

## Radio-Anatomical Study of Bohler's (Calcaneal) Angle of Southern Nigerians

### ABSTRACT

**Introduction:** Bohler's angle (BA) is the angle between two lines tangent to the calcaneus on the lateral radiograph of an ankle. These lines are drawn tangent to the anterior and posterior aspects of the superior calcaneus.

**Aim:** To establish a base line reference data of BA required when surgical realignment of the ankle or radiological diagnosis of ankle malalignment is required for the subject population establishing possible difference of BA among Southern Nigerian population.

**Method:** A total of 140 normal lateral plain radiographs of the foot and ankles, comprising of 57 male and 83 females between the ages of 10 and 60 years of age were randomly selected to establish normal BA in the study population using standard methods.

**Results:** The mean BA reported for this study was  $36.480 \pm 4.95^0$  with a range of  $25-36^0$  and a direct proportional relationship between BA and age of the subjects. Female subjects had a mean BA of  $36.38 \pm 6.02$  while their male counterparts had a BA of  $36.63 \pm 8.42$ .

**Discussion:** There was no significant gender difference and bilateral asymmetry in reported BA at  $P > 0.05$ . The range of variation in calcaneal angle have never been reported to exceed  $15^0$ , while the lowest and highest reported BA has been  $25^0$  and  $40^0$  respectively, this was similar to finding among population of close similarity.

**Conclusion:** Bohler's angle of Southern Nigerians do not have a significant difference from those of other Nigerian subjects.

Keywords; Vascular steatosis, non-alcoholic fatty liver disease, *Moringa oleifera*

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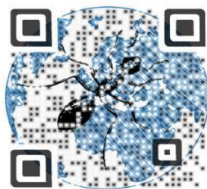
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## INTRODUCTION

The Calcaneus is the largest among the tarsal bones, easily identified as the heel of the foot. It articulates with the talus and cuboid bones and provide attachment to ligaments and muscles<sup>1</sup>.

The Bohler's angle (BA) also known as the Salient angle, Calcaneal angel, Tuber angle is a geometric angle resulting from three points of reference on the calcaneus. It is formed by the intersection of a line traversing the anterior and posterior facets and another line intersecting the former arising from the superior aspect of the calcaneal tuberosity<sup>2</sup>. Since all the reference points are on the calcaneus, any distortion of the calcaneus will result in variation in the BA. Furthermore, restoration of the BA has been the standard practice in ankle fracture reconstruction, therefore evaluation of BA in different population is necessary to reflect racial specific anthropometry in the use of BA.

Several studies of the BA have been out, this includes the evaluation of Bohler's angle and its correlation to treatment outcome in a displaced intra-articular calcaneal fractures by Loucks and Buckley who analysed 88 clients out of the 95 that were sampled and measured the clinical outcome using previously validated visual analogue (VVA) and The Short Form (36) Health Survey (sf-36) health service scores<sup>3</sup>. They reported that patients initially presenting with a severely decreased Bohler's angle have poor two-year outcome regardless of treatment and fracture of initial displacement as measured by Bohlers angle had higher scores on both VVA and sf-36 health services scores with BA having a significant prognostic value in predicting morbidity regardless of treatment modalities<sup>3</sup>.

Studies among African subjects of Malawians decent were investigated, a total of 220 lateral ankle radiographs comprising 102 female and 118 males within the ages of 18-54 years. BA was reported to be within 30° to 34° class limit with a mean of  $30.11^\circ \pm 6.29^\circ$  with no significant bilateral asymmetry ( $p > 0.5$ ), however there was sexual dimorphism, ( $p < 0.5$ ) within the Malawian and Ugandan subjects<sup>4</sup>. Also Ugandan BA of 206 radiographs of the lateral aspect of the foot comprising 114 males and 92 females, aged 20 to

40 were studied. The findings revealed a mean BA of  $35.1^\circ \pm 7.5^\circ$  and  $37.6^\circ \pm 5.6^\circ$  of males and females respectively. Females were reported to have a significantly higher values than males ( $p < 0.01$ )<sup>5</sup>.

Subjects from Asian population have also been studied to evaluate their BA, Saudi subjects comprising 229 lateral radiographs comprising 158 females and 71 males within the age range of 17 to 72 were studied and reported a mean BA of  $31.21^\circ$  with no significant gender or age variability. When compared to other studies reported in literature<sup>6</sup>.

Eastern Asian subjects from Uyghur nationality in Xinjiang were studied and the normal range of BA were reported to provide reference for clinical medicine and anthropology. a total of 107 subjects including 53 male and 54 females were studied and reported mean BA of  $35.1^\circ \pm 5.2^\circ$  and  $35.1^\circ \pm 5.6^\circ$  for male and female subjects respectively with no significant sex differences<sup>7</sup>.

