



Biomechanical foot function: a Podiatric perspective

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Introduction:

Bipedal upright locomotion is one of the defining characteristics of the human race, yet it is so often taken for granted. The feet are essentially the foundation for the rest of the body and are literally pivotal in allowing us to walk efficiently. Understanding normal function is a fundamental part of assessing dysfunction and effectively treating patients. However, an understanding of the basic underlying structure is essential. This paper intends to describe some of the current concepts relating to foot function from a podiatric perspective. Having developed these concepts, Part 2 will describe how abnormalities may result in dysfunction and pathology. An attempt has been made to provide tests that enable the reader to gain a basic understanding of foot function. Some of these tests have a clinical value when assessing patients. Part 2 (to be published in a future issue of What's Afoot) will describe in more depth the consequences of abnormal findings.

Anatomical structure and function

In the 1950s Hicks produced two papers that described basic osseous and soft tissue function of the foot (Hicks 1953, 1954). In the first paper, he concentrated on the osseous structures of the foot, primarily the subtalar joint (STJ), mid-tarsal joint (MJT) and the metatarsophalangeal joints (M.T.P.Js) (see Fig.5).

Hicks (1953) demonstrated by the use of rods and pointers that joints rotated around axes rather like the hinge of a door and that, because these axes are angulated against the primary body planes, motion will occur in more than one plane.

The STJ exhibits tri-planer motion where pronation is represented by eversion, abduction and dorsiflexion whilst supination is represented by inversion, adduction and plantarflexion (See Test 1).

The MTJ actually consists of the talo-navicular joint (TNJ) and the calcaneo-cuboid joint (CCJ); the combined motion of these two joints allows tri-planer motion (Test 1). In addition

to the STJ and MTJ, the 1st and 5th metatarsals also have their own axes of motion, primarily dorsiflexion and plantarflexion (Test 1).

These motions of the STJ, MTJ and metatarsals are all essential to allow normal foot function and are interlinked. If the foot were a rigid structure then pronation of the STJ (evident by eversion of the calcaneus) would cause the lateral border of the forefoot to lift off the ground. Similarly, supination (evident by calcaneal inversion) would result in the medial aspect of the forefoot lifting off the ground. This clearly does not happen during walking and this is because of the compensatory mechanisms that can occur in the mid-tarsal and forefoot. Namely, pronation results in MTJ inversion, 1st metatarsal (1st ray) dorsiflexion and 5th metatarsal plantarflexion. The opposite is true with supination (Test 2). Thus, the foot is able to adapt to varying positions enabling locomotion over uneven surfaces whilst maintaining balance. Hicks postulated that rigidity in the mid-tarsal area would result in a loss of balance.

In his second paper, Hicks (1954) described the role of the plantar aponeurosis (fascia) in stabilization of the foot. The fascia originates from the plantar aspect of the calcaneus and inserts via the plantar pad and the flexor apparatus into the base of the proximal phalanges of the digits. As a result, he likened the fascia to a windlass mechanism with the fascia the cable, the metatarsal heads the drum and the toes the arms. Thus, dorsiflexion of the digits results in a tightening of the windlass mechanism which in turn results in plantarflexion of the metatarsals. As this effect is greatest at the 1st metatarsal, there will be a relative inversion of the foot, thus the arch will rise and the leg, via the STJ, will externally rotate. This function actually occurs in the latter part of stance as the foot dorsiflexes over the stable toe and will help provide intrinsic stability to the foot (Test3).



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In 1979, Bojsen-Moller described how the metatarsal axes would effect foot function. He described two axes, namely the oblique or low gear axis represented by the 2nd-5th MTPJs, and the transverse or high gear axis represented by the 1st and 2nd MTPJs (Fig. 1). He observed two basic types of toe-off, namely low and high gear. When a subject demonstrated toe-off through the high gear axis (i.e. 1st and 2nd MTPJs) he observed that the plantar fascia and peroneal tendons were tight and that the 1st MTPJ was dorsiflexed. This suggests that the windlass mechanism described by Hicks (1954) is active. As a result, the 1st ray will be plantarflexed and stabilized against the ground by peroneus longus. In addition, the tension in the peroneus longus tendon will cause a rotation at the cuboid (as this is its fulcrum point) thus further stabilizing the mid-tarsal area. In contrast the soft tissue structures were not taut with a low gear toe-off (i.e. through the 2nd, 5th MTPJs) and the hallux was plantar flexed to help stabilize the medial aspect of the forefoot. Thus, the stabilizing effect of the windlass mechanism and the peroneus longus are lost.

