# Sonographic Evaluation of Heel Pad Thickness in A Nigerian Population

**Egwu OA*, Anibeze CIP**, Akpuaka FC*****

*Lecturer in the Department of Anatomy, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria, ** Professor of comparative anatomy and human morphology. Currently the Deputy provost of the College of Medicine and Health Sciences, Abia State University, Uturu, Southeast Nigeria,***Professor of Applied Anatomy and Plastic Surgery and Chair of Anatomy at the Department of Anatomy, Abia State University, Uturu, Southeast Nigeria

**Abstract**: Background: The heel pad is an important element of foot biomechanics and knowledge of structural inclinations in populations is important in the pathological assessment of the foot. Subjects and Methods: The thickness of the Heel pad (HPT) was evaluated in a student population in Nigeria using ultrasound and correlated with some anthropometric variables to assess which variable can easily be used to predict HPT. Results: Results showed a mean HPT of 9.06±1.26 and 9.00±1.73 (mm) for the right and left side respectively; height, Body Mass Index (BMI) and Body Surface Area (BSA) showed positive correlation with the HPT. As a result Simple regression equations were deduced for HPT using height, BMI and BSA as independent variables. Conclusion: The results are not comparable to previous studies and suggest ethnic/racial impact on heel pad fat distribution and thus, opined the validation of these equations for expanded use in our population. [A Egwu et al NJIRM 2012; 3(1) : 77-81]

**Key Words:** Sonography, Heel Pad Thickness, Correlation, Anthropometric variables.

Author for correspondence: Egwu, OA, Lecturer in the Department of Anatomy, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria. His specialty is in Forensic Podiatry and Morphology.E-mail egwuoc@yahoo.com.

**Introduction:** The heel pad is an important factor in determining stresses observed in healthy and pathologic feet. It constitutes part of the weight bearing and pressure cushioning part of the foot. As a result, it is subject to repeated weight bearing and functions as an efficient shock absorber [1].

It is located beneath the calcaneus and acts as a hydraulic shock absorbing layer [2]. The average heel pad is 18mm thick and contains elastic adipose tissue organized as spiral fibrous septa anchored to each other, to the calcaneus and to the skin. The septae are U-shaped fat filled columns designed to resist compressive loads and are reinforced internally with elastic diagonal and transverse fibres which separate the fat into compartments [3].

Some studies have examined its importance in the kinetics and kinematics of gait design and have repeatedly stated that deficit in its function may likely induce a high degree of biomechanical stress on other soft tissues of the foot like the plantar fascia [4].

Due to its constant use, heel pain can result from injuries associated with it and with the surrounding osseous and soft tissue structures. In the United States, the diagnosis and treatment of heel pain and the common plantar fascitis that leads to it results in 1 million patient visits per year [5]. In Nigeria, its occurrence has not been practically reported but it is believed that there is lots of undiagnosed Heel pain cases among peasants and middle class individuals because a lifetime prevalence of this condition has been estimated to be 10-15% in runners and in similar proportion in the general population [2, 6].

Other studies have described structural alterations of the heel pad in some systemic diseases like Diabetes Mellitus, Achillodynia, Familial Hypercholesterolemia, rheumatoid arthritis and HIV where the integral pad design is lost due to morphorlogical transformation or redistribution of Pad fat components[7,4,8,9,10,11]. As such, investigations into the structural disposition of heel pad have aided the diagnosis of some of these ailments like Diabetes Mellitus [12].

The study of fleshed foot variability and utility of foot uniqueness in personal identification has obvious significance in forensic anthropology and forensic science, respectively[13]. Since the heel pad structural orientation is an integral part of foot uniqueness because it contributes a great deal to the outline of the rear foot in loaded and unloaded situations, the anatomical and mechanical properties should be in contention and should obviously assist in forensic determination of individuals.

Therefore, the importance of the human heel pad as a factor in propulsion cannot be overemphasized and thus, it is absolutely necessary to explore its anatomical inclinations in a relatively young and active student population as a further guide to understanding its functions as it relates to other parts of the foot. This could enhance its appreciation and application in maintenance of the kinetics and kinematics of gait and comparative locomotion.

The choice of ultrasonography in the assessment of these soft tissues was guided by the recommendations of previous studies, which stated that high resolution ultrasound should be employed as it is versatile in diagnosing soft tissue pathologies in different body locations [14] and has long been a reliable tool in assessing human heel pad thickness [15].

Studies in our immediate environment have established values for heel pad but none has made comprehensive correlations with other anthropometric parameters like Height, Weight, age, sex, Body Mass Index (BMI), Body Surface Area (BSA). And since heel pad thickness has been a good diagnostic tool in the assessment of some systemic diseases [12], this study will ascertain which easily measurable anthropometric parameter can be used to determine their structural inclination in subjects. It will also create a deeper insight into the biomechanical aspects of the foot

**Material and Methods**: Ethical approval for this work was obtained from the Research/Ethics committee of the Faculty of Basic Medical Sciences, Abia State University, Uturu, Southeast Nigeria.

