

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-

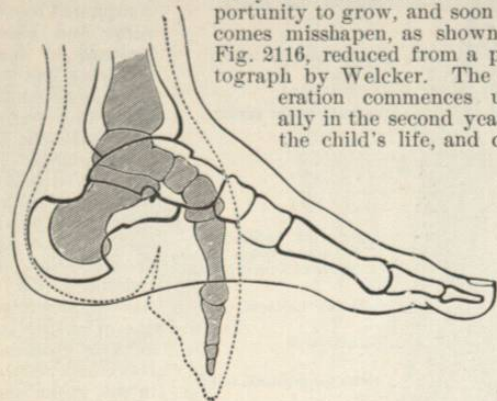


FIG. 2117.—Section of Natural Foot with the Bones, and a Corresponding Section of a Chinese Deformed Foot. The outline of the latter is dotted, and the bones are shaded. (Flower.)

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 (Stricker¹⁵). Fig. 2117 shows the skeleton of such a malformation. Frank Baker.

¹ Huxley, T. H.: Evidence as to Man's Place in Nature.
² Lebonou, H.: Le développement du premier métatarsien et de son articulation tarsienne chez l'homme. Ann., Soc. de méd. de Gand, 1882, III., 335.
³ Duchenne: Physiologie des mouvements.
⁴ Bradley, S. M.: The Secondary Arches of the Foot. Jour. Anat. and Physiol., London, 1875-76, X., 490.
⁵ Clark, Ann Elizabeth: The Ankle-joint of Man. Berne, 1877.
⁶ Aeby, Chr.: Beiträge zur Osteologie des Gorilla. Morph. Jahrb., Leipzig, 1878, IV., 288.
⁷ Hyrtl, Joseph: Handbuch der topographischen Anatomie, seventh edition, Wien, 1882.
⁸ Tillaux, P.: Traité d'Anatomie topographique, third edition, Paris, 1882.
⁹ Ruge, G.: Entwicklungsvorgänge an der Muskulatur des menschlichen Fusses. Morph. Jahrb., Leipzig, 1878, IV., Supp. 117. *Idem*: Untersuchung über die Extensorengruppe am Unterschenkel und Füsse der Säugthiere. *Ibid.*, IV., 592. *Idem*: Zur vergleichenden Anatomie der tiefen Muskeln in der Fusssohle. *Ibid.*, IV., 644.
¹⁰ Pettigrew, J. B.: Animal Locomotion, New York, 1874.
¹¹ Gegenbaur, C. von: Lehrbuch der Anatomie des Menschen, Leipzig, 1883.
¹² Beely, F.: Zur Mechanik des Stehens. Arch. f. klin. Chir., Berlin, 1881-82, XXVII., 457.
¹³ Langer, C. von: Anatomie der äusseren Formen des menschlichen Körpers, Wien, 1884.
¹⁴ Cunningham, D. J.: The Intrinsic Muscles of the Mammalian Foot. Jour. Anat. and Physiol., London, 1878-79, XIII., 1.
¹⁵ Stricker, W.: Der Fuss der Chinesinnen. Archiv für Anthropologie, 1870, IV., 241.

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

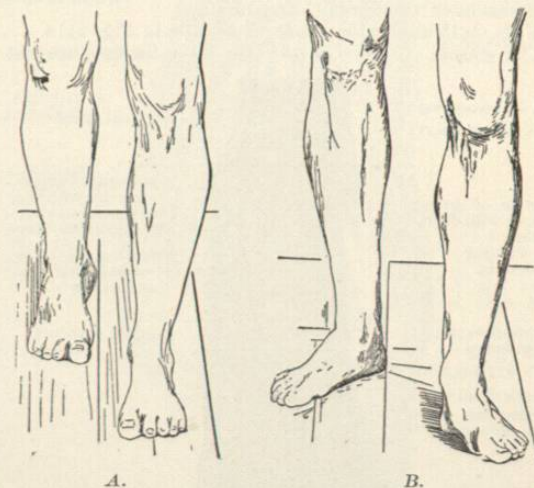


FIG. 2118.—A, The Proper Attitude in Activity, Illustrating the Abduction of the Fore Foot. B, The Improper Attitude of Outward Rotation of the Feet.

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.

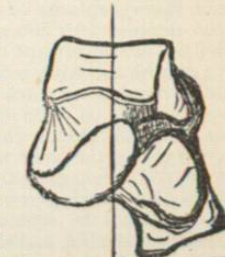
The Anatomy of the Weak Foot.—As has been stated, a persistence of the attitude of rest or inactivity is characteristic of the weak foot. This attitude in which the weight falls upon its inner border is sometimes called pronation or eversion of the foot, and, when at all marked, it might be described 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-scapoid, 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.



est point of the arch, which now supports the greatest burden.

In this change of relation between the bones, the arched part of the foot, or waist, appears much broader than normal, even broader than the front of the foot; the heel projects, the external malleolus is depressed and carried forward by the rotation of the leg and is much less prominent than normal; the internal malleolus is more prominent and with the astragalus it overhangs the bearing surface of the sole. The foot, considered as a mechanism, is twisted and out of gear, its motion is therefore very much restricted. It is manifestly impossible for the patient to adduct the fore foot, that is, to turn it inward about the head of the misplaced astragalus. Plantar flexion is also much limited because of the permanent position of adduction and plantar flexion that the astragalus has assumed. Dorsal flexion, on the other hand, may appear to be abnormally free, because the fore foot is abducted and slightly dorsiflexed upon the head of the astragalus. When, however, the displacement is reduced adaptive shortening of the calf muscle becomes evident in many instances.

Supposing the foot to have been normal before it began to break down, it is apparent that such deformity could not have been acquired without marked changes in its internal structure. In a general way these changes have been indicated by the description; the ligaments on the internal aspect of the foot and of the ankle joint are weak and distended; the unused portion of the articular surfaces of the joints may be denuded of cartilage, while new facets may have formed to accommodate the changed relation of the bones—as, for example, at the junction of the external malleolus with the os calcis. Evidence of injury and of abnormal pressure may be found in thickened periosteum and in formation of osteophytes, while the internal structure of the bones has been changed as well, to adapt itself to the new conditions. The muscles which are no longer used in the leverage function, the plantar flexors and adductors, have become atrophied—a change that is made evident by the shrunken calf. The muscles on the inner border of the foot have been overstretched, while those on the upper and outer part have become shortened and contracted. Such a foot represents an extreme, it may be an irremediable, degree of deformity. The machine is completely broken down; it can no longer perform its proper function; it is even less efficient than the wooden foot, because use is attended by discomfort.

