various kinds of food poisonings would be incomplete without some statement of the methods to be pursued in making examinations of suspected material. It not infrequently happens that the amount of food that is left over from a meal is very small and for that reason it should be put to the best possible use. Inasmuch as a chemical analysis is of very little value it is not advisable to use up the greater part of the material in such work. At all events it should be deferred until a complete bacteriological examination has been made. The chemical substances will in no wise suffer by such delay.

A considerable amount of time can be saved, and perhaps wrong conclusions avoided, by determining at the outstart whether or not the suspected food is really poisonous. This is apparently a simple proposition but not always one that can be easily carried out. Some animals are not susceptible to a given poisonous food, while others are. Consequently, as many different animals as possible should be fed or given, through a stomach tube, the material under investigation until some are found to be susceptible. In comparatively mild poisonings the experimenter has been known to make the crucial test on himself.

In the case of pork and its products the presence or absence of trichinæ should be determined at the outstart. In case the poisonous nature of the food is established by feeding experiments the affected or dead animals may be examined by the usual methods for bacteria. It should be remembered, however, that there are cases in which no bacteria can be detected in the dead body, for the reason that they may be unable to multiply in the living body, although they may elaborate powerful poisons in the food itself. Death in such instances would be the result of a true intoxication. On the other hand, the poisonous organism may grow in the body and an infection proper may result, in which case the germ will be found distributed through the body.

The feeding experiments should be supplemented by injections, subcutaneous and intraperitoneal, of macerations of the food in sterile water. Eventually, aërobic and anaërobic cultures should be made with the poisonous food and the toxic organism should be isolated and its effects, in pure culture, studied upon susceptible animals. The presence of soluble poisonous products in such cultures may be demonstrated by filtration through porcelain.

Frederick G. Novy.

FOOT.—It is natural to compare the foot, as the distal member of the lower extremity, with the hand, the corresponding member of the upper; and by such a comparison we get most valuable aid to a comprehension of

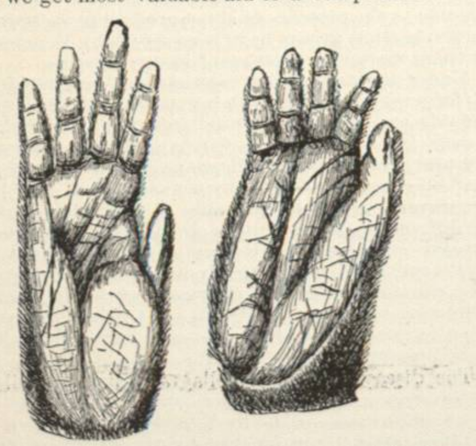


Fig. 2099.—Hand and Foot of a Chimpanzee. (Vogt.)

its structure. It has been said that the foot is merely a hand altered by the functions of support and locomotion which it has had to perform. While it is in general true that foot and hand are constructed upon a similar plan, it must be remembered that the differentiation commences far down in the animal series. The similarity between the anterior and posterior extremities of a quadruped,

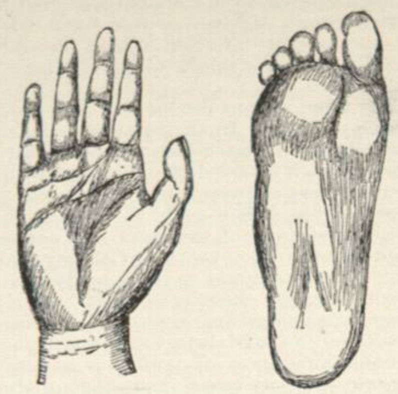


Fig. 2100.—Hand and Foot of Man. (Vogt.)

such as the horse for instance, disappears to a considerable extent when the anatomical structure is closely examined. Even in quadrupedal locomotion the posterior extremities are the ones most active in propelling the body, the anterior limbs being mainly for support and equipoise. The impression of the forefeet of an unshod horse is different from that of the hindfeet on this account. As the forelimbs come to be more used for the pur-

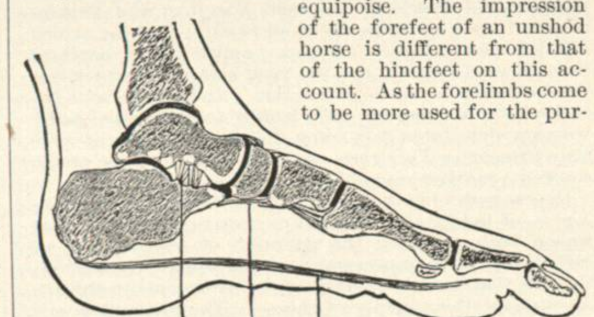


Fig. 2101.—The Antero-posterior Arch of the Foot. The bones shown are those cut by a longitudinal section through the axis of the great toe. The calcaneum forms the posterior branch of the arch; the scaphoid, internal cuneiform, the first metatarsal, the anterior branch; and the astragalus is at the summit. A sesamoid bone is seen under the head of the first metatarsal. In front are the phalanges of the great toe.

poses of prehension and dexterity, the difference in structure becomes more marked. The higher apes were improperly called quadrumana, for no animal, speaking strictly, has four feet anatomically similar; still less has any animal four organs that can properly be called hands. The differences are various, according to the adaptation of the anterior and posterior members for the special activities of the animal. The bones of the carpus are never found to be the same as those of the tarsus, varying either in number or in the union of the various osseous elements. There is not, properly speaking, any opposability of the great toe in apes, as it cannot be carried around and placed at will against the various other toes; but it is set at a wider angle than the others, so that it can be used like the curve of a pincers or of a cramp-iron for grasping and climbing. The posterior extremities of apes are merely feet adapted for walking upon trees, the resemblances of the foot or "hind-hand" to a true hand being only skin deep (Huxley[1]).

There seems from the structure of the human foot no reason to doubt that it has been developed from an organ adapted for the same use. Strong evidence of this is found in the fœtal condition of the foot, which approaches in many respects that of the anthropoid apes,

there being less development of the heel, an arrangement of the joints which permits more inversion of the sole, and a difference in the corresponding length of the first and second metatarsal bones, indicating that the adult condition, in which the great toe is as long as, or longer than, the others, has been gradually acquired. Leboucq[2] determined the average proportion of the first metatarsal to the second to be in the child before birth as 1 is to 1.37; at fourteen years, as 1 is to 1.21; and in the adult as 1 is to 1.17.