DESIGN: This is an experimental research which was carried out within Abakaliki metropolis, southeast Nigeria. Abakaliki is a relatively large town with a population of over 500,000 people. It is the headquarters of Ebonyi State, Southeast Nigeria and thus accommodates variety of individual especially agriculturists.

STUDY CENTRE: The study centre is a private ultrasound scanning centre – Veramax Imaging centre, Abakaliki, Ebonyi State, Southeast Nigeria. This ultrasound and Imaging centre receives patients from within Abakaliki metropolis and beyond. Their patients are mostly obstetric patients and individuals with soft tissue pathology including all forms of intra-abdominal pathologies. It is well staffed with a total of twelve (12) resident Medical Imaging Scientists. The centre receives patients from all private hospitals in Abakaliki Metropolis and beyond and those not accommodated in the Federal Medical Centre, Abakaliki and Ebonyi State University Teaching Hospital, Abakaliki, Ebonyi State.

STUDY POPULATION: The study population comprises a convenient sample of 60 students (adults) of Ebonyi State University, Abakaliki, Southeast Nigeria, between the ages of 17 and 30 years who volunteered to participate in the study after an informed consent. The values from the subjects were generated within a period extending from June, 2010 to May, 2011.

INCLUSION CRITERIA: The subjects were apparently healthy; had no history of any systemic disease like diabetes, familial hypercholesterolemia etc and foot deformity or had undergone any form of foot surgery. This is to avoid any possible effect of these ailments. Those subjects who were not pregnant.

EXCLUSION CRITERIA:

- Subjects that had any history of foot deformity or foot surgery.
- Subjects who were pregnant. This is to avoid the effect of pregnancy on fat distribution and gait mechanics.
- Subjects with a history of any systemic disease like diabetes, familial hypercholesterolemia etc. This is to avoid any possible effect of these ailments.

INSTRUMENTS FOR DATA COLLECTION: A 7.5 linear-array transducer (Siemens sonoline 940- 2000 model) with a diameter of 39mm was used for the assessment of the thickness of heel pad. Other instruments for anthropometric measurement include: Caliberated wall to measure height of subjects and Automatic weighing balance. Body Mass Index (BMI) was calculated using the formula BMI= WEIGHT/(HEIGHT)$^2$. The Body Surface Area (BSA) was calculated using the formula by Du Bois and Du Bois [16]. BSA= (Weight $^{0.425}$ X Height (cm) $^{0.725}$) 0.007184.

EXPERIMENTAL PROTOCOLS: For this study, direct measurement techniques were employed. On the arrival of the subjects, their heights were measured using the calibrated wall and their weights taken with the automatic weighing balance. After which the scanning protocol was observed.

SCANNING PROTOCOL: Every heel assessed was penetrated with alcohol to allow the ultrasound to penetrate the soft tissue before examination[1] and a sufficient amount of jelly will be applied to the transducer to enhance contact between the transducer and the tested heel. During the measurement of Heel Pad Thickness (HPT), the subject lay prone on a couch with legs extended, the ultrasound gel was applied to the surface of the heel and the pad measured from its calcaneal boarder to the end of the pad [17]. All measurements were taken by one Medical Imaging Scientist to avoid interobserver variability and each measurement was taken three times for the two feet and the average obtained and recorded in a sheet. The data obtained from the measurements were analyzed using SPSS version 16.0.

**Result:** Table I describes the means ± standard deviations of measurements of HPT of the right and left foot taken a student population in Southeast Nigeria. Other descriptives for height, weight, age, BMI and BSA are also shown.

Table II shows correlations between HPT and the other assessed anthropometric variables. HPT of both sides of the body correlated with height, BMI and BSA. There was no correlation between HPT and age and weight.

Using HPT as the dependent variable and other anthropometric parameters as independent, four (4) simple regression equations were deduced to establish the relationships between HPT and height; HPT and BMI; HPT and BSA; and HPT and Weight. The equations include:

Between HPT and Height- HPT= 10.792[Height(m)] – 9.419.

Between HPT and BMI- HPT= 19.365 – 0.468 (BMI).

Between HPT and BSA- HPT=1.926+4.025 (BSA).