The disability and its accompanying deformity are found in every grade of severity. Pain begins when the support of the muscles being insufficient, the ligaments begin to give way under strain, allowing the bones to occupy an abnormal relation to one another. It is evident therefore that the individual in whose foot the arch is accentuated and whose ligaments are firm, may suffer from the symptoms of strain long before the arch has been depressed or deformity has become apparent; also that the lateral inward bulging, characteristic of advancing deformity, must in such a case be very great before the astragalus can reach the ground and the arch be completely flattened. On the other hand, if the individual has inherited a low arch, or if, as the result of weakness in early life, the arch has been depressed or has never developed, accommodative changes in the bones will have taken place during growth, so that the flat foot of this type will not be attended with as much change in its relation to the leg, and therefore disturbance of function, as in the typical case that has been described. This latter class of cases exemplifies the popular type of flat foot that may exist without pain or disability.

It is very evident that the lowering of the arch is a secondary element of the deformity and that the popular significance of flat foot, as an inherited and irremediable weakness, is most misleading. It is misleading also in that in the most painful type of weak foot there may be practically no lowering of the arch, as shown by an imprint of the sole, while the actual flat foot may exist without symptoms.

As has been stated, there is one feature common to every grade of the so-called flat foot: the foot regarded as a machine is weak, as compared with the normal standard—weak because of the persistence of the attitude of rest and relaxation, as contrasted with that of activity and strength, and weak because the proper relation between the power and the fulcrum is changed. Even the inherited flat foot, or the flat foot which has never caused symptoms, is weak, in the sense that in use it lacks the spring and elasticity characteristic of the perfect machine.

The term weak foot may be used then to indicate all types of the disability. In one weak foot the arch has disappeared; in another weak foot the arch is of normal depth, but the foot is abducted or pronated in its relation to the leg. In one case the deformity appears only under weight; in another the foot is held rigidly in the deformed position by muscular spasm. In one instance there may be great deformity without pain; and in another disabling weakness and pain without deformity. In one case the foot is unable to perform its functions because of its inherent weakness, in another the disability may be due simply to the improper use of a normal structure. In all cases, however, disability as exemplified by the symptoms of pain and weakness is due to a disproportion between the burden or strain that is put upon the foot and the ability of the mechanism to perform this task.

This theory accounts for the fact that the weak foot, although very common in childhood, does not, as a rule, cause discomfort until adolescence, when the weight and strain put upon it are increased. It explains also why the foot which may be fairly normal in structure breaks down more often in later adolescence or early adult life when the continuous strain of regular occupation is undertaken. It is evident that an occupation requiring the long continuance of the passive attitude,—that of waiters, cooks, and bartenders for example,—exposes the feet to greater strain than one which permits alternation of postures, and that the symptoms are likely to be more severe and the deformity to be greater among those who are obliged to labor than among those who are not. Overwork or strain, of occupation or otherwise, may be temporarily disproportionate because of local or general weakness, as for example during pregnancy or after recovery from exhausting disease or because of local injury or disease of the foot itself or simply because of the strain of more constant use. On this theory one may very easily explain what has proved such a stumbling block for students, viz., that there is no constant relation between the degree of deformity and the severity of the symptoms; for although all flat feet are weak feet, yet all weak feet are not necessarily painful feet. Pain is not caused because the foot is flat; it is a symptom of progressive deformity, of strain and injury to the joints; it shows that the foot is becoming flat; it is a symptom of the injury that the weak or flat foot has received. The progress of the deformity may be temporarily or permanently checked at any stage, either by a removal of the exciting cause or because of the resistance of the tissues; then the pain ceases. On the other hand, this stability may not be attained until the entire sole of the foot rests upon the ground, and even then the patient may suffer from discomfort and pain.

This conception of the foot as a machine, of which grades of efficiency may be recognized, has a great advantage, since it enables one to perceive wherein a foot is weak even though the weakness causes no symptoms whatever. Thus one may prevent deformity by avoiding the extra strain that improper attitudes entail, and by strengthening the muscles on whose ability its integrity depends. Finally, from this standpoint one may better appreciate the etiological importance of improper shoes, in this as in practically all of the disabilities to which the foot is liable.

As has been stated, the symptoms of the weak foot, although similar in type, vary in severity according to the local condition and the disturbance of function, the work to be performed, and the susceptibility of the individual.

Symptoms.—The most characteristic symptom is the sensation of weakness. The patient begins to recognize as familiar, a feeling of discomfort, of tire and strain about the inner side of the foot and ankle, sometimes after long standing, a dull ache in the calf of the leg, or pain at the knee, hip, or in the lumbar region, symptoms more common in women than in men; or, after overexertion, a momentary sharp pain radiating from the point of weakness; thus the patient often dates the history of his trouble from a long walk. After a time the patient may become aware that he is accommodating his habits to his feet; he rides when he once walked; he sits when he once stood; he no longer runs up or down stairs or jumps off the street car. His feet have lost their spring as he expresses it, which means that the foot is no longer supported and controlled by muscular activity and is no longer used as a lever. Not infrequently, early symptoms are pain and sensitiveness at the centre of the heel, explained in part by the jarring heel walk which is always assumed when the foot is weak, and in part by the strain upon the attachments of the deep plantar ligaments. The patient may complain that he cannot buy comfortable shoes; the reason is that the weak foot under use is changed in shape, so that the shoe that was comfortable in the morning compresses the foot painfully at night. Thus increasing discomfort, due in part to corns, bunions, painful great toe joints, and deformities of the toes, is experienced. Coldness and numbness, congestion and increased perspiration, caused by the impaired circulation and weakness, are common symptoms in this class of cases. Actual pain is, as a rule, felt only when the foot is in use. It ceases under temporary rest or relief from disproportionate work, and it is this remittance of symptoms, together with the fact that the discomfort is usually more marked in damp weather, that leads so often to the mistaken diagnosis of rheumatism. The foot is weak and vulnerable; the patient recognizes the fact that he has what he speaks of as a weak ankle, or sprain, or gout, or rheumatism; but if he has accommodated himself to the weakness, but little discomfort is experienced. In many instances such relief or accommodation is impossible, and it is therefore among the working class that one oftener sees the rapid development of the disability and deformity. The range of motion becomes more and more restricted; the habitual attitude, at first exaggerated to deformity only under the influence of the weight of the body, becomes a permanent displacement. The weak and distorted foot is subjected to constant injury, to what may be likened to a succession of slight sprains; thus local congestion, swelling, and sensitiveness may appear together with muscular spasm, rigidity, and pain on passive motion. Because of the rigidity of the foot, which has lost the power to accommodate itself to inequalities of the surface, the patient dreads to cross a rough pavement, for every misstep is a source of pain. Another characteristic symptom is the discomfort felt on changing from a position of rest to activity. This, although it is usually present in slight degree at every stage, now becomes more prominent. The patient after sitting, or on rising in the morning, is unable to walk, but staggers and limps for several minutes, a symptom explained by the fact that when the foot is at rest there is a partial reposition of the displaced bones, which must be again forced into the deformed posture that has become habitual. The local tenderness and muscular spasm are increased by use, so that the patient may have difficulty in removing the shoe at night, and the symptoms relieved by the rest of Sunday become progressively worse during the week.