Fig. 2099 shows the hand and the foot of the chimpanzee contrasted, while Fig. 2100 shows the same members in adult man. In the gorilla the resemblance to the human hand and foot is still greater. The feet of a child that has never walked show decided differences in power of using the toes, there being considerable grasp and the same imperfect opposability of the great toe as is seen in apes. The markings upon the sole show this to some extent.

The markings on the foot of a child that has never worn a shoe, nor stood alone upon its feet, resemble somewhat those of the palm of the hand, indicating considerable freedom of flexion and a certain amount of independent use of the great toe. They almost entirely disappear after the foot is used as a support. The power of the great toe may, however, be kept up if the feet are not confined, and many savage tribes use the foot for grasping. Among Australian savages this grasping power is of great assistance in climbing trees, and they habitually pick up a spear or similar object with the foot. Nubian horsemen are said to use the reins, and Chinese boatmen to pull an oar, by means of the great toe. Occasionally persons may be found who, either born without hands or, losing them early in life, have acquired the habit of using the foot for various acts ordinarily performed by the hands, and can thread a needle (as do the Hindoo tailors), use scissors, or even write, with the toes. The fact that walking in the erect position is learned only with difficulty shows that it is a late acquirement.

The main characteristics of the human foot are, therefore, those which adapt it for support and locomotion. For this purpose a most beautiful structural arrangement has been effected, combining great strength with peculiar elasticity and lightness. The bones are set in the form of a vault supported at the points connected by arches, two of these starting from the same point of the heel (the tuberosity of the calcaneum), and extending forward, one to the ball of the great toe (head of first metatarsal), the other to a corresponding point on the little toe. The third arch is transverse, connecting the anterior ends of the longitudinal ones.

The inner arch is formed by the calcaneum behind and the first, second, and third metatarsals, the cuneiform,

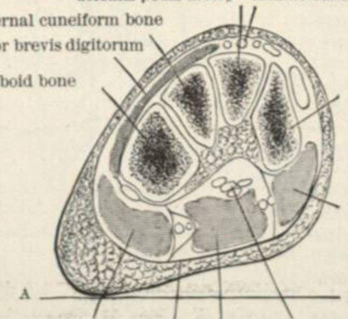


Fig. 2102.—The Transverse Arch of the Foot. Section through the anterior row of tarsal bones. The line *A B* represents the surface upon which the foot rests when the individual stands erect.

and scaphoid bones in front, with the astragalus set at the vertex as a keystone (see Fig. 2101). The outer arch, which is much flatter, is formed by the calcaneum, cuboid, and two outer metatarsals which articulate with it. The transverse arch is formed behind by the three cuneiform bones and the cuboid (Fig. 2102), in front by the metatarsal bones. It should be noted that this arch becomes shallower and shallower as the toes are approached, until at last upon reaching the heads of the metatarsals the weight is borne fully upon them all. The imprint of a normal human foot, shows this clearly. The height of the arches forms the instep, a feature peculiar to man, and which varies considerably in different races, being generally higher in the Indo-European than in others. Arabs are said to boast that their insteps are so high that water will run under them without wetting the sole, and the Andalusian instep is famous. A popular saying has it that the foot of the negro is so flat that it makes a hole in the ground. A very amusing proof of this primitive condition of the negro foot may be noticed in Southern cities, where, during the heat of summer, it is customary to wet the pavements in the evening. It is not unusual to see barefooted negro boys, whose feet are so flat that atmospheric pressure makes them adhere slightly when applied to the wet and smooth pavement, in the same way that a boy's leather sucker adheres to a smooth stone, and it is a favorite pastime with such gifted individuals to walk the streets, producing a somewhat startling report every time the foot is withdrawn from the pavement. It is perhaps not without some reason that the height of the instep is considered a mark of pure blood, as it appears to be one of the signs of complete adaptation to the erect posture and to locomotion in that position.

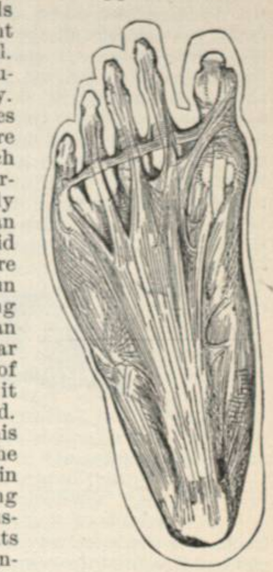


Fig. 2103.—Dissection of the Foot showing the Plantar Fascia. (Marshall.)

Man is the only animal that has the foot placed at right angles to the axis of the body, most mammalia not touching the ground with the calcaneum at all. The horse, for instance, literally walks upon the points of the toes, the hoof being comparable with the nails of the human foot, and the hock or "knee" being the tuberosity of the calcaneum. There appears to be some relation between this ascension of the calcaneum and the fleetness of the animal, as those which are the swiftest have the bones so arranged that they walk merely upon the tips. If support alone were needed there would be no necessity for the metatarsal bones and toes, as may be seen in those who have had them amputated. The anterior part of the arch is therefore for purposes of locomotion, and it may be noted that in running the heel is raised off the ground, and the anterior part only is used, the anatomical relation of the bones to the soil being similar to that which occurs ordinarily in the foot of the carnivora. The great swiftness and lightness of motion of a *première danseuse* is owing to her ability to dispense entirely with the posterior portion of the arch.

Owing to this difference of formation the anterior and posterior pillars of the longitudinal arches differ—the posterior, being for support, is short, thick, and strong, being of but one bone; the anterior, composed of several bones, is longer, so that the motion of raising the heel can be quickly performed. The length of the heel in the African race is merely apparent, and caused by the flattening of the arch rather than by a real projection. The number of bones in the anterior arch greatly aids in the distribution of the force, as any one may see who will take the trouble to note the difference in shock which ally into four groups—an anterior, supplied by the anterior tibial nerve and composed of the tibialis anticus, extensor proprius hallucis, extensor longus digitorum, and peroneus tertius; a lateral, supplied by the peroneal

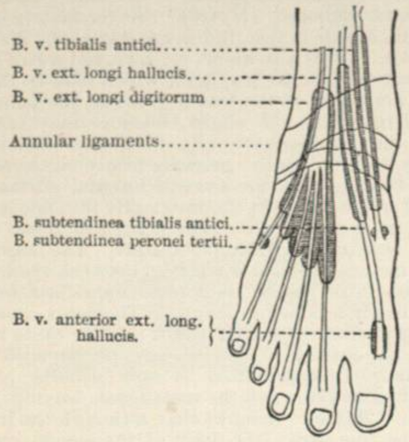


FIG. 2107.—Synovial Sheaths on Back of Ankle and Foot.

nerve and composed of the peroneus longus and brevis; and two posterior, the superficial supplied by the internal popliteal nerve and composed of the muscles inserted into the tendo Achillis (gastrocnemius, soleus, plantaris), and the deep, supplied by the posterior tibial nerve and composed of the tibialis posticus, flexor longus digitorum, and flexor longus pollicis. All of these pass over two joints, the ankle joint or astragalo-crural and the astragalo-calcaneal, and therefore occasion motion at both, but in very varying degrees.

