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VALGUS DEVIATION OF THE DISTAL PHALANX OF THE GREAT TOE

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In the typical adult European foot, the distal phalanx of the great toe exhibits a valgus deviation (Griffiths, 1902). This has been ascribed to the wearing of shoes (Elmslie, 1939), but there is evidence that it may be a congenital condition, at any rate in some people (Craigmile, 1953; Wilkinson, 1954).

In the present investigation, an attempt has been made to determine the average orientation of the distal phalanx of the hallux in living adults and children and in stillborn foetuses of several races. In view of Wilkinson's statement that valgus deviation of the distal phalanx was not present in the hallux of a chimpanzee, an unspecified baboon and a rhesus monkey, the feet of a series of primates have also been examined.

MATERIAL AND METHODS

Both feet of twenty-five unshod natives of New Guinea were examined radiologically by means of the standard technique of Hardy & Clapham (1951). This series included thirteen men (aged 26·8 ± S.D. 9·7 years) and twelve women (aged 24·9 ± S.D. 7·5 years). The radiographs were compared with those of both feet of 173 normal British adults, comprising ninety-six males (mean age 22·4 years:

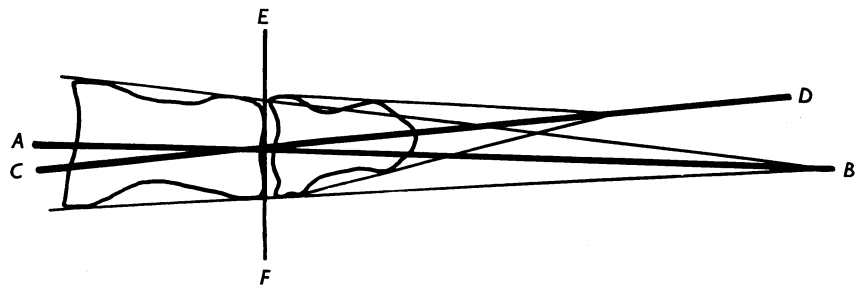

Fig. 1. The method used for measuring the deviation of the distal phalanx.

forty-eight were aged 18 or 19 years) and sixty-seven females (mean age 20·4 years: fifty were aged 18–20 years) and both feet of forty-five British children aged 4 years—twenty-two boys and twenty-three girls.

Burry's method (1957) was followed for measuring the angle between the long axes of the proximal and distal phalanges on each radiograph (Fig. 1). Tangents were drawn to the medial and lateral profiles of the two bones and the lines bisecting the angles between the tangents (*AB* and *CD*) were taken to be the long axes of the phalanges. The use of a special protractor with a rotating arm made the measurements less laborious and gave consistent results. The angles were measured to the nearest even number of degrees.

In sixty feet—thirty from New Guinea, thirty British—an assessment was made of the extent to which the deviation of the distal phalanx was due to an oblique orientation of the articular surface on the head of the proximal phalanx rather than an asymmetrical form of the distal phalanx itself. On radiographs, a tangent was drawn to this saddle-shaped surface and the angle between this line (*EF*) and the long axis of the proximal phalanx (*AB*) was measured (Fig. 1). The amount by which this angle differed from 90° was an indication of the obliquity of the articular surface.