The pain and discomfort are more general in character, and are often referred to the dorsum of the foot, representing muscular rigidity and tension to the irritated plantar fascia, and to the outer side of the ankle, where the external malleolus is grinding out a facet in the projecting os calcis. The patient may now complain of discomfort in the feet and of cramps in the legs, even when in bed, and the appearance of weakness, awkwardness, and depression of spirits may be so noticeable that the

case is sometimes mistaken for serious disease of the nervous system.

The appearance of such a foot has already been described, and the effect of the deformity on its function should be evident. The gait is slouchy and cloddy; the feet are simply pushed by one another in the attitude of eversion, the knees are slightly flexed and the weight is borne entirely upon the posterior segment of the foot. The muscles have atrophied, the foot is cold and congested from its continual inactivity, and it usually is bathed in perspiration. A certain range of motion remains at the ankle joint, but adduction is absolutely restricted by the shortened and spasmodically contracted muscles on the outer and upper surface. This type represents of course only the severe variety that is more likely to be seen in hospital than in private practice; and it would seem, were it not for the evidence to the contrary, which the histories of the patients present, that the nature of the trouble must be recognized at a glance, although in the milder and earlier cases the diagnosis is not always so easily made.

Diagnosis.—In all cases in which weakness of the foot is suspected, a thorough and orderly examination should be made, not only of its appearance, but also of its functional ability and of the manner in which it is used. Such an examination is not merely for the purpose of confirming a diagnosis which is usually evident on inspection, but rather that the amount and character of the temporary or permanent changes in structure may be estimated.

Attitudes.—One begins the examination by noting the manner of standing and walking. The heel walk, the exaggerated turning out of the feet, the slouchy gait in which the leg is never completely extended, in which the power of the calf muscle is not applied and in which the essential postures of the foot are disused, are all elements of weakness that should be corrected whether they cause symptoms or not. The distribution of the weight of the body and the habitual use of the foot are often made evident by examining the worn shoe. If it is bulged inward at the arch or worn away on the inner side of the sole, it shows weakness. The same observations are then made on the bare feet, particular attention being paid to the line of strain or leverage. Thus, a line drawn down the crest of the tibia from the centre of the patella continued over the foot, should meet the interval between the second and third toes; if it falls over or inside the great toe, it shows that the foot is working at a disadvantage.

The contour of the foot should then be examined. Its internal border should curve slightly outward, so that if the feet are placed side by side with the toes and heels in apposition, a slight interval remains between the arches;



FIG. 2122.—Extreme Deformity in Adolescence.

if this slight concavity is replaced by a noticeable convexity when weight is borne, the foot is weak. This change in contour is the earliest and sometimes the only evidence of deformity. The arch of the foot properly protected by the muscles and by a proper attitude, sinks but slightly under weight; there is a slight elasticity only, as the strain is thrown more to the inner side of the median line, and if the depression is marked it shows weakness.

Bearing Surface.—The exact amount of bearing surface may be shown by an imprint upon carbon paper or by smearing the sole with vaseline; then as the patient stands upon a sheet of white paper the outline of the foot should be traced, so that the relative size of the imprint to that of the foot may be shown and compared with the normal standard.

The Range of Motion.—The range of motion is next to be tested, for its limitation is one of the earliest signs of disuse of function and weakness. This range of motion varies somewhat within normal limits; it is usually greater in childhood than in adult life, greater in the slender than in the massive foot, and greater in the foot used properly than in one that is not. The first test is applied to simple dorsal and plantar flexion; the leg must be fully extended at the knee, the line of strain must be in its normal relation so that the foot is neither adducted nor abducted, and the observation must be made upon its outer border. The patient should be able to flex the foot from ten to twenty degrees less than the right angle, and to extend it from forty to fifty degrees beyond the right angle, the range of motion being from fifty to sixty degrees.

By far the most important test, however, is that of adduction or inversion of the foot, the test of the medio-tarsal and subastragaloid joints, a motion in which the os calcis is drawn forward and inward under the astragalus, as the fore foot is flexed about its head. With the leg extended as before, the foot is turned inward as far as possible. The elevation of its inner border (supination) and the turning in of the heel are shown in the accompany-

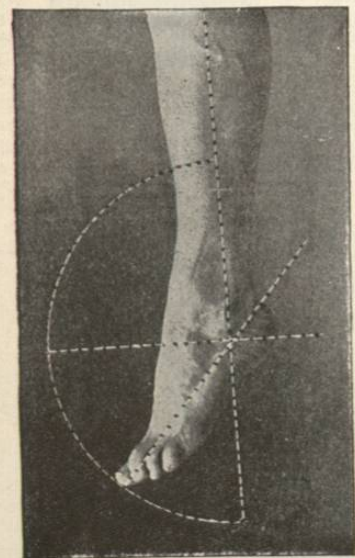


FIG. 2124.—Voluntary Plantar Flexion.

ing figure. The actual range of adduction is somewhat difficult to measure, but it is about thirty degrees (Fig. 2125). Even the mild and early cases of weak foot usually show some limitation of this most important motion, and in many instances it is completely lost, the patient turning the entire leg in the effort to adduct the foot. The less important range of abduction may then be tested; normally it is about half that of adduction. It may be noted that the range of supination or inversion of the sole is nearly twice as great as that of pronation or eversion of the sole; in other words, the internal border of the foot can be raised twice as far from the floor as can the external border.

