SOME FOOT FAULTS RELATED TO FORM AND FUNCTION *

BY

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It is not proposed to discuss frankly deformed feet, but the apparently normal foot which aches and swells, causing its owner much misery. For the problem, which remains unsolved for far too many doctors, is—Why does a good foot break down under the stress of exercise or work? And what should be done to prevent and to cure foot fatigue, muscle spasm or stiffness of joints which are not diseased?

In the foot fatigue cases, the symptoms are almost exclusively those of fatigue of muscles. Because the symptoms are muscular and because it is easy to study the physiology and anatomy of muscles, and because a great deal of research work has been done on postural and contractural tonus, on reflex inhibition and augmentation of tonus, on reciprocal innervation and many similar matters, there has been a tendency, in the case of the foot, to confuse cause and effect, and to ascribe to the muscles primary functions which belong to other structures. There is no constant relationship between shape and symptoms. You may see an apparently normal foot associated with much aching and fatigue and immediately afterwards a badly deformed one which gives rise to few or no symptoms.

We have to study, therefore, those structural factors which give rise to or are capable of causing muscle over-work. The understanding of foot strain rests on a knowledge of such factors. The central theme of this paper is an analysis of the way in which they cause muscle fatigue. But we must remember also that the foot is a small thing, into which are packed many important components of small and even minute size. An abnormality, therefore, may be—indeed usually is—not a glaring and gross entity, but something which needs a very critical eye or delicate finger to detect. The orthopaedic surgeon must learn to regard as important small changes of shape, structure and movement in the foot.

There is also that lamentable habit, to which we all fall victims at times, of attributing to every joint and ligament the characteristics of one particular

joint or ligament. We know that there are mobile, semi-mobile and immobile joints in the body; that there are non-weight-bearing joints in the upper limb and weight-bearing joints in the lower limb, and so on. In many diseases we have come to realize that each individual joint reacts in a different manner. Similarly we must not think of the foot and its joints as having the same reactions to stress and strain as a joint such as the sacro-iliac or the elbow.

In order to understand the faults we must study the anatomy and physiology of the normal, namely, (1) the structure of the *foot-unit*, (2) its shape, (3) the universal joint between it and the leg, and (4) the actions of the muscles. Much of orthopaedic surgery is concerned with posture and the position and control of joints, and so there has arisen an Orthopaedic concept of the foot.

The Orthopaedic Concept of the Foot

The rise of this concept is due to the work of Norman Lake and Lambrinudi in Great Britain and of D. J. Morton, Dickson and Diveley in the U.S.A. Like so much in present-day surgery of the limbs, it is the result of careful observation, scientific tests and applied mechanical or engineering principles. It states that the foot is a resilient shock-absorbing unit, attached to the leg by a universal joint in such a way that it is in equilibrium with, or squarely placed on, the ground, and capable of acting as a base or plinth, on which the leg can be maintained in an upright or in an inclined attitude under all but exceptional circumstances.

A resumé of the essential anatomy and physiology may be stated as follows. The foot-unit, as will be seen in fig. 1, is an inherently strong resilient domed structure. The talus is not a part of the skeleton of the foot-unit, but of the universal joint (*q.v.*). The British have laid stress on the rôle of the muscles to the exclusion of the ligaments of the foot. There is much evidence that this is incorrect. Ballet dancers' feet, for instance, are said to go 'flat' when in the position of rest with relaxed muscles. But, as will be seen in the case illustrated in fig. 2, there is no sign of 'flatness.' Further, observations on babies, whose ages range from fourteen days down to twelve hours, demonstrate that the arch is

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FIG. 1.—The skeleton of the foot-unit showing its domed shape.

