J. Anat., Lond. (1965), **99**, 1, 71–76
With 1 plate and 2 text-figures
Printed in Great Britain

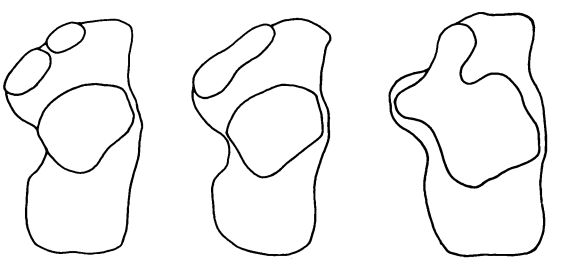
A comparison of adult and foetal talocalcaneal articulations

By P. S. C. BUNNING and C. H. BARNETT
Departments of Anatomy, St Bartholomew's Hospital Medical College, and St Thomas's Hospital Medical School, London

INTRODUCTION

Calcanei are classifiable into three types according to the number of superior articular facets present. Type A calcanei bear three facets for the talus, type B calcanei bear two and type C calcanei a single facet only (Text-fig. 1). As previously reported (Bunning and Barnett, 1963), the relative distribution of type A and type B bones in any given sample varies with race and sex.

This morphological variability of the calcaneal facets could result from differences in gait or other habit influencing these articular areas post-natally or it could be indicative of genetically determined variations. To investigate this problem a number of African, Indian and European foetal calcanei was examined and the findings were compared with those derived from a study of adult material.



Text-fig. 1. The three types of calcanei.

MATERIAL AND METHODS

The right and left calcanei from 246 adult Nigerian skeletons were studied. Details of this material have been recorded elsewhere (Bunning, 1964). Both calcanei from each of 39 complete adult skeletons from the Calcutta area were examined: the sex of these skeletons was unknown and was therefore determined as accurately as possible by means of the usual osteological criteria. Ten adult Veddah calcanei, of unknown sex, were also examined. Additionally, 194 wet calcaneus specimens were obtained from three British dissecting rooms and classified according to the pattern of their articular facets.

The foetal material comprised 206 feet, viz. 64 Nigerian, 107 British, 21 Sudanese and 14 Assamese, representing a total of 151 individuals. The age range of all the foetuses was 6–9 months: the sex of the African and of most of the British specimens

was known. Foetal foot-length in the European, Sudanese and Indian races was recorded (Table 1).

The foot length of the Nigerian foetal specimens was not recorded. The 26 male calcanei consisted of 12 type A and 14 type B. The 38 female calcanei consisted of 9 type A and 29 type B.

In an attempt to observe whether there were any racial differences in talocalcaneal mobility, many African and European adults were observed and photographed while walking both on flat and on specially prepared uneven surfaces.

Table 1. *Incidence of types A and B calcanei in foetal feet of known length*

Foot length (cm.)	European						Sudanese		Indian	
	Male		Female		Sex unknown		Sex unknown		Sex unknown	
	Type A	Type B	Type A	Type B	Type A	Type B	Type A	Type B	Type A	Type B
2·1–3	4	2	3	2	0	0	0	0	0	0
3·1–4	8	6	11	8	0	0	0	0	0	0
4·1–5	10	4	7	7	0	3	0	0	0	1
5·1–6	5	2	0	0	3	3	2	1	2	2
6·1–7	0	0	0	0	1	3	2	2	1	5
7·1–8	0	0	0	0	12	3	2	6	2	1
8·1–9	0	0	0	0	0	0	4	2	0	0

No measurement of the total articular area of the facets was recorded since preliminary observations indicated no relationship between this area and the pattern of the calcaneal facets. The total talocalcaneal articular surface area was estimated for 40 type A and 40 type B adult West African calcanei by tracing the margins of the articular facets directly on to tracing paper and then superimposing semi-transparent graph paper on the latter. The examination revealed an even spread of both types between the bones with the largest and those with the smallest total surface area.

A comparison of bones of the same length showed no relationship between the total articular area and the facetal pattern. Observations on the other series provided the same result.

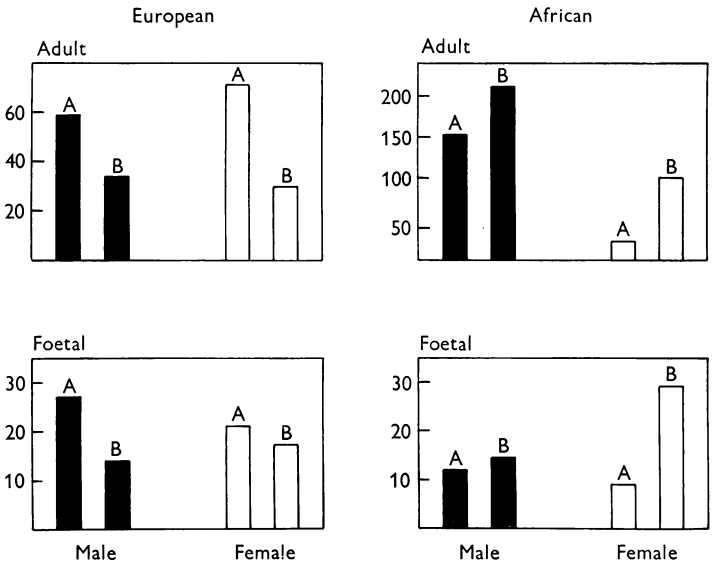
RESULTS

In most skeletons the two calcanei are of the same type (e.g. 86 out of 95 adult European skeletons). The type-findings of the Veddah and other races studied are shown in Table 2.