The range of passive motion is then tested. That of dorsal flexion is from five to ten degrees beyond that of voluntary motion, while passive extension, so far as it applies to the ankle joint, is about the same as the voluntary, although the fore foot may be still farther bent downward at the medio-tarsal joint. The limits of passive adduction and abduction are considerably beyond those of the voluntary range.

The test of passive motion serves several purposes; contrasted with the range of voluntary motion it shows the habitual use of the foot, since the motion least used is most limited. It also makes evident the slight restriction of motion and the presence of local tenderness, which, even in early cases, are usually present.

Thus, if pressure be made just in front of and below the internal malleolus, at the astragalo-scapoid junction, and if at the same time the foot be suddenly adducted, the patient will complain of pain at the point of pressure and of a feeling of constriction and tension about the dorsum of the foot, before the normal limit of motion is reached. When the foot is dorsiflexed the plantar fascia is put upon the stretch, and its condition may be noted, for a contracted and sensitive plantar fascia may cause symptoms of disability that induce, or are combined with, abduction and valgus. In other words, this mode of examination demonstrates the disability

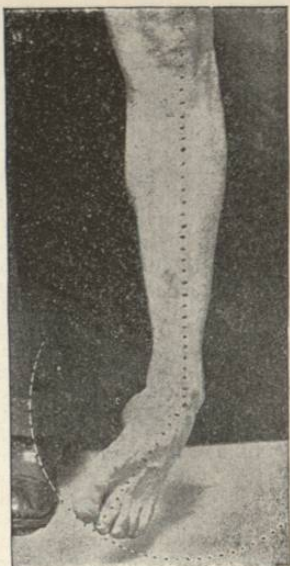


FIG. 2125.—Voluntary Adduction.

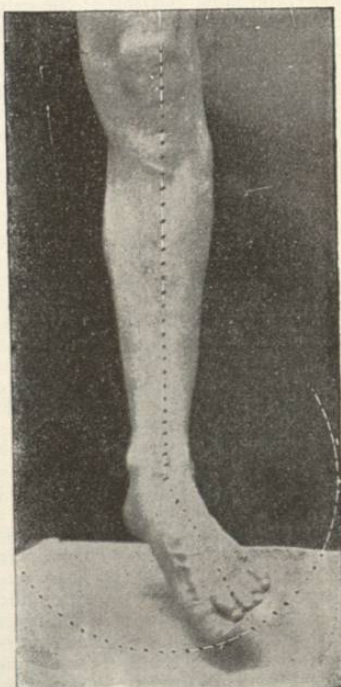


FIG. 2126.—Voluntary Abduction.

and permanent change in the machine which must be overcome before a cure can be accomplished. By it one will recognize several grades of weak foot.

Varieties of Weak Foot.—1. The normal foot improperly used, as shown by the manner of standing and walking.

2. The foot which, because of laxity of ligaments or insufficient muscular support, is forced by the weight of the body into an attitude of deformity.

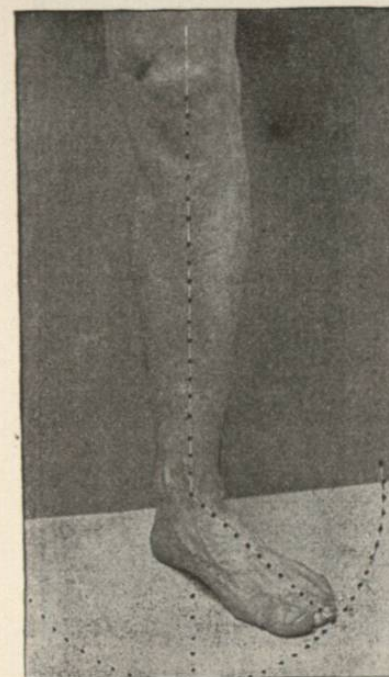


FIG. 2127.—An Attitude that Simulates Flat Foot.

ing surface. Indeed this may be even smaller than normal; thus an individual may suffer from so-called flat foot whose arch is in reality exaggerated.

3. The weak foot, which shows typical deformity under use and in which the range of voluntary motion is somewhat limited, particularly in the direction of plantar flexion and adduction. In this class forced motion causes discomfort and pain, showing a certain permanent accommodative change in structure which is not apparent when the foot is not in use. In these slighter grades of disability, the improper use of the foot, the loss of active leverage ("spring") is very evident when the patient walks.

4. The foot which presents typical and permanent deformity, whether it is in use or not, and in which the range of both voluntary and passive motion is much restricted.

This limitation of motion is an adaptation of structure to the habitual functional use and to the deformity. Such changes are first apparent in the muscles and ligaments; in more advanced cases, the articular surfaces of the bones are altered to accommodate the habitual subluxation. Added to this underlying limitation of motion there is usually a certain amount of muscular spasm, which varies in degree with the local congestion, irritation, and inflammation of the joints and tissues. In the quiescent weak foot it may be absent, but on renewed injury or overwork of the weak structure it again appears. It depends also upon the irritable condition of the overworked and contracted abductor muscles, practically the only group that retains functional power. Thus the spasm, as has been stated in describing the severe and painful type of weak foot, is greater after the day's use and re-

laxes somewhat during the night. The degree of muscular spasm and rigidity varies with the intensity of the

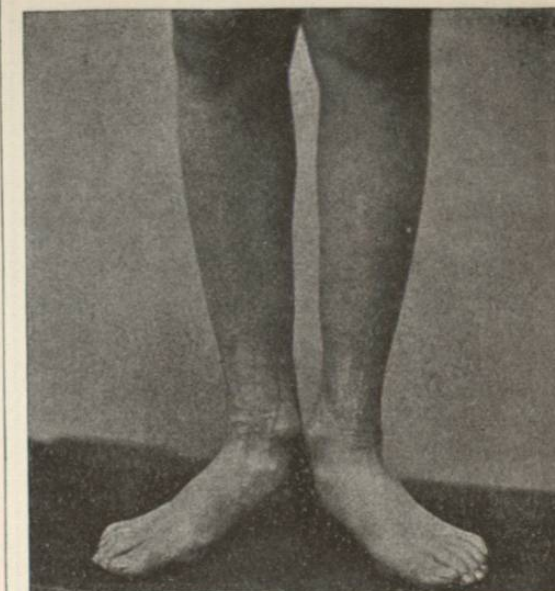


FIG. 2128.—Weak Foot in Childhood showing Habitual Abduction, without Depression of the Arch.

symptoms. It is often greater in the early stage of the disability than in the cases in which the deformity is of long duration.