FIG. 2.—With the camouflage of the ballet shoe removed the ballet-dancer's foot is anything but flat.

present long before the muscles could cause it to arise, and a girl with a completely paralysed foot and leg below the knee has been shown to possess a beautifully domed foot at rest and when weight-bearing. Lastly, there is Norman Lake's experiment with a freshly amputated leg. Here the leg is placed upright in a stand and weights are piled on it. The muscles are stripped and the various ligaments are divided in turn. X-rays confirm the naked-eye evidence that it is not until every ligament on the plantar aspect and between the bones have been cut that the foot goes flat. Of more importance is the fact that as soon as the spring ligament is divided, the foot-unit starts to pronate. The inner border commences to become convex, as well as to sag, because the combined action of eversion of the

foot and of inward rolling or rotation of the tibia, fibula and talus allow it to overbalance or overturn at the subtaloid portion of the universal joint. The movement can be further demonstrated in dealing with the universal joint by means of the articulated skeleton. The point is important because a true flat foot is rare. Nearly all the so-called flat feet are pronated or overturned feet. This is dealt with more fully under the section Pronated Foot. The *foot-unit* remains in equilibrium on the ground because of its shape, which is either a tripod or hexapod or like an outrigger canoe as shown in fig. 3.

The traditional British view is that it is a tripod, the legs being the heel posteriorly and the first and fifth metatarsal heads at inner and outer side respec-

FIG. 3.—The three views as to the weight-bearing properties of the foot unit. (A) Tripod. (B) Hexapod. (C) 'Balanced-line.'

tively of the front of the foot. D. J. Morton showed that all five metatarsals transmit weight in the proportion two units for the first and one unit each for the other four. M. A. MacConail of Sheffield claims that the outer part of the foot—the os calcis, cuboid and fourth and fifth metatarsals—transmits weight, while the scaphoid, cuneiforms and inner three metatarsals are the balancing portion and act

FIG. 4.—The equilibrium provided by metatarsal width.
(A) Wide and stable when bare-footed.
(B) Narrow and unstable with high heels.

in the same way as the outrigger of a Pacific canoe. It is obvious that, whichever hypothesis be correct, the width of the metatarsal arch and the stability of at least the first and fifth metatarsals determine the lateral balance or equilibrium of the foot-unit (see fig. 4).

The foot-unit is attached to the leg by a universal joint (see fig. 5) consisting of the ankle, which allows (up and down) movement round a transverse axis, and the joint between the talus and the rest of the

foot, which allows inward and outward bending round an antero-posterior axis together with an inward and outward rotation relative to the vertical axis of the leg. While each of these three types of movement can be performed separately to some extent, it is usual for all three to be associated, so that when 'the toes are pointed' the foot not only plantar flexes, but also inverts and rotates inwards; and vice versa. In particular, inversion and eversion movements are seldom made without inward and outward rotation. When the foot is fixed to the ground and cannot rotate, inversion of the foot is associated with the complementary movement of external rotation of the leg, while eversion or pronation of the foot is accompanied by inward rotation of the leg (see fig. 9). This association of movements is very important. It explains a number of cases of so-called foot strain.

The functions of the extrinsic muscles are three. Acting from the foot to the leg, they balance the leg on the foot rather like self-adjusting guy-ropes. They stabilise or balance the foot itself by their control of the universal joint. This is probably their most important postural action. Finally, they lock the bones together into firm apposition, thus strengthening the dome. All these functions are affected by the normality or otherwise of the foot structure. Provided the structure and position of the foot are normal, and the posture of the body such that its centre of gravity is directly over the ankle joint, the muscles have a minimum of work to do. Where there are defects of structure, their work is increased. Where there is defect or abnormality of tonus due to pain, poor posture, faulty footwear, bad habits, awkward occupation and the like, their work is increased. Under these circumstances fatigue may be rapid and, therefore, foot strain, which is muscle strain, arises.

FIG. 5.—Movements taking place at the subtaloid joint.
(A) Neutral position. (B) Pure inversion. (C) Inversion associated with inward rotation of the foot around the long or vertical axis of the leg.

