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Plantar Aponeurosis Thickness among Nigerians

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Abstract: The aim of this study was to determine the mean plantar aponeurosis thickness (PAT) in apparently normal adult Nigerians. The plantar aponeurosis thickness (PAT) of 224 apparently normal adult Nigerians were measured using ultrasound in a prospective cross sectional descriptive study. The fasting blood sugar level (FBSL) was determined after an overnight fast, using a digital glucose metre. The body mass index (BMI), age and sex of the subjects were also recorded. Data was analyzed with statistical package for social Science (SPSS) 14.0.Statiatical tests were two-tailed with $P<0.05$ to indicate statistical significance. The mean PAT was3.15 ±0.11mm for males and 2.36 ± 0.26mm for females. The plantar aponeurosis was significantly thicker in males than in females ($P<0.05$). PAT showed significant positive correlation with BMI ($r=0.6$, $P<0.05$) and age ($r=0.3$, $P<0.05$). The study has established reverence values of PAT for normal adult Nigerians, which could be useful in assessing the anatomical integrity of plantar aponeurosis.

Key words: Ultrasound · Plantar aponeurosis · Thickness · Nigerians

INTRODUCTION

The plantar aponeurosis (PA) is a subcutaneous complex ligamentous structure extending from the calcaneus to the ball of the foot [1]. It has a combined static and dynamic role in longitudinal arch support of the foot [2, 3] and the capability of allowing the loading capacity of the foot during weight bearing and jumping [4].

One of the indications for imaging of the plantar aponeurosis is the assessment of its anatomical integrity. This is very important in athletes engaged in running and jumping as rupture of the plantar aponeurosis, either complete or partial are common in competitive athletes [5, 6]. Rupture of the plantar aponeurosis had also been noted in trauma and repetitive stress as well as in patients with prior plantar fasciitis, especially in those treated with local steroid injections [7].

Abnormalities of the plantar aponeurosis are often encountered in many pathologic processes, the most common of this being plantar fasciitis. It had also been reported that diabetes mellitus affects the thickness of plantar aponeurosis in young people with typed 1 diabetes mellitus [8]. The process of non enzymatic glycation had been suggested as a possible cause of thickening of the plantar aponeurosis leading to the formation of a cavoid foot type with resultant plantar flexion of the metatarsal head [9].

Non enzymatic reaction between reducing sugars and several precursors such as collagen, plasma proteins, lipoproteins, cell membranes and intracellular proteins lead to the formation of multiple compounds collective named advanced glycation end products (AGEs) [10].

In diabetic patients hyperglycemia-mediated synthesis of new collagen and accumulation of products of glycation accelerate age-related changes to the skin, connective tissue andjoint as well as decreased elasticity, increased collagen cross-linking andloss of enzymatic digestibility of the extra cellular matrix [11].

Because their accurate measurement requires sophisticated and expensive techniques that limit their use in the clinical setting [12]. A simpler and more clinically useful technique is the measurement of tissues that are highly susceptible to the accumulation of AGEs sush as the planter aponeurosis. The thickness of plantar aponeurosis has recently been shown to predict the development of complications in adolescents with type I diabetes [12]. Thickened planter aponeurosis due to AGEs accumulation had also been shown to predict subsequent development of retinopathy and micro

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albuminuria [13] The plantar metatarsal area and the digits are common areas for the development of neuropathic ulcers [14, 15].

Although the plantar aponeurosis is another area of the foot which could be affected by the complication of various disease processes, it has never been examined in our locality.In view of the dynamic role and support function of the plantar aponeurosis to the foot and its susceptibility to various disease processes, further evaluation of the plantar aponeurosis is necessary. The aim of this study was to examine the plantar aponeurosis thickness (PAT) in normal adult Nigerians and establish a possible reference values for the normal population.

MATERIALS AND METHODS

A total of 224 healthy subjects (volunteers) were recruited for the study from June to December 2008. There were 121 men (age range 25-74 years; mean, 35.42±6.72years) and 103 women (age range, 25-66 years; mean, 30.71 ± 4.23 years)

Pregnant women, acromegalic subjects, those confirmed to be diabetic by clinical and laboratory assessments were excluded from the study. Relative of diabetic patients, subjects with joint diseases or acutely painful condition which could affect gait were also excluded from the study. The procedures and the objective were clearly explained to the subjects and they all gave informed consent. The Human Right and Ethic Committee of Ebonyi State University Teaching Hospital approved the study.

A digital gray scale ultrasound machine, sonoace 5500 (Medicol, korea) with a 10MHz high resolution transducer was used to obtain the sonographic measurements. The fasting blood sugar level (FBSL) of the subjects were measured using a digital glucose meter, Accu-check active with serial number GG03111364 (Roche Group, Uk).

The fasting blood sugar level was obtained from subjects who arrived in the morning without food (overnight fast), by pricking the finger with a lancet after the area had been appropriately swabbed with spirit and cotton wool. A drop of capillary blood was placed on a reagent strips and glucose level was determined electronically.

The weight and height of the subjects were obtained using electronic weighing scale and metre rule. The body mass index (BMI) was obtained as weight/height^2. The subjects sex and age were also recorded.

In measuring the plantar aponeurosis thickness (PAT), subjects lied prone in the examination couch with the knees flexed. The ultrasound gel was applied on the plantar aspect of the foot. The transducer was placed longitudinally over the center of the arch at least 3cm from the calcaneal insertion of the aponeurosis. Scanning was done longitudinally with emphasis on the central part of the aponeurosis. Measurement of the aponeurosis was made from its anterior to the posterior wall.

