

THE POSITION OF THE HALLUX IN WEST AFRICANS

By N. A. BARNICOT

Department of Anthropology, University College, London

AND R. H. HARDY

Department of Anatomy, University College, London

INTRODUCTION

Variation in the position of the great toe in adult Europeans remains a subject of discussion and conjecture, especially in relation to pathological degrees of valgus deformity. Operations to correct this deformity or its sequelae occupy a major place in orthopaedic operating lists, and methods of prevention are widely canvassed, particularly in connexion with the design of footwear.

Hardy & Clapham (1952) have shown that in school children the great toe has assumed a valgus position of adult degree by the age of 15 years, and they (1951) have also shown that females suffer a greater degree of deformity than males, and constitute 85% of those attending for subsequent orthopaedic correction. The associated widening of the angle between the first and second metatarsals has been shown by these workers to develop later than the valgus deviation of the toe and is not likely therefore to be a predisposing factor. Current opinion favours the effect of constricting footwear as a major cause of the deformity, and this view is supported by common-sense and observation alike (Craigmile, 1953). The importance of this factor is, however, difficult to assess in a habitually shod population, and for this reason it appeared useful to obtain some comparative data on the deviation of the great toe in a population which is barefooted.

A visit of one of us (N. A. B.) to Nigeria, West Africa, under a grant from the Colonial Medical Research Council, provided the opportunity to collect material from habitually barefooted Africans of both sexes and various ages.

METHODS

Material was collected by taking footprints of the subjects with a Scholl Pedograph. This instrument consists essentially of a rubber membrane, inked on its lower surface, on which the subject places one foot and applies his whole weight, thereby making a print on a piece of cartridge paper placed below the membrane. The method is simple and rapid and provides a permanent record from which various measurements can later be obtained. It is clearly less valuable for our present purpose than are X-ray photographs, but X-ray equipment suitable for a field survey was not available. From previous experience with a European sample, it was found that the angle of the hallux measured on footprints in the manner indicated below showed a correlation (r) of 0.56 with measurements of the angle between the 1st toe and metatarsal made on radiographs of the same sample; some caution is therefore required in arguing from data obtained by one method to that obtained by the other.

Measurements were taken on the footprints, which were all from the right foot, in the following way (see diagram, Fig. 1). A line was drawn from the most anterior point of the imprint of the 2nd toe (*A*) to the most posterior point of the heel (*B*); the length of this line was taken as the length of the foot. The most medial point in the region of the medial aspect of the 1st metatarso-phalangeal joint was then marked by eye (*C*), and a line was drawn from this point transecting the length line at right angles. A tangent parallel to the length line *AB* was drawn through the most laterally situated point on the lateral margin of the foot (*D*). The point (*E*) at which this tangent cut the transverse line was then found, and the line *CE* was taken as a measure of foot breadth. A line contacting the medial aspect of the heel imprint at (*F*) was drawn through the point *C* and further line contacting the medial aspect of the great toe at (*G*) was then drawn through *C* and prolonged to *H*. The angle *HCF* was taken as a measure of the hallux angle and was given a positive sign if the great toe deviated to the lateral side.

THE SAMPLE

The Nigerian sample was collected from towns and villages within 30 miles of Lagos. The majority of the subjects belonged to the Yoruba tribe.

With the exception of the series of Nigerian soldiers (kindly provided by Dr W. S. S. Ladell), who wore army boots, and of fifty-three schoolgirls who sometimes wore light leather sandals, the subjects were all habitually barefooted.

Details of the age distribution of the subjects are given below, in Tables 1 and 2. It falls into two main groups for each sex, one comprising children, most of whom were considered to be between 12 and 18 years of age, and a second comprising adults, most of whom were considered to be more than 35 years of age. It is difficult to obtain accurate information about age in African communities, so that the age distribution, particularly for the older adults, is subject to error, the magnitude of which it is hard to assess; it would not be unreasonable to regard the ages as accurate within ± 5 years, except perhaps in the age range 60–80 years, where error may be greater.

The European samples of both sexes are restricted mainly to young adults, most of whom were University students, nurses and teaching or research staff.