FIG. 6.—Pronated foot.

(A) Rear view showing everted heels. (B) Heel upright; first metatarsal head elevated, great toe plantar-flexed.

Defects of Structure and Equilibrium of Foot-Unit

Remembering that the foot may be regarded as a tripod we realize that, just as in the case of a three-legged stool, if one leg is short or at the wrong angle, the foot will tilt over or lean towards that faulty leg. The most common fault affects the first metatarsal. It may be permanently tilted upwards in comparison with the others because it has the wrong shape at its base or has been fractured, or it may be so poorly fixed by its ligaments that when weight is transmitted through it its head moves upwards (fig. 7). Lambrinudi named the former Elevated First Metatarsal or Metatarsus Primus Elevatus, and D. J. Morton calls the latter Hypermobile First Metatarsal. Sometimes the fault is that the metatarsal is too short. As the results of these conditions are similar, they are classed here together under the name of Incompetent First Metatarsal. As it is common, it is proposed to examine it in some detail because it gives the clue to so many points which must be observed in examining the foot. In examining the feet it is wise to adopt a standard position of standing. The feet should be parallel and about six inches apart.

Pronated Foot

When there is an incompetent first metatarsal, the first and obvious thing that happens is that, lacking effective support on the inner side, the foot rolls over inwards. It overbalances. The Americans call it Pronation; it is an excellent term. Nearly all cases of so-called 'flat foot' are not flat feet, but are pronated feet. The points of diagnosis are these.

The foot looks as if it were flat. The inner border is convex and depressed from prominence of the scaphoid and head of talus. It is perfectly mobile and the individual can easily stand on the outer border of the foot, i.e. can invert or supinate. On supinating the foot, the inner side of the fore-foot leaves the ground, but the hallux plantar flexes and we notice the rather large head of the elevated first metatarsal (fig. 6B). In the normal foot, supination is accompanied by dorsiflexion of the great toe. Do not be caught out by patients who have been receiving treatment in the massage department. They plantar-flex the great toe on supination because they have been taught to do so. In the pronated foot, the plantar flexion is due to the

FIG. 7.—Lateral view of x-ray of weight-bearing foot.
(A) Normal. (B) Elevated first metatarsal.
(Compare with 6B.)

FIG. 8.—The significant points of the AP x-ray.
(See text.)

muscles making use of the hallux to support the inner border of the fore-foot in place of the incompetent first metatarsal.

Turn the patient round and look at the heel from the back; it is turned out or everted (fig. 6A). Make the patient invert or supinate till the heel is upright and look at the fore-foot again. The head of the first metatarsal is lifted off the ground and the hallux plantar-flexed (fig. 6B). It is not until the patient allows the foot to overbalance or pronate that the first metatarsal head can touch the ground. But whether pronated or supinated there is no change in the height of the 'arch.' In other words, we are dealing with a structurally abnormal foot which has no inherent stability or equilibrium. The three-legged stool with a short leg has fallen over towards the short leg, and that leads to muscle overwork.

On examining x-rays taken with the heel upright, we see in the lateral view the elevated first metatarsal, the plantar-flexed hallux and a good longitudinal arch (fig. 7). In the antero-posterior view there are several significant points (fig. 8). (a) The first metatarsal may be a little short. If very short, its shortness explains its inability to act as an efficient leg to the stool. (b) There is a very wide joint space between internal and middle cuneiform bones. (c) There is a very poor joint or else no joint at all between the bases of the first metatarsal and the second, and sometimes none between the second metatarsal and the internal cuneiform. (d) A very significant point is the diameter of the shaft of the second metatarsal. When the first metatarsal fails in its action of being a support, greater strain is thrown on to the second, and either a march fracture occurs or else it hypertrophies.

If these points in the x-rays are not found to support the clinical diagnosis, the defect is not confined to the first metatarsal segment, but affects the whole of the fore-foot, or at least the inner three metatarsals and the cuneiforms. It is then called Supinated Fore-foot because the whole fore-foot is twisted or supinated.