In Europeans, the incidence of type A bones is significantly higher than type B ($P < 0{\cdot}01$). On the contrary, in both African and Indian series type B predominates ($P < 0{\cdot}01$).

Comparing the sexes (Table 3), one finds that the incidence in male and female Europeans is similar, but the incidence of type B in African and Indian females is significantly higher than in the corresponding males ($P < 0{\cdot}05$). This sexual dimorphism is striking when the two races are considered together: type A occurs in 40·1 % of males but only 17·7 % of females.

The results of the examination of the foetal material are shown in Table 1 and Text-fig. 2. The foetal African calcanei differ significantly from the European ($P < 0{\cdot}05$), the significance being increased if female specimens only are compared ($P < 0{\cdot}01$). In African foetuses, the type B calcaneus is significantly more common in the female than in the male ($P < 0{\cdot}05$).



Text-fig. 2. Histograms showing the distribution of calcaneal types in adult and foetal Europeans and Africans

Table 2. *Incidence of calcaneal types in the adult series*

Ethnic origin and total number examined	Type A	Type B	Type C
Veddah (10)	0	6	4
British (194)	130 (67 %)	64 (33 %)	0
Indian (78)	17 (22 %)	61 (78 %)	0
African (492)	176 (36 %)	312 (63 %)	4

Table 3. *Sex distribution of types A and B in three adult series*

		Type A	Type B
European	males	59	34
	females	71	30
African	males	153	211
	females	23	101
Indian	males	13	37
	females	4	24

An attempt to correlate the two principal calcaneal types with particular features of the foot (especially with length of the foot, total area of the talocalcaneal articulating surfaces and the height of the arches) failed to disclose any consistent relationship. Study of the films of Africans and Europeans walking upon uneven ground revealed no racial difference in the range of talocalcanean movement employed. Other attempted correlations (including a comparison of right and left feet) likewise proved negative.

During this investigation, some unusual patterns of calcaneal facets have been observed. Thus 1 % of the African and Indian type A calcanei show a tendency for the medial of the two anterior facets to lie alongside, or even—as in two of the Indian specimens—to fuse with, the posterior facet (Pl. 1, *a*, *b*). In 6 % of the African and 3 % of the Indian type B calcanei the distal facet is large and lies close to the proximal facet (Pl. 1, *c*, *d*): confluence of facets here produces the type C calcaneus (Pl. 1, *e*, *f*).

DISCUSSION

In the Indian and European series no type C calcanei were seen and there were only four specimens in the Africans; the rarity of this type in all but the Veddah material agrees with the observations of Laidlaw (1904).

The incidence of type A and type B calcanei in the Sudanese and Indian foetal feet has been recorded in Table 1, but no significance deductions may be drawn therefrom.

Testut (1896) records that in 50 calcanei examined, the racial origin of which is not stated, those of type B predominate (30 type B; 20 type A). From the present study, a comparison of the adult African, Indian and European bones reveals a distinct racial difference, for which no functional explanation can readily be offered. The adult African and Indian calacanei show statistical agreement in exhibiting a higher incidence of type B. They differ significantly from the adult European calcanei which show a significant preponderance of the type A pattern. The distribution of calcaneal types in non-Europeans cannot result from post-natal influence since a similar dominance of the type B calcaneus is observable in the corresponding foetal material also.

In both adult and foetal Europeans there is no sexual difference in the distribution of calcaneal types. However, in adult Africans and Indians a significant sex difference is found, the type A calcaneus being notably uncommon in the female. Such difference does not result from special habits or gait, for there is a concomitant and significant preponderence of the type B calcaneus in female African foetuses compared with the male. Since intrauterine conditions must be comparable for African foetuses of both sexes, it would seem that this sexual difference must be of genetic determination.

SUMMARY

1. Calcanei may articulate with the talus by three different facets (type A), two (type B) or—rarely except in a small Veddah series—a single facet (type C).

2. In Europeans, the incidence of type A is statistically significantly higher than type B in adults ($P < 0{\cdot}01$) and also in foetuses ($P < 0{\cdot}05$).

3. In Africans and Indians, type B predominates, especially in females, in whom it is more than four times as common as type A.

4. The racial differences and sexual dimorphism observed are also present in a foetal series, indicating that they are probably genetically determined.

We are greatly indebted both for advice and the provision of material to Professors R. E. M. Bowden, H. Butler, A. J. E. Cave, D. V. Davies and A. G. Smith. The photographs of the African bones were taken, in difficult conditions, by D. G. Stuart and the European and Indian bones by A. Pache.

