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Effects of Type Two Diabetes Mellitus on the Plantar Aponeurosis of Nigerians

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Abstract: The aim of this study was to assess sonographically the effects of type 2 diabetes mellitus on the plantar aponeurosis of Nigerians. A total of 400 subjects, (200 healthy, non-diabetic and 200 diabetic adult Nigerians) were studied. The non diabetic subjects consisted of 105 men (age range = 18 – 71; mean age ± SD = 42.40 ± 6. 72) and 95 women (age range = 23 - 69 years; mean age ± SD = 37.71 ± 4.23). Diabetic subjects were made up of 111 men (age range = 33 – 74 years; mean age ± SD = 62.53 ±9.21) and 89 women (age range = 35 – 69 years; mean age ± SD = 58.44 ± 6.12). A hHigh resolution, dedicated small parts ultrasound machine (with a 10 MHz transducer) was used to assess the plantar aponeurosis. The fasting blood sugar levels (FBSL) of all patients and the HbA1c were recorded against the plantar aponeurosis thickness. The data was analyzed using SPSS (version 14.0). The results show that the plantar aponeurrosis of the diabetics was significantly thicker than that of the control group($p<0.05$) Plantar aponeurosis thickness (PAT) was directly related to fasting blood sugar level. Male gender and BMI was also related to plantar aponeurosis thickness. PAT could therefore be useful in the assessment of blood sugar level and in the management of diabetes mellitus.

Key words: Ultrasound · Diabetes · Plantar aponeurosis · Thickness · Glycation

INTRODUCTION

Diabetes Mellitus (DM) is a chronic disorder of carbohydrate, fat and protein metabolism, owing to insufficient secretion of insulin or target tissue insulin resistance [1]. It occurs in two major forms, type 1 and type 2 DM, both differ in etiology, pathology, age of onset and treatment. About 95% of persons with diabetes mellitus have type 2 and the rest have type 1 [2]. The pathogenesis of type 2 DM is not well understood and remains enigmatic [3,4]. Insulin regulates carbohydrate metabolism by aiding the transport of glucose and amino acid from the blood stream into the storage organs such as liver and muscles. In diabetes mellitus, there is hindrance of glucose transport of such a degree that threatens or impairs health.

The plantar Aponeorosis (PA) or Plantar Fascia is a ligamentours structure that extends from the calcaneous to the proximal phalanges. It is composed primarily of type 1 collagen [5] and is divided into three parts, the central (the thickest and strongest part) the lateral and medial parts. The central part divides into five bands, one for each toe and thus provide an intermediary structure between the skin and the osteoligamentous frame work of the foot. It plays a dual static and dynamic roles in the longitudinal arch support in the foot [6,7]. The stress placed on the plantar skin and plantar aponeurosis during daily activities makes these tissues extremely susceptible to trauma particularly in subjects with diabetes [8]. Despite the facts that the PA is a structure of the foot which could be affected by the complications of various disease processes, it has not been examined comprehensively.

The incidence of type 2 DM is growing rapidly worldwide [9-11]. In Nigeria, there is a progressive rise in the incidence of diabetic nephropathy from 19% in 1971

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to 42% in 1988 [12]. Epidemiological studies has provided the evidence of rising prevalence of diabetes all over Africa [13]. The global estimate was put at approximately three million in 1994 and is due to go through a 2 to 3 fold increase by the year 2010 [14].

In adults, investigations of effects of diabetes on the skin of the upper and lower limbs had been carried out using ultrasound and punch biopsies [15-18] but plantar aponeurosis thickness in isolation has not been examined in this locality.

In view of the rising increase of diabetes myellitus worldwide and its effects on some vital organs of the body, assessment of the plantar aponeurosis of diabetic patients becomes very necessary.