Technology aided methodology has been applied in the study of BA, with the use of angle measurement software, having a sensitivity of 1/100mm, 268 subjects within the age range of 18 to 79, with sex distribution of 106 males and 162 females. The mean BA was  $33.8 \pm 4.8^\circ$  without any sex or bilateral differences at  $P = 0.177$ , however they reported age associated differences in BA, with the highest mean of  $35.2^\circ$  and lowest mean  $32.3^\circ$  recorded within the age range of 41 to 50 and 61 to 83 respectively<sup>8</sup>.

Comparative analysis of BA on radiographs and dry bone to determine possible variations, the mean BA recorded from dry bones was  $32^\circ$ , this value remain constant when X-ray incidences were modified with  $15^\circ$  in all directions from the external profile<sup>9</sup>.

Borhler's Angle have been studied among Nigerian subjects, with a reported mean BA of  $32.28^\circ \pm 2.84^\circ$  without significant relationship between gender and laterality<sup>10</sup>.

Although BA has been studied among Nigerians, we sort to evaluate a subset of the Nigerian population for possible difference and validation of the earlier for the purpose of reference.



## MATERIALS AND METHODS

A total of 140 lateral plain radiographs of the foot and ankles of subject aged 10 to 60 comprising of 57 males and 83 females were evaluated for this study. All radiographs were of normal and read by a single blinded individual with compass, protractor, ruler, pencil on an X-ray viewing box.

Bohler's angle was measured as a complement of the angle formed by two lines: the first line (ab) was drawn between the superior aspect of the anterior process and the superior aspect of the posterior articular surface. A second line (cd) was drawn between the same point on the posterior articular surface and the most superior point of the calcaneal tuberosity as seen in figure 3. The angle  $\theta$  between ab and cd was measured as the Bohler's angle.

a+b superior aspect of anterior process and posterior articular surface.

c+d Superior aspect of posterior articular surface and superior point of calcaneal tuberosity.

Radiology master class (n.d)

Precautionary measures were taken to maintain adequate and accurate measurements. Only normal ankle and foot radiograph were selected and any subject a history of abnormal ankle or fracture were excluded from the study. High dexterity was employed in the placement of the ruler and protractor in order to get an accurate measurement and avoid error due to parallax. Also sample was randomised while left and right radiographs were labelled properly. Radiographs with ambiguity were exclude as only one experienced personnel took readings to avoid inter-observer variation. This study was limited by the sample size therefore the final inference may not completely depict the BA of the study population.

