dagogo-Jack S.** Pattern of diabetes foot ulcer in Port Harcourt Nigeria. Pract Diab Digest 1991; 2:75-80.

39. **de-Sonnaiville JJ, Collig LP, Wijkel D, Heine RJ.** The prevalence and determinants of foot ulceration in type II diabetic patients in a primary health care setting. Diabetes Research and Clinical Practice 1997; 35:149-156.

40. **Caputo GM, Joshi N, Weitekamp MR.** Foot infections in patients with diabetes. American Family Physician 1997; 56: 195-202.

41. **Belmin J, Valensi P.** Diabetic neuropathy in elderly patients: What can be done? Drugs Aging 1996; 8: 416-429.

42. **Trautner C, Haastert B.** Incidence of lower limb amputations and diabetes. Diabetes Care 1996; 19: 1006-1009.