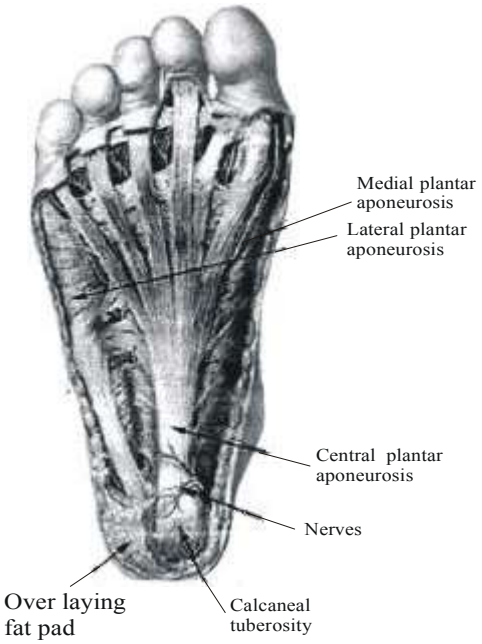
This study is designed to assess the effects of types 2 diabetes on the PA of Nigerians and to determine any association between plantar apponeurosis thickness with blood sugar level, body mass index and sex. This information will be useful in the management of patients with diabetes mellitus.

MATERIALS AND METHODS

A total of 400 subjects, (200 healthy, non-diabetic and 200 diabetic adult Nigerians) were studied. The non diabetic subjects consisted of 105 men (age range = 25 – 71; mean age ±SD = 42.40 ± 6. 72) and 95 women (age range = 26 - 69 years; mean age ± SD = 37.71 ± 4.23). Diabetic subjects were made up of 111 men (age range = 33 – 74 years; mean age ± SD = 62.53 ±9.21) and 89 women (age range = 35 – 69 years; mean age ± SD = 58.44 ± 6.12).

Pregnant women, acromegalic subjects, those with foot ulcers, joint diseases or acutely painful conditions which could affect gait were excluded from the study. The procedures and aims were clearly explained to the subjects and all gave informed consent. The human right and Ethics committee of Ebonyi State University Teaching Hospital approved the study. The ultrasound machine used in measuring the PA was a digital grey scale sonoace 5500 (Medicol, Koreamm) with 10MHz high resolution transducer. In measuring the PA, patient lay prone on the ultrasound couch, with knee flexed. Ultrasound gel was applied on the planter aspect of the foot and scanning was done longitudinally with emphasis on the central portion of the aponeurosis. To obtain this, the transducer was placed at least 3cm from the calcaneal insertion of the aponeurosis. Measurement of the aponeurosis was made from its anterior to the posterior wall. The PA of the diabetics werewas first measured before they were placed on anti diabetic drugs and regiments. The PA was measured again after 3weeks of treatment. The fasting blood sugar level (FBSL) of the subjects were measured using a digital glucose meter, Accu-check active with serial number GGo3111364 (Roche group, UK). The capillary blood was obtained by pricking the finger with a small lancet after the area had been appropriately cleaned with spirit and cotton wool. A drop of capillary blood was placed on a reagent strips and glucose levels were determined electronically. HbA1c was determined using in both control and diabetic subjects. The weight and height of the subjects were measured using electronic weighing scale and meter rule.

PAT was categorized according to FBSL, sex and age. SPSS software was used to analyze the data. The significant level was determined at $P<0.05$. T test was used to compare the PAT of male with that of female as well as that of non diabetic with those of diabetic patients. The association of PAT with FBSL, BMI and duration of DM was assessed using regression analysis.



RESULT

Table 2 shows that PAT of diabetics with increased FBSL are significantly thicker than that of their non diabetic counterpart in all age group. a A total of 400 subjects were included in the study. This comprised of 200 healthy, non diabetic subjects (control group) and 200 diabetic patients. The control group consisted of 105 males (age range =18-71 years, means age ± SD = 42.40 ± 6.72 years), and 95 females

Table 1: Comparing some variables between control and diabetic Subjects

Variables	Control	Diabetics
BMI	22.63±1.3	26.74± 3.5
Age	39.46± 3.51	60.71±6.60
Sex m; f.	105:95	111:89
FBSL (mg /dl)	83.61± 4.13	198.56±9.69*
PAT (mm)	3.13±0.15	4.20±1.31*
HAIC (%)	6.5	8.9*

* = P < 0.05

Table 2: Variation of PAT between non-diabetic and diabetic subjects with increased FBSL of same age group

	Control			Diabetic subjects			
Age (years)	FBSL Mean ± SD Mg/dl)	PAT Mean ±SD (mm)	N	FBSL Mean ±SD (mg/dl)	PAT Mean ±SD (mm)	N	P Value (PAT)
25-34	73.00±5.00	3.14±44	41	174.00±.32	3.30±.60	20	0.000
35-44	83.00±0.00	3.12±0.44	74	188.60±71.11	4.64±1.07	26	0.000
45-54	80.00±0.00	3.13±.47	45	213.62±101.20	4.39±90	55	0.000
55-64	92.00±2.50	3.14±.09	34	210.55±115.90	4.37±1.03	55	0.000
65-74	90.00±3.51	3.10±.38	6	206.09±107.00	4.28±84	44	0.000

(age range 23-69 years, means age ± SD =37.71 ± 4.23 years). The diabetic patient were made up of 111 males (age range = 33-74 years mean age ± SD = 62.53 ±9.21 years) and 89 females (age range =35-69 years), mean age ± SD = 58.44 years.

