

Research Article

Activity related differences in the thickness of heel pad of some occupational groups in Nigeria: An imaging based study

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Abstract

The effect of prolonged occupation-related physical activity can induce stress and strain on the plantar heel pad. These strains can lead to the thickening of the human heel pad. The effect of occupation-related physical activity on the thickness of the Heel pad (HPT) was assessed among four classes of occupation- Labourers/farmers, Dancers, Athletes and an inactive class (control/normal group) in a southeast Nigerian population. Results show that the inactive class had the lowest values for HPT (9.06 ± 1.26 ; 9.00 ± 1.73 mm for right and left sides respectively). The athletes had the highest values (15.15 ± 1.51 ; 15.18 ± 1.57 mm for the right and left sides respectively). Multiple comparison shows that Labourers, Dancers and athletes had significantly higher values than the control group ($P=0.000$; 0.036 ; 0.000 respectively). Our findings have conclusively established that occupation-related prolonged Physical activity induces thickening of the heel pad. Interventions should be initiated to avoid the setting in of degenerating conditions that may lead to plantar heel pain.

Keywords: Physical Activity, Occupation, Heel pad thickness, Nigeria

1. Introduction

Physical activity can be described as the degree of use of the musculoskeletal system. It is always done to improve health and physical fitness. However, in some cases it is highly related to the type of occupation of the individuals. The level of physical activity of individuals has been reported to influence the functional mechanics of the human musculoskeletal system and may obviously influence the geometry and biomechanics of Gait¹.

The biomechanical orientation of the foot during persistent work can be a factor in the thickening of the heel pad. In most developing countries human locomotion forms the basic tool in economic growth. The foot is also a veritable tool among athletes who are constantly involved in running, cycling, jumping and other sports that require a sustained use of the feet. Among dancers, it is fundamental in the artistic communication of the beauty of dancing especially in traditional groups where most cultural exhibition of skills are directly associated with finesse articulation of feet movements; a persistent manifestation of dexterity associated with twisting and turning that imposes relatively high degrees of stress and strain within the foot component¹.

Uzel *et al*² did not establish correlation between physical activity of about 11 hours/week and unloaded and loaded heel pad thickness in a healthy young adult population but Rchalis *et al*³ stated that the nature of activity undertaken by subjects may influence their heel pad properties after understudying two populations of different degree of physical activity. Egwu *et al*,^{1,4} also reported activity related differences in the thickness of the plantar fascia and Achilles tendon respectively which are other soft tissues associated with the bipedal dynamics of human locomotion. They further stated that the difference was connected with the occupation of the subjects. However, no study has investigated any activity related changes in the thickness of the heel pad in our Sub-saharan African environment where factors like the consistent use of the bipedal system of motion by farmers and their associates in the harvest and transportation of farm produce; by labourers in numerous construction sites without mechanization and who transport heavy work tools and building materials; by professional athletes who are constantly using their feet to earn a living by strenuous acts of running, jumping, cycling; by traditional dancers who entertain people by exhibiting extra-dexterity in feet movement, may impact on the structural and functional inclinations of the human heel pad. Since the heel pad is a stress soaking aspect of the foot, there is need to find out its structural dispositions in such individuals involved in excessive use of the foot without avoiding investigations in individuals that do not expose their feet to the strain and stress of overuse.

The heel pad is subject to repeated high impacts and is anatomically adapted to withstand these pressures. It is located beneath the calcaneus and acts as a hydraulic shock absorbing layer⁵. The human heel pad is anatomically divided into a superficial microchamber and a deep macrochamber layers⁶. Hsu *et al*⁷ described the two chambers as being functionally different because after ultrasonic examination, it was obvious that the macrochamber layer plays a major role in the heel pad resiliency i.e the ability to recover its shape after deformation caused by compression. This layer may be responsible for the cushioning effect in the heel pad during walking. The microchamber layer seems to function as an inherent heel cup that maintains most of the macrochamber layer beneath the calcaneus and prevent excessive macrochamber deformation⁷. The thickness of the heel pad is sine qua non in the relative examination of the anatomy and mechanical properties of the heel pad. Ozdemir *et al*⁸ investigated the factors affecting the thickness and elasticity of the heel pad and sought relationship between the heel pad thicknesses, its elasticity with heel pain. They concluded that the thickness of heel pad increases in relationship to age and weight, resulting in decreased elasticity. Rome *et al*⁹ assessed the heel pad thickness (HPT) as a contributing factor in plantar heel pain in young adults. Their results demonstrate that body mass index (BMI) has a significant effect on the heel pad thickness of all subjects. And Egwu *et al*,¹⁰ also established a relationship between the heel pad thickness and height and BMI in a Nigerian population.