**Table 1: Descriptive Statistics of HPT and some Anthropometric Parameters**

| | HPT (Rt) (mm) | HPT (Lt)(mm) | Height (m) | Weight (Kg) | Age | BMI | BSA |
|---|---|---|---|---|---|---|---|
| Mean± St. Dev | 9.06±1.26 | 9.00±1.73 | 1.71±0.57 | 65.9±4.61 | 24.8±2.07 | 22.5±1.32 | 1.25±0.02 |
| Range | 6.9-11.1 | 6.0-11.0 | 1.63-1.79 | 59-76 | 23-29 | 20.2-24.2 | 1.21-1.30 |

**Table 2: Showing Correlations between HPT and other anthropometric variables.**

| | Height | Weight | Age | BMI | BSA |
|---|---|---|---|---|---|
| HPT (Rt) | | | | | |
| Pearsons correlation | 0.488** | 0.052 | 0.058 | 0.371* | 0.384* |
| P- value | 0.006 | 0.784 | 0.759 | 0.043 | 0.036 |
| HPT (Lt) | | | | | |
| Pearsons Correlation | 0.484** | 0.063 | 0.094 | 0.363* | 0.405* |
| P-value | 0.007 | 0.740 | 0.620 | 0.049 | 0.027 |

*Correlations is significant at P≤ 0.05 (2tailed),**Correlations is significant at P≤ 0.01 (2 tailed)

**Discussion:** Stresses within the foot structure are dependent on the three-dimensional geometry of its components (hard and soft tissues), including anatomical areas through which muscular and skeletal forces are transferred. The directions and magnitudes of these forces in the three-dimensional space, which are functions of the activity performed (e.g, gait, running, jumping, etc.)

are also basic factors that determine the stress state of the foot[18]. These vectored forces are transferred via the soft tissues of the foot to the ground. As such, stress states of the foot can also manifest on the structural inclinations and activity-related dynamics of the soft tissues there-in.

Results from this study have revealed the HPT of an adult student population in Nigeria. The values for HPT (9.6mm and 9.0mm for Rt and Lt foot respectively) is quite lower than those reported by Standring et al [3] – 18mm; Gooding et al[15] – 16.6mm; Erdemir et al [19] – 14.3mm; Nass et al [20] - 14.6mm for men and 12.2mm for women. Later, Uzel et al [21] reported that unloaded heel pad thickness in normal subjects ranged from 14-26mm with an average of 20mm. This huge difference may be associated with environmental and genetic and racial factors peculiar to the Nigerian setting where the subjects were recruited from. These factors may have affected the individuals' fat-distributing inclinations resulting to low fat deposition at the heal pad because in a study by Mueller et al [22] among female Varsity athletes, they stated that fat distribution in the extremities and trunks were affected by ethnicity.

Pearsons correlation coefficient indicated that the HPT of both sides correlated with height, BMI and BSA. These anthropometric variables, especially the height of the individuals, can be used to assess the HPT of young adults within the area of study. However, the anatomical relationship between these parameters cannot be broadly established but this study has shown strongly that there is a statistical relationship. Therefore, the regression equation established between HPT and height and BMI and BSA should be revalidated in order to be a working document among sonographers and individuals seeking evaluation of HPT in normal individuals and by extension in some systemic conditions like Diabetes Mellitus, Familial Hypercholesterolemia, achylodynia, rheumatoid arthritis, spondyloarthropathies and acromegaly.

The non-correlation of HPT observed with age goes contrary to other reported studies. Rome et al [23] and Ozdermir et al [24] have reported that increase in HPT and occurrence of hypertrophy is associated with ageing, which leads to reduced shock absorbency of the heel pad [25]. This observed non-correlation may be due to the thin spread of the age of the subjects because the subjects were almost of the same age bracket.

Ozdermir et al [26] implicated increased weight as a factor responsible for increased HPT. This report was not corroborated in this study as weight did not show any form of correlation with HPT. This could probably be attributed to the thin weight range of the subjects in the study population and a follow-up study on the effect of weight gain on HPT per subject was not carried out.

The novelty of our study draws from the fact that it should enable anthropometric assessment of some heel pad parameters without the use of ultrasound. This study should be extended to Diabetics to ascertain which anthropometric parameter could be most suitably used to assess HPT in our environment for easier diagnosis.

**Conclusion:** Racial/ethnic and environmental factors are capable of affecting the fat distribution mechanics within the heel pad and so, should have accounted for the difference observed in this study when compared to others and the derived equations in this study can be used to estimate HPT in our population. Therefore, they should be tested and validated by biomedical scientists in our population for possible application in other populations.