Two Extreme Types of Weak Foot.—1. Persistent Abduction.—In one type of rigid foot, the foot is twisted

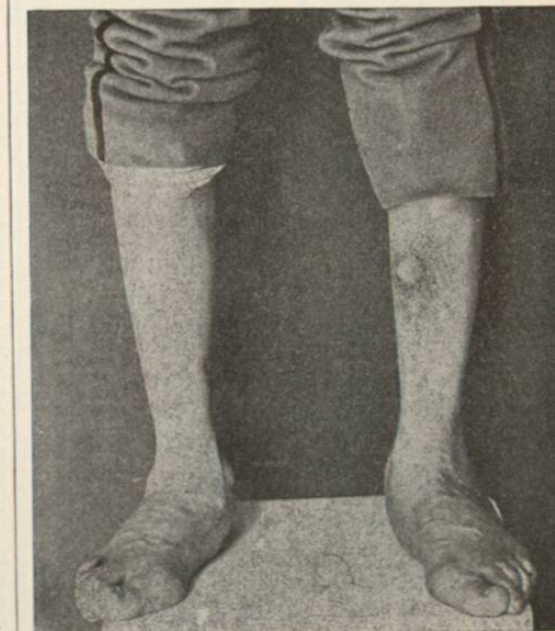


FIG. 2129.—Extreme Deformity in Adolescence; Abduction and Complete Sinking of the Arch.

outward and upward. It may be pronated to such an extent that practically the weight is borne upon the heel and ball of the great toe. In such instances the astrag-

alus, although rotated inward upon the pronated os calcis, is, of course, not plantar-flexed nor is the anterior extremity of the os calcis depressed. The entire foot is simply held in an attitude of extreme abduction and slight dorsal flexion, by the spasm and contraction of the flexors and abductors; so that the leg must be bent at the knee and inclined forward to bring the sole to the ground. Such extreme cases are uncommon. They are often the direct result of injury ("chronic sprain"), and when the deformity is reduced the arch will be found to be exaggerated in depth. Less extreme types of this class are often seen and they serve to emphasize the statement that the most important disability of the weak foot is due to the change from the normal relation between the leg and the foot (valgus) and not to the depression of the arch, (planus) which is, in most instances, a secondary deformity.

2. *Pes Planus*.—As has been stated already and as is well known, there is a type of painless deformity sometimes called *pes planus*. To this type the term flat foot may be properly applied because the flatness of the foot is more noticeable than the other components of the deformity that have been described. This class is probably the effect of inherited laxity of ligaments or of rachitis or other form of acquired weakness in early life, so that a normal arch was never present. Such a foot controlled by efficient muscles may be strong and serviceable, but it is nevertheless deformed, and it is doubtful if its possessor ever could attain the grace and elasticity of gait possible under normal conditions. It is said also that a low arch is normal in certain races, for example the negro, but it is certain that the American negro is not exempt from the pain and disability incidental to the broken-down foot, whether his arch was originally low or not.

It is evident that the breaking down of a properly shaped foot, provided with normal ligaments, must be attended by greater pain and disability than of one in which the arch was originally low and of which the ligaments were weak, because it is during the progression of the deformity, and particularly in its early stages, that such symptoms are most prominent. When the bones of the arch rest upon the ground or when final stability has become assured, pain may cease, and permanent accommodation to the new condition may increase the ability of the deformed member. Such an adaptation might be quickly accomplished in the foot originally flat,



FIG. 2130.—Adduction of the Fore Foot Combined with Valgus; an uncommon type.

while in the other instance the symptoms, although remitting from time to time, might continue during the life of the sufferer.

WEAK FOOT IN CHILDHOOD.—There can be no doubt that in many instances the origin of the weak foot may be traced to early childhood. Certainly, deformities and improper attitudes are very common at this period and it is much more likely that they are ingrown than outgrown. Actual pain from the weak foot is unusual at this age. The child may complain of fatigue and may be weak and awkward, but it is usually because of the very evident deformity, rather than because of symptoms, that advice is asked. In these cases, as in every case, the habitual attitudes and use of the feet are of the first importance.

One of the most frequent of the improper postures is that of exaggerated outward rotation of the feet, which

is not only an ungraceful attitude, but a direct cause of weakness as well. The opposite attitude of inward rotation of the feet, the so-called "pigeon-toed" walk, is most offensive to relatives and friends, and it is for correction

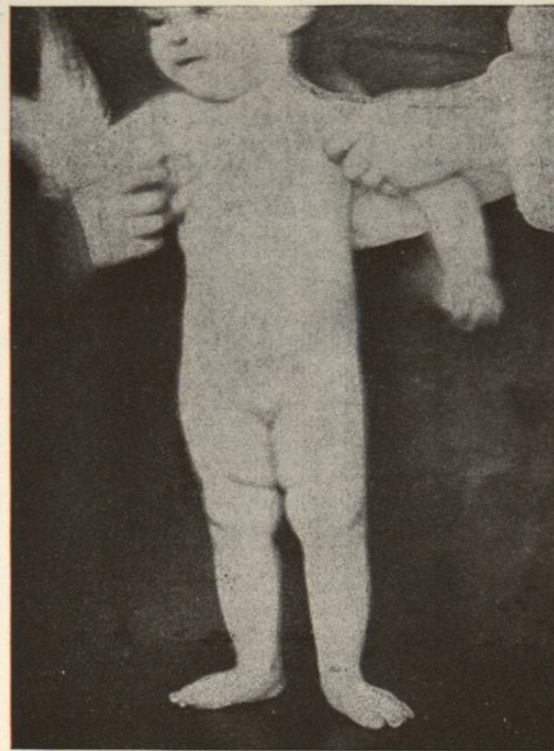


FIG. 2131.—Flat Foot in Early Childhood.

of the attitude that the child may be brought for treatment. The attitude is, in many instances, a sign of the weak foot, for on examination the bulging on the inner side, the inward rotation of the leg in its relation to the foot, and the flattened arch, show very plainly that it is the foot and not the attitude that requires treatment; in fact the attitude is, in this class of cases, really a safeguard against increasing deformity and it will correct itself when its cause is removed. Particular emphasis is laid upon this point, which is very generally overlooked, because the routine treatment of the "pigeon toes" in these cases might be the cause of direct harm.