It may be wondered whether, if the structural defects enumerated are basic causes, the condition of pronated foot is found in early life. It is. The writer has seen many new cases each month at a school orthopaedic clinic. But it is noteworthy that the children are sent to this only because the school doctor or teacher has spotted the deformity. They have no symptoms. Incidentally, genu valgum is almost invariably accompanied by pronated feet.

Onset of Symptoms

Then why are there no symptoms in childhood? Why do fatigue symptoms arise later in life? It is because the early symptoms are due to muscle fatigue that, in the past, it has been usual to ascribe so much of foot trouble to the muscles rather than to structural defects.

The answer is that, as already stated, one action—probably the most important action—of the muscles is to control the universal joint in order to

stabilize or balance the foot itself. With a foot of normal structure they have little work to do; it can be likened to someone on roller skates. When the foot structure is abnormal its state is very like that which exists when one wears ice skates. There is no inherent stability, and the muscles have to do most of the supporting or balancing. In young and healthy persons, they are capable of this compensating action. But let anything happen which reduces their power and over goes the foot. At first the muscles make strong efforts to preserve the balance so that the symptoms of muscle strain and fatigue, aching in the legs and tiredness of the feet arise. Excessive standing or walking cause them rapidly to tire, and so we find that long route marches or long hours of standing, or the debility of an illness, or increased body-weight, or distorted shoes give rise to symptoms without there being any apparent deformity. In a sentence—the demands made on the muscles determine symptoms, and when the foot structure is poor the muscles have only a small reserve of strength with which to meet new or extra demands.

Squinting Knees

The next point for which to search is anything which alters the normal rotation of the whole leg.

FIG. 9.—Squinting knees. (A) Knees appear normal. Feet are abducted and pronated. (B) Feet appear normal. Knees squint.

For instance, there is the clinical condition called 'squinting knees'; a silly term, but graphic. It is found most commonly in cases of spastic paraplegia of infancy, or birth paralysis. It is also caused by exaggerated lordosis, which causes the pelvis to tilt forwards; owing to altered muscle tonus the legs turn inwards.

Internal rotation of the leg means that the toes are turned in—'pigeon-toed.' But that is ugly and the parents, doctor and school teacher make the child's life a misery until he 'learns to walk properly.' To do that, i.e. to turn out his toes without turning his hips, he has to make use of the universal joint. As has already been seen, he can turn out his feet only if at the same time he pronates them (fig. 9). Consequently, when the lad with

squinting knees does 'learn to walk properly' he pronates. Then he is sent for treatment of so-called flat foot.

Muscle Length

An interesting group of cases is that where there is alteration of the length of muscles. The tendo achillis is often much too short or tight so that the individual cannot dorsiflex the ankle sufficiently to allow easy walking. Whereas the normal range of dorsiflexion should be some 20 to 40 degrees, in these cases it is much less. It must be tested with the knee straight, for Bohler showed that there is a gain of about half an inch by flexing the knee. When the foot will not go above a right angle, it is yet found that the patient can walk. But he does it by pronating the foot. We may test the range by holding the heel upright and by pressing on the sole. If we allow the heel to evert, i.e. let the foot pronate, we find that we can get another 10 to 15 degrees of apparent dorsiflexion. This then is the reason why the foot pronates. The powerful tendo achillis will not give way, but the foot must dorsiflex and so the weaker inverting muscles submit to force and allow the ligaments to stretch. Obviously, the treatment is to ignore the foot and to attempt to stretch the tendo achillis by exercises and if that fails, to perform an operative lengthening.