**Figure 3: Is a diagram of the calcaneus and talus showing normal Bohler's angle**



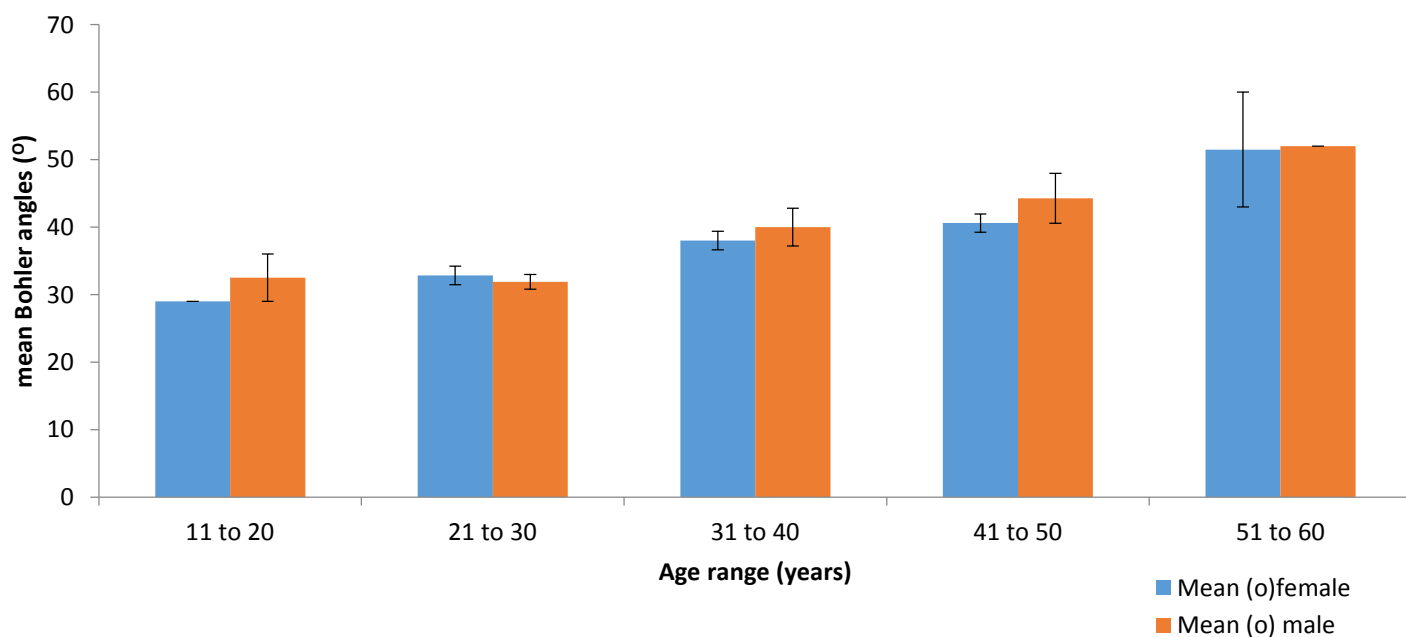
**RESULTS AND DISCUSSION**

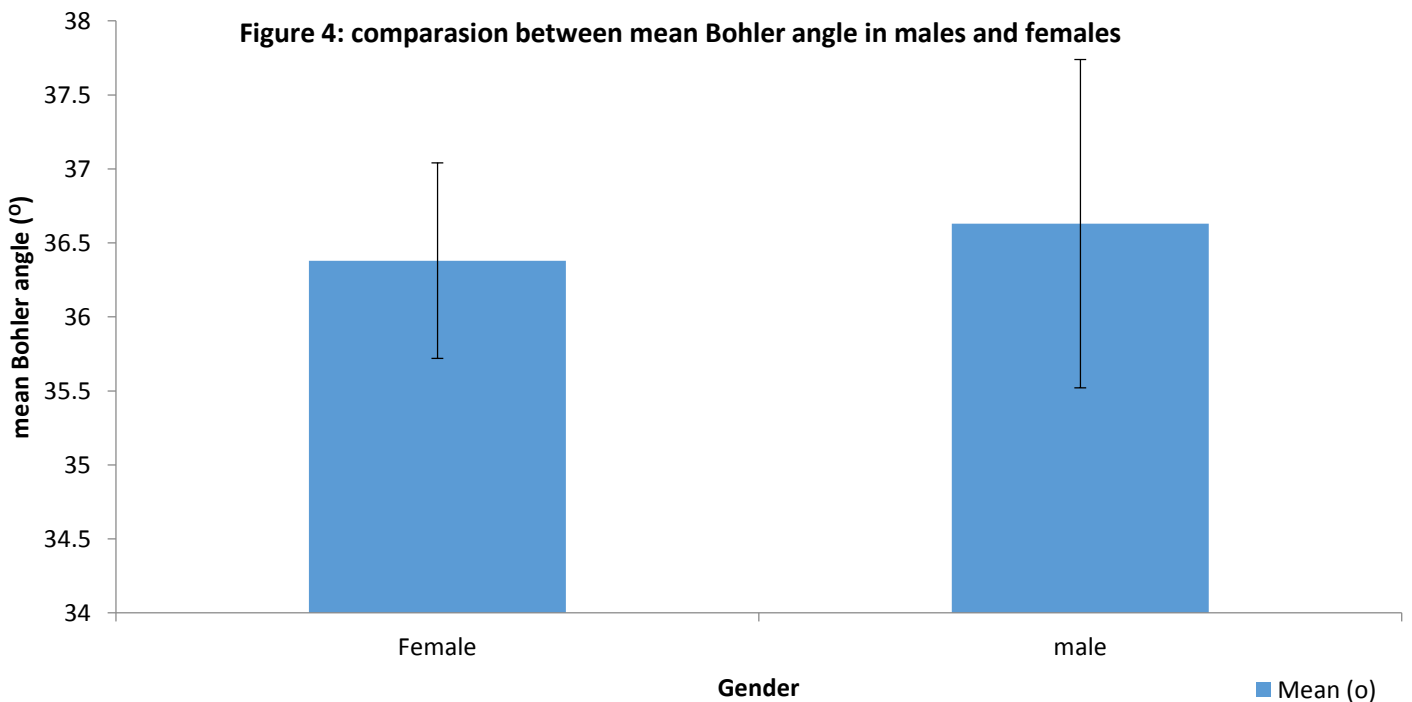
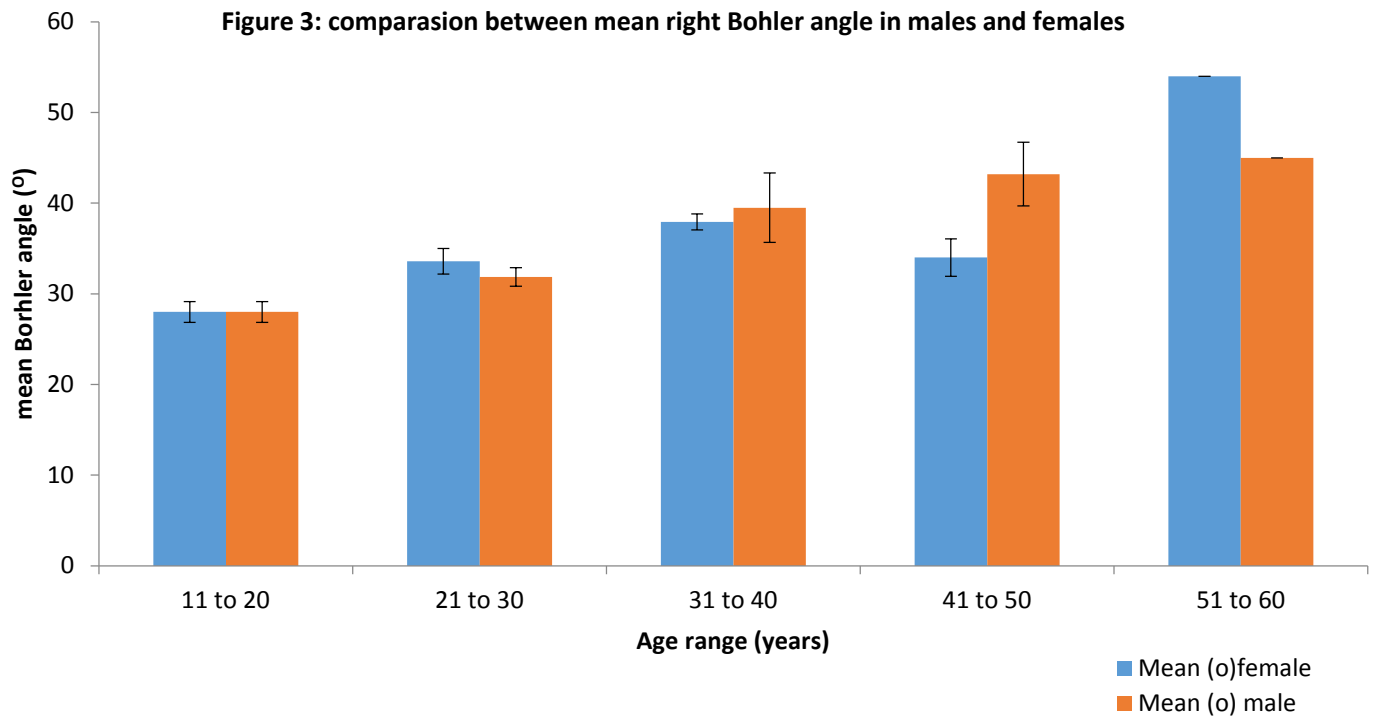
The BA data collected were subjected to statistical report the mean, standard deviation, among subjects analysis using version 15 SPSS statistical package to were represented as tables and bar charts.