"Weak ankle" is a term popularly applied to the weak foot of childhood, in which the foot is in a position of valgus when in use, so that the shoe is worn away on its inner side. Weak ankles are very common in very young children and are often one of the results of general weakness due to defective assimilation. At this age the foot is, in addition, usually flat, although in the valgus or weak ankle of later years the arch is often normal in outline.

In older children prominent or "outgrown" joints often attract the mother's attention; the internal malleoli appear prominent because of the position of valgus, or, because of the eversion of the feet, the malleoli may strike against one another, "interfere," and thus there may be an actual hypertrophy of the projecting bones from local irritation.

Another type is the long slender foot in which the scaphoid bone is prominent because of the strain and pressure put upon it by the improper attitudes; its position is often shown by the point of wear in the leather of the shoe. In the weak foot of childhood, although restriction of voluntary and passive motion may be pres-

ent, there are, as a rule, but little local tenderness and muscular spasm, and as has been stated, but little pain. Thus it differs greatly from the adult type, the reason being that the weak foot in childhood is not subjected to the strain of constant occupation or to the burden of the increased weight of the body. There is another important difference also: the foot in the adult is obliged to bear a greater burden than any other part, and although fairly normal in structure it may be overstrained. Thus in many instances the weakness of the foot may be the only disability. In childhood, on the other hand, a weak foot is very often a local indication of general weakness and loss of tone.

The direct effects of the weak and painful foot have been described in detail. It must be borne in mind that the feet are the foundation of the body, and that an insecure foundation affects the entire mechanism. General functional weakness and awkwardness, the flat chest, round shoulders or other curvatures of the spine, are often observed as accompaniments or effects of weak feet. As a rule, the systematic treatment of any form of postural weakness in childhood must include the treatment of the feet as well.

Recapitulation.—The disability and deformity of the weak or so-called flat foot are caused by disproportion between the strength of the foot and the weight and strain to which it is subjected.

The foot may be weakened by injury or disease; it may be overburdened by the body weight, or overstrained by laborious occupation, or the broken-down foot may be simply one indication of general bodily weakness. It is unnecessary to enumerate all the various factors that singly or combined lead to this disability.

It may be stated, however, that the painful weak foot as seen in adult life is in many, or most, instances the only evidence of weakness. The most constant of the predisposing causes are improper shoes, and the mechanical disadvantage to which the foot is subjected by the assumption of improper attitudes.

All weak or flat feet are mechanically weak, but all weak feet are by no means painful feet. Pain, the symptom of overstrain or injury, bears no definite relation to the degree of deformity.

In certain instances, exaggeration of the arch may be combined with persistent abduction of the foot; in others, the flattening of the arch may be the most noticeable deformity, but in most cases, the two are combined in varying degree. And as each deformity is an evidence of weakness, it seems hardly necessary to make a radical distinction between the two.

Treatment.—The principles of the treatment which leads to the permanent cure of the weak foot are very simple, but their application varies somewhat according to the grade and duration of the disability. The object of treatment is so to change the weak foot that it may conform, not only in contour but in habitual attitudes and in power of voluntary motion, to those of the normal foot, because cure is impossible until function is regained. The first step must be, therefore, to make passive motion free and painless to the normal limit. In other words, the obstructions to the motion of the machine must be removed before the power can be properly applied; for normal function is manifestly impossible, while motion is restrained by deformity or pain or by adhesions or contractions.

The weak foot, because of inefficient ligaments and muscles unable to hold itself in proper position, must be supported, in many instances, until regenerative changes have taken place in its structure. Such support is necessary to retain the joints in proper position, and to hold the weight and strain in normal relation to the foot. When these essentials are provided, the patient may cure himself by the proper functional use of the foot, and by the avoidance of attitudes that place it at a disadvantage.

It may be well to describe first the treatment that must be applied to all classes of weak foot in which a cure is to be attempted, and which by itself is sufficient in the

milder types, before calling attention to the modifications that may be necessary in special cases.

The Shoe.—In practically all cases it will be necessary to provide the patient with a proper shoe, for the shoe is usually the direct cause of the minor deformities, and the indirect cause, in many instances, of more serious disability. Indeed most of the deformities and disabilities of the foot are incidental to civilization and are confined to the shoe-wearing people.

The direct effect of the ordinary shoe is to lessen the size and balancing power of the fulcrum by cramping the toes together while the high heel throws more strain upon the arch and the ankle. Indirectly it causes deformities, corns, bunions, and the like, which serving to make active movement or leverage painful, induce the habitual assumption of the passive attitude which predisposes to deformity.

The proper shoe should contain sufficient space for the independent movements of the toes. This motion is illustrated in the walk of the barefoot child. As the weight falls on the foot the toes expand, and as the body is raised on the foot they contract. The important leverage action of the great toe and the support afforded by it to the arch of the foot have already been mentioned. The shape of the sole should correspond to the shape of the undistorted foot and the heel should be broad and low.

The prevention of distorted toes and the discomforts that result from the abuse of the foot is of great importance in childhood, but, unfortunately, little children are often seen wearing shoes of the shape usually assumed at years of discretion. In this regard, girls suffer more than boys, as women do more than men. The girl who may have worn comparatively harmless shoes until the age of ten years or thereabouts, changes suddenly to the high heel and narrow sole and the process of distortion begins, the amount of distortion and the degree of discomfort depending on the amount of work required of the foot. Wide soles without heels should be worn as long as possible by children because of the greater stability and because the high heel limits the necessity for, and therefore the use of, the entire range of motion of the foot and ankle.

A simple expedient in the treatment of the weak foot and an aid in balancing it properly, is to make the inner border of the sole and heel of the shoe slightly thicker in order to throw the weight toward the outer side of the foot. This is of especial importance in the treatment of the slighter degrees of what is known as weak ankle, but it is always of service in the treatment of any grade of weak foot.