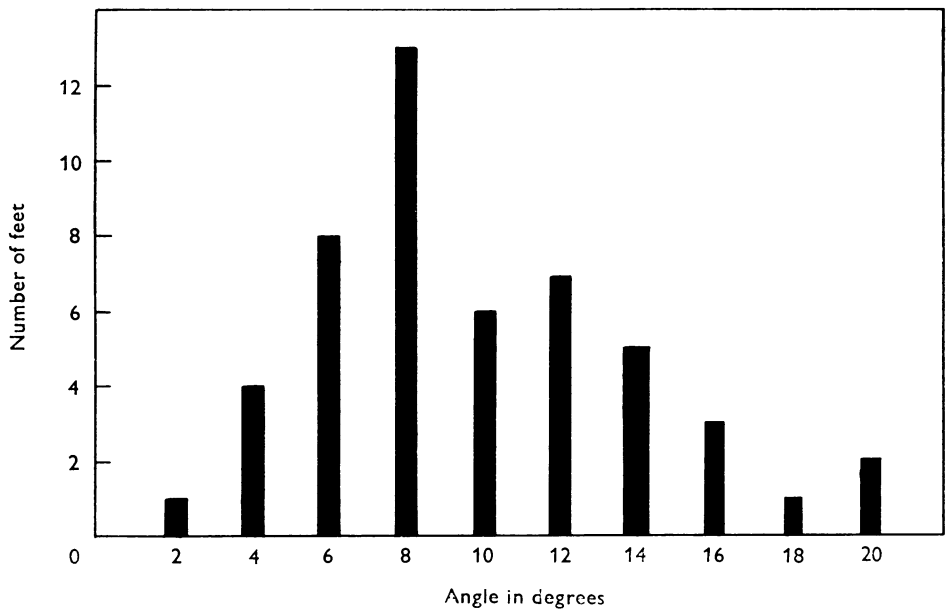

Fig. 2. The degree of valgus deviation in fifty feet of New Guinea natives. (Mean angle and S.D. in males: $8{\cdot}0 \pm 2{\cdot}14$; in females: $10{\cdot}0 \pm 2{\cdot}96$.)

The foetuses included twenty-five from Great Britain, twenty-two from the Sudan and twelve from Assam. Measurements were not practicable, but the hallux in each left foot was classified as straight (i.e. the proximal and distal segments of the toe in line as seen from above) or deviated (the distal phalanx showing valgus deviation). In addition, six great toes were sectioned longitudinally in the horizontal plane, the sections then being stained with haematoxylin and eosin.

The other primate species examined are listed in Table 2. In most of the smaller animals, preserved feet were available with the skeleton *in situ*; the skin was not dissected away but the left and right halluces were compared by placing the medial margins of the proximal segments of these toes in line with one another. It was then clear whether the proximal and distal segments were in line (classified as 'straight') or whether the distal phalanges showed valgus or varus deviation. Dried foot bones of the larger primates were available; the phalanges of the hallux were articulated together and the toes again classified as straight or deviated. Although the dried articular surfaces lacked a coating of hyaline cartilage they fitted together well and

it is unlikely that the classification of these dry specimens was affected by this deficiency; in human material the contour of these surfaces is similar in wet specimens and dried bones.

RESULTS

Analysis of the measurements derived from the left and right feet in the British series does not reveal any statistically significant difference in the degree of deviation of the distal phalanges on the two sides. There is no correlation between the degree of valgus deviation and the age of the New Guinea subjects; almost all the British subjects are young adults and no such correlation can usefully be attempted.