Podiatric concepts:

In 1977 Root et al described their concept of normal and abnormal foot function. This primarily revolved around the position and function of the STJ, MTJ and 1st ray. They described a neutral foot position such that the foot is in its neutral position when the subtalar joint is in neutral (neither supinat-

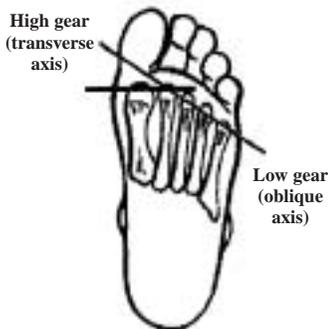


Fig 1. The high gear (metatarsals 1-2) and low gear (metatarsals 2-5) axes as described by Bojsen-Moller (1979)

ed nor pronated) and the midtarsal joint is maximally pronated.

They further proposed that the posterior bisection of the calcaneus and the lower one-third of the leg would be parallel and at a right angle to the weight bearing surface and that the plane of the metatarsals (forefoot) would be parallel with the weight bearing

surface when the foot is in this neutral position (fig. 2).

In order to assess these osseous alignments there are several methods of placing the foot into its neutral position. The first stage is to place the STJ into neutral. Root et al (1997) postulated that two-thirds of the range of STJ motion would be in supination (as indicated by calcaneal inversion) with one-third in pronation (as indicated by calcaneal eversion). Thus, by measuring the total range of motion and performing a simple calculation, the relationship of the heel to the leg in STJ neutral can be obtained. However, some research has indicated that, whilst the average STJ neutral demonstrates a one-third to two-thirds ratio, there is considerable variation amongst normal subjects (Bailey et al 1984). Furthermore, the repeatability of these measurement techniques, particularly between examiners (inter-tester), is extremely poor and therefore questions the validity (Weiner Ogilvie et al 1997).

An alternative technique of placing the STJ into neutral is via

Test 1.



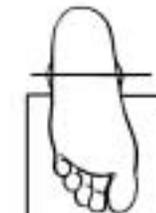
Have your patient lay prone with the feet hanging over the end of the examination couch. Flex the hip and knee on the side you are not examining and externally rotate this leg as shown in the diagram (A) so that it rotates the leg you are examining. You should aim to rotate the leg sufficiently so that the malleolar axis is parallel with the floor (B). This places the heel of the foot in the frontal plane. Now grasp the 4th and 5th toes with your thumb and

index finger (C) and take foot through a pronation and supination movement. Note how the heel inverts with adduction and plantarflexion (supination) whilst heel eversion is associated with abduction and dorsiflexion (pronation). Now fix the subtalar joint with one hand and repeat the motion. Note how the forefoot moves on the fixed rearfoot. Now hold the 2nd to 5th metatarsals in one plane with the thumb and index finger of one hand. Then grasp the 1st metatarsal with the same fingers of the other hand and you will be able to dorsiflex and plantarflex the 1st metatarsal in relation to the lesser metatarsals (D). Compare the amount of motion in each direction. This test can be repeated for the 5th metatarsal.

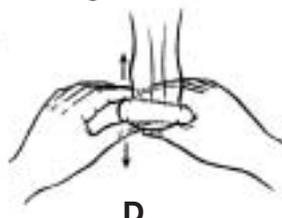
A



C



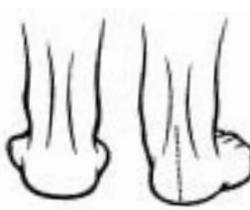
B



D



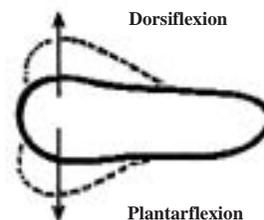
Supination=
inversion,
adduction,
plantarflexion



Pronation=
eversion,
abduction,
dorsiflexion

Objectives:

- to rotate the leg so that the heel can be viewed in the frontal plane
- to examine the range of supination and pronation which should have a ratio of 2:1 respectively
- to examine the range of forefoot motion
- to examine 1st and 5th ray motion. There should be equal amounts of dorsiflexion and plantarflexion
- to enable the practitioner to estimate the quality and direction of motion available and thus the effects on function that may be caused by increased or reduced motion



