Journal of Anatomy and Physiology.

THE INFLUENCE OF FUNCTION, AS EXEMPLIFIED IN THE MORPHOLOGY OF THE LOWER EXTREMITY OF THE PANJABI.

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THE influence exercised by pressure and posture in producing modifications in the skeleton has on several occasions been discussed in this *Journal*, and I may especially refer to papers by Mr W. Arbuthnot Lane, Sir W. Turner, and Mr Arthur Thomson[1] on this subject.

As further illustrations of the changes in structure that function may bring about, the morphological differences observed between certain bones of the lower extremity of the Panjabi and European are of much interest. The European sits upon a chair, and cannot adopt, save at great inconvenience, the squatting posture generally assumed by the Oriental. Fig. 1 illustrates the position in question, which is customary to the native, whether in field labour, or engaged in culinary operations, or pursuing the avocations of an artisan. He can sleep as comfortably in this as in the supine posture. The position—sartorial—figured in fig. 2 is alike commonly used.

The joints where changes, due to increased mobility, would naturally be observed are, the hip, the knee, and the ankle. In each of these articulations, in the great majority of Panjabi skeletons may be seen exemplified the points referred to in this paper, and illustrated by the accompanying figures.

The positions in question are adopted by males and females

[1] *Jour. of Anat. and Phys.*, vols. xxi., xxii., xxiii., xxiv.

alike, and consequently the peculiarities are observed in the bones of both sexes. There is no restriction as to the sitting posture amongst Panjabi women like that mentioned by Mr Arthur Thomson (quoting Dr St John Brooks)—*Jour. of Anat. and Phys.*, vol. xxiv. p. 211—as holding amongst Zulu females.

In the squatting posture shown in fig. 1, the back of the thigh

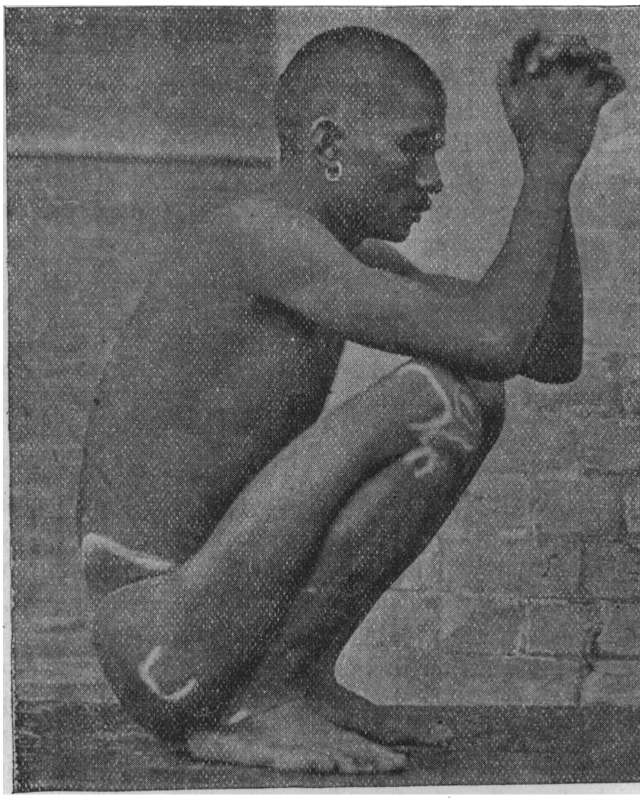

Fig. 1.

rests upon the calf, the front of the tuber ischii being in close apposition with the heel; in fact the trunk weight is supported by the heels, the extreme flexion of the hip, knee, and ankle allowing of this. The heels are apart about the distance that separates the ischial tuberosities. The toes are turned outwards. I agree with Mr Arthur Thomson (*Jour. of Anat. and*

Phys., vol. xxiii. p. 623) in thinking that the increase in convexity of the external condylar surface of the tibia much facilitates the consequent movement of the external semilunar cartilage down and back, ensuring safety to the joint. The extreme flexion of the knee is rendered easy, not only by this, but also, as I shall point out, by a greatly increased articular area on the *upper* surface of the internal condyle of the femur (fig. 4), which is received upon the internal condylar surface of