REFERENCES

BUNNING, P. S. C. (1964). Some observations on the West African calcaneus and the associated talo-calcaneal interosseous ligamentous apparatus. *Amer. J. Phys. Anthrop.* (in the Press).

BUNNING, P. S. C. & BARNETT, C. H. (1963). Variations in the talocalcaneal articulations. *J. Anat., Lond.*, **97**, 643.

LAIDLAW, P. P. (1904). The varieties of the os calcis. *J. Anat., Lond.*, **38**, 133–143.

TESTUT, L. (1896). *Traite d'anatomie humaine*, vol. I. Paris: Doin et Cie.

EXPLANATION OF PLATE

a. Right calcaneus from African adult male. Type A—proximal and middle facets lie beside each other, well separated from distal facet.

b. Right calcaneus from Indian adult, probably female. Bears two facets, hence classified as type B, but is a rare example in this series of fused proximal and middle facets.

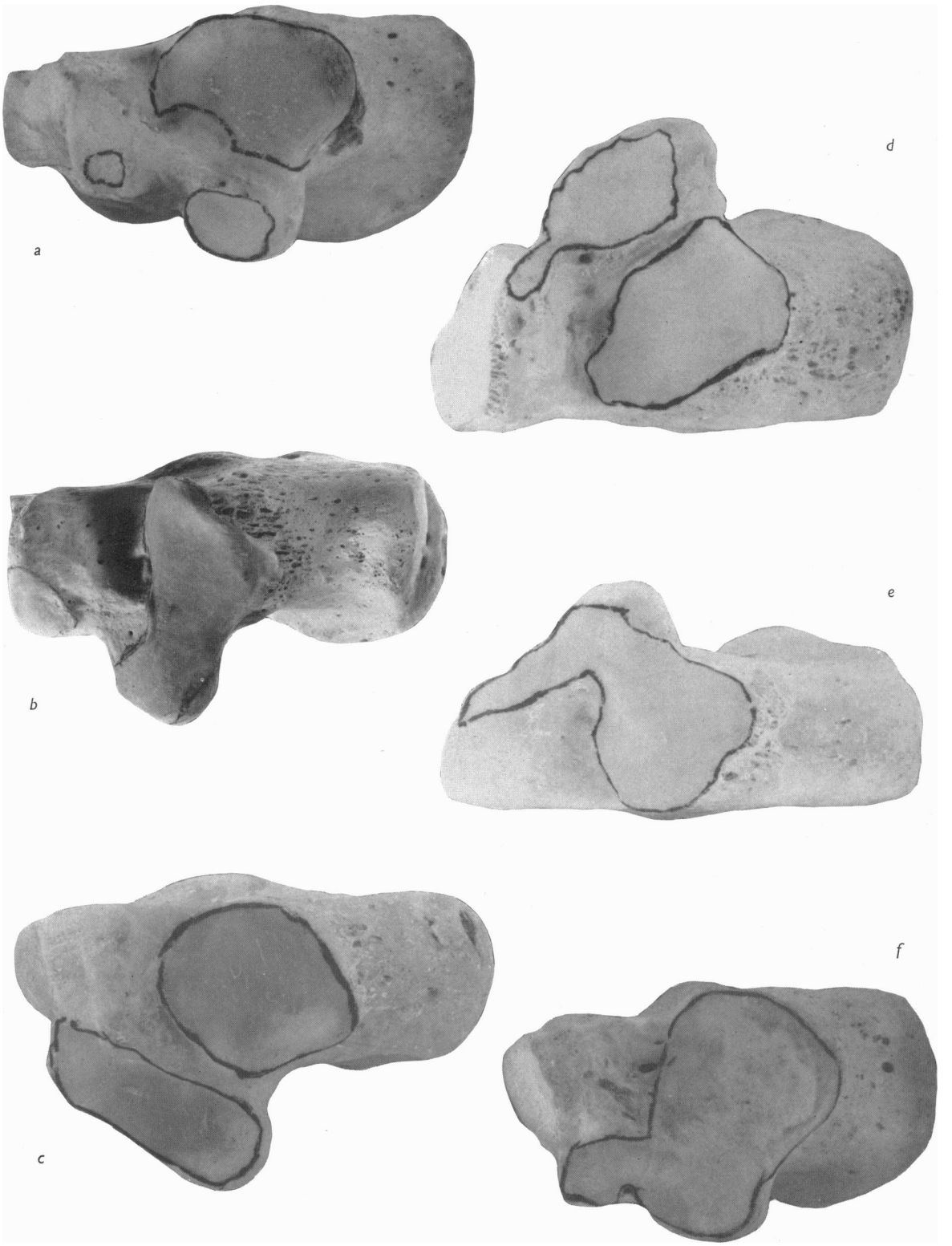
c. Right calcaneus from African male aged 41 years. Type B—unusually large distal facet.

d. Left calcaneus from African male aged 38 years. Type B—large distal facet of unusual form.

e. Left calcaneus from African female aged 30 years. Type C.

f. Right calcaneus from African male aged 28 years. Type C.

In all specimens the articular margins have been indicated by India ink.


a
d
b
e
c
f