The tendons of the anterior group may be seen in Figs. 2106, 2107, and 2113, and passing down over the ankle, where they are held in position by thickened bands of fascia known as the annular ligaments. There are two of these, an upper one (ligamentum transversum cruris), not shown in the figures, extending across the lower part of the leg from fibula to tibia, and a lower one (ligamentum cruciatum), in the form of a ≺, placed thus on its side (the shape best shown in Fig. 2107), the main stem being a strong loop-like band which lies on the outer portion of the ankle, springing from the fore part of the calcaneum in the deep fossa between that bone and the astragalus known as the sinus tarsi. It completely surrounds the tendons of the peroneus tertius and extensor longus digitorum (see Fig. 2108, *a*). This band was first described by Retzius, who gave it the name of ligamentum fundiforme tarsi. It is of considerable strength, and gives a new direction to the tendons, so that they pull more exactly in the line of the toes (see Fig. 2113), thus forming a sort of trochlea like that which the superior oblique muscle of the eye has. According to Hyrtl it usually becomes cartilaginous in old people. By a sprain the tendons may be torn from this connection, and will then be seen to take a much more direct line to the toes. From this band the two branches of the ligamentum cruciatum diverge, passing over the tendons of the extensor proprius hallucis and the tibialis anticus. The tendons which pass down over the dorsum are provided with certain synovial sheaths which are shown in Fig. 2107. The tendon of the tibialis anticus (14′ in Fig. 2106) is the largest and strongest, and may be easily made out whenever the foot is flexed and the sole at the same time bent inward. As it is inserted into the internal cuneiform and base of the first metatarsal, it necessarily flexes the foot and inverts the sole. It will be seen that the attitude is much like that of varus, and in fact this muscle is one of the most active agents in that deformity. In dividing the tendon care must be taken not to open the astragalo-calcaneal joint.

The tendon of the extensor proprius hallucis comes next (see Fig. 2113). It is also very large and strong and is the most prominent cord in front during flexion of the foot. On this account it is the first to suffer from any tightness of the covering about the ankle. It is inserted into the last phalanx of the great toe, which it strongly extends in the last act of walking just as the foot is about to leave the ground. Continuing its action, it flexes the foot on the leg and assists the tibialis anticus to invert the sole. It is more firmly enclosed by the cruciate ligament than the tibialis anticus, and its pull upon that band raises the arch slightly so that its impression is fainter.

The extensor longus digitorum sends tendons to the four outer toes which unite with those of the extensor brevis and are inserted into the second and third phalanges. Closely associated with this muscle is the peroneus tertius, a thin muscular slip which sends a tendon to the metatarsal bone of the little toe. It hardly deserves a separate name.

The action of the extensors upon the toes is reinforced by the lumbricales from the sole of the foot. These muscles arise from the *flexor* tendons and pass around the phalanges to be inserted into a triangular aponeurosis, which is common to the extensor muscles. In walking, therefore, as the flexors assist in raising the foot they give a firm basis for the pull of the lumbricales, so that in the final act of rolling the weight forward upon the toes they can assist the extensors. It should be remembered that the division of the muscles into flexors and extensors is not, in so far as it implies an antagonistic condition, entirely correct.[10] Those muscles which extend the toes also flex the foot, and *vice versa*. There is no loss of muscular force, as there would be did one set pull directly against the other.

The extensor brevis (see 10, Fig. 2108), though an intrinsic muscle, should be mentioned here, as it belongs morphologically to the same group. It was originally a leg muscle, and has gradually slipped down, all stages of its descent being seen in different animals.[9] It arises from the forepart of the upper and outer surfaces of the calcaneum, and presents, on the outer side of the foot, a considerable muscular belly, which contributes to the modelling of that part of the foot, and is soft and pulpy to the touch. This should be remembered in examining the ankle for suspected joint disease, or after a sprain. When struck lightly it will quiver, and this movement has been mistaken for fluctuation, and the muscle has been incised in mistake for an abscess. The tendon which goes to the great toe is usually somewhat separated from the others, and that part of the muscle has been described separately as an extensor brevis hallucis.

The extensor brevis varies considerably, especially with regard to the amount of division of the various muscular bellies of which it is composed, and there is occasionally seen a tendency for it to become merged with the dorsal interossei, elements of an entirely different origin.

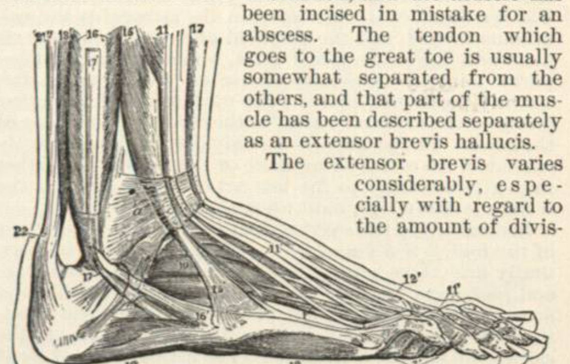


FIG. 2108.—View of the Muscles and Tendons on the Outer Side of the Right Foot. *a*, Ligamentum fundiforme; 1*a*, abductor minimi digiti; 7′, insertion of the tendons of the flexor longus digitorum; 10, extensor brevis digitorum; 11′, tendons of the extensor longus digitorum; 12′, tendon of the extensor longus hallucis; 15, tendon of the peroneus tertius; 16′, tendon of the peroneus brevis; 17′, tendon of the peroneus longus; 22, tendo Achillis. (Marshall.)

