

## MAN'S ATROPHIC FEET

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'For the most part we have but little pride in our feet, and it is a pity that this is so.'<sup>1</sup>

Wood Jones, 1943

'Man's foot is all his own. It is unlike any other foot. It is the most distinctly human part of the whole of his anatomical make-up. It is a human specialisation and, whether he be proud of it or not, it is his hallmark and so long as Man has been Man and so long as he remains Man, it is by his feet that he will be known from all other members of the animal kingdom.'<sup>1</sup>

*The Arches of the Foot*

'Thirty years ago it was not uncommon to meet with surgeons who regarded "flat foot" as the collapse of a mechanical arch—one which depended on the shape of the bones and the strength of the supporting ligaments. I thought this conception, a vitally wrong one for men in practice, would die with the generation which held it, but in this I find myself mistaken.'<sup>2</sup> These were the words of Prof. Sir Arthur Keith, distinguished scientist and one-time curator of the museum of the Royal College of Surgeons of England, and they were spoken during his reading of the third H. O. Thomas Memorial Lecture in Liverpool on 11 May 1928. It is questionable whether they are any less valid today.

The arches of the foot are two-fold, i.e. the longitudinal arch which extends from heel to head of hallux metatarsal, and the transverse arch which spans the metatarsals.

The longitudinal arch conforms to no structural standard, neither does its height constitute an index to its integrity or its functional efficiency. An appreciation of this fundamental concept is basic to the understanding of the foot and its problems, for it serves to explain the apparent anomaly of the foot of the highly-trained ballet dancer, which may be 'flat' yet capable of the most exacting and, at the same time, pain-free physical performances (Fig. 1). In direct contrast, the congenitally high-arched foot which displays a longitudinal arch of undoubted excellence, is often associated with the symptoms normally attributed to 'flat foot' (Fig. 2).

The joints of the foot of the ballet dancer are supple, and their capsular ligaments permit of a greater range of movements because of the assiduous training to which the foot has been subjected during the early, plastic phases of its development. The congenital high-arched foot has not enjoyed the same advantages, and the taut plantar ligaments are a potent pain-producing factor.

'Nature never uses ligaments as prime supporters in the structure of the animal body; always muscles are used for the purpose. Ligaments serve only as safeguards; they come into action only when the muscular defence has broken down. Not even the anterior ilio-femoral ligament of the hip joint is an exception to this rule. The ligament under the head of the astragalus—the inferior calcaneoscaphoid ligament—carries superincumbent weight only when the reflex defensive mechanism of the tibialis posticus has broken down.'<sup>2</sup>

It follows that while the reflex defensive mechanism of the muscles of the foot remains normal and uninhibited, function is both smooth and painless; and that when the muscles are ineffective, the ligaments are subjected to abnormal stresses and strains which give rise to pain and the symptoms of incipient flat foot. Clearly, the term 'foot strain' which is both accurate and descriptive, could with advantage replace the hackneyed term 'flat foot' during the incipient stages of the breakdown, while the latter term could with justification be applied to the advanced case with flattening of the longitudinal arch, rigid, osteoarthritic mid-tarsal joints, and valgus (pronation) deformity.

The transverse metatarsal arch is of transitory appearance only. It owes its existence largely to the dorsal interossei which draw the 3rd, 4th and 5th metatarsals towards the 2nd metatarsal, and pull each successive head into a plane below (plantar to) that of its more mesial neighbour.<sup>3</sup> The metatarsals assume the form of an arch during the latter portion of the support phase of walking, when the digits are pressed against the ground, while the heel is lifted from the supporting surface in order to initiate forward propulsion. The arch does not maintain its curve during standing, nor does it exist during the first part of the supporting phase of walking. The footprint which depicts the 'collapse' of the metatarsal arch, is in fact a normal phenomenon.

It is timely that the importance and the value of the muscles of the foot be re-emphasized, for it is in their preservation and development that the solution to the problem may be re-discovered.

## THE INTRINSIC MUSCLES OF THE FOOT

Only the intrinsic muscles will be considered, because they appear to hold the key to the solution.

In the foot, unlike the hand, the intrinsics are responsible for a group action which has a triple purpose, namely, the support and the strengthening of the longitudinal arch, the bracing of the metatarsal heads in order to form a fulcrum upon which the digits flex, and the initiation of the act of walking by flexing the digits at the metatarso-phalangeal joints and squeezing the toes against the weight-bearing surface.

