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Crescent Journal of Medical and Biological Sciences
Vol. 3, No. 3, July 2016, 81–85
eISSN 2148-9696

Comparative Study of the Foot Arch Index Among Pregnant and Non-pregnant Women in a South Eastern Nigeria Community: A Cross-Sectional Analysis

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Abstract

Objective: Physical and hormonal changes during pregnancy result in biomechanical alterations which result in re-adjustments in the musculoskeletal system. Influence of these changes on the foot during gestation has been understudied. The aim of this study was to compare the arch indexes of pregnant and non-pregnant women and then determine the relationship between arch index and each of gestational age and body mass index (BMI) of pregnant women.

Materials and Methods: In this study, 328 (215 pregnant women in different trimesters and 113 nulliparous women) participants were selected from Enugu in South-Eastern Nigeria. Their arch indexes were obtained from their foot prints. Data was summarized using frequency counts, mean, standard deviation and percentages. Inferential statistics of independent t test and Pearson correlation test were used to determine the differences and relationships among variables with alpha level set at $P<0.05$.

Results: Results showed that a greater percentage of the pregnant women (57.2% on the right foot and 59.1% on the left foot) had low arches, indicating pes planus as compared to their age-matched nulliparous counterparts (19.5% on the right and 23.3% on the left). Statistical analysis further showed significant differences between the arch indexes of women in both groups. No significant relationship was found among gestational trimesters, BMI and arch index of pregnant women.

Conclusion: Pregnant women have lower arch indexes, indicating pes planus, than nulliparous women. Gestational trimesters and BMI had no associations with the arch index during pregnancy.

Keywords: Pregnancy, Arch index, Body mass index, Gestational trimesters, Nigeria

Introduction

The weight bearing and distribution functions of the foot are fortified by the presence of the foot arches. The arches of the foot, especially the medial longitudinal arch add to the weight bearing capacity and resiliency of the foot (1). As pregnancy progresses, the position of the centre of gravity is altered as well as an increase in body mass which translates to an increase in the load transferred to the weight bearing joints. The resultant effects of these changes increases in relation to the distal weight bearing segments of the body, especially the foot, causing muscle imbalances, distorted integrity of the weight bearing structures and their related soft tissues. Studies have reported a posterior shift in the centre of pressure of the foot in compensation for the increased anterior abdominal mass during pregnancy (2). In addition to these physical changes, hormonal influences of relaxin and oestrogen lead to an increased ligamentous laxity, compromising joint stability (3,4), with a resultant arch collapse during pregnancy (5,6). Studies in different locations have reported changes in the foot arches, indicating an increased likelihood towards the occurrence of pes planus, in the pregnant population (3,7-11). Other studies have also shown significant increases in foot width, length, and volume with a concomitant decrease in arch height during pregnancy (12,13). However, such pregnancy-related changes and their associations with gestational trimesters have not been investigated in a Nigerian population.

Obesity is an associated risk factor for pes planus (17). Previously, changes in anthropometric indices indicating obesity have been reported among Nigerian pregnant women (14-18) but their relationship with pregnancy-induced arch collapse (pes planus) have not been explored. This gap in knowledge may be contributing to the limited or lack of foot care during pregnancy and postpartum periods, among women's health physiotherapists in Nigeria. With the aim of providing baseline information needed for enhancement of research in this green uncultultivated area of women's health practice in Nigeria, there is need to compare the arch indexes of pregnant and nulliparous

Received 9 April 2016, **Accepted** 15 June 2016, **Available online** 18 June 2016

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non-pregnant women. Thus, this study was aimed at determining the arch index of pregnant women, in comparison with their age-matched nulliparous non-pregnant counterparts as this will serve as a primer for future prospective studies. It also went further to determine if any relationship exists between arch index and each of BMI and gestational trimesters.