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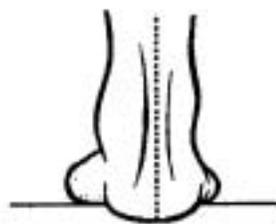


Fig 2. The neutral position described by Root et al (1977) whereby the posterior bisection of the lower one-third of the leg and calcaneus are parallel and at the right angle to the supporting surface. The plane of the metatarsals is parallel with the supporting surface.

palpation of the head of the talus. The practitioner places the thumb and forefinger on the medial and lateral aspect of the head of the talus. The STJ is then taken through its range of motion with the medial aspect of the head of the talus prominent with STJ pronation, whilst the lateral aspect of the head is prominent on STJ supination. Neutral is achieved when neither aspect of the head is prominent. This technique clearly causes problems when there are variations in anatomy or any soft tissue swellings present.

It has been this author's clinical observation that, when the foot is placed into the frontal plane and allowed to hang with gravity, the relationship of the calcaneus to the leg is extremely close to the palpated or calculated STJ neutral position. This would therefore appear to be a simpler way for many practitioners to perform the assessment. Indeed, there would be some logic in this assumption as all the osseous and soft tissue structures around the STJ would be in equilibrium at this point and thus in their own form of neutral position.

Once STJ neutral has been achieved, pressure beneath the 4th and 5th metatarsal heads to maximally pronate the MTJ is required to place the whole foot into neutral. However, this pressure should only be sufficient to pronate the MTJ and not the STJ. If any eversion of the calcaneus is observed once STJ neutral has been achieved, too much pressure has been applied to the forefoot (Test 5).

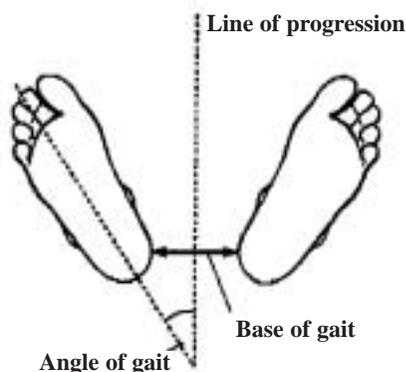
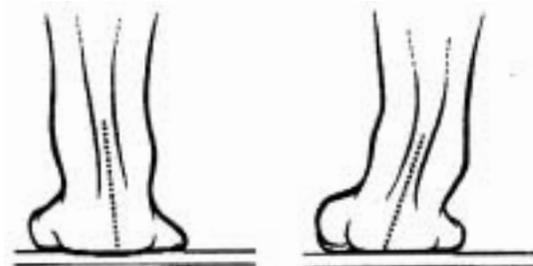


Fig 3. The angle the foot makes in relation to the line or direction of progression (angle of gait) and the distance between the two feet (base of gait).

Once the foot has been placed into neutral, the relationship of the heel to the leg (STJ position) and the plane of the forefoot to the rearfoot (as determined by a perpendicular to the bisection

Test 2.



A

B

Stand upright bare foot. Pronate your foot by internally rotating your leg. You will note that the heel everts (a) whilst the increased pressure on the inside of the ball of your foot causes the forefoot to invert and the 1st ray dorsiflex. Concomitant 5th ray plantarflexion occurs.

Now supinate your foot by externally rotating the leg and observe the opposite occurring (b). This test also demonstrates how internal and external leg rotation are converted by the subtalar joint into pronation and supination respectively.

Objectives:

- to demonstrate the effect of internal and external rotation of the leg on subtalar joint motion.
- to demonstrate the effect of subtalar joint pronation and supination on the midtarsal joint and metatarsals.
- to allow the practitioner to estimate the potential motion available for compensation for excessive motion of the leg and/or subtalar joint

of the posterior aspect of the calcaneus) can be assessed as either inverted, parallel or everted.

The position of the 1st and 5th rays can be assessed by examining the amount of dorsiflexion and plantarflexion of the metatarsals in relation to the central three metatarsals. The metatarsal being examined is placed in the same plane as the central metatarsals as a baseline. A greater degree of dorsiflexion than plantarflexion indicates a dorsiflexed ray whilst the converse represents a plantarflexed ray (Test 1).