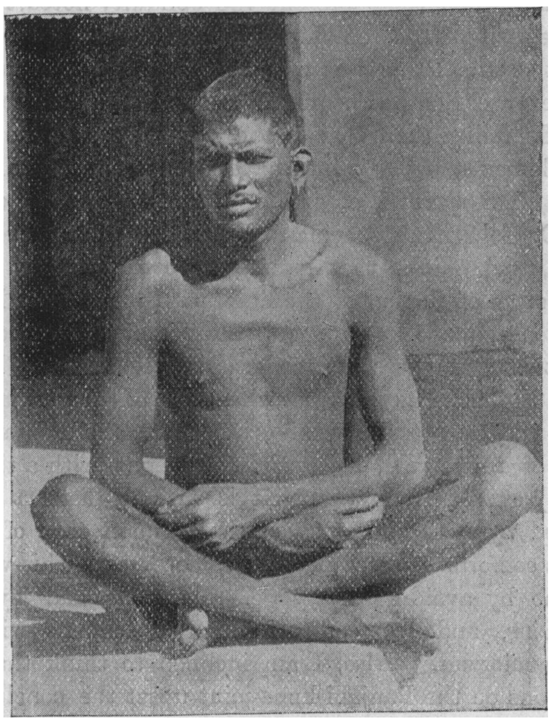

Fig. 2.

the tibia. The latter is a very oblique plane, sloping down from the tibial spine (fig. 6). The position of this plane is partly due to the slanting manner in which the upper epiphysis is set upon the shaft, and in part to the backward curve of the upper portion of the tibial diaphysis. The amount of the backward curve varies, but it is distinctly seen in all, and is made specially obvious when compared with the bone of an European.

I have no doubt but that it is due to the habit of extreme flexion of the joint, acting from the earliest childhood. The ligament of the patella has its attachment to the diaphysis. In complete flexion, before the junction of the epiphysis to the shaft, the tension of the ligament posteriorly upon the front of the former would have a tendency to push it backwards. I do not agree with Dr Collignon ("Description des Ossements fossiles humains," *Revue d'Anth.*, vol. ix., Paris, 1880), who thinks that when tibiæ present the obliquity noted, it is probable the gait of the individual was less erect than ordinary. The gait of the Panjabi is as erect as that of a guardsman! He, however, either has acquired, or inherited, a knee-joint of greater flexibility than that of the European, and the morphological elements of the joints have been modified to suit his customs. This point is of greater interest when one considers that in Dr Collignon's speculations he notes this peculiarity of the tibia, and thinks that it might be induced by a more habitual state of flexion of the limb, with which view I concur, and in consequence he supposes the gait of these people was less erect than that of their modern representatives. He then contrasts the tibiæ he describes with those of the gorilla. Here his suppositions are, I think, erroneous. The Panjabi is an example of a man with an upright gait, but with a tibia very materially curved backwards! It is wise to distrust opinions till proved by facts, and to avoid the common error of making the facts conform to preconceived hypotheses. This would be best done by avoiding hasty generalisations, and by careful observations, and the comparison of specimens with their modern analogues. Also, I am inclined to think that these observations on the Panjabi knee-joint upset the conclusions of M. Fraipont (quoted by Mr Arthur Thomson in his paper, *opus cit.*, vol. xxiii., 1889), founded on an examination of the tibiæ of the men of Spy, that in the erect position the men of Spy "appeared to have the tibia and femur inclined to one another at an angle not so marked as we have seen in anthropoids, but still sufficiently pronounced as to render the difference between Quaternary man and the modern European very characteristic." It is probable that had I had the opportunity of examining only the tibiæ and femora of Panjabis, I might have formed like conclusions with reference to them; but, having studied these people both when alive and when dissected, I understand how it is that the thigh and leg are not inclined to one another at an angle, though they may resemble Quaternary man as to their tibiæ. Such considerations are too often overlooked by observers in the study of human remains, and it is possible to reach the most opposite ideas from limited investigation or imperfect knowledge of the *reliques* and customs of tribes that might have precisely the same habits, which would account for similarity in osseous peculiarities.[1]

Quaternary man probably squatted and sat after the manner of Orientals, as opposed to Europeans.