The peroneus longus and brevis (16′ and 17′, Fig. 2108) were primitively upon the front of the fibula, but their tendons have been shifted behind the outer malleolus for adaptation to climbing. They are here held by a strong sheet of fascia (retinaculum superius), and are similarly sheathed (retinaculum inferius) where they lie in a groove on the outer side of the calcaneum. Notwithstanding this secure attachment the tendons are more frequently displaced than any others in the body. Leaving the groove they diverge from each other, the brevis being inserted into the tubercle of the fifth metatarsal, and continued by a thin tendon as far as the toe, the longus passing across under the arch of the foot in the groove on the inferior surface of the cuboid, and being inserted into the tubercle of the first metatarsal bone (see Fig. 2105). They strongly evert the sole, producing a condition like that of valgus.

The peroneus tertius, the extensor longus digitorum, and the extensor brevis digitorum, were originally parts of the same muscle sheet which belonged to the back of the foot and front of the leg. The twisting over of the foot into its position with the plantar surface downward has caused them to appear in their present situation. Extra peroneal muscles are not infrequent, and in one dissection performed by the author a set of five were found.

The main body of the flexor tendons passes down on the inner side of the ankle. Fig. 2109 shows, in a diagrammatic form, how they are arranged, and their tendons are seen in Fig. 2106. Besides these there should be mentioned those muscles (the soleus and gastrocnemius) which are inserted through the tendo Achillis upon the calcaneum. Duchenne's experiments[2] in the faradization of muscles led him to the conclusion that these latter act as extensors and adductors of the foot, while the peroneus longus is an extensor and abductor. In order to get a powerful and equal extension of the foot both of these act together, and this may be increased by a simultaneous contraction of the flexor longus digitorum and flexor longus pollicis. He supposes that the reason for the peculiar action of the tendo Achillis in causing adduction is occasioned by the arrangement of the plantar ligaments. The strongest bands lie on the outer side of the foot, and this determines a deviation of the line of action in that direction.

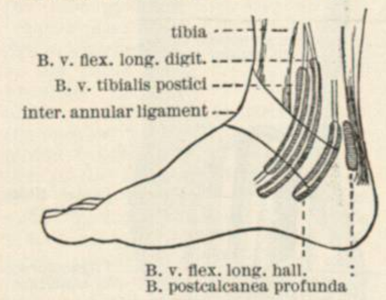


FIG. 2109.—Synovial Sheaths of Inner Side of Foot.

It was formerly supposed that the severing of the tendo Achillis was a necessarily fatal injury. Hippocrates was firmly of this opinion, and one of the names given to the tendon is chorda magna Hippocratis. It was undoubtedly a serious matter when the wound was an open one and proper drainage not secured; but with the modern resources of surgery it is often safely divided for the relief of club foot. For about an inch and a half above its lower end it is free from muscle fibres, and narrows slightly, and it may be cut there, care being taken to avoid the vessels and nerves at its inner side, and the bursa which exists just above its insertion (see Fig. 2109). Rupture of the tendon has occurred from violent muscular action in jumping.

The tendons of the tibialis posticus, the flexor longus digitorum, and the flexor longus hallucis pass down behind the internal malleolus in a special compartment, confined by a strong band of fascia known as the internal annular ligament, which passes from the malleolus to the calcaneum, enclosing not only the tendons but the vessels and nerves which accompany them. They have special synovial sheaths (Fig. 2109), and are so arranged that the tendon of the flexor longus hallucis is nearest the tendo Achillis, that of the flexor longus digitorum next, and that of the tibialis anticus nearest the malleolus, the tendon of the digital flexor twisting around it from with-

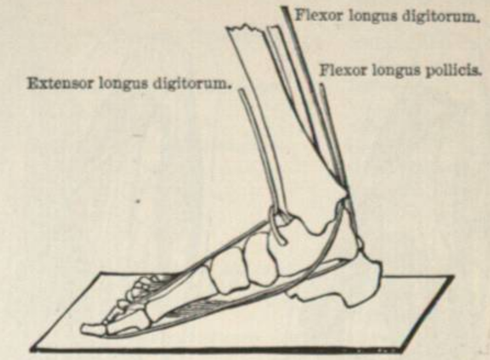


FIG. 2110.—Diagram Showing the Manner in which the Flexor and Extensor Tendons are Reflected around the Ankle. (Langer.[13])

out inward, and then passing downward, forward, and outward under the sole. Were it not for this the tendon of the tibialis posticus would be likely to slip from under the malleolus or the sustentaculum tali as it passes forward to be inserted into the tubercle of the scaphoid, and by a tendinous expansion into all the bones at the upper part of the vault except the astragalus. It strongly inverts the sole and raises the head of the first metatarsal. Spigelius called it musculus nauticus, because it was necessarily used by sailors in climbing masts.

The flexor longus digitorum and the flexor longus hallucis are arranged somewhat like the flexor profundus digitorum and the flexor longus pollicis of the hand, as they have an arrangement of tendons which pass in a similar way through those of the flexores breves to be inserted into the terminal phalanges of the toes. But

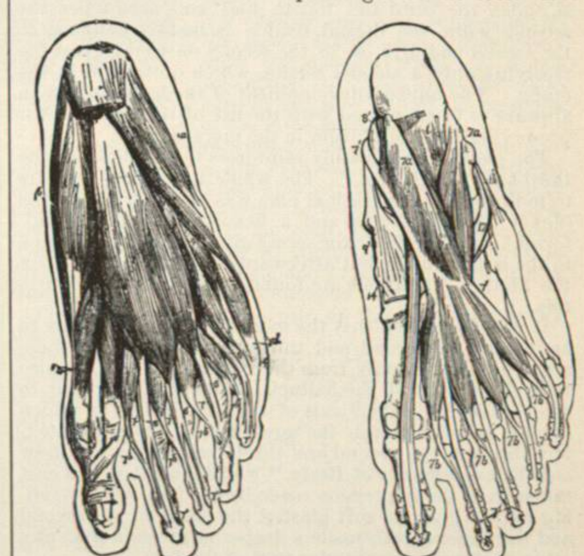
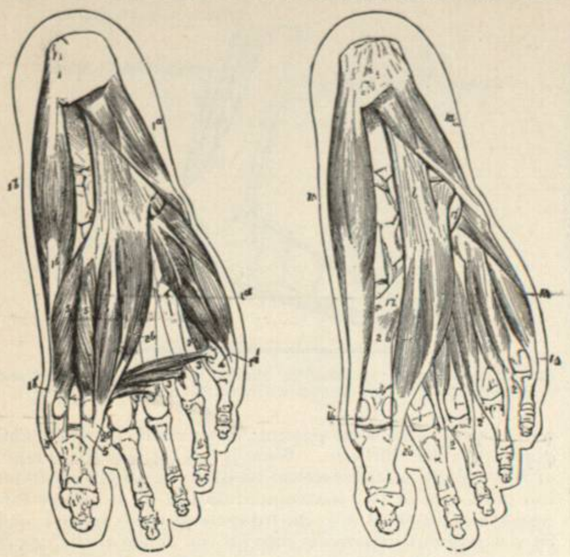