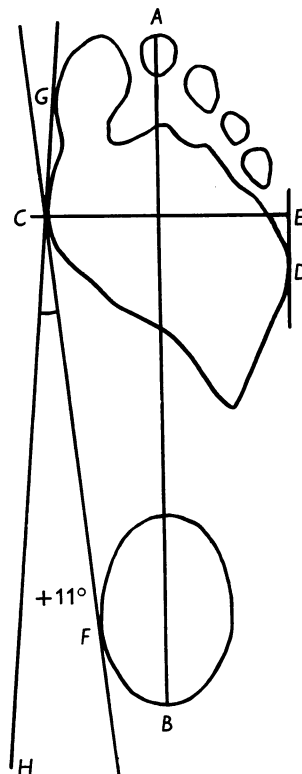


Fig. 1. Method of measuring foot length, breadth and Hallux angle on a footprint.

RESULTS

Table 1. *Male subjects*

Sample	No.	Mean hallux angle	s.D.	Mean age (years)	s.D.
1. Europeans	66	+6.9°	5.3°	25.9	7.8
2. Nigerian soldiers	113	+2.2°	7.2°	—	—
3. Nigerians—25 years and older	108	+1.1°	6.8°	49.9	14.0
4. Nigerians below 25 years	106	+2.3°	5.8°	16.2	3.6
5. Nigerians—2 and 3 pooled.	221	+1.7°	7.0°	—	—
6. Total Nigerian males	327	+1.88°	6.6°	—	—

Table 2. *Female subjects*

Sample	No.	Mean hallux angle	s.D.	Mean age (years)	s.D.
1. Europeans	68	+11.0°	5.1°	21.4	3.3
2. Europeans (morbid group. Hallux valgus)	84	+21.9°	7.0	—	—
3. Nigerians—25 years and older	148	-0.03°	7.2°	45.5	9.8
4. Nigerians below 25 years	177	+0.49°	5.8°	15.5	2.7
5. Nigerians below 18 years—shoeless	120	+0.18°	6.1°	—	—
6. Nigerians below 18 years—shoes	53	+1.36°	5.1°	—	—
7. Total Nigerian females	325	+0.24°	6.5°	—	—

COMPARISONS OF THE MEAN HALLUX ANGLE

The difference of 4.1° between the hallux angle of the European males and females is very highly significant ($t=4.63$ for D.F. 132). The hallux in the females is deviated laterally to a greater extent than in males. Comparing first the African male series with the European males, the difference of angle of 5.8° between the Africans of 25 years and over and the Europeans is again highly significant ($t=5.9$ for D.F. 172). The Europeans also differ very significantly from the Africans of less than 25 years whose age range is more closely comparable ($t=5.20$ for D.F. 170).

In the young adult European male, therefore, the great toe is on average deviated laterally about 5.0° more than in African adults or adolescents.

Among the Africans themselves, comparison of the two rather widely contrasted age groups provides no evidence that the mean Hallux angle changes between adolescence and later adult life; the mean angle for a group of forty-eight subjects said to be more than 50 years of age was +1.73°.

The angle in the group of Nigerian soldiers who had worn army boots for a number of years was +2.21°, which is not significantly different from the angle of shoeless Africans of either age group. This sample was, therefore, pooled with that of shoeless Africans of 25 years and over for the purpose of further comparisons.

The mean hallux angle in African females differs even more from the European value than it does in males on account of the much greater lateral deviation of the toe in European females. The mean angle, which is close to 0°, does not differ

significantly between the two age groups of African females, nor it is significantly higher in the group of girls who had worn light footwear.

Pooling the various samples of African females, we obtain a total sample of 325 subjects, giving a mean angle of $+0.24^\circ$ compared with a mean of $+1.88^\circ$ for the pooled sample of African males. This small difference which is opposite in sign to that between the sexes in Europeans is statistically significant ($t=3.2$ for D.F. 650).

The distribution of the hallux angle in a group of eighty-four European females who had presented themselves for operation on account of valgus deformity, is shown in Fig. 2; the mean angle was $+21.87^\circ$, which is clearly significantly different from the mean of either the European or Nigerian female samples. It will be noted, however, that there is considerable overlap of the distribution not only with the normal European one but also with the Nigerian.