The rearfoot position should be examined further with the patient standing. The patient is asked to take a few steps on the spot and then stop without re-adjusting to the foot position. This enables them to stand in the angle and base of stance, i.e. the feet have a similar position towards one another and the direction of progression as they would do during walking (Fig. 3). In this resting position, the angle the heel makes to the ground indicates the degree of compensation occurring and is known as the relaxed calcaneal stance position (RCSP). By placing the STJ into neutral, the overall neutral calcaneal stance position (NCSP) can be assessed. This position has the added advantage of introducing the tibial angle to the overall rearfoot position. By comparing the NCSP to the RCSP one has



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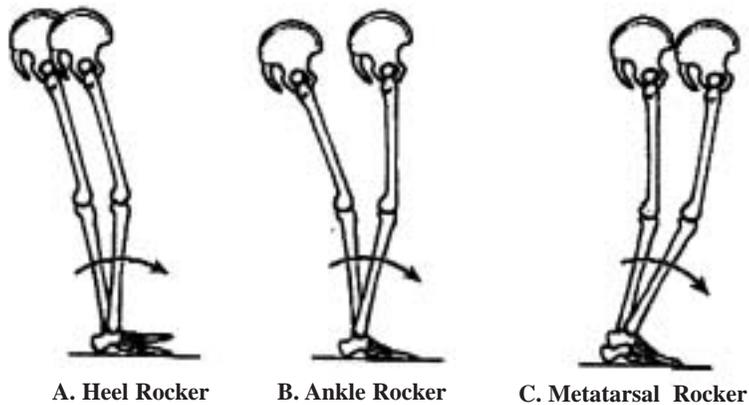


Fig 4. The heel (A), ankle (B) and forefoot (C) rockers which allow weight transfer during the support phase of gait (Perry 1992)

In 1986 and 1993, Dananberg described a sagittal plane model of foot and leg function. The basis of his concept was the pivotal nature of the weight bearing foot that has been described by Perry (1992). Essentially, the foot is a pivot over which the body is able to progress forward. Perry described a rocker system whereby there is weight transfer from the heel rocker to the ankle rocker and finally the forefoot rocker (fig. 4, Page 4). In order for this system to function effectively there must be ankle joint plantarflexion and associated knee and hip flexion following heel strike to foot flat (heel rocker). The ankle joint then dorsiflexes whilst the knee and hip extend during the ankle rocker phase. Thus, as the leg prepares for the forefoot rocker, the knee and hip are relatively extended to provide

an indication of the degree of motion that is occurring (Test 6). In the 1980s, Kirby described the position of the STJ axis in relation to the transverse plane of the foot (Kirby 1987, 1989). He described a method of palpating the plantar aspect of the foot to determine the position of the axis (Test 7). The STJ axis on the plantar aspect of the foot represents the point of equilibrium. Thus, any pressure applied to the sole of the foot medial to this axis will cause supination whilst pressure lateral to this axis will cause pronation. By determining the position of this axis on the plantar aspect of the foot, the practitioner is able to gauge the relative amounts of pronation and supination moments being placed across the STJ axis.

mechanical advantage for the hip flexors to accelerate the leg into swing. As the foot goes into the forefoot rocker phase, the MTPJs dorsiflex, the ankle joint plantarflexes and the knee and hip flex. The swing limb is then accelerated forward by the hip flexors until the weight of the limb passes body mass at which time momentum and gravity pull the body forward. This permits an efficient mode of function.

In order for the motion to be efficient, adequate 1st MTPJ and ankle joint dorsiflexion, normal knee and hip function, and equal leg lengths are required for a smooth transfer of the rocker system.

Test 3.

Have your patient stand upright and allow you to dorsiflex their hallux. As the MTPJ dorsiflexes, you will note a relative plantarflexion of the 1st ray with an increase in arch height, inversion of the heel and external rotation of the leg. This test is known as

the Great Toe Extension Test. Similarly, if you stand upright and go up onto the ball of your foot you will feel a similar motion occur. Now repeat the great toe extension test with the patient fully weightbearing. How much motion can now occur?

Objectives:

- to demonstrate the effect of the 1st toe dorsiflexion on 1st ray, arch, heel and leg motion via the windlass mechanism.
- to allow assessment of the effect of foot function on this mechanism when the test is repeated on a patient fully weightbearing. A failure for this mechanism to function may indicate abnormal function. When this occurs, yet there is a normal range of motion available at the 1st MTPJ, this is known as a function hallux limitus.