**Table 1: Mean and standard deviation of the Right and left Bohler’s angle of subjects.**

Age group	Female Right Mean (°)±SD	Female Left Mean (°)±SD	Male Right Mean (°)±SD	Male Left Mean (°)±SD
11-20	28.00±2.00	29.00±0.00	28.00±2.00	32.50±4.95
21-30	33.60±5.46	32.85±5.15	31.86±3.82	31.89±3.29
31-40	37.94±3.79	38.00±3.36	39.50±10.86	40.00±8.89
41-50	34.00±3.60	40.60±2.88	43.20±7.85	44.25±7.41
51-60	54.00±0.00	51.50±12.02	45.00±0.00	52.00±0.00

**Figure 2 comparasion between mean left Bohler angle in males and females**





## DISCUSSION

The mean BA reported for this study was  $36.480 \pm 4.95^\circ$  with a range of  $25-36^\circ$  and a direct proportional relationship between BA and age of the subjects. Female subjects had a mean BA of  $36.38 \pm 6.02$  while their male counterpart had a BA of  $36.63 \pm 8.42$ . There was no significant gender difference and bilateral asymmetry in reported BA at  $P > 0.05^{5,8}$ . The range of variation in calcaneal angle have never been reported to exceed  $15^\circ$ , while the lowest and highest reported BA has been  $25^\circ$  and  $40^\circ$  respectively, this is similar to finding among population of close similarity.<sup>5,8</sup>

There was no significant difference in BA between this study and the study among Nigerian at  $p > 0.05$ , however the relationship between the age and BA was reported for the first time<sup>9</sup>.

## CONCLUSION

Bohler's angle of Southern Nigerian do not have a significant difference from those of other Nigerian subjects. Therefore, BA reference of Nigerian population can be made irrespective of racial and geographical location, however, age specific BA consideration is necessary to avoid over or under estimation.

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