I have noted that the trunk weight in the squatting posture is supported mostly by the heels and backs of the tibiæ. From the tibiæ the weight falls on the astragali—the necks of which have one, or may be two, extra facets, and the inner surfaces specially prolonged articular pyriform portions (figure 8), all of which are due to the excess of function in the joint owing to the position of extreme flexion in the ankle. From the astragali the weight is transmitted to the inferior calcaneo-scaphoid ligament, which thus bears a relatively greater strain than in the European, and, therefore, the tib. postici will have more to support, as also will these same muscles have greater work to perform when the individual rises from such a squatting posture. An excess in development will naturally be the result, and consequent alterations will occur in the muscular attachments to the tibiæ. The tibiæ should be flatter. The index of platyknemia amongst Panjabis is comparatively high—varies from 58·5 downwards,—the average of 52 tibiæ taken promiscuously being 69·9. Of the 52, forty-five possessed inferior anterior facets, and of these 55·5 per cent. showed distinct evidence of flattening, in some cases very pronounced. The remaining seven, on which the facets are absent, only show signs of flattening in 28·5 per cent., and when present it is but slight. There is thus a certain relation between the breadth of the

[1] M. Manouvrier, in an "Étude sur la Rétroversion de la tête du Tibia," in the *Mémoires de la Société d'Anthropologie de Paris*, 2e série, t. iv., 1890, has employed a similar line of argument to that in the paper. M. Manouvrier's observations were made chiefly on the tibiæ of Neolithic men, modern Parisians, and California Indians.—EDITOR.

tibia and the power of flexion at the ankle-joint. The tibia is flatter when the facets are present—though not always—that is, when most strain would be thrown on the calcaneo-scaphoid ligament. That the flattening was not due either to hill climbing, or acquired from indulgence in the chase, will be understood when it is known that these Panjabis were all dwellers on a plain (Panjab) as level as Holland, had most probably never revelled in the pursuit of "game" higher than that of a crow or sparrow, and their only "mountaineering" was within the limits of a glimpse of the Himalayan snows in the far horizon! The explanation of the occurrence of comparatively flat tibiæ amongst them must be sought not here. Will the strain thrown on the posterior tibial muscles by the squatting posture do so? If not, what will? May not the more frequent occurrence of platyknemia in ancient, savage, and Oriental races, and its diminution in frequency under the influence of civilisation, be due in a measure to the adoption of the chair to sit on amongst the civilised, in contradistinction to the squatting habits of the former. If so, the history of the influence of the chair upon the tibia has got to be written. Look at figure 1 and see the squatting posture. When it is borne in mind that a great portion of the individual's life is passed in this position —in which he works, eats, can sleep, and enjoy "sweet converse" with his friends in "the cool of the evening" all equally well—it cannot be doubted that changes in the bones, muscles, and joints will be found, in virtue of the physiological law that function makes the organ. Mr Arthur Thomson (page 627, vol. xxiii., *opus cit.*), in speaking of the external condyloid (tibial) convexity and the inferior anterior tibial facets, and the facets on the neck of the astragalus of the Neolithic skeleton in the Oxford Museum, says that in these respects it presents a marked contrast to the modern European type, and a close resemblance to the contemporaneous lower races. Most certainly; and doubtless the explanation is that our Neolithic ancestors did not enjoy the luxury of a chair any more than many of our fellow-subjects in India at the present day. Circumstances remaining similar, there is little variation; and so a close similitude in osteological configuration may be due to resemblance in habit and conditions of existence.

At the hip-joint a certain amount of abduction is combined with the extreme flexion, and the abdomen is received between the two thighs. The position is quite as easy to a Panjabi Falstaff as it is to an Oriental with the proportions of a Slender. This shows the extreme mobility of the hip-joint in these races. In the European it often happens that increasing corpulence deprives the individual of the power of tying his shoe latchet! not to mention that he would find it impossible to attempt the squatting posture! As the lower and inner lip of the acetabulum in the Panjabi is more developed (figure 3), safety from