Muscle function:

Strength and flexibility of the associated musculature is extremely important. Contrary to popular belief, the majority of muscles function eccentrically, rather than concentrically, during walking. Therefore, their strength and flexibility in controlling motion is extremely important. If muscles are inflexible they will not allow normal function, whilst if they are weak they will be unable to control function. With particular reference to the foot, calf muscle inflexibility and tibialis posterior muscle function are important. Inflexibility of the calf muscle will limit ankle joint dorsiflexion whilst weakness of tibialis posterior will reduce the control it exerts on STJ pronation.

Root et al (1977) postulated that when the foot was placed in neutral there was adequate calf muscle flexibility if the foot could be dorsiflexed to 10 degrees past the right angle (Test 8).

While testing of the functional strength of the muscles acting around the ankle it is important the mechanical advantage of the tibialis posterior muscle and tendon should also be assessed (Test 9). It is not uncommon in patients who demonstrate severe pronation for the tibialis posterior tendon to become lengthened (attenuated). In these instances, mechanical advantage is lost. Because the tendo Achilles insertion is located close to the STJ axis this is unable to initiate inversion of the heel. However, the tibialis posterior tendon is the most medial tendon in the ankle and this is able to aid inversion. As the heel inverts, the tendo Achilles insertion becomes relatively medial to the STJ axis and therefore continues the inversion motion.

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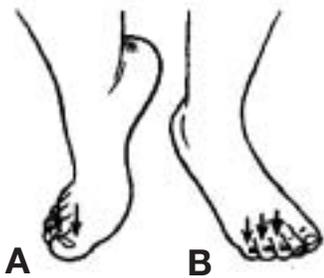
Test 4.

Stand comfortably in bare feet. On one foot, lift your heel and direct pressure through your 1st and 2nd metatarsal heads (high gear axis). You should feel that the 1st MTPJ is dorsiflexed, the 1st ray plantarflexed, the plantarfascia taut and your heel relatively in line with your leg. Now repeat the test but this time direct your weight towards your 2nd-

5th MTPJs. This time you should feel that your hallux is relatively plantarflexed thus preventing 1st ray plantarflexion, your fascia is not taut and your heel is inverted in relationship to the leg.

Objective:

- to demonstrate the effect of the metatarsal axes on foot position and function. Abnormal pressures beneath the metatarsal heads or an abnormal position of the heel may indicate abnormal function. This may be the result of an altered axis alignment, uneven metatarsal lengths or variations in the angle of gait (Fig.3).



Normal gait:

As previously described, the sagittal plane requirements for normal function as described by Perry and Dananberg. Root et al also describe normal foot function primarily relating to the frontal plane. They divided the walking cycle into the stance (weight bearing) phase and swing (non weight bearing) phase. The stance phase was further divided into heel strike, foot flat,

mid-stance, heel lift and toe-off. They describe how the heel would contact the ground slightly inverted but, due to ground reaction forces, the subtalar joint would pronate at foot flat. They believed this pronation aided shock absorption. However, because the other leg is in the swing phase, and therefore being accelerated forward at this stage, there must be an external rotation being placed on the weight bearing leg. This external rotation of the weight bearing leg will result in supination of the weight bearing foot. Thus, the supination of the STJ (as a result of the external rotation of the leg) will cause the foot to go from a pronated position through neutral to a supinated position. They postulated that the neutral position would occur in the middle of mid-stance (i.e. the point at which the malleoli are level). Pronation was thought to be required at foot flat to allow the foot to become mobile so that it could adapt to varying terrain, whilst supination at toe-off was required for the foot to be a rigid lever for propulsion.

However, more recent research has indicated that STJ remains pronated while the heel is in contact with the ground (McPoil & Cornwall 1994, Pierrynowski & Smith 1996). It would therefore appear that the external rotation of the weight bearing limb is not sufficient to overcome the pronation moment provided by ground reaction forces.

Combining the literature covered in this paper it would suggest that the following broad concepts are necessary for normal function.

1. Forward progression is caused by acceleration of the non-weight bearing limb and the momentum of body mass.
2. At heel strike, the heel rocker is active and the heel is relatively inverted in the frontal plane.
3. At foot flat, the body passes into the ankle rocker phase and the STJ is pronated by ground reaction forces.

Test 5.