FIG. 2111.—The Muscles of the Sole of the Foot. 1*a*, Abductor minimi digiti; 1*b*, abductor hallucis; 6, flexor brevis digitorum; 7′, tendon of flexor longus digitorum; 7*a*, its plantar head, or flexor accessorius; 7*b*, 7*b*, lumbricales; 8′, tendon of flexor longus hallucis; 17, tendon of peroneus longus; 9′, insertion of tibialis posticus.

they are very differently related in the sole, for they not only decussate and unite there, but the flexor longus digitorum receives a reinforcement from an accessory head, the flexor accessorius, or caro quadrati Sylvii, arising from the tuberosity of the calcaneum, and inserted at the decussation. The crossing in the sole is such that in the greater number of cases the tendon of the flexor hallucis sends to the decussation a lateral twig, which again divides in slips for the second and third toes, unit-



Third Layer. Fourth Layer.

FIG. 2112.—The Deep Muscles of the Sole. 4, 4, Flexor brevis minimi digiti; 5, 5, flexor brevis hallucis; 2b, adductor pollicis, with its detached heads; 3, 3, 3, also called the transversus pedis; 1, 1, 1, dorsal interossei; 2, 2, 2, plantar interossei.

ing with the tendons of the flexor digitorum. The slip to the third toe may be wanting, but sometimes one is sent to the fourth. This arrangement recalls the musculature of the ape's foot, where the hallucis tendon supplies the third and fourth toes, and sometimes the second, while the digital tendon is mainly confined to the second and fifth, or to the second only, the great toe receiving only a slender tendon which quite fails in the orang. The unusual development of the hallucis in man appears to be connected with the use of the great toe for preserving the equilibrium in the erect position.

The plantar head mainly reinforces the tendons for the third and fourth toes.[11] The whole apparatus appears to indicate that the original plan was for a flexor fibularis (flexor longus hallucis) and a flexor tibialis (flexor digitorum), and that the flexor accessorius originally belonged to the latter muscle, but afterward lost its insertion upon the fibula. Variations are found which tend to confirm this.

It will be noticed that the most direct pull appears to be toward the second and third toes; the tendons there are supplied, not only from the common flexor, but also from the tendon of the hallucis. This would appear to show that the original axis of the foot, or line on which it rolls, is not through the great toe, as usually stated, but through the second and third toes, and would bear out the experiments of Beely,[12] who found that in a cast taken from the impression made by his foot while standing upon a layer of soft plaster, the heads of the second and third metatarsals made a deeper impression than any other portion of the anterior part of the foot.

The action of the flexor is to bend the toes and contribute to the stability of the foot in standing. After bending the toes they also flex the medio-tarsal joint.

So it follows that these muscles all co-operate in lifting the heel from the ground and flexing the foot, and that, as this is done, the toes are strongly flexed and pressed against the ground like an elastic spring (see Fig. 2110).

They are often divided in orthopædic operations, usually at the malleolus, as it should be remembered that the posterior tibial artery lies near the flexor longus digitorum, being exactly in the middle of the space between the posterior margin of the internal malleolus and the internal border of the tendo Achillis. The nerve is in the same sheath with the artery and behind it.

The intrinsic muscles of the sole, which are quite numerous, are shown on Figs. 2111 and 2112. They are arranged in three groups, separated from each other by appropriate layers of fascia, as shown in Fig. 2102. The external group is composed of muscles relating to the little toe, the flexor brevis and abductor minimi digiti; the inner is a similar group relating to the great toe, the flexor brevis and abductor hallucis; while the middle set is related to the muscles which come down from the calf, the flexor accessorius and the lumbricales, together with the flexor brevis digitorum and adductor pollicis. Deep under all these lie the interossei. The muscle sometimes described as transversus pedis is not entitled to a separate description, as it is clearly shown by the evidence of embryology to be a portion of the adductor pollicis.

These muscles are of special use in supplementing the action of the ligaments in supporting the arches, giving an elastic support variable according to the nature and direction of the strain. The interossei are in two groups, the plantar and the dorsal, the latter not being prominent on the sole. All originally developed upon the sole, the

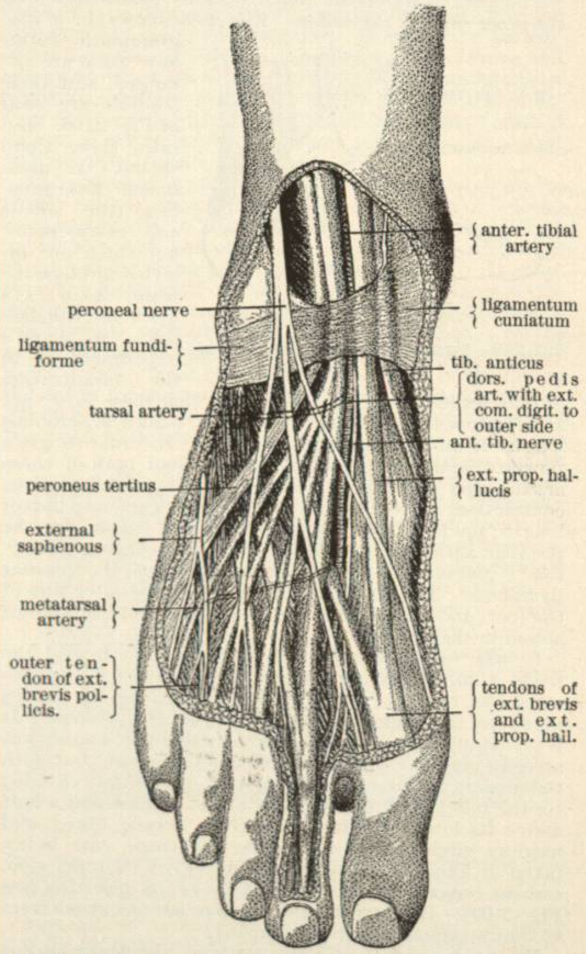


FIG. 2113.—A Dissection Showing the Deeper Structures on the Dorsum of the Foot.