**References:**

1. Hsu C, Tsai W, Wang C, Pao S, Shau Y, Chuan Y. Microchambers and Macrochambers in heel pads: are they functionally different? J Appl Physiol , 2007;Vol 102(6): 2227-2231.
2. Aldridge T. Diagnosing heel pain in Adults. Am fam phys. 2004; 70;332-338
3. Standring S, Ellis H, Healy J, Johnson D, Williams A eds; Gray's Anatomy. 39thed 2005; pp 807-808. Chuchill Livingstone.
4. Stupar M, Tibbles A. Heel pain and HIV-associated lipodystrophy: a report of two cases. J Can Chiropr Ass 2008; 52(2): 103-109.
5. Riddle DL, Schappert SM. Volume of ambulatory care visits and patterns of care for patients diagnosed with plantar fascitis: a national study of Medical doctors. Foot Ankle Int 2004; 25(5):303-310.
6. DeMaio M, Paine R, mangine RE, Drez D. Plantar Fascitis. Orthopadics 1993;16(10): 1153-1163.

7. Hsu CC, Tsai WC, Hsiao TY, Tseng FY, Shau YW, Wang CL . Diabetic effects on microchambers and macrochambers tissue properties in the human heel pads. Clin Biomech (Bristol, Avon) 2009; 24(8):682-686.
8. Buchbinder R. Plantar Fascitis. N Eng J Med. 2004; 350: 2159-2166.
9. Falsetti P, Frediani B, Acciai C, Baldi F, Filipou G, Marcolongo R. Heel fat pad involvement in Rheumatoid Arthritis and in Spondyloarthropathies : an ultrasonographic study. Scand J of Rheumatology2004; 33(5): 327-331.
10. Thomas JL, Christeiensen JC, Kravitz SR, Mendicino RW, Scheberth JM, Vanore JV . The Diagnosis and treatment of Heel Pain. J Foot Ankle Surg 2001; 40(5):329-340.
11. Jorgensen U . Achillodynia and loss of heel pad shock absorbency. Am J sports Med 1985; 13: 128-132.
12. Ugwu AC, Udoh BE, Njoku CO, Eteudo AN . Roles of Sonographers in theManagement of Diabetes. A proposed framework. J diag Med Son.2008; 24:84-87.
13. Krishan K. Determination of stature from foot and its segments in a north Indian Population. Am of For Med & Path 2008; 29(4):297-303.
14. Ophir J, Garra B, Kallel F, Konofagou E, Righetti R, Varghese T Elastographic imaging. Ultrasound Med Biol 2000; 26(1) 23-29.
15. Gooding GAW, Stress RM, Graf PM, Grunfeld C. Heel Pad Thickness; determination by high resolution ultrasonography. J Ultrasound Med. 1985; 4;173-174.
16. Udoh BE. Effects of type 2 Diabeties mellitus on the plantar aponeurosis and heel pad in an adult Nigerian population. MSc thesis, University of Nigeria, Enugu Campus. 2006.
17. Du Bois D, Du Bois EF. A Formula to estimate the approximate body surface area if height and weight be known. Archives of Internal Med 1916; 17:863-871.
18. Gefen A, Megido-Ravid M, Itzchak Y, Arman A. Biomechanical analysis of three dimensional foot structure during gait: A basic tool for clinical application. J Biomech Eng 2000; Vol 122: 630-639.
19. Erdemir A, Viveiros ML, Cavanagh PR. A Numerical-Experimental approach for characterizing subject specific Hyperelastic Properties of the Heel Pad. Summer Bioengineering Conference, June 25-29, 2003; Sonesta Beach Resort in Key Biscayne, Florida.
20. Nass D, Hennig EM, van Treek R. The thickness of the heel pad loaded by bodyweight in Obese and normal weight adult. Biomechanics Laboratory, University of Essen, 2005, Germany, D45117.
21. Uzel M, Cetinus E, Bilgic E, Ekerbicer H, Karaoguz A. Comparison of Ultrasonography and radiography in the assessment of the heel pad compressibility index of patients with plantar heel pain syndrome. Measurement of fat pad in plantar heel pain syndrome. Joint Bone Spine 2006; 73(2):196-199.
22. Mueller WH, Shoup RF, Malina RN. Fat patterning in athletes in relation to ethnic origin and sport. Annals of Hum Biol 1982; Vol 9(4): 371-76
23. Rome K, Campbell R, Flint A, Haslock I . Reliability of weight bearing heel pad thickness measurements by ultrasound. Clin Biomech 1998;13:374-375.
24. Özdemır H, Söyüncü Y, Özgörgen M, Dabak K. Effects of Changes in Heel Fat Pad Thickness and Elasticity on Heel Pain J Am Podiatr Med Assoc 2004; 94(1): 47-52,
25. Kinioshita H, Francis PR, Murase T, Kawai S, Ogawa T. The Mechanical properties of the heel pad in elderly adults. Europ J of Appl Physiol. 1996; Vol 73(5)
26. Ozdemir H, Urguden M, Ozgorgen M, Gur S. The relationship between the thickness and elasticity of heel pad and heel pain. Acta Orthop Traumatol Turc, 2002; Vol 36, No 5