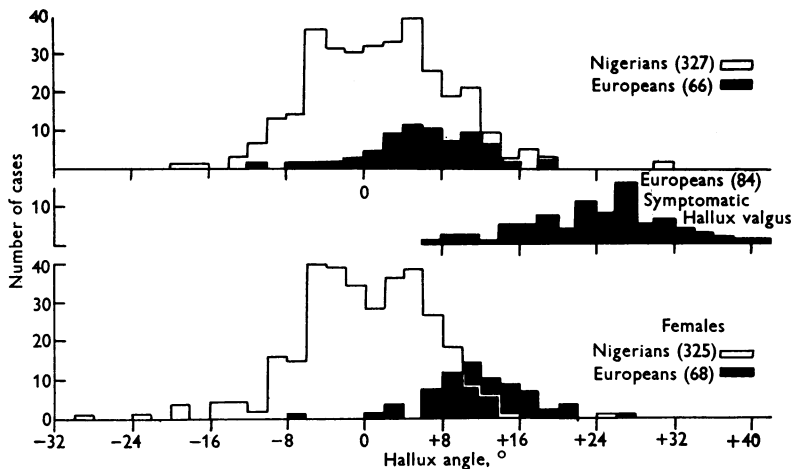


Fig. 2. Distribution of the Hallux angle in Europeans and Africans and in European females with symptomatic Hallux valgus.

THE VARIABILITY OF THE AFRICAN SAMPLES

Although, as we have shown, the mean values of the hallux angle do not differ significantly between the two age-groups in the Africans, there is a suggestion that the dispersion is greater in the older subjects than in the younger ones. The variance for the older group of males including the Nigerian soldiers ($2+3$) is 48.99 and for the younger 33.23 . Tested as the variance-ratio, the difference gives a value of $F=1.47$ which, for D.F. $n_1=221$ and $n_2=106$, is significant at 1.0% . Similarly, in the female samples the variance for the 25 years of age and over sample is 52.34 and for the younger group, 34.10 , which again gives a significant F value. It will be noted that the male and female variances are substantially the same for each age group.

THE DISTRIBUTIONS OF THE HALLUX ANGLE

The distributions of the hallux angle for Africans and Europeans of both sexes are shown as histograms in Fig. 2. Since the Nigerian samples are quite large when pooled for each sex, the normality of the distribution can be examined. We have computed

the statistics for the 325 Nigerian females only. We find $\gamma_1 = 0.375$ with approximate s.e. 0.134, indicating significant negative skewing. There is thus an excessive number of cases with extreme medial deviation of the hallux. Judging from the appearance of the distributions this tendency is less marked in the males. The distribution is also significantly leptokurtic, that is to say, both the positive and negative tails of the distribution contain more observations than is expected in a normal curve ($\gamma_2 = 2.053$, approximate s.e. 0.272). In both sexes the central region of the distribution appears to be remarkably flat. Since there is some evidence of a change in the degree of dispersion of the angle with age, these abnormalities of the pooled samples are probably in part related to this. It would be premature to attempt to interpret the shape of the distribution without a much larger material of varying age groups, but there is a suggestion that in the older ranges, the distribution is tending to become bimodal.

THE SIZE AND PROPORTIONS OF THE FOOT

It was felt worth while to see whether there was any notable difference between European and Nigerian samples in this respect. The mean values for the length and breadth are given below in Table 3. The comparison was made for subjects of 25 years of age and above only.

Table 3. *Dimensions of the footprint*

Sample	No.	Mean length (cm.)	Mean breadth (cm.)	Ratio breadth/length
Nigerian females	148	22.0	8.03	0.36
European females	68	22.6	8.32	0.37
Nigerian males	221	24.3	8.86	0.37
European males	60	25.0	8.94	0.36

The European measurements are slightly larger than the Nigerian ones for both dimensions and in both sexes. The proportions of the foot are, however, similar. We may note that the sample of 113 Nigerian soldiers gave a mean length of 24.9 cm. and a mean breadth of 8.94 cm., which are very close to the European male values and may be due to some selection for stature in recruiting.

There appears to be no clear relationship between the proportions of the foot and the hallux angle as seen by plotting the variables on a scatter diagram.

MISCELLANEOUS OBSERVATIONS

A wide gap between the first and second toe is commonly observed in Africans, and probably in most barefooted peoples. We measured the minimum distance between the imprints of these two toes in footprints from seventy-six of our Nigerian girls and found a mean value of 6.9 mm. compared with 4.9 mm. for sixty-six European females. Though we have not investigated the point fully, there does not appear to be a very close correlation between the hallux angle and the width of this interdigital gap. This is probably due in part to deviations of the 2nd and more lateral toes occurring in the same direction as the great toe, and perhaps also to variations in the degree to which the 2nd phalanx of the great toe is angulated on the 1st phalanx. In the course of collecting the material it was remarked that injuries to the great toe

and injuries and loss of lateral toes were frequent among the village people, but no systematic records were kept. Engle & Morton (1931) also noticed that loss of toes due to injuries and to yaws was very common among natives of the Belgian Congo. We may also note that although in some of our specimens the medial aspect of the sole of the foot touches the ground in a manner which Wells (1930-1) regards as characteristic for the South African Bantu, in the majority of cases the footprint is markedly indented on this aspect.