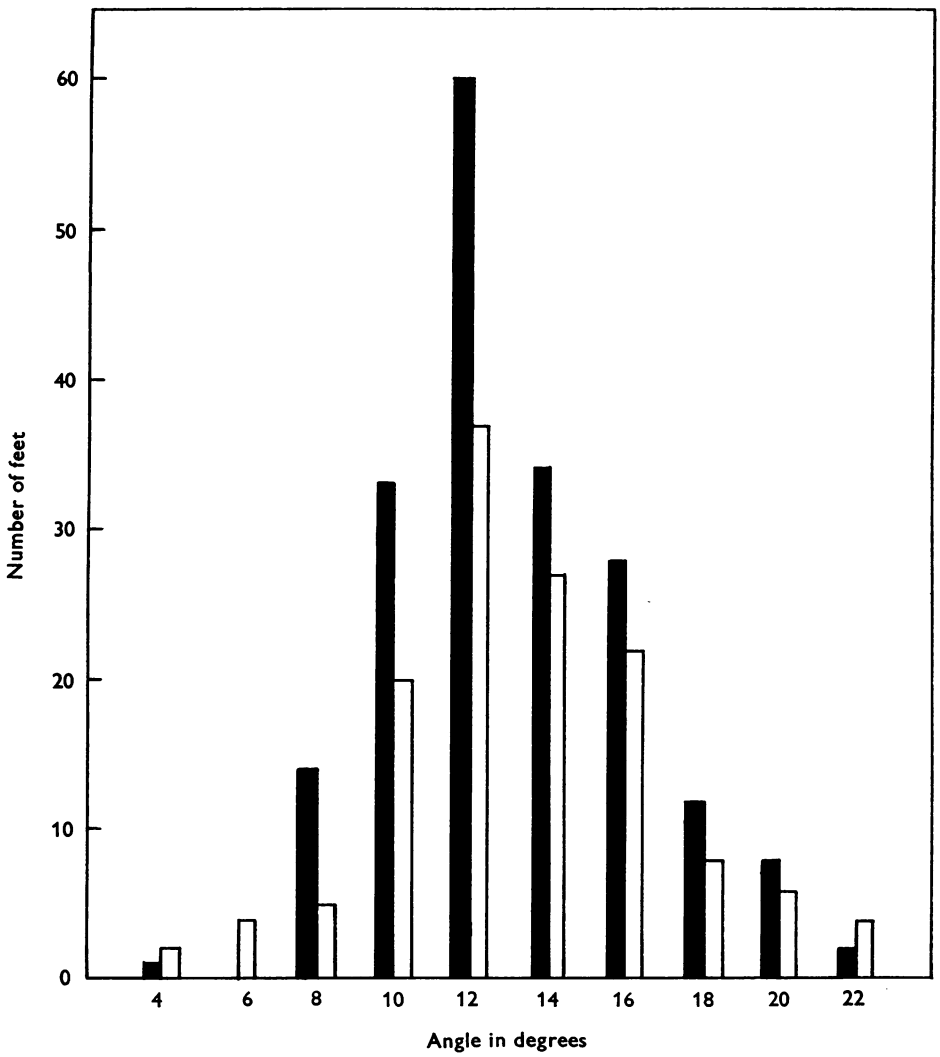

Fig. 3. The degree of valgus deviation in 346 British feet. (Mean angle and S.D. in males: 13·0 ± 3·72 (left feet) and 13·1 ± 2·34 (right feet); in females: 13·3 ± 3·54 (left feet) and 13·5 ± 3·53 (right feet). ■, males; □, females.

For convenience of comparison the deviation of the distal phalanges in the adult and children's feet is shown by means of histograms (Figs. 2–4). Mean angles and the standard deviations are given in the legends to these figures.

Although at first sight the British feet—both adult and immature—seem to exhibit a greater degree of valgus deviation of the distal phalanx than those from New Guinea, the difference between the two groups is not statistically significant.

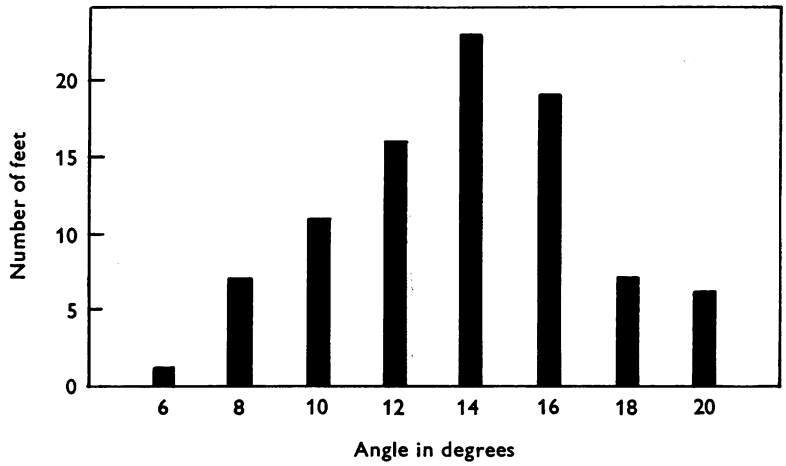

Fig. 4. The degree of valgus deviation in ninety British children's feet. (Mean angle and S.D. in boys: $13{\cdot}1 \pm 3{\cdot}36$; in girls: $14{\cdot}5 \pm 2{\cdot}98$.)