To these ends evolutionary changes include the transference of the origin of the flexor digitorum brevis muscle from the tendon of the flexor digitorum longus to the inferior surface of the os calcis, and the development of the abductor hallucis which in man has become stronger than in any ape but which, because man's big toe can no longer be abducted, is devoted to the purpose of the alignment of the phalangeal part of the digit. The abductor hallucis is assisted in the latter important function by both the flexor hallucis brevis which has attained a characteristic strength and power, and the oblique part of the adductor hallucis, the transverse part of the latter muscle having undergone an evolutionary retrogression.<sup>2</sup>

Levick stated in 1921: 'The role played by the flexors of the toes (especially the flexor brevis hallucis and the flexor brevis digitorum) in supporting the longitudinal arch of the foot was a very important one, because when the weight of the body was thrown forward onto the toes with the heel off the ground, the action of both the long and the short flexors was

to draw the heel towards the toes, acting as a bow-string across the arch from heel to toe.<sup>3</sup>

The evolution of the human foot forms a subject of absorbing interest and the reader is referred to the appropriate literature. Suffice it to stress the fact that the human foot has been adapted to meet the demands of plantigrade, terrestrial as opposed to pronograde, arboreal progress. 'The foot is a postural structure; it cannot undergo any change of an advantageous kind unless every other structure in the body, which is concerned with the maintenance of posture, undergoes a harmonious alteration at the same time . . . no one who has followed the researches of Sir Charles Sherrington . . . can doubt that if we are to understand how the foot of man and of ape has become modified for utility's sake, then attention must first be directed to its prime movers—its muscles.'<sup>2</sup>

#### ABUSES OF THE FOOT

' . . . probably there are few who have any real regrets that their feet are hidden from the sight of their fellows by being encased within their boots.

'Our lives would not gain much in aesthetic pleasure did we all go barefooted as do some of the happier sections of mankind (Fig. 3) for the booted foot of the so-called higher races has a justifiably shamefaced appearance when deprived of its wonted covering. Once babyhood is passed, there is little that is particularly pleasing in the appearance of most people's feet.'<sup>1</sup>

The foot of the middle-aged matron serves as an outstanding example (Fig. 4). It is a foot familiar to us all; it is characterized by bunions, claw toes and callosities, and by intrinsic muscles the atrophic degeneration of which may be attributed to a number of factors.

#### Causes of Degeneration of Intrinsic Muscles

1. *Footwear*, which is ill-designed and ill-fitting. Ladies' fashions have dictated the form of footwear throughout the ages, and modern shoes differ in few respects from those found in tombs of the pre-Christian era. The small, high-heeled, sharp-pointed shoe has the advantage over all others of elegance; some of its disadvantages are clearly seen in the accompanying illustrations (Fig. 5). It will be noted that superincumbent body-weight bears down upon the toes, that the toes are bunched together so as to conform to the shape of the shoe, and that there is hyperextension at the metatarso-phalangeal joints of the digits. Flexion at these joints has been rendered a physical impossibility.

2. *Modern hose*. Close-knit hose exercises a somewhat cryptic form of constriction on the feet, but a constriction no less real because it is unsuspected. Once more, the dictates of fashion are accorded top priority.

3. *Excessive body-weight*. When the superincumbent body-weight is regarded as the hammer, the foot is the wedge which is driven tightly into its constricting footwear. Ischaemia is the inevitable result, with claudication which compels the individual to rest a while and to kick off her shoes in order to gain relief. Inability to do so for the moment, wrings from the lips of countless female 'martyrs' at all social levels the cry of 'my feet are killing me'.

4. *Lack of exercise and foot hygiene*. 'Many take real delight in the appearance of their hands and find aesthetic pleasure in regarding the hands of others. . . . That anyone should praise the perfections of the human hand at the expense of the human foot is an absurdity.'<sup>5</sup>

Manicure enjoys the expenditure of time, money and energy on an enormous scale; pedicure is a subject about which the masses display astonishing and pathetic ignorance.

#### INTRINSIC-MUSCLE ATROPHY

It is claimed that functional paralysis followed by atrophy of the intrinsic muscles of the feet is the factor responsible for the great majority of foot complaints in middle-aged females. The claim may be supported by a consideration of the deformities associated with intrinsic paralysis from other causes, and by a demonstration of the fact that the clinical picture is the same, irrespective of the aetiological factor.