Males had significantly thicker PAT, 3.25± 0.11mm than females, 3.00 ± 0.26mm (P< 0.05). Diabetic subjects had significantly thicker PAT, 4.36±0.94 mm than the non-diabetics, 3.12±0.18mm(P=0.000). There was a strong positive correlation between PAT and FBSL (r = 0.69), (P< 0.05). BMI also had a strong positive correlation with PAT (r = 0.484). There was no significant correlation between age and PAT. 35% of the diabetic subjects whose blood sugar were well controlled, had their PAT reduced to the range of the healthy subjects.

DISCUSSION

The range of PAT for the apparently normal subjects in our study is 2.88mm to 3.45 mm for the males and 2.75mm to 3.33mm for the females. The mean thickness is 3.25 ± 0.11mm for the males and 3.00 ± 0.26mm for the females. These are similar with the findings are similar to earlier studies of Berkowitz *et al*. [19] and Bolton *et al.* [20] that showed PAT of normal adults to be 3.0, using magnetic Resonance imaging (MRI). Bolton *et al*. [20] in their study using computed tomography noted PAT of normal adults to be 3.6mm. Males had significantly thicker PAT than females (P<0.05). This conforms to the anatomical variation between males and females. Differences in hormonal constitution between male and female is the most possible reason for the differences noticed. PAT in the diabetic ranged from 3.31mm to 7.60mm with a mean of 4.36 ± 0.94mm. This is significantly thicker than that of normal subjects (P<0.05). Other studies, Duffin *et al.* [8] and Bolton *et al*. [20] has showed planter aponeurosis to be significantly thicker in diabetic subject than their non diabetic counterpart. Thickened plantar aponoreusis had also be observed in patient with planter fasciitis [19,21]. In plantar fasciitis patient usually present with pain on the heel and plantar aspect of the foot. In our diabetic patients with thickened PA pains was not complained of (throughout the period of study). The pathogenesis of this thickening is non enzymatic glycation [8]. Non-enzymatic glycation is the process by which glucose is chemically attached to the amino group of proteins without the aids of enzymes [3].

The PA is composed primarily of densely compacted collagen fiber [5] which is highly susceptible to non enzymatic glycation [8]. The collagenous component of the PA in the presence of excess glucose undergoes non enzymatic glycation resulting to thickening of this tissue in the diabetic.

FBSL had a strong positive correlation with PAT (r=0.696). This means that the higher the blood sugar level, the thicker the PAT. This is due to the facts that the degree of non-enzymatic glycation is directly related to the level of blood glucose and indeed, the measurement of glycosylated hemoglobin HbA levels in the blood is a useful adjunct in the assessment of blood glucose level and in the management of diabetes mellitus [3].

Non-enzymatic glycation is a reversible process and so if the factors that encourage its progress such as presence of glucose in the blood stream are withdrawn or controlled, the reversed process (i.e detachment of glucose from amino groups of proteins) would occur; leading to a reduction in the size of the tissue to a normal level. In our study, 35% of the diabetics had good control of their blood sugar levels (mean level, 90.20 ± 5.13mg/dl). Their mean PAT was 3.47 ± 0.25mm. Their PAT reduced in size to a mean of 3.47±0.25mm that is, in diabetic subjects whose blood sugar levels were brought under good control, their PAT reduced to normal size. Regression analysis shows that a unit rise in FBSL results in 0.003127 ± 0.001mm rise in PAT.

It would be interesting to know how long it would take the PA to retune to normal size with good control of the blood sugar level.

Diabetes, thus affects not only the skin of the diabetics, but also the deeper structures such as the PA. PAT is directly related to the blood sugar level and could therefore be useful in the monitoring of blood glucose level.

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