DISCUSSION

The outstanding findings are first, the large difference between the mean hallux angle in Europeans and Nigerians; and secondly, the virtual absence of the marked sex difference in this angle in Africans.

The mean hallux angle in the Nigerians is close to zero, and in this respect, may be compared with the small angle found in European infants of 4-6 years of age by Hardy & Clapham (1952) using radiographic methods.

The markedly greater valgus deviation in European females than males may reasonably be correlated with more constricting footwear and the very much smaller difference between the sexes in Africans tends to support this interpretation. We do not know whether the condition of the great toe shown in our African material would also occur in other barefooted peoples irrespective of ethnic affiliations. Wells (1930-1) states that in the South African Bantu and Bushman foot the first metatarsal is abducted but the first phalanx deviated laterally to a more valgus position than is usual in Europeans; he gives no measurements, however. Neither Engle & Morton (1931) nor James (1939), who examined the feet of Solomon Islanders, deal with this particular problem. Although yaws and probably gonorrhoea are common in Southern Nigeria, we have no clinical data on our subjects which would enable us to assess the contribution of these diseases to skeletal changes in the feet. Some footprints kindly sent us by Dr B. Kalcev of natives of Madagascar showed, however, a similar distribution of the hallux angle.

Although the mean hallux angle does not show much evidence of change with age in Africans, we have presented some evidence that deviations of the great toe both medially and laterally, become more extreme with advancing years. It would be reasonable to suppose that some variation of the hallux angle around zero may be present even at birth and that such pre-existing deviations tend to become exaggerated with increasing age. We have no definite proof of this interpretation, however, nor do we know the factors which produce the increased frequency of large deviations.

It will be noticed that although the mean angle of the hallux is considerably greater in a group of Europeans suffering from symptomatic hallux valgus than it is in normal Europeans, nevertheless, the distribution overlaps the range of angle of normal subjects of both sexes. A large lateral deviation of the toe is therefore not necessarily associated with clinical symptoms in all cases. To some extent the larger angle often associated with symptomatic bunion may be a result of the contact point *C* which is used in the measurement being displaced medially by the thickening in the region of the metatarso-phalangeal joint, thus giving a somewhat spurious impression of the angular deviation of the toe on the metatarsal. It appears that

only a long-term study on individuals could determine how far a large lateral deviation present from an early age increased the liability to symptoms. It seems unlikely from histories given by patients that particularly tight footwear can be the only factor which leads to pathological degrees of the condition.

The distribution of the angle in symptomatic Europeans not only overlaps the European normals but also the Africans, so that a considerable number of Africans have lateral deviation of the great toe equal to or even greater than those observed in many Hallux valgus cases. We have no evidence as to whether these larger deviations in Africans are associated with any discomfort or disability. Occasional valgus deviation of more than $+20^\circ$ are sometimes found in barefooted Africans, and in both sexes some 20–30% of the sample falls within the European symptomatic range. Deviations of more than $+10^\circ$ are not infrequent in Africans below 25 years of age, although they tend to increase in frequency in older age groups. It is clear that, whatever may be the cause of such deviations in Africans, footwear can play no part in their production.

SUMMARY

1. Evidence from footprints collected from 327 male Nigerians and 325 females is examined in relation to the position of the great toe and compared with European footprint material obtained from clinically normal subjects and those suffering from Hallux valgus.

2. The distribution of the hallux angle in the Nigerians of both sexes is around a mean of approximately zero which differs by a statistically significant amount from the mean values for European males and females which are $+6.9^\circ$ and $+11.0^\circ$ respectively.

3. The mean hallux angle is not significantly different as between the two age groups of Nigerians examined. There is evidence, however, of an increase in the dispersion of the values with age. A degree of valgus deviation falling well within the European pathological range occurs in some African subjects.

4. The results are discussed in relation to the causation of valgus deformity.

We are indebted to the District Officer, Ikeja Division, for assistance in obtaining samples from villages, and to Dr W. S. S. Ladell, Hot Climate Physiological Research Unit, Lagos, for allowing Mr E. A. Osinyemi to supplement some of our material. We also wish to acknowledge the loan of a Scholl Pedograph by the British Boot, Shoe and Allied Trades Research Association.

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