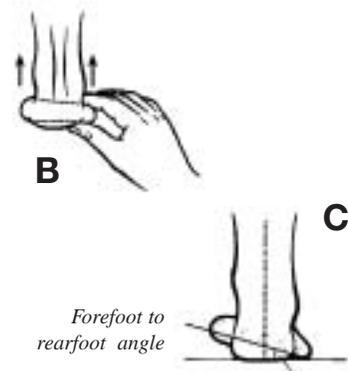
Place your patient in the position described in Test 1. This places the foot into the frontal plane and the position of the heel to leg will be extremely close to STJ neutral. Now grasp the 4th and 5th toes in the webbing with your thumb and forefinger. Gently plantarflex and distract the toes (to avoid any dorsiflexion at the MTPJs) (a) and dorsiflex the whole foot to resistance (b). Whilst you are doing this, observe the heel to leg relationship, to ensure that the STJ does not pronate (demonstrated by calcaneal eversion). Observe the angle of the heel to the leg, also observe the angle that the plane of the forefoot makes in relationship to a

perpendicular bisection of the posterior aspect of the calcaneus (c). This indicates the forefoot to rearfoot alignment. Once you have done this, increase the dorsiflexion force on the foot. You will note that the toes dorsiflex and the calcaneus everts past neutral. This indicates too much force has been placed on the foot and it is no longer in neutral. Thus, when increased force is placed on the lateral forefoot and the MTJ is maximally pronated as it was with the foot in neutral, then the only way the foot can allow further pronation is for STJ compensation.

Objectives:

- to allow the foot to be placed in neutral
- to allow assessment of subtalar joint position by the relationship of the posterior bisections of the leg and heel. If no subtalar joint abnormality exists, these lines will be parallel. If the heel is inverted or everted to the leg, abnormal function may occur on walking

• to allow assessment of the midtarsal joint position by the relationship of a perpendicular to the posterior bisection of the heel and the plane of the metatarsal heads. Again a parallel relationship is normal whilst inversion or eversion may result in abnormal function.



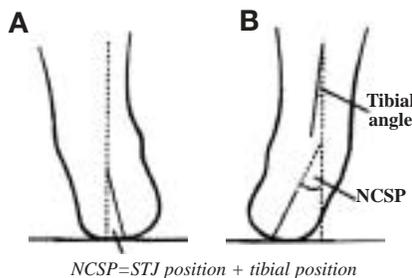
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Test 6.

Have your patient take a couple of steps on the spot. They should not readjust their foot position when they stop. Observe the angle the heel makes to the horizontal (a). This is the relaxed calcaneal stance position (RCSP) and will either be everted, zero or inverted. Now place the STJ into neutral. This can be done by either palpating the head of the talus as previously described or, more easily, by getting the patient to invert their foot until the angle the heel makes to the leg represents that which was observed when the foot was placed into neutral on the couch (test 5). The overall angle the heel makes with the horizontal now represents the neutral calcaneal stance position (NCSP) and will be either inverted, zero or everted (b). This angle may well be greater than the subtalar position observed on the couch because it includes the tibial angle which is often inverted (varus). Now ask your patient to relax their foot and observe the amount of motion that occurs from NCSP to RCSP.

standing position and thus the degree of compensation that is occurring in the foot on standing.

- to allow assessment of the neutral calcaneal standing position by including the subtalar and leg positions. Little data exist for normal values although these would tend to be within about 2 degrees to a perpendicular to the weightbearing surface. Greater values will require compensation in order to allow the foot to weightbear normally.



Observation:

- to allow assessment of the relaxed calcaneal

4. As the body progresses through the ankle rocker phase pronation is maintained but the knee and hip extend while the ankle joint dorsiflexes.

5. As the body passes into the metatarsal rocker the MTPJs dorsiflex, the ankle joint plantarflexes and the hip and knee begin to flex as the hip flexors start to accelerate the leg. The MTJP dorsiflexion initiates the windlass mechanism and this combined with the high gear toe off, facilitates a stable base for toe off.

II Postural compensatory process. JAPMA 83(11): 615-624 Hicks JH 1953 *The mechanics of the foot, Part I. The joints, Journal of Anatomy 88: 25-31* Kirby KA 1987 *Methods for determination of positional variations in the subtalar joint axis. JAPMA 77(5): 228-234* Kirby KA 1989 *Rotational equilibrium across the subtalar joint axis, JAPMA 79(1): 1-14* McPoil T Cornwall MW 1994 *Relationship between subtalar joint neutral position and pattern of rearfoot motion during walking. Foot & Ankle 15(3): 141-145* Perry J 1992 *Basic functions. In: Perry J (ed. Gait Analysis: Normal and Pathological Function Slack, Thorofare NJ) Pierrynowski MR Smith SB 1996 Rearfoot inversion/eversion during gait relative to the subtalar joint neutral position. Foot & Ankle 17(7): 406-412* Root ML Orien WP Weed JH 1977 *Clinical Biomechanics: Normal and Abnormal Function of the foot, Vol 2. Clinical Biomechanics Corp Los Angeles Weiner Ogilvie S Rendall GC Abboud RJ 1997. Reliability of open kinetic chain subtalar joint measurement. The Foot 7(3): 128-134.*

These concepts enable a basis for evaluating function (Test 10).