In one case which would have been impossible to solve if one had no conception of the control of the universal joint, a girl of twenty gave an unprompted story in almost these words. 'She wears lace-up shoes with wide and low heels. When walking her ankle frequently "turns" (into inversion) causing pain. When wearing high-heeled shoes she never "turns her ankle" but her legs ache.' Examination showed normal feet. Her shoes wear down on the outer side, confirming her story of turning the ankle. Test of the tendo achillis revealed that it was too tight. Thus dorsiflexion was limited and the foot tended to invert in order to gain extra movement. Inverting gains extra dorsiflexion in the same way as pronation does. The tendo achillis was not very tight and, provided her muscles acted perfectly in their control of the universal joint, all was well. When one group happened to be off guard for a moment, and she failed to put her foot down squarely, the tendo achillis caused inversion and 'turned her ankle,' causing a mild sprain.

The high-heeled shoes compensated for the short muscle, but gave rise to a new set of circumstances, such as may affect anyone who wears high-heeled shoes for walking or working. It is due to the length of the metatarsals or more correctly, though more clumsily stated, the distance which each projects forwards. The shafts of the metatarsals lie in a plane corresponding to the surface of a cone, short radius posteriorly, longer radius anteriorly. Their posterior ends are a little distance from the floor. Their anterior ends touch when the foot is bare (fig. 4A). To do so it is necessary for the lengths of the middle metatarsals to be greater than the inner and outer ones for the intersection of a

cone and a plane surface is a conic section. Now in high-heeled shoes the inclination of the metatarsals is increased so that, when they are vertical, only the two central, i.e. the second and third metatarsal heads, touch the floor. The metatarsal width is reduced to a very small one (fig. 4B). The foot tends to 'wobble,' the onus of balance is thrown on to the muscles, and exactly as in the case of the incompetent first metatarsal or supinated fore-foot, they are subjected to overwork, and protest by aching.

Muscle Tonus

There is yet another series of causes to be considered. Throughout the whole body there are opposing groups of muscles called agonists and antagonists. The nice balance of power between them, whether in their dynamic actions or static functions, depends on their tonus. Sherrington proved that an increase of tonus of one group caused decrease in the opposing group by means of simple and complex nervous reflex arcs. He also showed that the tonus of any particular group was affected by sensory stimuli of many kinds. The simplest was a harmful one. As regards the foot we know that a painful stimulus to the sole, such as stepping on a tack, causes withdrawal of the foot. A less painful stimulus causes increased tonus of the dorsiflexors of the ankle and the flexors of the knee and decreased tonus of the tendo achillis and the quadriceps muscles, preparing the leg for withdrawal if necessary.

Such an alteration of the tonus, i.e. of the balance of power between opposing groups, means that if the individual continues to walk or stand while the painful stimulus persists one group of muscles has to act against a reflex desire to relax, while the added stimulus of weight-bearing further increases the tonus of the group already in enhanced tonus. This conflict is found when the patient has such painful conditions as corns or a projecting nail in the shoe, and is a fruitful source of foot fatigue, i.e. of muscle strain.

Another cause for altered tonus is an abnormality of posture. When body posture is normal the centre of gravity is immediately over the hip, knee and ankle joints. The muscles stabilizing or balancing the joints are doing minimal work under such circumstances. If the individual sags or lets the spine flex and the head hang forward or if he has to work at a job requiring him to lean over a bench or tool the centre of gravity shifts forward, and to keep himself from falling forwards there has to be an increase of tonus of the tendo achillis, and a diminution of that of the anterior tibial group of muscles. As before the disturbance of the balance of power leads to muscle fatigue.

Muscle Inco-ordination

The least well-known effect of pain is muscle inco-ordination. In certain cases of painful feet from various causes, we find that the patient cannot or will not let the tips of the toes touch the floor.

Sometimes there is flexion, but in the worse cases there is extension of the interphalangeal joints and the toes are held stiffly at 20 to 30 degrees off the floor. The long extensors of the toes and the interossei are in spasm or increased tonus. So persistent is the tonus that the patients are unable to dissociate the action of the toe extensors and ankle dorsiflexors and cannot make the toes plantar-flex while dorsiflexing the ankle. The spasm starts by being protective against pain or foot fatigue from relative or absolute muscle overwork. Established spasm leads to further muscle fatigue symptoms and is very difficult to cure.