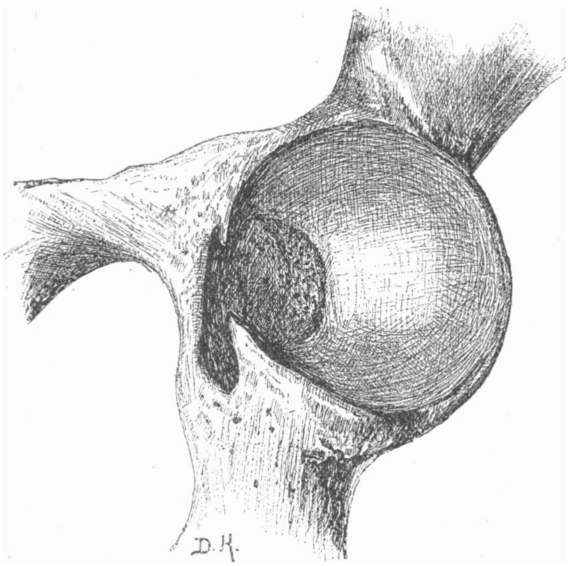

Fig. 3.

luxation is ensured. It is the vicarious use of the two positions, squatting and sartorial, that accounts for the modification in the ischial portion of the cotyloid cavity, the increased articular area on the head of the femur, and probably the somewhat elongated femoral neck, which an examination of a considerable number of specimens impresses on one as being typical of the Panjabi hip-joint.

I shall note now the chief anatomical points of comparison in the lower extremity.

The most distinctive differences between the morphology of the acetabulum of a native of the Panjab, and probably also of most Orientals who adopt the same habits of sitting and squatting, are to be found

1st and principally, in the great size of the ischial portion of the facies lunata. The rim of the acetabulum here is very prominent—the groove for the obturator externus below it being consequently deep (fig. 3).

2nd. In the extension forwards and widening out of the lower horn of the facies lunata, whereby the cotyloid notch is, as it were, partly bridged over, instead of being an irregular open space. It looks as if the transverse ligament were ossified on its ischial side.

3rd. The cotyloid notch, which in the European os innominatum is as a rule an open notch, presents in every well-marked Panjabi pelvis the characteristic, shown in fig. 3, of being partially arched over by the forward and upward prolongation of the inferior cornu of the facies lunata. The superficial boundary of the cotyloid notch in the European consists of the transverse ligament alone; the same boundary in the Panjabi consists of *bone* (portion of the ischium) plus the transverse ligament. The vessels entering the joint pass under the bony roof, and not under the ligamentous portion. The reason of this I will consider further on.

In the squatting posture (fig. 1) the upper and back part of the head of the femur rests against the ischial portion of the facies lunata—being supported by bone. Were an European able to flex the hip-joint to such an extent, and practise temporarily a like habit of squatting, the head of his femur would be supported partly against his transverse ligament, and the strain would be borne by the weakest part of the capsule, thus obviating luxation. In this posture in the Panjabi security is obtained by the femur resting on the enlarged inferior cornu, and the arthritic vessels are better protected—the spine of bone above and outside them guarding them.

A comparison of fig. 3 with the European pelvis will demonstrate clearly the differences I have noted.

The anatomical points in the upper end of the femur, due to increased mobility in the Oriental hip-joint, are, a larger articular area in proportion to the size of the head, and a well-marked neck, which allows by its length of a greater range of motion. Fig. 4 shows the upper end of a Panjabi femur. The view is from above, and, if compared with a European femur, a difference in the outline of the articular surfaces will be seen. In the European it is generally a line more or less straight. In the Panjabi, the outline, superiorly and anteriorly, is curved

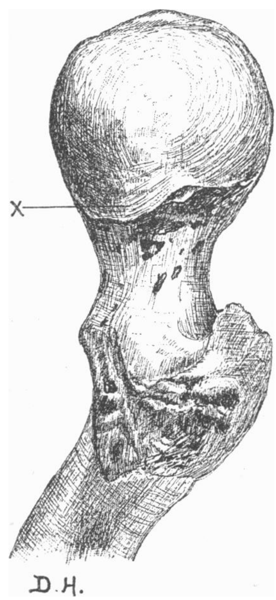

Fig. 4.

where it joins the neck, and at the antero-superior border forms a well-marked convexity (x). Posteriorly, the convexity comes into apposition with the greatly-developed inferior cornu of the facies lunata of the acetabulum in the squatting posture. The groove for the obturator externus tendon on the posterior surface of the neck below the articular surface is always very well marked. This is not so frequently found in European specimens. The tuber colli inferior is also of considerable size, as the pubo-femoral ligament, in the majority of bodies, is found to be a structure of very considerable strength, quite unlike "the prominent but weak internal accessory band" described by Prof. Macalister from dissections of European bodies.