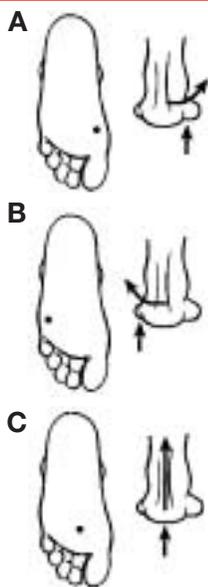
Conclusion:

There is much literature relating to normal and abnormal foot function and gait. By reviewing some of the literature available, and determining fairly simple clinical tests, it enables the clinician to form a basis about which to assess and treat patients. It is clear that more research is needed for us to fully understand normal foot function. In the second paper these concepts will be reviewed and related to abnormal function. Methods of treatment and further areas of investigation will be covered.

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Test 7.



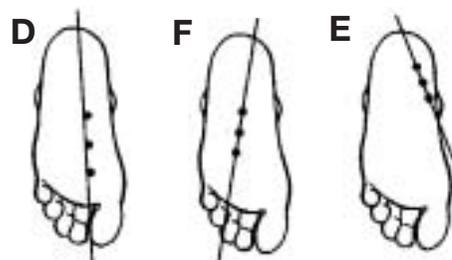
Place your patient into the position described in Test 1. Place the foot into neutral and place a dorsiflexion pressure on the 1st metatarsal head (a). In a normal foot, you will observe inversion of the heel (supination of the foot). Now move laterally across the foot but in the same line and repeat the force (b). This time you should observe eversion of the heel (pronation). Keep repeating this test until you find a spot between these two points at which the heel does not invert or evert (c). This represents the point of equilibrium and

Observation:

- to allow assessment of the position of the subtalar joint axis on the plantar aspect of the foot. A normal axis position will facilitate equilibrium of the bony and soft tissue structures acting on the foot. Deviation of the axis will alter the equilibrium and therefore foot function.

A medially deviated axis (e) or laterally deviated axis (f) are demonstrated.

thus the STJ axis. Now move slightly proximally and repeat the test again. When you find the point of equilibrium move proximal one more time and repeat the test. This should leave you with three points of equilibrium that can be joined in a straight line (d) This represents the STJ axis in relation to the transverse plane of the foot. In a normal foot, the axis will lay between the 1st and 2nd metatarsal heads.



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Test 8.

Place the foot into neutral as previously described (Test 5). Now maximally dorsiflex the foot whilst preventing STJ pronation. Observe the angle the lateral aspect of the foot makes in relationship to the leg (a) as this will indicate the degree of gastrocnemius muscle flexibility. Some patients have increased motion in the mid-foot that allows the forefoot to dorsiflex. If this occurs then the angle that the lateral aspect of the heel makes to the leg is the relevant factor (b). Similarly, some patients have a forefoot equines whereby the forefoot is plantarflexed on the rearfoot (c) Whilst the overall angle that the lateral aspect of the foot makes to the leg is relevant in this case, the presence of a forefoot equines should be noted. Now repeat this test with the knee flexed to assess soleus muscle flexibility.

A simpler method of assessing ankle joint dorsiflexion in the clinic is to have your patient

stand on a 15 degree slope with the feet slightly adducted. If adequate dorsiflexion is available they will be able to stand upright. If inadequate motion is available then the patient will have to lean forward to maintain balance.

Objectives:

- to allow assessment of the functional flexibility of the gastrocnemius muscle with the foot held in neutral position. Normal motion should allow for 10 degrees past a right angle. If less motion is available, the leg will not be able to advance over the foot during walking and compensation will be required. This may take the form of genu recurvatum, early knee flexion, early heel lift or pronation at the subtalar joint.

- to allow assessment of the

presence of a forefoot equines. There are no normal values, but this angle becomes relevant when it exceeds the heel cant of the shoe (the angle caused by the heel height of the shoe). This will require ankle joint dorsiflexion and have a similar effect to gastrocnemius inflexibility.