Treatment

Although I have described many ultimate causes which appear to demand radical and extensive surgical measures, it is fortunately possible in many cases to relieve symptoms by simple means.

In the past it has been usual to class foot deformities as mobile and fixed. But now we divide them into reversible and irreversible. The reversible conditions respond to what used to be called palliative measures, such as chiropody, physiotherapy and surgical alterations to shoes. The irreversible ones are those which require surgical measures or which are so severe that nothing can be done to restore the individual to full normality.

The principles which guide us in the non-operative treatment are these:

1. Where there is much pain, where swelling and spasm exist, we order rest in bed and physiotherapy, such as radiant heat, infra-red rays and effleurage massage.

2. After a few days we start non-weight-bearing exercises, deeper massage and faradic stimulation of weak muscles, and chiropody directed to the relief or removal of painful points.

3. Following this stage, and in all less severe cases, we give active exercises out of bed, faradism and re-education exercises designed to correct the faulty action of muscle groups. We supply various supporting types of surgical alterations to shoes.

4. Next we start physical training and further exercises associated with alterations to shoes which throw a deliberate progressive stress on the feet in an attempt to over-compensate by excessive muscular development.

5. Finally, real games and heavy exercises.

It is only when the ultimate cause is severe or when conservative measures fail that we resort to surgery.

Chiropody

We have already considered that any painful stimulus affects muscle tonus. Thus, if there is a tender callosity under the first metatarsal head the muscles, such as tibialis anticus, will go into increased tonus, while the tonus of peroneus longus will decrease in order that there shall be less pressure on the painful spot. In other words, the patient will put less weight on the inner side of the foot and tend to walk mostly on the outer side. It is not surprising that muscle strain symptoms arise and

that later muscle spasm supervenes. Bunions, corns, hammer toes and the like have similar effects. It is in such cases that chiropodists are invaluable.

Surgical Shoes

There is little space here to expand the subject of surgical alterations to shoes and boots. But it is necessary to stress one point. In the past, the treatment of pronated or so-called 'flat foot' by surgical shoes has consisted of wedging and elongating the inner border of the heel and wedging the inner side of the sole. In some cases the waist of the shoe was 'blocked' or filled in by carrying the elongation right forwards to the sole. Such alterations are mechanically, anatomically and physiologically wrong. We have seen that the fault is a supination of the fore-foot relatively to the heel. If we are going to attempt to correct the deformity we must not put any wedge or patch under the first metatarsal because it elevates it; we want to depress it. If any alteration is done to the sole it should be a wedge to the outer border. A wedge of the inner border is wrong for quite other reasons. It throws the weight on to the outer side of the shoe to such an extent that the shoe quickly becomes distorted. With a level sole or a patch or wedge on the outer border, this over-tilting is avoided and the patient feels more secure or stable. This is no theoretical point. The writer has put it into practice for the past fifteen years and in many cases the patients, who previously had the incorrect alteration, have stated how much better they felt.

Prevention

Finally, two examples have been shown of the importance of dealing with inherent latent defects in early life in order to prevent serious disability later on.

The first deals with one cause of hallux rigidus and the second with what is called spastic or spasmodic flat foot.

A frequent cause of hallux rigidus is exemplified by the case of a lady who has a normal right foot. The left first metatarsal is hypermobile or incompetent. As a result, the foot fell over into pronation. As usual her foot tries to compensate for the poor support of the first metatarsal by powerful flexion of the great toe. This results in spasm of the short flexors of the great toe, which results in the loss of the movement of dorsiflexion at the metatarso-phalangeal joint. When she walks each step causes impingement or jarring between the metatarsal and the phalanx (fig. 10). Impingement causes irritation and finally osteoarthritis, which is hallux rigidus. Hallux rigidus causes pain in the great toe, and, owing to inability to walk properly, much strain in the whole foot and leg, to be cured only by an operation.