The most noteworthy point in the modification of the articular surface of the femur at the knee, exemplifying a modification of structure due to function, is seen in the great prolongation of the internal condylar articular surface upwards to the origin of the gastrocnemius. Fig. 5 shows the posterior view of the lower extremity of a Panjabi femur. When the figure is compared with a European femur, it will be at once apparent, even

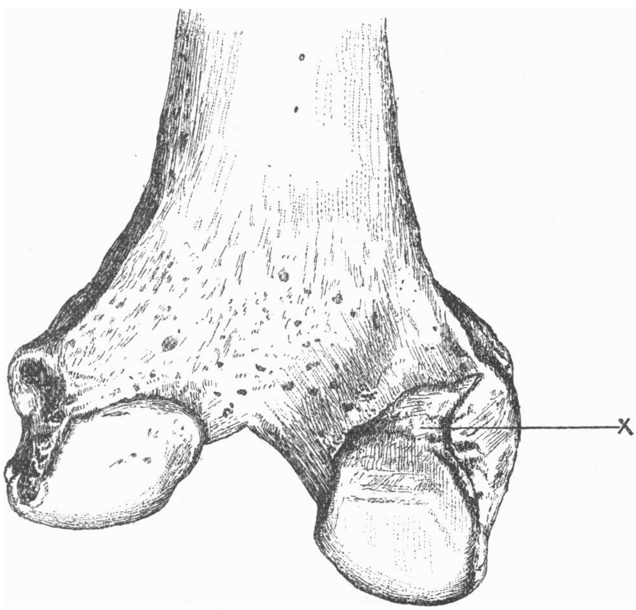

Fig. 5.

from a cursory glance, that the articular surface in the former case is much more largely developed. In the very extreme flexion of the knee which occurs in squatting, it is the surface in question that is in relation with the internal semilunar cartilage on the internal tuberosity of the tibia, which is, as I shall show, also developed more in a backward direction than is usually found in Europeans. Were it not for this mutual coaptation of parts the femur would have a tendency to slip downwards and backwards from off the tibia. The femoral internal condyle of a Panjabi, therefore, has a *superior* surface (x) *which is articular.* (It presents—1. an articular facet (x); 2. origin of gastrocnemius.) The superior surface of the internal condyle of an European femur is *non*-articular, and is occupied by the origin of the gastrocnemius only.

The modifications of the superior surface of the external tuberosity of the tibia, so well shown by Mr Arthur Thomson, I have found to be exemplified in all the tibiæ in my collection. As to the true description of this surface, I agree with that anatomist in considering that, antero-posteriorly, flatness is the exception, and convexity the rule. The degree of convexity would be 2·5 to 3 of Thomson's scale. I may note, however, that this convexity of the external condylar surface is associated also with the backward curve of the upper extremity of the tibia. It is doubtful, therefore, whether a backwardly-curved tibia is compensatory to a flat external condylar surface. In some of my best-marked specimens the convexity of this surface is considerable, and it is associated with obliquity of the upper extremity of the tibia, a degree of platyknemia and well-marked inferior anterior facet. As far as I have observed, I have not noted that *flatness* of the condylar surface is associated with obliquity of the shaft. The great obliquity of the upper extremity of the tibia renders the internal tuberosity very prominent posteriorly. The upper surface of this tuberosity is also itself very slantingly placed. Figure 6 represents the inner surface of the head of a Panjabi tibia. When compared with a European, it will be noted that the tibial spine, with a portion of the articular surface, is quite visible in the former, whereas in the latter nothing is seen of either.