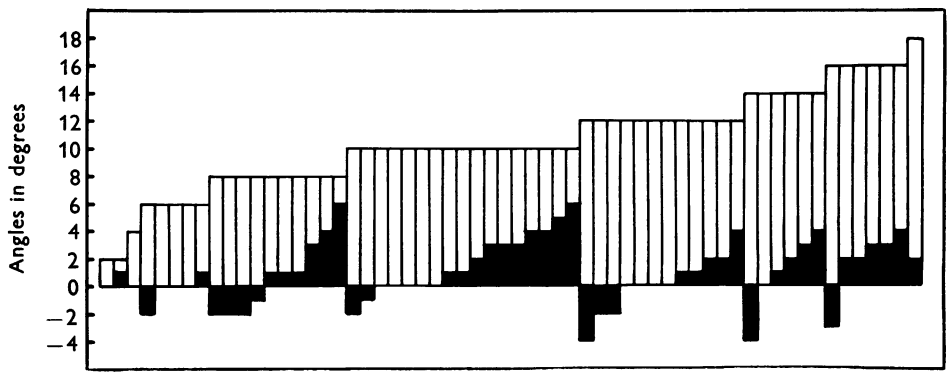

Fig. 5. Total deviation of the distal phalanx in sixty adult feet (total height of columns above horizontal line). Superimposed is a histogram showing the obliquity of the articular surface on the head of the corresponding proximal phalanx (black columns).

Even though a larger series of New Guinea feet might reveal a statistical difference, it is clear that in these people the distal phalanx of the hallux is congenitally deviated, since there is no question of pressure from shoes. It is noteworthy that there is no evidence of an increase in deviation as British children grow to maturity.

Fig. 5 shows the part played by asymmetry of the distal phalanx in the causation of valgus deviation. Sometimes an oblique orientation of the articular surface on

the head of the proximal phalanx contributes towards the deviation, but this is by no means invariably true and in some feet this surface faces somewhat medially, i.e. tends to cause a deviation of the distal phalanx in a varus direction. However, the varus effect is always masked by the asymmetrical form of this phalanx, the long axis of the bone not being perpendicular to the base.

Table 1. *Valgus deviation of the distal phalanx of the hallux in fifty-nine foetuses*

Foot length (cm.)	Foetuses from Great Britain		Foetuses from Sudan		Foetuses from Assam	
	Total no. of feet	No with valgus deviation	Total no. of feet	No with valgus deviation	Total no. of feet	No. with valgus deviation
4–4·9	2	2	0	0	0	0
5–5·9	4	4	1	1	5	5
6–6·9	3	2	2	2	1	1
7–7·9	13	12	9	9	6	4
8–8·9	2	1	9	8	0	0

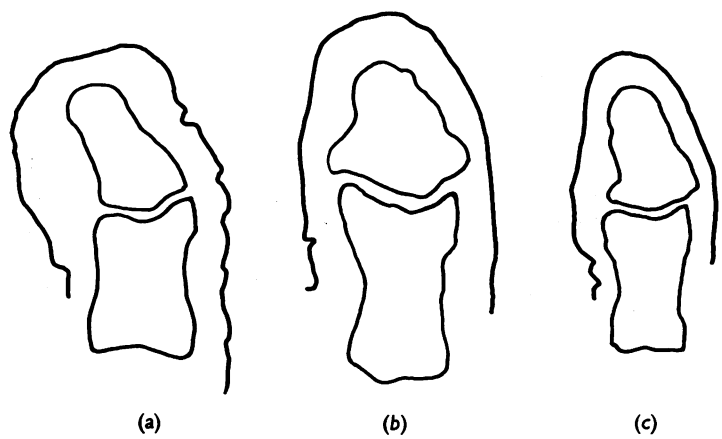

Fig. 6. Tracings of horizontal sections through three left foetal great toes: (*a*) from Great Britain, (*b*) from the Sudan, (*c*) from Assam.

The foetal feet yield the results shown in Table 1. In only six feet is the great toe recorded as straight, all the remainder showing definite valgus deviation of the distal segment. The chronological ages of the foetuses are not known but the foot lengths are given in the table. Three typical sections are depicted in traced outline in Fig. 6.

The results of the examination of non-human primate feet are listed in Table 2. It can be seen that the distal phalanx is almost invariably in line with the proximal phalanx. The varus deviation recorded in a few of the halluces is never more than 5 degrees.