Attitudes.—When the patient is provided with a proper shoe, his attention is called to the attitudes that protect the foot from strain. He should endeavor to hold the feet nearly parallel to one another in walking and to

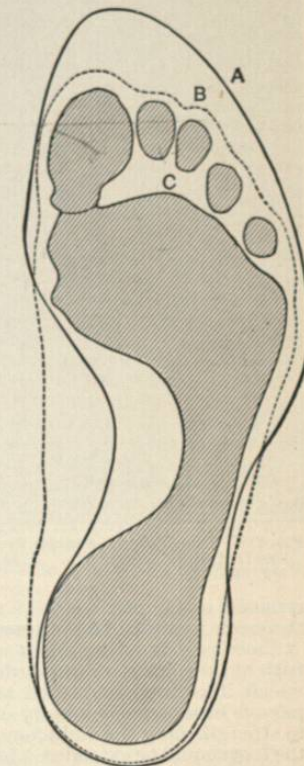


FIG. 2132.—The Proper Relation of the Sole to the Shape of the Foot. A, outline of sole; B, outline of foot; C, imprint of foot.

throw the weight as far as possible on the outer border of the sole of the shoe. The significance of the bulging on the inner side of the foot is pointed out to him and how this may be prevented by voluntarily inclining the

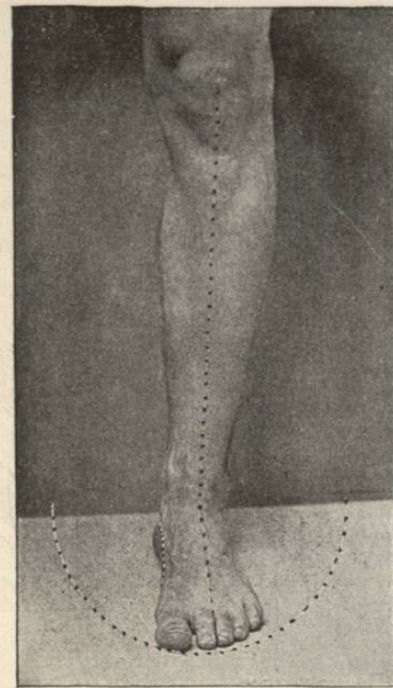


FIG. 2133.—Illustrating Voluntary Protection of the Foot from Over-Strain. (Compare with Fig. 2127.)

weight to the outer side of the foot and by aiding the arch by the power of the great toe.

The importance of leverage is shown him, he is told that he must try to press down the sole of the shoe with his toes and employ the active lift of the calf muscles by fully extending the leg and raising the body on the foot from time to time. Finally, he must avoid long-continuation in one position, especially the passive posture which simulates the attitude and deformity of flat foot. In short, he must be instructed in the mechanics of the foot and taught how the weak foot may be protected and strengthened.

Exercises.—It is important also to demonstrate to the patient the normal range of motion of the foot, a range which if restricted must be regained by voluntary and passive exercise. Voluntary exercise should be devoted to strengthening the adductors and plantar flexors; thus the foot should be extended, adducted, and supinated over and over again at every opportunity. Tip-toe exercises are particularly useful. The patient holding the feet parallel to one another, or better in inward rotation, raises the body on the toes from twenty to one hundred times, the limbs being fully extended at the knees, resting in the intervals on the outer border of the feet. The best of all exercises is, however, the proper walk, in which at each step the leverage power of the foot is employed and in which it passes through the proper alternation of postures.

Treatment by massage and special gymnastic exercises is, of course, of benefit, if the patient can command it, although by no means essential to the cure.

Support.—In many instances the simple treatment that has been outlined is all that is required and the symptoms of tire and strain are quickly relieved. In the more advanced type of disability the patient is not able to prevent deformity voluntarily; consequently a support is necessary to hold the foot in proper position and to relieve discomfort. It is usually necessary in the treatment of the weak and flat foot of childhood, because one cannot command the aid of the patient.

In selecting a support for the weak foot the nature of the deformity that is to be prevented must be borne in mind. The acquired flat foot, for example, is not a direct breaking down of the arch, as is usually taught, but a lateral deviation and sinking—a compound deformity, as has already been described. Thus a brace to be efficient must hold the foot laterally as well as support the arch. In fact, as has been stated, the prevention of

valgus is far more important than the direct support of the arch. The brace must not prevent the normal motions of the foot, and thus interfere with the increase of muscular strength and ability, on which ultimate cure depends.

The supports that are ordinarily employed do not fulfil the conditions; the pads and springs placed beneath the arch are intended to support it by direct pressure without regard to the lateral distortion; they are usually ill-fitting and are often of such length and shape as to splint the foot and thus prevent its motion. Leg braces which more directly control the valgus do not often hold the foot accurately, and their weight and unsightliness are fatal objections to their use in the early cases, in which prevention of subsequent deformity is of such importance.

A brace should never be applied to a deformed and rigid foot because it is not able to shape itself to the support; the spasm and rigidity must be first relieved by preliminary treatment, as will presently be described.

The Construction of the Brace.—If a brace suitable for meeting these conditions is to be constructed, it is necessary to provide the mechanic with a plaster cast of the foot, taken in the attitude in which one wishes to support it. Such a model may be easily and quickly made in the following manner:—

The Plaster Cast.—Seat the patient in a chair; in front of him place another chair of equal height; on it lay a thick pad of cotton batting and cover it with a square of cotton cloth. Put about a quart of cold water into a basin and sprinkle plaster of Paris on the surface until it does not readily sink to the bottom; then stir. When the mixture is of the consistency of very thick cream pour it upon the cloth. The patient's knee is then flexed and the outer side of the foot, previously smeared lightly with vaseline, is allowed to sink into the plaster, and the borders of the cloth being raised the plaster is pressed against the foot until rather more than half is covered. The foot should be at a right angle with the leg and the sole should be in the plane perpendicular to the seat of the chair. As soon as the plaster is hard, its upper surface is coated with vaseline and the remainder of the foot is covered with plaster; the two halves are then removed, smeared lightly with vaseline and bandaged together. The interior is dampened with soapsuds and is then filled with the plaster cream. In a few moments the plaster shell may be removed and one has a reproduction of the foot, which, when properly made, should stand upright without inclination to one side or the other. In many instances it will be of advantage to deepen in the plaster model the inner and outer segments of the arch, in order that the arch of the brace may be slightly exaggerated, especially at the heel, so that the depression of the anterior extremity of the os calcis may be prevented.