These anthropometric relationships with the HPT have not been linked to occupation related physical activities in our environment and as such, it is absolutely necessary to x-ray the impact of occupation related degree of physical activity on the heel pad. The study will give further insight into the structural inclination of the heel pad in the different foot biomechanical orientations associated with the occupations and form a basis for other occupation related studies on biomechanics within our sub-saharan African environment.

3. Subjects and Methods

3.1 Design

This is a quasi experimental research which was carried out within Abakaliki metropolis, Ebonyi State, Southeast, Nigeria.

3.2 Study Centre

The study centre was done in an ultrasound scanning centre – Veramax imaging centre, Abakaliki, Ebonyi State. 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 twelve¹² 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.

3.3 Study Population

Abakaliki Metropolis is made up of the capital territory of Ebonyi State, Nigeria. It has a land mass of about 2000 sq. km and bordered in the north by Benue State, in the west by Enugu State, in the east by Cross River State and in the south by the rest of the state. It has a population of over 400,000 people. Agriculture is the main stay of its economy and the people are essentially farmers. It has a rich cultural heritage and also known for the popular Quarry Industries where some

of its people are exposed to a myriad of hazards, especially the women folk. These women are continuously involved in lifting of crushed stones and probably imposing stress and strain on the natural weight bearing/cushioning parts of the foot. Also due to the large production of stones, a lot of construction sites abound. These women and some few men are always continuously lifting building materials, at times without appropriate podiatric wears. These individuals, earning a living in this case, are most likely to induce plantar pressure on their feet¹¹.

As a result of her rich cultural heritage, the Ebonyi State Government established a State Council for Arts and Culture and the metropolis plays home to a lot of cultural/traditional dance groups that are always training to earn a living through it and to entertain vigorously, the entire populace. With these categories of people, the Metropolis has all the classes of individuals required for this extensive study and that was why we considered it an ideal choice.

Thus, the study populations comprise the following groups:

- a. A convenient study population of 30 Igbos whose occupation is not very physically involving. For instance young Bankers, Lecturers, Teachers, Students who are resident in Abakaliki metropolis.
- b. A convenient sample population of 30 Igbos whose occupations are labourious – they undergo a high degree of strenuous work. Examples are those in the Quarry industry, Abakaliki and labourers in building and construction sites and full-time farmers resident in Abakaliki metropolis.
- c. A convenient Sample population of 30 highly active individuals who are athletes or involved in active sports like football, sprints, Long Jump, cycling etc.
- d. A convenient Sample population of 30 Traditional music dancers in Abakaliki Metropolis, Ebonyi State who are also highly active.

3.4 Inclusion Criteria

- a. The subjects must be apparently healthy; must have no history of any systemic disease like diabetes, familial hypercholesterolemia etc and foot deformity or have undergone any form of foot surgery. This is to avoid any possible effect of these ailments.
- b. The group (a) study population must not have any other type of job that increases physical activity and must have worked for a minimum of two (2) calendar years.
- c. The group (b) study population must not have any other job impeding his /her degree of physical activity except his normal rest periods and must have worked for a minimum of four (4) calendar years.
- d. The group (c) study population must be professional athletes/sportsman registered in any state owned sports outfit within Abakaliki and Enugu Metropolis and must have trained for a minimum of four (4) calendar years.
- e. The group (d) study population must be professional traditional music dancers Abakaliki Metropolis registered with the Ebonyi State Council for Arts and Culture and must have danced for four (4) calendar years.

3.5 Exclusion Criteria

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

3.6 Instrument 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 the plantar fascia.

3.7 Scanning Protocol

Every heel that was assessed was penetrated with alcohol to allow the ultrasound to penetrate the soft tissue before examination⁷ and a sufficient amount of jelly was applied to the transducer to enhance contact between the transducer and the tested heel. During the measurement of Heel Pad Thickness (HPT), the subjects lay prone on a couch with legs

extended, the ultrasound gel was then applied to the surface of the heel and the pad measured from its calcaneal boarder to the end of the pad¹².