Table 2. *Deviation of the distal phalanx of the hallux in non-human primates*

Common name	Species and no. of feet examined		No. with straight distal phalanx	No. with deviation
Spider monkeys	*Ateles goefroyi*	6	4	2 varus
	A. belzebuth	6	6	0
Capuchins	*Cebus capucinus*	8	8	0
	C. fatuellus	2	2	0
	C. monachus	2	2	0
Guenons	*Cercopithecus cephus*	14	14	0
	C. nictitans	16	16	0
	C. diana	4	4	0
	C. hamlyni	4	4	0
Mangabey	*Cercocebus* sp.	8	8	0
Baboons	*Papio leucophaeus*	14	12	2 varus
	P. anubis	4	4	0
Mandrill	*Mandrillus sphynx*	14	10	4 varus
Guerezas	*Colobus badius*	24	24	0
	C. l'hoesti	12	12	0
Chimpanzee	*Pan satyrus*	12	12	0
Gorilla	*Gorilla gorilla*	6	6	0
Gibbon	*Hylobates hoolock*	8	4	4 varus

DISCUSSION

The results of the present investigation strongly suggest that valgus deviation of the distal phalanx of the great toe is a distinctive human feature. It has been consistently demonstrated in adults, children of pre-school age and foetuses of several human races, but not in any other primates.

It may be assumed that this characteristic deviation is related to man's unique gait. At the final 'push off' phase of walking there is a tendency for the foot to rotate laterally upon the ground, a fact readily demonstrated by force-plate studies (Harper, Warlow & Clarke, 1961). Except in slippery conditions, the friction between the toes and the ground prevents this rotation and there is instead a torque within the foot skeleton, so that a compressional force is directed forwards and laterally within the bones of the great toe. The deviation of the distal phalanx allows the lines of force to be guided down the long axis of the bone, an example of a general principle concerning the disposition of the long bones of the skeleton (Barnett, Davies & MacConaill, 1961). Thus there is no tendency for the toe to buckle in the horizontal plane.

In assessing the differences between man and other primates a number of 'hall-marks of mankind' have been suggested (Wood Jones, 1948). Deviation of the distal phalanx of the hallux should perhaps be added to this list, though examination of many members of all the principal primate species would be necessary before this distinction can be regarded as absolute. Unfortunately the distal phalanx of the hallux is seldom recovered intact in fossil form, but the discovery of a valgus deviation in the bone of an extinct creature would provide evidence for a human type of gait.

SUMMARY

The orientation of the distal phalanx of the great toe has been determined in adults, children and stillborn foetuses of several races. Valgus deviation is constantly present even in the unshod, due largely to asymmetry of the distal phalanx. Such a deviation has not been observed in a series of primate feet. It is suggested that this difference is associated with man's unique gait.

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REFERENCES

BARNETT, C. H., DAVIES, D. V. & MACCONAILL, M. A. (1961). *Synovial Joints.* London: Longmans, Green and Co.

BURRY, H. S. (1957). The effect of shoes on hallux valgus: a significant study. *Research report* 147: British boot, shoe and allied trades research association.

CRAIGMILE, D. A. (1953). Incidence, origin, and prevention of certain foot defects. *Brit. med. J.*, **2**, 749–752.

ELMSLIE, M. (1939). Prevention of foot deformities in children. *Lancet*, **2**, 1260–1263.

GRIFFITHS, J. (1902). The normal position of the big toe. *J. Anat., Lond.*, **36**, 344–355.

HARDY, R. H. & CLAPHAM, J. C. R. (1951). Observations on hallux valgus. *J. Bone Jt Surg.*, **33B**, 376–391.

HARPER, F. C., WARLOW, W. J. & CLARKE, B. L. (1961). The forces applied to the floor by the foot in walking. *National Building Studies Research Paper* 32. London: H.M. Stationery Office.

JONES, F. WOOD (1948). *Hallmarks of Mankind.* London: Baillière, Tindall and Cox.

WILKINSON, J. L. (1954). The terminal phalanx of the great toe. *J. Anat., Lond.*, **88**, 537–541.