The Brace.—Upon the model, the outline of the brace is drawn as illustrated in the diagrams. The best sheet

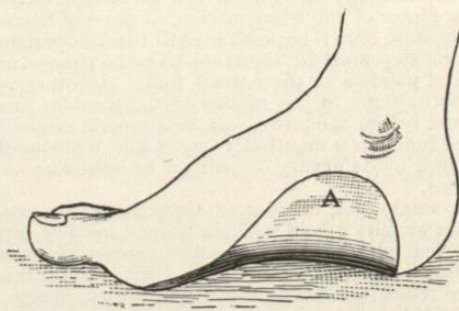


FIG. 2134.—A, The Astragalo-Scaphoid Junction.

steel, 18 to 20 gauge, cut after the pattern is moulded upon it and tempered, so that, as it is applied for the purpose of preventing deformity, it may be practically unyielding to the weight of the body.

It will be noted that the brace clasps the weak part

of the foot and holds it well together; the broad internal upright portion covers and protects the astragalo-scapoid junction, rising well above it. The external arm covers the calcaneo-cuboid junction and the outer aspect of the



FIG. 2135.—B, The Calcaneo-cuboid Junction.

foot to a height sufficient to hold the foot securely. The sole part provides a firm, comfortable support, yet, reaching only from the centre of the heel to a point just behind the metatarso-phalangeal joint of the great toe, it does not restrain the normal motions of the foot.

The brace may be nickel-plated and japanned, which makes a smooth finish, or tin-plated, which is a rather more durable covering. It may be covered with leather or an inner sole may be placed on its upper surface; but this is not usually necessary. As it is fitted to the foot it finds and holds its own place in the shoe, so that no attachment is required; thus it may be changed from one shoe to another. Not only does it hold the foot laterally and from beneath, but there is an element of suggestiveness in the slight leverage action which is very important. The patient, instructed to throw his weight upon the outer side of the foot and wearing a shoe which has been tilted in the same direction by thickening the inner border of the sole and heel, presses down the external arm and thus lifts the internal flange against the inner side of the foot, which is instinctively drawn away from the pressure and thus toward the normal contour. Thus he no longer everts the foot in walking because of the discomfort, and he is not likely to assume the passive attitude because of the suggestive lateral pressure of the support. This brace is therefore, when properly adjusted, a positive aid in the physiological cure as contrasted with the negative action of the ordinary sole plate.

The shape of the brace, in general like that of the diagram, may be modified in certain cases; for instance, the entire internal aspect of the foot may be weak and must be covered by the internal flange. In very heavy subjects the sole portion must be made larger, or other slight modifications may be necessary. If any portion of the rim of the plate causes discomfort, the edge may be turned away slightly at the point of pressure by a wrench. After a few days the patient no longer notices the presence of the brace, and as its presence in the shoe is not evident, it may be worn indefinitely. It is usually necessary to wear it for from three months to a year or longer, according to the condition of the part and the use to which the feet are put. The brace, properly made and adjusted under the proper conditions, causes no more pressure or discomfort than a well-made shoe, for its principle is quite different from that of ordinary supports that are in common use, to which this objection has been made. This brace supports the arch primarily by preventing abduction, consequently its pressure is first felt upon the lateral aspect of the foot, a pressure that the patient can relieve by improving the attitude. The brace should provide support when necessary, and at all times suggest and enforce a proper attitude; it is, however, but one of the essential factors in the general scheme of treatment.

In the treatment of children, passive movements of the foot should be carried out in all directions, but particu-

larly in dorsal flexion and adduction to the full limit, at morning and at night, until the child has regained the normal muscular power and ability. Special gymnastics and massage are always desirable and they may be necessary in certain cases. Bicycling may be cited as one of the best, and roller skating as one of the worst, exercises for the weak foot. A year is about the time required for the cure of the weak foot in childhood, although attention to the shoes and the attitudes must be kept up indefinitely.

THE RIGID WEAK FOOT.—One may now contrast with these mild types of weakness that have been described, those cases of extreme deformity in which the symptoms are disabling and in which the foot is rigidly held in the deformed position by muscular spasm. Such cases, often considered hopeless as regards a cure or even relief, are in reality the most satisfactory from the remedial standpoint, and in no other type of painful deformity can so much be accomplished by rational treatment as in this class. The deformity must be considered as a dislocation, in which the astragalus has slipped downward and inward from off the os calcis, which in turn is tipped downward and inward and into a position of valgus. The remainder of the foot is turned outward, so that the relation of the fore foot and the leg is entirely changed; in fact the fore foot is almost entirely disused.

Corresponding to the duration of the disability, one finds the accommodative changes in the soft parts and in the bones, but such changes are by no means as marked as those recorded in the reports of autopsies which have been made in cases of advanced and irremediable deformity. In fact, by far the greater number of patients are young adults in whom the extreme deformity is of comparatively short duration, and in whom complete cure is possible.

In the treatment of such a condition, one must first reduce the dislocation and overcome the obstacles that contracted muscles and ligaments may offer to free and normal motion. Then rest must be assured to the injured and congested parts in order to relieve the patient from the pain that he has suffered so long.

Forcible Over-Correction.—By far the most effective treatment is forcible over-correction of the deformity, under anesthesia. When the patient is under the influence of the anæsthetic the muscular spasm relaxes, and it will be seen that this accounts for about half the restriction of motion, the remainder being caused by the adaptive changes that have been mentioned. One now endeavors to overcome this residual obstruction and to assure the patient against a relapse, by fixing the foot in the position of extreme adduction and supination, the attitude directly opposed to that which has become habitual.

This is the object of forcible over-correction as the first step in the systematic repair of the disabled mechanism. Its principle must not be confounded with forcible correction carried out with the object of simply remoulding the arch of the foot, or in which the simple correction of the deformity is the object in view.

One first extends the foot forcibly, then flexes it to the normal limit, then abducts and adducts, the different motions being carried out over and over, until the rigid foot has become perfectly flexible. In cases of long standing it is often necessary to draw the patient to the end of the table so that the foot may be taken between the knees, in order to supply the required force by the thigh muscles. This forcible manipulation is accompanied by the audible

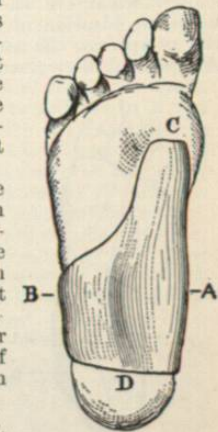


FIG. 2136.—C, The Metatarso-Phalangeal Joint; D, the centre of the heel.