Spasmodic flat foot arises in a similar way, except that osteoarthritic changes are very late and the parts affected are the mid-tarsal and subtaloid joints. We find it in adolescents and nearly always they have just started a job which involves prolonged standing and walking. Sometimes there has been

a definite sprain due to an accident. When seen, the cause appears to be an arthritis of the sub-taloid or mid-tarsal joint, with protective muscle spasm. But the cause of the arthritis is regarded as obscure. There is not the slightest doubt in the writer's mind that injury and infection are merely exciting or secondary factors. The basic cause in most cases is pronation of the foot, due to structural defects, which causes or permits the onset of an irritative

the adhesions can be ruptured and full mobility obtained. To be absolutely certain that there will be no recurrence it is often necessary to operate to correct the elevated first metatarsal or supinated fore-foot.

Preventive Measures in Childhood

In childhood there should be a regular inspection so that at the first sign of abnormality inside or outside the foot the appropriate measures may be put into force. We must supervise footwear and it is possible that we shall have to decide that, at least in the case of city children, all shall wear special shoes. They would probably be of the 'twisted last' type with which the Boot and Shoe Trades Research Council has been experimenting. In brief, the last on which the shoes are made is so shaped that the heel is a little inverted and the fore-foot everted because of increased thickness of the inner border of the heel and of the outer part of the sole.

Stockings must also be examined to make sure that there is plenty of room for the toes, for constricting socks are a very potent cause of foot complaints.

Prevention for Adults

All individuals who are to do work involving a good deal of strain on the foot, such as standing at a machine or driving a tram or who have to walk about all day in an awkward way like waitresses, who carry trays and cannot swing their arms and body—all those who have been in bed for more than a very few days, particularly if they have had toxic illnesses like tonsillitis or 'flu—all who have put on weight must be examined to exclude the conditions here discussed. Unsuitable cases must be directed to more appropriate jobs. Doubtful and unsuitable alike must be given the correct type of footwear, such as the 'twisted-last' shoe. As a substitute the wedging may be added to ordinary good shoes. A massage department of complexity and size depending on the nature of the problem must be set up. A skilled chiropodist should give regular attention to all the employees once a week or once a fortnight. The construction and operation of the processes which are known to lead to foot symptoms must be subject to review for advice as to modification which will eliminate incorrect posture or displacement of the centre of gravity of the body.

Conclusion

The various points here brought out have, it is hoped, shown that the problem of foot fatigue is not so difficult as it seemed. To deal with it successfully necessitates a certain amount of specialized knowledge and a definitely specialized type of mind.

But if the conception of muscle strain or fatigue due to structural defects or reflex causes is always in front of the mind the greatest part of the difficulty has disappeared and we are capable of relieving the complaints of our patients whether civilians, in industry or in the armed forces.

NOTE.—The illustrations are from a cine film available on application to the author.

FIG. 10.—The common cause of Hallux Rigidus.

arthritis. The spasm is the usual protective for the joints. Injection of a local anaesthetic into the joints breaks the reflex arc, whilst rest relieves the irritation of the articular surfaces. When the muscles relax we see a typical mobile pronated foot.* If the spasm has been present for some time a local anaesthetic may not be sufficient because adhesions are present. Under a general anaesthetic

* Since the lecture was given the last link in the chain of evidence has presented itself. In 1942 a boy of fifteen was treated conservatively for pronated foot due to elevated first metatarsal. He ceased attending after a period. In July, 1943 he re-attended because of pain, and on examination a typical spasmodic flat foot was found. Until this case one could not present indisputable evidence that the structural defect and pronation preceded the spasm, and were not coincidental or even of subsequent onset.