Materials and Methods

This study involved 328 (215 pregnant women and 113 nulliparous non-pregnant women) participants. The pregnant participants in their different trimesters were conveniently selected from the antenatal clinics of four (4) health centres in Enugu state, South-Eastern Nigeria between December, 2014 and March, 2015. Women with lower limb amputations, chronic diseases affecting collagen metabolism, spinal or lower limb traumatic injuries or surgery were excluded. Ethical approval was sought and obtained from the University of Nigeria Health Research and Ethics Committee. Written informed consent was also requested and obtained from the subjects before their participation in the study. After collecting data on the relevant personal and obstetric information (i.e., gestational age, number of previous childbirths, medical history in their present pregnancy) from the subjects, their body weight (kg), height (cm), body mass index (BMI) (kg/m^2) were measured.

The static arch indexes were obtained from both footprints, using the method proposed by Cavanagh and Rodgers (19). With the participants in a static standing stance, each foot was stepped on a wooden board covered with talc powder and then stepped on a sheet of coloured carbon paper. The imprints were traced out on a calibrated plain sheet. The truncated foot length (without the toes) of the footprint area was divided equally into three sections, including the rear foot area (A), mid foot area (B) and forefoot area (C). On obtaining the areas of the three sections, the arch height index (AHI) was calculated by dividing the mid foot area (B) by the total foot area (without the toes): AHI=B/ (A+B+C).

The participants' foot were classified into three categories based on the principles used in previous studies (20- 22) which included high arch (AHI is less than 0.21), normal arch (AHI between 0.21 and0.26) and low arch (AHI greater than 0.26).

The collected data was analyzed using SPSS software version 21, with an alpha level set at $P<0.05$. Descriptive statistics of mean, standard deviation, frequency and percentage was used to summarize the data. Significant differences between the arch indexes of women in both groups were determined using Independent *t* test. Furthermore, Pearson and Partial correlation tests were used to determine the relationships between the arch index and each of gestational trimesters and BMI of the pregnant participants.

Results

The mean height, age, weight and BMI of the participants were 1.65 ± 0.1metres, 24.88 ± 4.5 years, 69.44 ± 13.0 kg and 25.34 ± 9.6 kg/m^2, respectively. Table 1 shows the socio-demographic characteristics (age and BMI) of participants in both groups as well as the gestational trimesters of the pregnant participants. In both groups, a greater percentage of the participants were within the normal BMI range. There was a low prevalence of obesity among the participants in both groups (pregnant = 22.8%; non-pregnant = 2.7%). Majority of the pregnant women (42.8) were within the age range of 24-29 years while majority of the non-pregnant women (53.1%) were within 18-23 years. Most of the pregnant women (57.21%) were in their third trimester. There were no significant differences in age and BMI of subjects in both groups. The distribution of arch indexes is presented on Table 2. Among the pregnant subjects, there was a higher prevalence of low arch indexes, indicating pes planus (57.2% on the right foot and 59.1% on the left foot) as compared to the nulliparous subjects (19.5% on the right and 23.3% on the left). Table 3 shows the independent t-test results of the arch indexes of pregnant and non-pregnant women. The mean arch

Table 1. Socio-Demographic Characteristics of the Participants

Variables	Pregnant No. (%)	Non-pregnant No. (%)
BMI		
Normal (18-24.99 kg/m^2)	97 (45.1)	86 (76.1)
Overweight(25-29.99 kg/m^2)	69 (32.1)	24 (21.2)
Obese (≥30 kg/m^2)	49 (22.8)	3 (2.7)
Total	215 (100)	113 (100)
Age (years)		
18-23	74 (34.4)	60 (53.1)
24-29	92 (42.8)	46 (40.7)
30-34	38 (17.7)	4 (3.5)
35-40	11 (5.1)	3 (2.7)
Total	215 (100)	113 (100)
Gestational trimesters		
First	13 (6.0)	-
Second	79 (36.7)	-
Third	123 (57.2)	-
Total	215 (100)	-

Abbreviation: BMI, body mass index.