Extreme flexion of the knee, with full security from luxation, is facilitated by (1) the peculiarity of an articular facet on the *upper* surface of the femoral internal condyle; (2) the convexity of tibial external condylarsurface with the prolongation of thesame surface down posteriorly for tendon of popliteus and external semilunar cartilage (as shown by Mr Arthur Thomson); (3) obliquity of articular surface of internal tuberosity; (4) obliquity of upper extremity of tibia to its shaft; (5) a well-marked tubercle to the tibia, giving attachment to a *long* and strong lig. patellæ.

I introduce here the measurements of the diameters of 52 tibiæ, with the platyknemial index computed for each, as well as

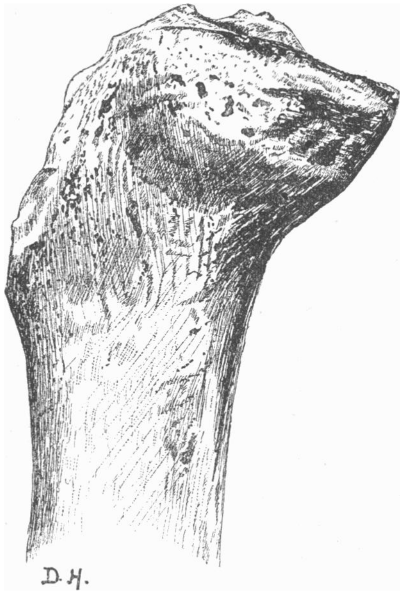

Fig. 6.

a column showing the presence or absence of the inferior facet. The measurements are after Broca's method. Facets will be seen to be present whether the platyknemia be high or low.

TABLE.

Table of Measurements of 52 Tibiæ, showing Degrees of Flattening of Shaft when Anterior Inferior Facet is present or absent.

Serial No.	Diams. of Tibiæ.		Index of Platyknemia.	Facet.	Serial No.	Diams. of Tibiæ.		Index of Platyknemia.	Facet.
	Trans-verse.	Antero-Posterior.				Trans-verse.	Antero-Posterior.		
1	20	30	66·6	F.	27	20	30	66·6	F.
2	25	34	73·5	...	28	21	34	61·7	...
3	21	30	70	...	29	20	29	68·9	F.
4	22	32	68·7	F.	30	21	33	63·6	F.
5	21	31	67·7	F.	31	19	24	79·1	...
6	26	34	76·4	F.	32	22	34	64·7	F.
7	19	24	79	F.	33	21	30	70	F.
8	20	34	58·8	F.	34	21	30	70	...
9	24	37	64·8	F.	35	21	33	63·6	F.
10	21	31	67·7	F.	36	24	41	58·5	F.
11	20	29	68·9	F.	37	25	39	64·1	F.
12	27	40	67·5	F.	38	19	24	79·1	...
13	27	37	72·9	F.	39	19	21	90·4	F.
14	25	35	71·4	F.	40	24	34	70·5	F.
15	25	34	73·5	F.	41	19	30	63·3	F.
16	25	36	69·4	F.	42	24	32	75	F.
17	22	29	75·8	F.	43	21	31	67·7	...
18	20	30	66·6	F.	44	17	25	68	F.
19	24	34	70·6	F.	45	24	35	68·5	F.
20	19	24	79·1	F.	46	24	31	77·4	F.
21	16	25	64	F.	47	23	36	63·8	F.
22	23	34	67·6	F.	48	22	36	61·1	F.
23	27	34	79·4	F.	49	21	29	72·4	F.
24	24	35	68·5	F.	50	29	38	76·3	F.
25	29	39	74·3	F.	51	21	29	72·4	F.
26	21	29	72·4	F.	52	22	34	64·7	F.

Average Index of Platyknemia of 52 Tibiæ = 69·9.
Facet present in 45.
,, absent in 7.
Amongst the former, 55·5 per cent. present evidences of flattening, and in some cases this is pronounced.
Amongst the latter, only 28·5 per cent. show signs of flattening, and even when present it is but slight.

The changes brought about in the ankle-joint by peculiarities of posture are :—

1. Those on the inferior extremity of the tibia.
2. Those on the upper surface of the astragalus.
3. Those on the inner surface of the astragalus.