dorsal gradually passing up between the metatarsal bones during fœtal life. Cunningham[14] thinks that the primitive typical arrangement of the intrinsic plantar muscles is the same as that of the hand, viz.: that there is a plantar layer of adductors of the toes represented by the

adductor hallucis and its detached head, the transversus pedis, and the three plantar interossei; an intermediate layer of flexores breves, composed of the flexor brevis minimi digiti and the flexor brevis hallucis; and a dorsal layer of abductors of the toes represented by the abductor hallucis, the abductor minimi digiti, and the dorsal interossei. The layers have lost their relative planes in the foot partly because of the arched condition, and partly by suppression of the flexores breves for the second, third, and fourth toes.

The nerves of the foot give us important evidence with regard to the value and previous history of the muscles. Those derived from the lumbar plexus do not have any motor functions, but supply sensation to the integument of the inner side (long saphenous nerve). The sacral plexus gives sensations to the remaining portions, viz., by the external saphenous on the inner side, the musculo-cutaneous over the dorsum, and the plantar nerves on the sole, the internal plantar supplying the first three toes and half of the fourth, the external supplying the other half of the fourth and the fifth. The nerves of the dorsum are shown in Figs. 2113 and 2115; those of the sole in Fig. 2114.

The vessels of the foot (see the same figures) are not very numerous or large. Upon the dorsum we have the continuation of the anterior tibial artery, which, as it passes under the annular ligament, changes its name to dorsalis pedis. It is accompanied by two veins, and passes forward to anastomose, at the space between the first and second toes, with the external plantar. It is believed to correspond to the radial artery of the hand, and it will be seen that the twisting over of the dorsal surface has given it a less devious course. It is easily secured in the upper part of its course, where it lies quite superficially and just external to the tendon of the extensor longus hallucis. Aneurism has occurred in it as a sequel to a sprain. The posterior tibial artery, coming down behind the ankle, divides, just before entering the sole, into external and internal plantar, the latter being the smaller. The external runs outwardly across the foot, deep under the muscles, and then turns again to the inner border and anastomoses with the dorsalis pedis. It is not practicable to reach these for ligature in the sole, except by resection of the metatarsal bones.

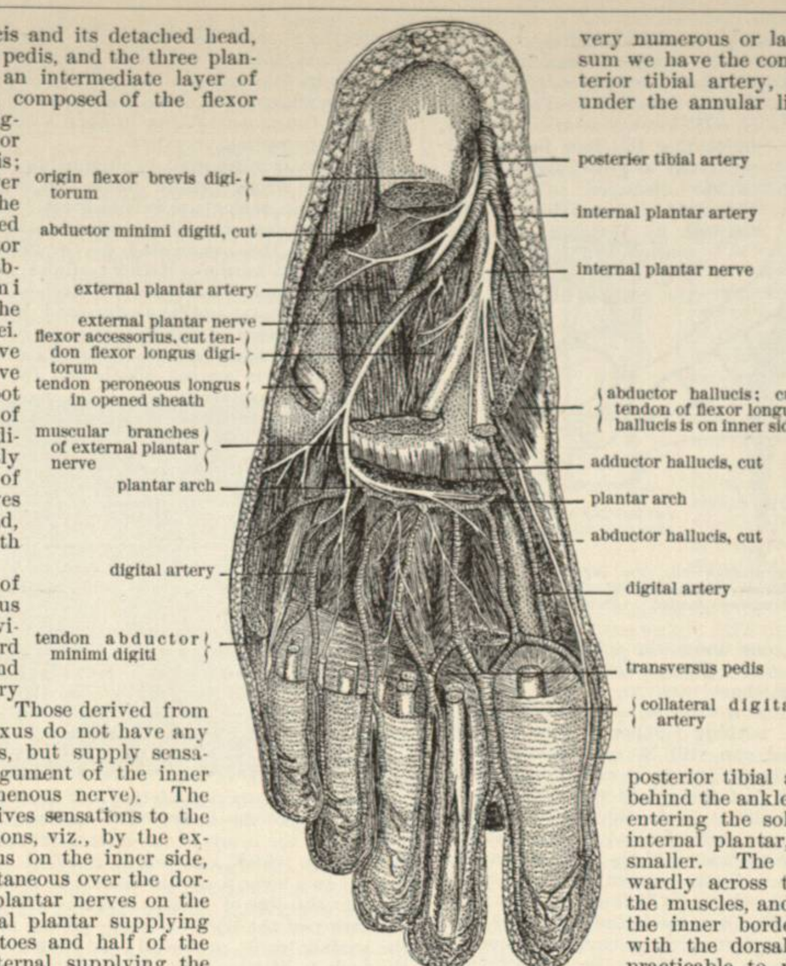


FIG. 2114.—A Dissection showing the Deeper Structures on the Sole of the Foot.

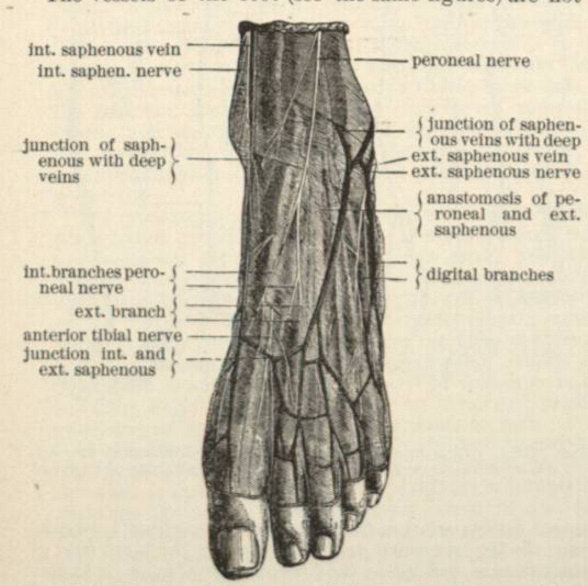


FIG. 2115.—The Superficial Veins and Nerves of the Dorsum of the Foot.