3.8 Statistical Analysis

All measurements obtained were expressed as means± standard deviation. The data obtained were analyzed using Statistical package for social sciences (S.P.S.S) version 16.0.

3.9 Ethical Approval

In line with Belmont report of 1979 where respect for persons, beneficence and justice are recommended in every research involving human subjects, ethical approval was obtained from the Ethics/Research committee of the College of Health Sciences, Abia State University, Uturu after the subjects had given their consent to partake in the study.

4. Results

Table 1 shows HPT for all the groups

	Control (Relatively Inactive group)	Labourers	Dancers	Athletes
HPT (RT)	9.06±1.26	12.11±2.84	10.13±1.83	15.15±1.51
Range	6.9-11.1	8.2-16.8	7.1-13.0	12.0-18.1
HPT (LT)	9.00±1.73	12.07±2.85	10.25±1.90	15.18±1.57
Range	6.0- 11.0	8.2- 16.5	7.1-13-2	12.0-18.5

Figure showing the HPT (Rt and LT) for all the groups

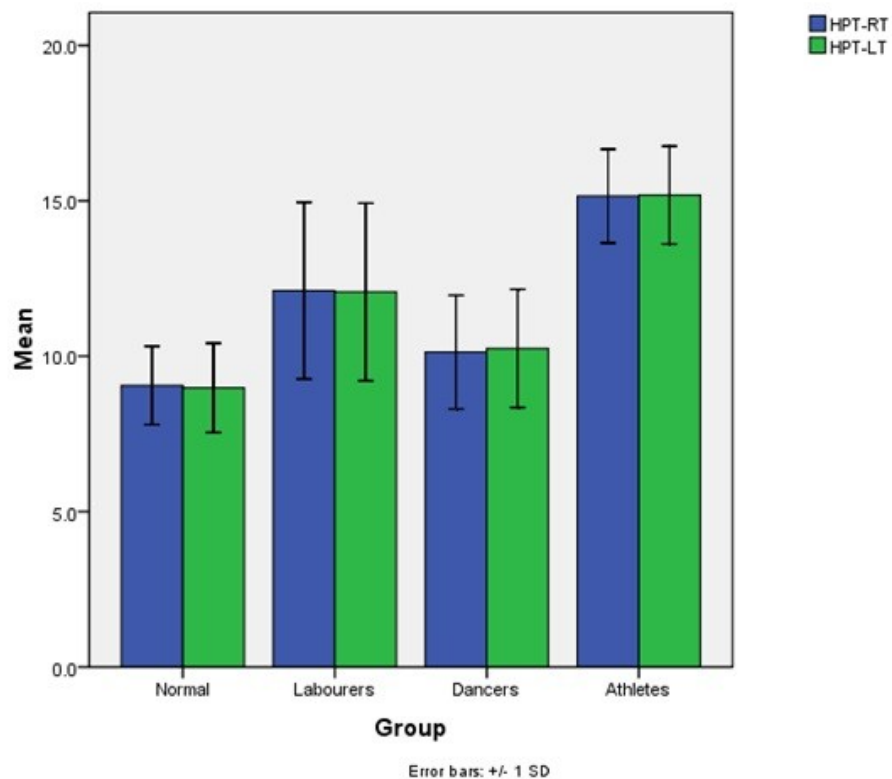


Table 1 shows the mean \pm SD of HPT of both sides for all the groups. The value of HPT for the athletes was the highest- 15.15 \pm 1.51 and 15.18 \pm 1.57mm for right and left sides respectively. Those of the control group (Normally inactive group) formed the least values- 9.06 \pm 1.26mm and 9.00 \pm 1.73mm for the right and left sides respectively. The figure shows a Bar chart comparing the HPT of all the groups for each side of the body.

Table 2 Showing Comparison between groups (ANOVA)

		Sum of Squares	Df	Mean Square	F	Sig
HPT (RT)	Between groups	644.75	3	214.92	56.29	.000*
	Within groups	442.92	116	3.82		
	Total	1087.67	119			
HPT (LT)	Between groups	652.83	3	217.61	53.31	.000*
	Within groups	473.54	116	4.08		
	Total	1126.37	119			

*P<0.05 (significant value)

The table above shows that there is a significant difference in the values of HPT (RT and LT) (P= 0.000 and 0.000 respectively) between the four (4) groups.