Poliomyelitis is not infrequently associated with paralysis of the small muscles of the feet, whose innervation is derived

from the 1st, 2nd and 3rd sacral segments. The insidious deformity which follows (Fig. 6), gives rise to a foot indistinguishable from that of the middle-aged matron.

Leprous involvement of the peripheral nerves of both the upper and lower extremities at below-elbow and below-knee level results in intrinsic-muscle paralysis without, and sometimes with, involvement of the long muscles. Bunions, claw toes and callosities are encountered in severe degree (Fig. 8), and while the final picture is complicated by the presence of trophic ulcers and loss of digits, the initial deformity bears a close resemblance to the feet which are the subject of this presentation.

Traumatic division of the 1st, 2nd and 3rd sacral roots, confirmed at operation, was the aetiological factor in one case in this series; the foot on the ipsilateral side developed the characteristic deformity associated with intrinsic palsy (Fig. 9).

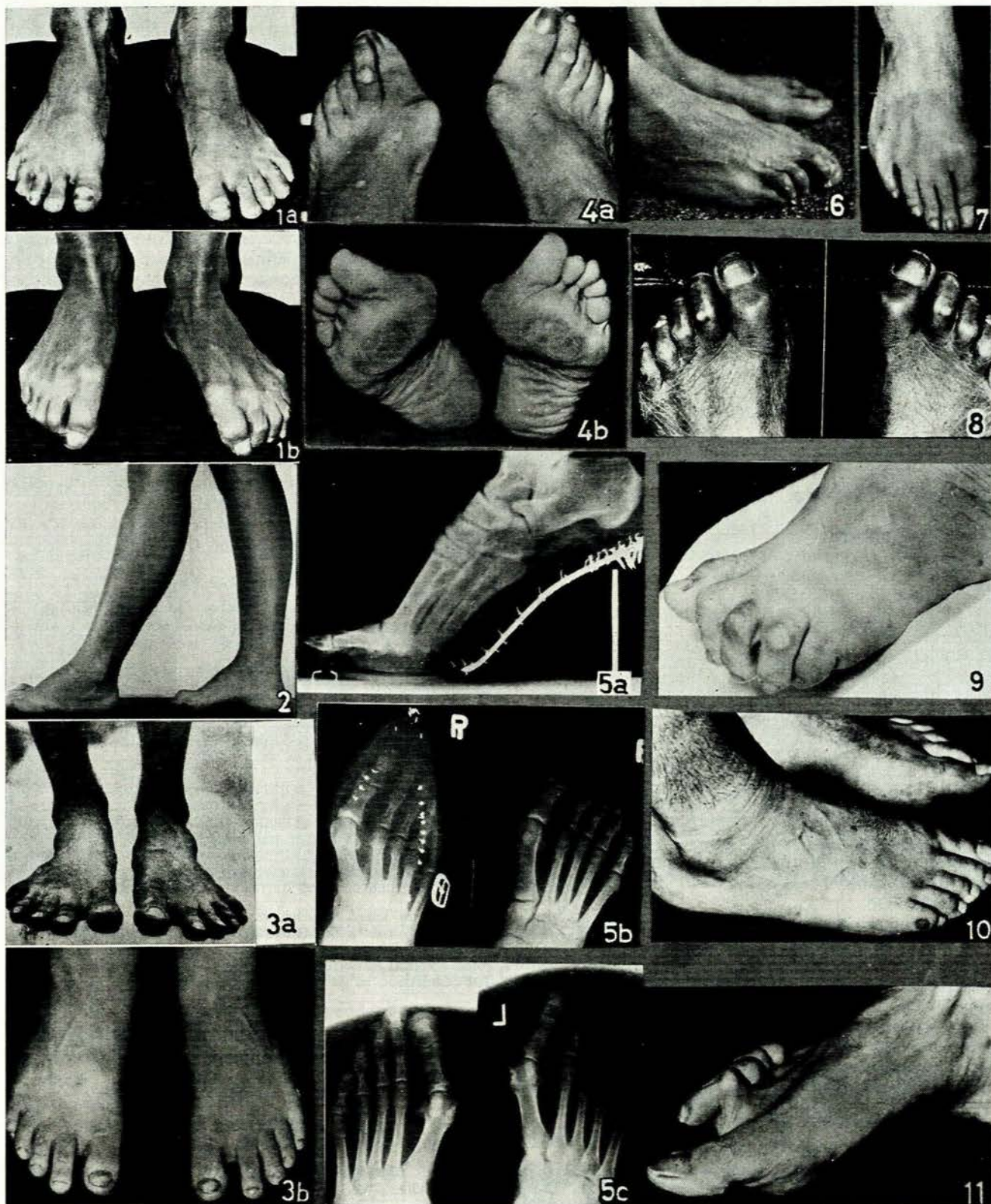
Finally, let us consider the severe claw-toe deformity which is a frequent concomitant of congenital pes cavus (Fig. 11). Pes cavus is usually associated with shortening of the tendons of the long extensors of the digits, as a result of which flexion at the metatarso-phalangeal joints is prevented. A characteristic hyperextension deformity develops, with hyperflexion at the proximal interphalangeal joints. The intrinsic muscles are stretched to their limits and are functionally disabled; persistence of this functional disability gives rise to structural alterations with eventual atrophy of the intrinsic muscles.