The superficial veins are found mainly upon the dorsum. A reference to Fig. 2115 will show that the internal and external saphenous veins coming down from above anastomose with each other across the metatarsal bones, forming an arch with the convexity toward the toes. Tight boot-lacings may so compress these veins as to produce a stasis, with pain and swelling. Veins of any considerable size are wanting upon the sole.

The integument of the sole of the foot is intimately united with the layer of subcutaneous fat, which is here not loose and movable, but shut into distinct compartments by septa of connective tissue. This forms a very compact and elastic cushion for supporting the weight of the body.

Smallness of these members has been during all modern times considered a mark of beauty. There seems to be no

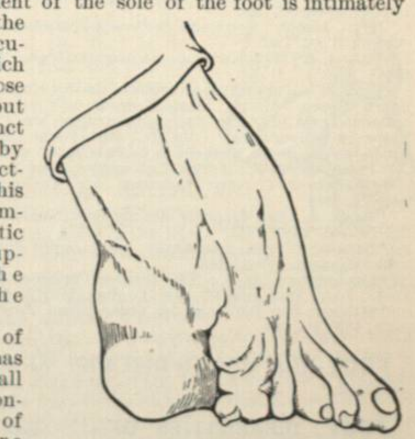


FIG. 2116.—Deformed Foot of a Chinese Lady of Rank. (Langer.)

good reason for this, except that it indicates a general delicacy of construction of the body and can hardly be associated with habits of labor. Structurally a small foot would seem to be an ineffective organ. The Chinese women of rank are, as is well known, so treated in infancy that the foot has no opportunity to grow, and soon becomes misshapen, as shown in Fig. 2116, reduced from a photograph by Welcker. The operation commences usually in the second year of the child's life, and con-

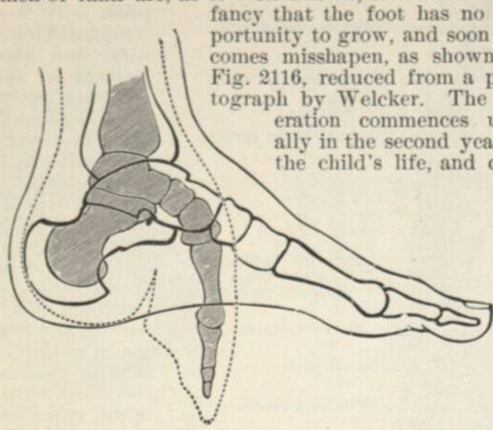


FIG. 2117.—Section of Natural Foot with the Bones, and a Corresponding Section of a Chinese Deformed Foot. The outline of the latter is dotted, and the bones are shaded. (Flower.)

sists in turning the toes under the sole and confining them there by bandaging. The procedure is said to be quite painful, and sometimes fatal to delicate children. If the parents belong to a class in which labor will be required of the child, nothing further is done, and the foot, though deformed, can still be used for walking. If they are wealthy, the deformity is carried further by so bandaging the foot that the great toe approaches the heel as nearly as possible. As to the motive for this strange custom, it seems probable that it originated in an attempt to increase the value of the female as an object of sexual appetite. As the woman can move about but little, a greater deposit of fat is found on the mons veneris, and the nymphæ are thickened. Besides this, it is said these deformed feet are kept carefully covered, because they resemble in appearance the vulva. Only prostitutes display their feet, and for the purpose of enticing customers (Stricker[15]). Fig. 2117 shows the skeleton of such a malformation. *Frank Baker.*

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FOOT-AND-MOUTH DISEASE. See *Hoof-and-Mouth-Disease.*

FOOT, DISABILITIES OF.—I. THE WEAK FOOT. (Synonyms: Splay foot; flat foot.) The most common and by far the most important of the disabilities of the foot is the so-called flat foot. This affection, although so common, is still very imperfectly understood and in order to make its etiology, and the principles that should govern its treatment, clear, one must contrast the appearance and the functional ability of such a disabled foot with those of the normal member.

The foot is supported by ligaments, by the muscles, and by the strong plantar fascia that covers in the sole. When it is in active use it is in great part supported by the muscles, but when it serves as a passive support, as in standing, the ligaments bear the greater part of the strain, and its normal elasticity allows the bearing surface to expand slightly as the arches are slightly depressed. It must not be understood, however, that the longitudinal arch is simply flattened by direct pressure and by elongation of elastic ligaments and fascia. Ligaments and fascia are not elastic and they are not, in the normal foot, overstretched. The change in contour is the effect of normal motion in the joints of the foot, by which it is placed in the most favorable attitude for weight bearing without muscular exertion.

Of the changes of contour that distinguish the foot used as a passive support from the one that bears no weight, the most significant is the obliteration of the outward curve of its internal border. This change is due to the fact that the astragalus, bearing the leg, rotates inward and downward on the os calcis until it is checked by the resistance of the ligaments and by the interlocking of the bones. The head of the astragalus thus becomes slightly prominent; the inner border of the foot is depressed, and an attitude is attained in which the weight of the body may be supported with but slight muscular exertion. This position of the foot is one of a series of similar changes in the relation of the bones of the lower extremity, which are instinctively assumed when the limb is placed in the so-called attitude of rest.

The second function of the foot is as a lever to raise and to propel the body. The calf muscles supply the power and the heads of the metatarsal bones serve as the fulcrum on which the weight is lifted. When the foot is used as a lever it should be held in such relation to the leg that the line of weight, passing downward through the centre of the knee and ankle joints, is continued over the second toe or practically the centre of the foot. As the body is lifted over the fulcrum, the fore foot is turned

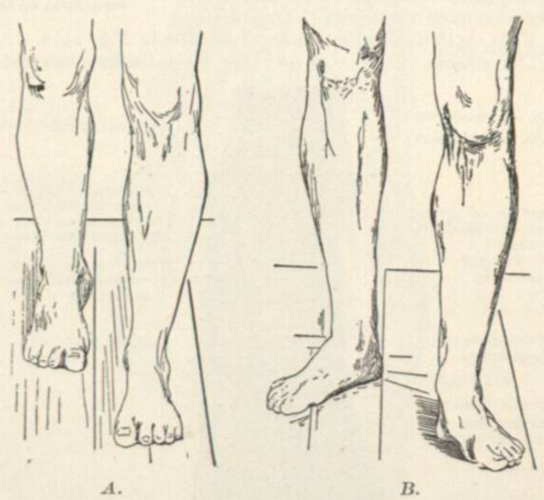

FIG. 2118.—*A*, The Proper Attitude in Activity, Illustrating the Adduction of the Fore Foot. *B*, The Improper Attitude of Outward Rotation of the Feet.

inward in its relation to the leg or, more properly speaking, the leg is turned outward, because the inner side of the fulcrum, formed by the first metatarsal bone, is longer than its outer side. Thus the strain is directed toward the outer and stronger side of the foot (Fig. 2118, *A*).