- to allow functional assessment of soleus muscle flexibility. A further 20 degrees of flexibility should be available. Similar compensations can occur to gastrocnemius inflexibility but tends to be more relevant during running.

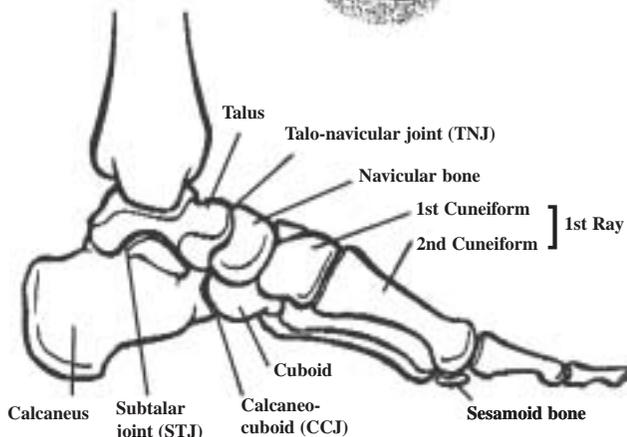
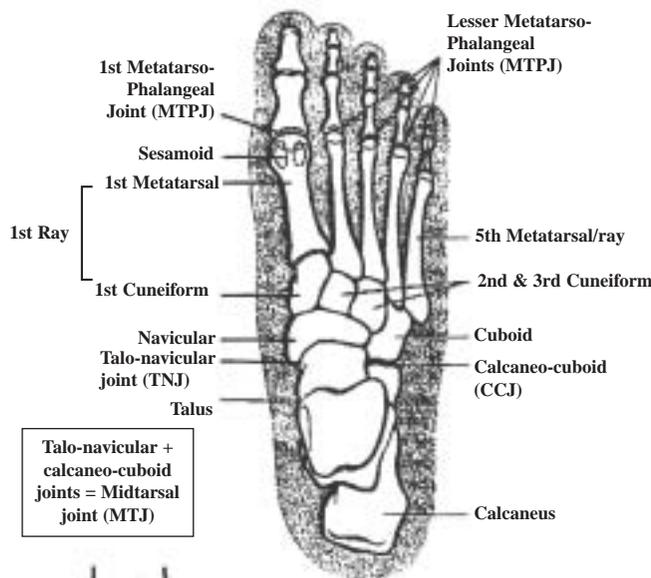
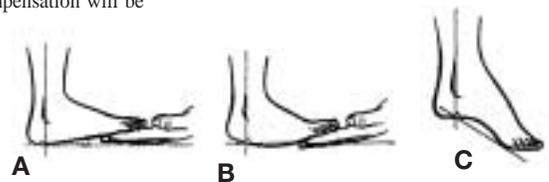


Fig 5. A diagram of the foot in a dorso-plantar (top) and lateral view to describe the anatomical landmarks.

Test 9.

Have your patient stand on one leg. They may rest their hand on something for balance. Ask them to lift their heel so that they stand on tiptoes. As they do this, observe the heel.

If the tibialis posterior tendon is functioning correctly, the heel will invert. Attenuation of the tendon is indicated if the heel lifts yet does not invert. In some cases, the patient is unable to lift the heel from the ground.

Objective:

- to assess the function of the tibialis posterior muscle and tendon. A failure of heel inversion following heel raise indicates dysfunction. This would indicate some damage to the tendon which in more chronic/severe cases may seriously inhibit function.

Test 10.

Walk along a corridor barefoot. At first concentrate on the rocker phases of gait and the pivotal motion this encourages. You should feel first your heel, then your ankle and then your MTPJs functioning. Once you have grasped these motions, concentrate on the relative positions of your knee and hip. Do your knee and hip extend towards the latter part of stance? Next, concentrate on

the frontal plane position of your foot. You should note pronation in the earlier stages with re-supination and initiation of the windlass mechanism towards toe-off. Once you have grasped these concepts see how walking with shorter and then longer steps varies these motions. You will now be in a position to observe somebody else walking.

Objectives:

- to allow the practitioner to assess the three rocker phases of the stance phase of gait.
- to allow the practitioner to assess the position of the knee and hip during this cycle.
- to allow the practitioner to assess the relative position of the foot during this cycle.
- to allow the practitioner to assess how variations in step length affect these functions.