In sharp contrast, preservation of the function of the intrinsic muscles of the foot when combined with paralysis of the long muscles of the digits (appearing in one patient as a post-laminectomy phenomenon), was associated with the retention of a foot with a strikingly normal, outward appearance (Fig. 7). The patient developed a drop-foot deformity which required the permanent use of a surgical appliance. The digits remained completely free from deformities.

#### FURTHER DEFORMING FACTORS

The insidious nature of the onset of certain foot deformities has already been stressed, and functional disuse of the intrinsic muscles has been advanced as the principal aetiological factor. Undoubtedly, there are others, not the least of which is the position of subluxation in which the metatarso-phalangeal joints are held by ill-fashioned, ill-fitting footwear. The base of the proximal phalanx of the hallux is subluxated in both a lateral and a dorsal direction (Fig. 5), while those of the other digits are

*Fig. 1 (a & b)*. The feet of a prima ballerina. Although apparently 'flat' when relaxed, they enjoy the support of powerful and effective intrinsic muscles. The arches are readily constituted by voluntary effort. *Fig. 2*. High-arched feet (congenital) which, despite the presence of well-formed arches, were associated with the symptoms of 'flat feet' (Note claw toe deformities). *Fig. 3 (a)*. 'Dorsal view of weight-bearing feet of a Bago-bo, showing toe separation, adduction of great toe and minute folds in skin.' Unquestionably, these are happy feet. (Photo by courtesy of the Editor, *Journal of Bone and Joint Surgery*, American volume.) *3 (b)*. The healthy feet of a 10-year-old White boy. They bear a strong resemblance to those of the primitive tribesman. The convex medial margin of the healthy feet should be noted. (The convexity becomes a concavity in pathological flat feet.) *Fig. 4 (a & b)*. The feet of a middle-aged matron, showing the effects of abuse, and of the use of ill-fitting footwear over a period of many years. Note the typical rotation deformity of the hallux, and the extension of the digits at the metatarso-phalangeal joints. *Fig. 5 (a)*. Radiograph of a female foot, weight-bearing in a high-heeled shoe. The hyperextension of the proximal phalanges relative to the metatarsals is well shown. *5 (b)*. Dorsal radiograph of the shod female foot, on left showing subluxation of the hallux metatarso-phalangeal joint, on the right the partial reduction of the subluxation when the foot is unshod. *5 (c)*. Chronic subluxation of the metatarso-phalangeal joint of the hallux—irreversible. *Fig. 6*. Post-poliomyelitic paralysis of the intrinsic muscles of the feet of a White adult male, with characteristic deformity due to intrinsic muscle paralysis. This illustration should be compared with those in Figs. 2, 4, 8 and 9. *Fig. 7*. The foot of a White adult male, in whom the intrinsic muscles are normal, while the long muscles of the digits together with the tibialis and the peroneal muscles are paralysed. There is a striking absence of deformity. *Fig. 8*. The feet of a leper, with paralysis of the intrinsic muscles and with characteristic hallux valgus and claw-toe deformity. *Fig. 9*. The feet of a White adult female, in whom there was traumatic division of the 1st, 2nd and 3rd sacral nerve roots. The patient is attempting to flex the toes at the metatarso-phalangeal joints, and is unable to do so. *Fig. 10*. The feet of a White adult male, following the Girdlestone-Taylor procedure for claw toes. The operation scars are well shown. The pre-operative appearance of these feet bore a strong resemblance to the feet shown in Fig. 11. *Fig. 11*. Congenital pes cavus with hallux valgus and claw-toe deformity associated with short extensor digitorum longus tendons.



subluxated dorsally. The hallux metatarso-phalangeal joint acts as a hinge and becomes a torque convertor joining two segments at an angle; rotation about the long axis of both segments automatically follows. In addition, there is chronic non-articulation of the medial and plantar aspects of the metatarsal head, with degeneration of the non-articulating surfaces (Fig. 5). The remaining digits display dorsal subluxation only of the base of the proximal phalanx relative to the metatarsal head. Osteo-arthritis and irreducible subluxation of the hallux and dislocation of the other digits, are the inevitable sequelae.