Table 2. Distribution of Arch Index of Subjects

Arch Index	Frequency (Percentage)			
	Pregnant		Non-pregnant	
	Right	Left	Right	Left
High arch	37(17.2%)	41 (19.1%)	33 (15.3%)	30 (14.0%)
Normal arch	55 (25.6%)	47 (21.9%)	38 (17.7%)	33 (15.3%)
Low arch	123 (57.2%)	127 (59.1%)	42 (19.5%)	50 (23.3%)

index values for pregnant women are 0.27 ± 0.07 (right) and 0.28 ± 0.07 (left) while for the values for the non-pregnant women are 0.24 ± 0.07 (right) and 0.25 ± 0.07 (left). In similar trends, independent t-test analysis revealed significant differences (P = 0.001) between the both feet arch indexes of the pregnant and non-pregnant participants. Correlations between both feet arch indexes and gestational trimester of the pregnant women was shown in Table 4. Pearson correlation tests showed that there were non-significant weak positive correlations between both feet arch indexes and gestational trimester (p-value: right = 0.252; left = 0.547). Partial correlation tests whilst controlling for some variables (age and BMI) also showed non-significant weak positive correlations between both feet arch indexes and gestational trimester (P value: right = 0.476; left = 0.705) . In Table 5, the correlation results between both feet arch indexes and BMI of the pregnant women were shown. A non-significant weak positive correlation existed between right arch index and body mass index while there was a non-significant weak negative correlation between left arch index and body mass index of the pregnant women (P value: right = 0.085; left = 0.455). Partial correlation tests whilst controlling for some variables (age and gestational trimester) also revealed that there was a non-significant weak positive correlation between right arch index and body mass index while there was a non-significant weak negative correlation between left arch index and body mass index of the pregnant women (P value: right = 0.344; left = 0.256).

Table 3. Independent T Test Results Showing the Statistical Differences Between the Arch Indexes of Subjects in Both Groups

	Right Foot	Left Foot
Pregnant	0.27 ± 0.07[a]	0.28 ± 0.07[a]
Non-pregnant	0.24 ± 0.07[a]	0.25 ± 0.07[a]
t value	3.269	3.507
P value	0.001[b]	0.001[b]

[a]indicates mean ± standard deviation values. [b]indicates significance at $P < 0.05$.

Table 4. Correlation Between Both Feet Arch Indexes and Gestational Age of the Pregnant Women

Correlation	Right Foot	Left Foot
Pearson		
R value	0.079	0.041
P value	0.252	0.547
Partial		
R value	0.049	0.026
P value	0.476	0.705

Table 5. Correlation Between Both Feet Arch Indexes and BMI of the Pregnant Women

Correlation	Right Foot	Left Foot
Pearson		
R value	0.118	-0.051
P value	0.085	0.455
Partial		
R value	0.065	-0.078
P value	0.344	0.256

Abbreviation: BMI, body mass index.

Discussion

This study compared both feet arch indexes of pregnant and nulliparous non-pregnant women. In both groups of women, there were high prevalence of pes planus with pregnant women showing a higher prevalence. Previous studies (3,7-11) have found similar results, demonstrating lower arches of the feet/pes planus during pregnancy. Physical and hormonal changes during pregnancy compromise the integrity of the soft tissues supporting the foot. Physical changes are predominantly as a result of the increase in body weight (23,24). During pregnancy, the resultant weight gain alters the body's centre of gravity, body mass and distribution of body weight, predisposing subjects to foot disorders (25). In this study, a large percentage of the pregnant women were overweight. There could be a possibility that the high prevalence of pes planus among these pregnant women may be the resultant effect of their body weight as studies have found relationships between BMI and arch index (26-28). In addition to physiological changes and increase in the size of the uterus, foetus and breasts, lifestyle changes may also contribute to the weight gained during pregnancy. Nigerian women have poor lifestyle practices during pregnancy. Poor feeding and exercise habits are common among them. Sedentary lifestyle is also not uncommon. These factors are likely as a result of primitive traditional beliefs. Many cultures in Africa, based on fatalistic views observe taboos during pregnancy and postpartum (29). It is believed that a pregnant woman should consume more quantities of food since she is feeding for two. It is also believed that practice of physical exercises or active involvement in usual daily activities is detrimental to the mother and foetus. These factors undoubtedly contribute to increased body weight gain in pregnancy, which will lead to increased load transfer to the foot, resulting in collapse of the arches. However, further correlation tests in this study contradicted these claims as no relationship was found between the BMI and arch indexes of these pregnant subjects. Bearing in mind that the arch indexes and BMI values of the pregnant women before and through pregnancy were not known, associating changes in their arch index to pregnancy-related increase in body mass should be done with caution.