1. *Those on the Inferior Extremity of the Tibia.*—The facet mentioned by Mr Arthur Thomson in his valuable paper already

quoted, is generally present in 75 per cent. of those examined. In addition, there is frequently a second of a smaller size, occupying a more internal position (fig. 7). This facet, in addition to

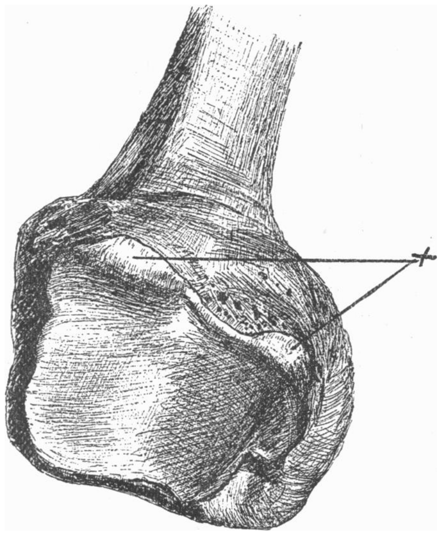

Fig. 7.

being smaller, is of a more elongated form than the external one. The same cause doubtless produces both.

Inferior Tibial Facets. Tibia examined = 52	Outer and inner facets present	= 9
	Outer alone present .	= 36
	Inner alone present .	= 0
	Both absent . . .	= 7

2. *Upper Surface of Astragalus.*—Very rarely does the appearance presented by the astragali figured in English text-books of anatomy hold good that the trochlear articular surface ends in front, bounded by a more or less definite transverse line, and presenting a rough neck anteriorly. In the majority of Panjabis will be observed a prolongation on the outer side (fig. 8), which encroaches on the upper surface of the neck, and which is received during extreme flexion into the larger (the external) of the two facets on the anterior margin of the lower extremity of the tibia.

To the inner side another facet, which is an anterior prolongation of the trochlea, and is continuous internally with the pyriform malleolar facet (fig. 8) is frequently prcsent.

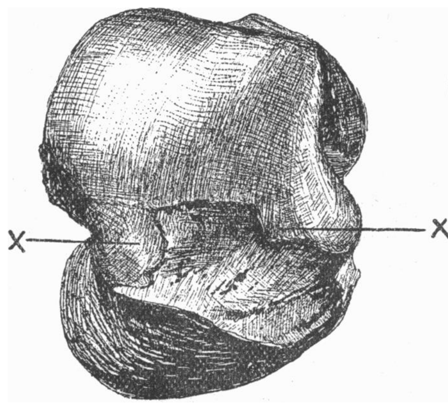

Fig. 8.

Facets on upper surface of neck of Astragalus = 53 Astragali.	Outer and inner facets present	= 18
	Outer only present .	= 16
	Inner only present .	= 7
	Outer doubtful .	= 6
	Both absent . . .	= 6

This is interesting when compared with Mr Thomson's criticism on Mr Shattock's conclusions (page 213, vol. xxiv., *Journal of Anatomy and Physiology*). Further on Mr Thomson states, with reference to the anthropoids:—" In some cases there was an extension forwards of the inner portion of the superior articular surface, but in no instance did this articulate with the facet on the anterior margin of the inferior articular surface of the tibia."

I have specimens which show the presence of an external facet (Mr Thomson's) on the neck of the astragalus for articulation with an external facet on the anterior surface of the lower extremity of the tibia (fibular side), as well as a prolongation of the trochlear surface forwards, which was received in articulation with the second facet to the inner part of the anterior surface of the lower extremity of the tibia.

There may be two facets on the anterior surface of the lower extremity of the tibia, and, corresponding to these, two facets on the upper surface of the neck of the astragalus. All these are much better seen in the recent specimens when coated with cartilage than on the dried and macerated bones.

3. *Inner Surface of Astragalus.*—The most striking difference here is the great prolongation anteriorly of the pyriform articular surface. In a well-marked bone it passes as far forwards as to occupy half the inner portion of the neck. It is concave from before back, and continuous with the internal of the two facets (when it is present) on the upper surface of the neck. Figure 8 illustrates this peculiarity. It is easy to understand how the position of extreme flexion of the ankle in squatting (fig. 1), or extreme adduction of the foot in the sartorial posture (fig. 2), will be facilitated by the presence of the modified articular surface in question. The neck of the astragalus is much shortened in comparison with European bones, and the outer margin is also thinner.