#### THE CARE OF THE FEET

The gradual manner in which structural deformities develop is the key to the solution, and the application of simple measures is effective and rewarding, both prophylactically and therapeutically.

*The care of the skin* of the feet requires prime consideration, for is it not true that on every working day the feet are subjected to the wear and tear of prolonged weight-bearing, wrapped up and entrained as they are in constrictive hose and footwear?

The care of the skin includes meticulous hygiene, self-administered massage of painful, pressure areas, the application of a soothing cream (lanoline) before retiring at night, and the use of a drying agent (methylated spirits) together with talc powder once, twice or even three times daily.

Next in order of importance, the advice of a medical practitioner should be sought in the event of hyperhidrosis, skin lesions which fail to heal, infections of the skin or of the nail folds, persistent pain of an unaccountable nature, or the threat of a developing deformity.

Thirdly, the performance of simple, active and passive exercises of the joints of the digits and foot should be undertaken for 5-10 minutes daily. The exercises are simple and they have a dual purpose — to retain the ability to flex the metatarso-phalangeal joints fully and strongly, and to forestall the development of contractures. Every joint is moved through its full range of movements during the course of the daily exercises. It is a strange, yet undoubted fact, that the digits of the normally shod individual, particularly the female individual, have become functionless appendages because of the position of mechanical disadvantage in which they are held during walking. It is to the restoration of the normal action of the digits, and to the exertion of firm pressure upon the supporting surface by the digits with every step in walking, that foot exercises are directed.

Finally, the choice of *footwear*. No useful purpose would be served by condemning out of hand all attractive types of shoes, for 'our lives would not gain much in aesthetic pleasure did we all go bare-footed as do some of the happier sections of mankind'.<sup>5</sup>

Footwear should be suitable to the occasion, and 'ultra' shoes which are elegant and the height of femininity, are both legitimate and desirable when appropriate. More comfortable and capacious shoes, which leave the digits

unentrained, are the obvious choice for shopping expeditions, while stout 'lace-ups' are needed for rambles in the country and across uneven territory. There is no need to wear stiletto heels with slacks.

Those whose feet are in a reasonably young and healthy condition, are advised to wear open sandals during the performance of household duties. Attractive designs in sandals are available, and the wearer enjoys that protection of the skin of the feet, which it is the sole, physical purpose of footwear to provide.

#### SURGICAL CORRECTION OF FOOT DEFORMITIES

It is not the purpose of this presentation to embark upon a discussion of those numerous operative procedures which have as their aim the correction of bunions and hammer toes. However, one operation will be specifically mentioned, namely, the Girdlestone-Taylor procedure for the reconstruction of the lumbrical and interosseous muscles.<sup>4</sup> The tendon of the flexor digitorum longus is divided near its insertion, then transposed to the dorsal expansion over the proximal phalanx of the digit. It takes up the position and assumes the function of the lumbricals and the interossei. At the same time, it removes a deforming factor at interphalangeal level. I have performed this operation on many occasions during the past 12 years, with results which have been very gratifying: it has 'redeemed' a number of feet which were otherwise 'doomed' to a remorseless process of deterioration (Fig. 10).

#### SUMMARY AND CONCLUSIONS

Atrophy of the intrinsic muscles of the feet is cited as the prime factor in the production of foot disabilities and deformities encountered among civilized races, particularly among female members.

It is claimed that the atrophic changes in the feet are caused by ischaemia of the intrinsics, and by the functional disuse which is imposed upon these muscles by the wearing of ill-fitting, ill-designed footwear. Yet another factor is the unjustified lack of pedicure (as opposed to manicure), particularly when due consideration is given to the daily demands which are made upon the feet.

The atrophic feet of abuse are compared with feet in which intrinsic paralysis has been caused by organic disease processes such as poliomyelitis and leprosy. *There is no essential difference in the appearance of the deformities.*

The gradual nature of the onset of the deformities is stressed, and remedies are suggested for their prevention as well as for their reversal during the early stages.

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