In the proper walk, which is the best illustration of the leverage function, the feet should be held practically parallel to one another, so that the line of strain may fall through the centre of the foot. As one foot is advanced it first bears weight momentarily on the heel, then upon its outer border; the heel is then raised and the body is lifted over the toes, the great toe giving the final impulse, so that if the walker is looked at from behind, he appears to be in-toeing at the termination of each step. Thus, during the walk, there is an alternation of postures, and the foot, under muscular control, assumes the attitudes most opposed to that of passive support.

The alternation of postures and the leverage action of the foot are by no means necessary to simple progression; for example, both feet might be fixed in plaster bandages yet walking would be possible just as it is possible on two wooden legs. Indeed an approximation to such a man-

FIG. 2119.—Typical Weak Foot of Moderate Degree, Illustrating the Component Elements of Abduction and Depression of the Arch.

ner of walking is often seen, in which the passive attitude persists, leverage and its attendant motions being absent. Such a walk is necessarily jarring and ungraceful, and if it is not the result of weakness and deformity it predisposes to them because of the disuse of the proper function of the foot.

One of the most common causes of interference with the leverage function is the custom of turning the feet outward. Outward rotation of the feet is normal in the passive attitude of weight bearing, because it locks the joints and throws the strain upon the ligaments to relieve the muscles (Fig. 2118). On this very account it is the improper attitude for activity because the strain falls upon the inner border of the foot or to the inner side of the fulcrum, making the proper exercise of muscular power, and alternation of postures, impossible. Thus it will appear that a persistence of the passive attitude, or an approximation to it, is abnormal when the foot is in active use.

The persistence of an improper posture may be simply a habit, but it is evident that if an individual were overweighted by a heavy burden he could not walk with an elastic step, nor could he, if his muscular power were insufficient for normal activity, nor if the structure of the foot were weak, nor if active movements caused pain. In any one of these instances the passive attitude would be assumed habitually and the foot would approximate in appearance, to a greater or less degree, the so-called flat foot which is merely an abnormal persistence, and an exaggeration of, the attitude of rest.

If one contrasts the appearance of the foot in activity, under the control of, and supported by, the muscles, with one that is inactively supporting weight, he will appreciate the distinction between activity (strength) and passivity (weakness). If then the foot habitually assumes the passive attitude it may be properly called a weak foot, because it is weak in the sense that it is in danger of progressive deformity and because the sensation of weakness is the earliest and most constant symptom. Many weak feet, in the early stage at least, would not be recognized as deformed (flat) feet. Flat foot is therefore a misnomer, and it is an especially unfortunate term, in that it calls attention to deformity rather than to disability. The term weak foot will be used therefore to include all varieties of disability of the foot which are characterized by the habitual attitude of inactivity, of which the more advanced types might be properly described as flat feet.

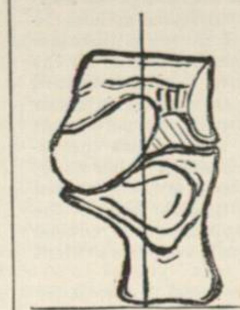

FIG. 2120.—The Normal Relation of the Astragalus to the Os Calcis.

The Anatomy of the Weak Foot.—As has been stated, a persistence of the attitude of rest or inactivity is characteristic of the weak foot. This attitude in which the weight falls upon its inner border is sometimes called pronation or eversion of the foot, and, when at all marked, it might be described properly as valgus. This latter term is, however, usually associated with more advanced or fixed deformity (talipes) and it is therefore rarely applied to the disability under consideration.

One may analyze the attitude and the deformity of the weak foot somewhat as follows. 1. The leg is displaced inward so that the weight falls upon the inner side of the foot. 2. The leg is rotated inward so that a line drawn through its centre prolonged from the crest of the tibia, instead of falling over the second toe, now points inside the great toe, or even over the centre of the internal border of the foot (Fig. 2119).

It has been stated that under normal conditions, in the act of passive weight bearing, the astragalus rotates downward and inward upon the os calcis, depressing its anterior and internal border until the movement is checked by the strong ligaments connecting the bones (the calcaneo-scaphoid, the deltoid, and the interosseus); in other words, the leg has a tendency to slip downward and inward from off the foot. In the weak foot this inclination has become an accomplished fact, for the normal movement has become so exaggerated by the distention of the ligaments and by the weakness of the supporting muscles that a partial dislocation has taken place (Figs. 2120, 2121). The astragalus has rotated and slipped far to the inner side of its normal position and is in an attitude of exaggerated rotation and moderate plantar flexion, so that its head can be plainly felt on the internal border of the foot. The anterior extremity of the os calcis is depressed and turned slightly inward and its internal border is lowered. The scaphoid bone is lowered together with the head of the astragalus, although to a less degree, and has been forced farther away from the os calcis, and with it the entire border of the foot is depressed also. Thus the depression of the arch, the third element in the deformity, is always accompanied by a bulging inward of the inner side of the foot. The foot is, as it were, broken in the centre, the posterior division having turned inward and downward; that is, the astragalus has rotated inward and downward to an extreme degree and has slipped from off the os calcis. The latter bone, although forced outward in its relation to the astragalus, still turns inward slightly, while the fore foot in its relation to the leg and to the posterior divisions of the tarsus is greatly abducted. The dislocation may be so extreme that the entire sole of the foot rests upon the ground, and a callus even may be found at the point that usually represents the high-

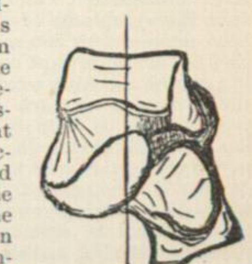

FIG. 2121.—The Relation of the Astragalus to the Os Calcis in the Confirmed Weak Foot.