Before ending, I may note an observation as regards the facet or facets present on the upper surface of the os calcis for articulation with the head of the astragalus. Of a total of 57 bones, 34 had the facet double, the same as that figured on page 193 of Professor Macalister's *Text-Book of Human Anatomy*. In 23 bones the facet was single, similar to the figure on page 130 *Quain's Anatomy*, vol. ii. part 1, though most generally there was no indication whatever of any transverse line showing a tendency to subdivision.

Resumé.

1. The acetabulum of the Panjabi presents certain points of contrast with that of an European.

2. The differences are most notable in the cotyloid notch and the shape and size of the inferior cornu of the facies lunata.

3. The articular surface of the head of the Panjabi femur is of greater extent relatively and absolutely than that of an European bone. The articular area on the former is specially prolonged to adapt itself to the modified facies lunata of the acetabulum during extreme flexion and partial abduction of

the hip-joint occurring in the squatting posture so commonly assumed by the native of India.

4. The neck of the femur in the Panjabi is longer relatively than in the European.

5. The *upper* surface of the internal condyle of the Panjabi femur is partly articular.

6. The articular surface mentioned in No. 5 is due to the power of extreme flexion possessed by the Panjabi knee-joint.

7. The head of the tibia in the Panjabi is set on the shaft very obliquely. A Panjabi tibia can be easily held by the finger and thumb when the internal tuberosity is grasped behind by them.

8. The upper surface of the internal tuberosity of the Panjabi tibia slopes considerably down and in—it is never flat.

9. The external tuberosity of the Panjabi tibia has its condylar surface convex from before backwards, and the articular area is prolonged down posteriorly.

10. The upper part of the tibial diaphysis in the Panjabi is commonly directed obliquely backwards.

11. Flattening of the tibial shaft is fairly common amongst natives of the Panjab.

12. The individuals whose tibiæ have been examined were neither hunters nor hill-men, but dwellers in the plains. Any degree of platyknemia present could not, therefore, be due to the generally assigned causes.

13. A facet upon the anterior surface of the inferior extremity was in the great majority of cases present.

14. This facet is for articulation with a like surface upon the neck of the astragalus.

15. The facets upon the anterior inferior surface of the tibia and on the neck of the astragalus come into apposition during extreme flexion of the ankle-joint in the squatting posture.

16. In upwards of 17 per cent. of the tibiæ examined a second facet, occupying a more internal position to that mentioned in No. 13, was present.

17. This facet articulates with an anterior prolongation of the trochlear surface of the astragalus upon the upper portion of the neck of that bone.

18. There may thus be two facets upon the anterior surface

of the lower extremity of the tibia. Of these the external is the commoner. The internal facet I have not found without the external being also present.

19. The Panjabi astragalus contrasted with the European differs considerably. There is a facet on the upper surface of the neck to the outside; there is a facet on the same surface more internally, which is continuous posteriorly with the trochlea and internally with the pyriform malleolar articular area. This pyriform articular area on the inner surface is greatly prolonged forwards, and, when so, it is concave from before backwards.

20. The outer facet alone may be present.

21. The inner facet alone may be present.

22. The greatly elongated pyriform facet on the internal surface may be the only distinctive character.

23. The sartorial position is rendered easier by the presence of this last-mentioned elongated articular area.

24. The foregoing peculiarities in the morphology of the hip-, knee- and ankle-joints of the Panjabi skeleton are owing to the influence of the squatting and sartorial postures which are commonly assumed by Orientals when engaged in their daily avocations or when indulging in rest after their labours.

25. The resemblances between the osteological remains of the lower extremities of prehistoric man and that of savage or Oriental races of the present day may be due to the influence of common habits.

26. It is highly probable that all the foregoing peculiarities are acquired; but that heredity has no influence has yet to be proven.

I have to thank my friend Dr W. P. Dickson, of the Central Jail, Lahore, for the great pains and trouble he has taken in photographing the specimens. The figures are in part from these photographs, and in part from sketches made by Dr David Hepburn from the photographs and from bones presented by the author to Sir William Turner.