Another factor that possibly contributes to arch collapse is the effect of some pregnancy hormones, especially relaxin which alters the mechanics of joints (30) as it enhances the stimulation of the production of collagenase (31), matrix metalloproteinases and plasminogen activator (32). These factors lead to ligamentous support insufficiency, resulting to joint laxity. Studies have shown that relaxin may increase joint laxity (31,33-36). Bearing in mind that the major support of the medial longitudinal arch is from the ligaments on the plantar surface of the foot, there is every possibility that the effects of pregnancy hormones on these ligaments will lead to structural instability of the foot arches, leading to arch collapse. However, further longitudinal studies may be required to correlate changes in the concentrations of relaxin and other pregnancy related hormones with the

changes in the structure of the medial longitudinal arch during and after pregnancy.

The therapeutic use of foot insoles for maintenance of the foot arches as well as clinical interventions aimed at prevention and management of foot deformities is not common practice in South Eastern Nigeria. This may also be a contributing factor to the high prevalence of pes planus during pregnancy.

Another important finding in this study is the high prevalence of pes planus among the nulliparous (control) subjects. In a similar trend with the BMI values of the pregnant subjects, some of these control subjects were overweight. This may possibly be a predisposing factor to the incidence of pes planus in a non-pregnant population. This suggests that pes planus among the pregnant women may not be solely associated with pregnancy-related changes. Further studies among Nigerian women are needed to assess the structure of the foot in a normal female population as well as evaluating possible predisposing factors to pes planus before pregnancy amongst them. This will help in fabricating early preventive measures before pregnancy as the condition may likely be worsened during pregnancy.

Despite the fact that women in both study groups showed high prevalence of pes planus on both feet, a significant difference existed between their arch indexes on both feet. There is a dearth of previous related literatures to serve as basis for comparison of these results. Since pregnant Nigerian women have been known to have lower foot arches than their age-matched nulliparous women, there is then need for further prospective studies designed to monitor the changes in the foot structure before, during and after pregnancy.

An interesting finding in this study the predominance of pes planus on the left foot, in comparison to the right foot of women in both groups. This will require additional data for clarification. Thus, it is beyond the scope of this study to give appropriate reasons for this difference. Further studies will need to associate changes in arch index with selected human gait parameters and limb dominance of the subjects.

Finally, it was hypothesized that prevalence of pes planus will be higher in women with advanced pregnancies but this was disproved by the findings of this study as no significant relationship was found to exist between the arch indexes of both feet and the gestational trimesters. Further statistical analysis with partial correlation test similarly showed no relationship between these variables, after controlling for some possible intervening variables (age and BMI). These findings are in accordance to the results of a previous study (12) which reported no changes in the length and width of the feet as pregnancy progressed. In contrast, Gijon-Nogueron et al (9) showed contradicting results as they reported that the foot of pregnant women tends to flatten out as gestational weeks progress. As recommended earlier, a prospective study through pregnancy will give a better knowledge of any possible relationship between pes planus and gestational age.

Ethical Issues

Ethical approval was obtained from the University of Nigeria Health Research and Ethics Committee and written informed consent was also obtained from the subjects before participation.

Conflict of Interests

Authors declare that there is no conflict of interest.

Financial Support

None.

Acknowledgements

We would like to thank the management of all the hospitals from which subjects were recruited for this study.