Plantar aponeurosis thickness was categorized according to age and sex. Statistical Package for Social Sciences (SPSS)version 14.o software was used to analyze the data. Statistical tests were two tailed with $p<0.05$ to indicate statistical significance l. Comparison between Plantar aponeurosis thickness in males and females was done. Pearson's correlation analysis was used to evaluate the relationship between PAT with BMI and age.

RESULTS

The table is a possible reference values of PAT in males and females of various age groups. The mean value of PAT for males was 3.15 ±0.11mm and 2.36±0.26mm for females. The table shows that PAT of normal males are significantly thicker ($P<0.05$) than that of females in all age groups.The mean value of PAT in each age group is also shown. Pearson's correlation analysis shows that BMI has a positive correlation with PAT ($r=0.6$, $p<0.05$).

Table 1: Variation of PAT between males and females of same age group

	Male		Female		
Age	Mean ± SD (mm)	N	Mean ±SD(mm)		P value
25-34	3.11±. 06	25	2.3±. 25	30	.000
35-44	3.17±. 12	30	2.39±. 27	29	.000
45-54	3.18±19.15	37	2.35±. 27	27	.000
55-64	3.19±. 12	23	2.35±. 07	10	.000
65-74	3.10±. 12	6	2.35±. 35	7	.000

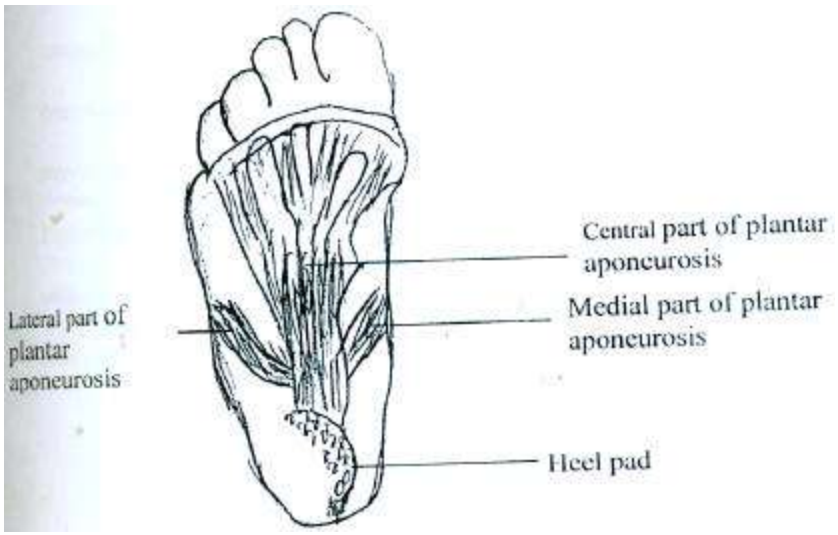

Fig. 1: Plantar aspect of the foot

DISCUSSION

Our results show that PAT of males are significantly thicker than that of emales ($P<0.05$) The mean value of PAT in males was 3.15± 0.11mm (range = 2.88mm to 3.75mm) while that of female was 2.36± 0.26mm (range = 2.00mm to 3.51mm). These values are similar to the findings of Berkowitz *et al.* [16] who reported PAT of normal adults to be 3.0mm using magnetic resonance Imaging (MRI). Bolton *et al.* [14] in their study using computed tomography noted PAT of normal adults to be 3.6mm. The slight variation in the values of PAT from these studies could be as a result of the existing differences in the imaging modalities as well as differences in geographical locations.

The variation in the thickness of PAT between males and females could be as a result of the differences in hormonal and anatomical composition between males and females. Different recreational activities, occupation and life styles may also play some roles in the difference noticed.

Correlation analysis shows that BMI had positive correlation ($r=0.6, p<0.05$) with PAT. It is most probable that higher BMI increases the mechanical load on the PA and this could lead to thickening.Age, on the other hand, had a weak but significant correlation with PAT ($r=0.3, p<0.05$).

Certain pathologic processes that affects the PA had been reported [16, 17], with Plantar fasciitis being the most common condition [14]. Plantar fasciitis is a low-grade inflammatory process involving the PA. It is not usually disabling but may deter patients from occupational, weight-bearing, athletic and recreational activities [4] and may be associated with altered gait pattern [18].

The thickness of PA had been reported to be up to 7mm in patients with plantar fasiciitis [4]. Diabetes mellitus has also been reported of affecting the PA in young people with type 1 DM [8] and the adults [19-21]. It has been suggested that the process of non-enzymatic glycation may affect the collagen in PA causing thickening of the tissue [8] and formation of a cavoid foot type with resultant plantar flexion of the metatarsal heads [19]. The thickness of PA is usually affected in most pathologic conditions effecting it [7, 8, 19] and so PAT is one major index of the anatomical integrity of the PA.

Conventional radiography lack enough contrast resolution to properly demonstrate the PA. Although other imaging modalities such as conventional radiography, bone scintigraphy, computed tomography and magnetic resonance imaging have been recognized previously as aid in the clinical evaluation of patients with abnormalities affecting the PA [10, 22, 21], they are more expensive. Diagnostic ultrasound was used for this study.

Ultrasonography thus offer effective alternative to computerized tomography and magnetic resonance imaging in the assessment of plantar aponeurosis. It is not expensive or time consuming.

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