Table 3 Showing Multiple comparisons between groups using Post Hoc test (P<0.05 as significant) for HPT

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
HPT	Control	Labourers	-3.0533*	.5045	.000
		Dancers	-1.0733*	.5045	.036
		Athletes	-6.0933*	.5045	.000
	Labourers	Control	3.0533*	.5045	.000
		Dancers	1.9800*	.5045	.000
		Athletes	-3.0400*	.5045	.000
	Dancers	Control	1.0733*	.5045	.036
		Labourers	-1.9800*	.5045	.000
		Athletes	-5.0200*	.5045	.000
	Athletes	Control	6.0933*	.5045	.000
		Labourers	3.0400*	.5045	.000
		Dancers	5.0200*	.5045	.000

The table above shows comparative analysis of HPT across the four (4) groups. Taking P<0.05 as being significant, it is clear that there's significant difference between Control group and other groups (P=0.000; 0.036; 0.000); between Labourers' group and the others (P=0.000; 0.000;0.000); between Dancers and the other groups (P=0.036; 0.000; 0.000) and Athletes' and other groups (P=0.000; 0.000;0.000).

5. Discussion

Multiple comparisons between the groups revealed that their values were quite significantly higher than those of the normal group (table 3). This is a direct pointer towards the effect of prolonged physical activity on the mechanical and structural properties of the heel pad. In a study by Uzel *et al*², there was no relationship between physical activity of about 11 hours/week and loaded and unloaded heel pad thickness in a healthy adult population. However, in this study these subjects ranging from the labourers and dancers to the athletes are involved in continuous use of the feet in highly physically involving activities that may disrupt the biomechanics of the individuals' gait leading to gradual reconfiguration and thickening of the integral fat pad compartments resulting in the higher values obtained for them in this study.

The labourers/farmers who have engaged in the occupation for a reasonable part of their entire lives are involved in lifting building materials for lack of mechanization, transporting these materials to construction sites, transport farm produce to markets on barefoot or even without appropriate podiatric packaging. These factors will definitely impose high degrees of stress and strain on the Heel pad and in response, the fatty compartments within possibly undergo thickening and reduced elasticity that could be associated with occupation-induced premature ageing of the heel since ageing is a factor associated with thickening of human heel pad^{13, 14}.

Traditional dancers employ little or no podiatric packaging in the course of their display of high biomechanical dexterity and finesse of the foot. Through these events, high degrees of pressure are induced on the plantar heel pad that may lead to tears and wears. When this is continuously done for a reasonable part of a life time, it can initiate structural and biomechanical alterations of the soft tissues, like thickening, which can be likened to premature ageing of the human heel pad. These factors may have contributed immensely to the results obtained in this study as the normal geometrical orientation of their feet components are consistently altered in the line of duty resulting in these high values.

The athletes have shown even highest values of HPT (15.15 and 15.18mm for right and left sides respectively) which may be due to associated increased plantar pressure in faster paces (fast walking and running) as has been documented by Burnfield *et al*¹¹ and this predisposes the subjects to tissue injury, ulceration and pain. Another reason that may have accounted for the significant difference in values between the athletes and the control groups may be the fact that these subjects undergo a minimum of 5 hours/day of intense physical activities in a relatively unfriendly turf with very inappropriate or inferior and consistently worn podiatric wears that may inadvertently induce structural biomechanical deviation of the human heel pad.

Generally, this study corroborates the findings of Rchalis *et al*³ who stated that the nature of activity undertaken by subjects may influence heel pad properties after understudying two populations of different degrees of physical activity. Even though the incidence of plantar heel pain among these occupational groups was not assessed, this study has created an insight into the type of occupational groups that may have increased incidence of podiatric medical problems concerning the heel pad and has created the need for the design of intervention programs to avoid the possible occurrence of overuse syndromes associated with the heel pad. In a study by Shibuya *et al*¹⁵, there was increased prevalence of podiatric medical problems in retired war veterans than in non-veterans and because these farmers, labourers, dancers and athletes have a prolonged career of consistent induction of plantar heel strain and stress, a time may come when these observed thickening of the heel pad may become a podiatric problem due to outright loss of fat pad elasticity. Therefore, possible intervention programs for such class of individuals should also be initiated and sustained to avoid an increased level of dependence by the affected occupational class in the future.

6. Conclusion

The study had conclusively established that prolonged occupational related physical activity affects the structural and biomechanical disposition of the human heel pad due to occupation-induced premature ageing of the heel pad and intervention programs should be initiated to avoid the setting in degenerative plantar heel pain.

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