References

1. Egwu OA, Okafor IJ, Ukoha U, Ogugua PC, Igwenagu NV. Pes planus. Int J Adv Res. 2012;03(03):166.
2. Nyska M, Sofer D, Porat A, Howard CB, Levi A, Meizner I. Planter foot pressures in pregnant women. Isr J Med Sci. 1997;33(2):139–46.
3. Bird AR, Menz HB, Hyde CC. The effect of pregnancy on footprint parameters. A prospective investigation. J Am Podiatr Med Assoc. 1999;89(8):405-9. doi:10.7547/87507315-89-8-405
4. Kravitz L, Heyward VH. Flexibility Training. http//www.drlenkravitz.com. Accessed 21st September, 2014.
5. Calguneri M, Bird HA, Wright V. Changes in joint laxity occurring during pregnancy. Ann Rheum Dis. 1982;41:126–128. doi:10.1136/ard.41.2.126
6. Awonuga AO, Merhi Z, Awonuga MT, Samuels TA, Waller JK, Pring D. Anthropometric measurements in the diagnosis of pelvic size: an analysis of maternal height and shoe size and computed tomography pelvimetric data. Arch Gynecol Obstet. 2007;276:523–528. doi:10.1007/s00404-007-0370-0.
7. Dunn J, Dunn C, Habbu R, Bohay D, Anderson J. Effect of pregnancy and obesity on arch of foot. Orthop Surg. 2002;4(2):101-4. doi:10.1111/j.1757-7861.2012.00179.x.
8. Segal NA, Boyer ER, Teran-Yengle P, Glass NA, Hillstrom HJ, Yack HJ. Pregnancy leads to lasting changes in foot structure. Am J Phys Med Rehabil. 2013;92:232-240. doi:10.1097/PHM.0b013e31827443a9.
9. Gijon-Nogueron GA, Gavilan-Diaz M, Valle-Funes V, Jimenez-Cebrian AM, Cervera-Marin JA, Morales-Asencio JM. Anthropometric foot changes during pregnancy: a pilot study. Journal of American podiatric medical association 2013;103(4):314-321.
10. Fitzgerald CM. Musculoskeletal Health in Pregnancy and Postpartum: An Evidence-Based Guide for Clinicians. USA: Springer; 2015.
11. Hoefs J, Jagroo D. Your Best Pregnancy: "The Ultimate Guide to Easing Aches, Pains, and Uncomfortable Side Effects During Each Stage of Your Pregnancy". New York: Demos Medical Publishing; 2014.
12. Alvarez R, Stokes IA, Asprinio DE, Trevino S, Braun T. Dimensional changes of the feet in pregnancy. J Bone Joint Surg Am. 1988; 70(2):271-274.
13. Wetz HH, Hentschel J, Drerup B, Kiesel L, Osada N, Veltmann U. Changes in shape and size of the foot during pregnancy. Orthopade. 2006; 35(11):1124.
14. Chigbu CO, Aja LO. Obesity in pregnancy in Southeast Nigeria. Ann Med Health Sci Res 2011;1(2):135-140.
15. Okereke C, Okeke T, Anyaehie B, Nwagha U, Iyare E, Nwogu-Ikojo E. The Effect of Gravidity on Anthropometric Indices of Pregnant Women in Enugu, South East, Nigeria. African Journal Biomedical Research. 2012;15(3):165-170.

16. Okereke CE, Anyaehie UB, Dim CC, Iyare EE, Nwagha UI. Evaluation of some anthropometric indices for the diagnosis of obesity in pregnancy in Nigeria: a cross-sectional study. Afr Health Sci. 2013; 13(4):1034-1040. doi:10.4314/ahs.v13i4.25.
17. Shibuya N, Jupiter, DC, Ciliberti, LJ. Characteristics of adult flatfoot in the US. JFAS. 2010;49(4):363-368.
18. Bamaiyi AJ, Adelaiye AB, Igbokwe VU. Relationship between anthropometric and haematological parameters among third trimester pregnant women in Sokoto State, Northwest Nigeria. Niger J Physiol Sci. 2013;28(2):211-219.
19. Cavangah PR, Rodgers MM. The arch index: an useful measure from footprint. J biomechanics. 1987;20:547-551.
20. Engel GM, Staheli LT. The natural history of torsion and other factors influencing gait in childhood. Clin Orthop Relat Res. 1974;99:12-17.
21. Staheli LT, Corbett M, Wyss C, King H. Lower-extremity rotational problems in children. J Bone Joint Surg Am. 1985;67:39-47.
22. Hernandez AJ, Kimura LK, Laraya MH, Favaro E. Calculation of staheli's plantar arch index and prevalence of flat feet: a study with 100 children aged 5-9 years. Acta Ortop Bras. 2007;15(2):68-71. doi:10.1590/S1413-78522007000200001.
23. Hytten FE, Leitch, I. The Physiology of Human Pregnancy. Oxford: Blackwell; 1971:265-285
24. Rössner S. Weight gain in pregnancy. Journal of Human Reproduction. 1997;12 (suppl 1):110-115.
25. Butterworth PA, Landorf KB, Smith SE, Menz HB. The association between body mass index and musculoskeletal foot disorders: a systematic review. Obes Rev. 2012.13(7):630-642. doi:10.1111/j.1467-789X.2012.00996.x.
26. Kelly A, Kevany J, de Onis M, Shah PM. WHO collaborative study of maternal anthropometry and pregnancy outcomes. Int J Gynaecol Obstet. 1996;53:219-33.
27. Yazdani S, Yosofniyapasha Y, Nasab BH, Mojaveri MH, Bouzari Z. Effect of maternal body mass index on pregnancy outcome and newborn weight. BMC Res Notes. 2012;5:348. doi: 10.1186/1756-0500-5-34.
28. Ahmadu B, Mustapha M, Garba M, Ayodele A, Mohammed A, Jose P. The effect of maternal pregnancy body mass index as a measure of pregnancy weight gain on neonatal birth weight in Maiduguri metropolitan council of Borno state, Nigeria. Greener Journal of Medical Sciences. 2012;2(6):168-172.
29. Mbada CE, Adebayo OE, Awotidebe TO, et al. Practice and pattern of antenatal and postnatal exercise among Nigerian women: a cross-sectional study. International Journal of Women's Health and Reproduction Sciences. 2015;3(2):93-98. doi:10.15296/ijwhr.2015.18.
30. Dehghan F, Haerian BS, Muniandy S, Yusof A, Dragoo JL, Salleh N. The effect of relaxin on the musculoskeletal system. Scand J Med Sci Sports. 2014;24(4):e220-9. doi:10.1111/sms.12149.
31. Lubahn J, Ivance D, Konieczko E, Cooney T. Immunohistochemical detection of relaxin binding to the volar oblique ligament. J Hand Surg Am. 2006;31(1):80-84.
32. Qin X, Garibay-Tupas J, Chua PK, Cachola L, Bryant-Greenwood GD. An autocrine/paracrine role of human decidual relaxin. I. Interstitial collagenase (matrix metalloproteinase-1) and tissue plasminogen activator [Research Support, Non-U.S. Gov't Research Support, U.S. Gov't, P.H.S.]. Biol Reprod. 1997;56(4):800-811.
33. Saugstad LF. Persistent pelvic pain and pelvic joint instability. European Journal of Obstetrics and Gynaecology and Reproductive Biology. 1991;41(3):197-201.
34. Steinetz BG, Williams AJ, Lust G, Schwabe C, Bullesbach E. E, Goldsmith LT. Transmission of relaxin and estrogens to suckling canine pups via milk and possible association with hip joint laxity. Am J Vet Res. 2008;69(1):59-67. doi:10.2460/ajvr.69.1.59.
35. Dragoo JL, Castillo TN, Braun HJ, Ridley BA, Kennedy AC, Golish SR. Prospective correlation between serum relaxin concentration and anterior cruciate ligament tears among elite collegiate female athletes. Am J Sports Med. 2011;39(10):2175-2180. doi:10.1177/0363546511413378.
36. Dragoo JL, Castillo TN, Korotkova TA, Kennedy AC, Kim HJ, Stewart DR. Trends in serum relaxin concentration among elite collegiate female athletes. Int J Womens Health. 2011;3:19-24. doi:10.2147/IJWH.S14188.