# Part 2 - The Foot

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AiM

**Anatomy in Motion (AiM) has allowed us to study the human foot in motion and connect it to the rest of the body. AiM has been expressed by many as breaking the mould of anatomical thinking by offering an alternative perspective and this, together with its key principles and laws of motion, was discussed in the previous article.**

**We now move on to AiM's approach to observation of the foot, which will help simplify and enhance the understanding of biomechanics.**

AiM adopts a structural approach where we choose to work on the structure and organisation of the bones and joints regardless of the symptoms. Pain symptoms will not normally be able to exist where optimal movement is present (e.g. if your pelvis is level and has optimum movement, lower back pain symptoms will not occur.)

This contrasts to other approaches to studying and treating anatomy, such as:

- Symptom based approach where solutions are provided for certain symptoms
- Open chain (non-weight bearing) observations – i.e. assessing the patient whilst they are sitting in the chair in front of you.
- Closed chain (weight bearing) observations - i.e looking at a patient in gait and stance positions.

Open chain and closed chain observations can show different ranges of motion, leading to confusion in how well structures are moving. AiM considers both aspects and any mixed messages become crystal clear when considering both isolated and integrated movement, for example when assessing a patient with hallux limitus.

This article will explore AiM's approach to assessing pronation and supination and explain the dynamic potential between these two resting positions.

## Key Principles

The foot has 26 bones and 33 joints all capable of moving in three dimensions. In order to maximise this potential, each joint must play its role in moving into a pronation and a supination shape. There are some key considerations when observing the foot in the closed chain to identify if it is a real possibility to achieve this optimal movement.

## The Human Foot is a Tripod

The body can be viewed as being made up of a number of triangles and tripods. This can be seen in multiple relationships between bones, muscle and tendon shapes throughout the body. This occurs because the triangle is the most stable structure to achieve balance in nature.

The tripod of the foot creates a stable base for us to stand upon and is marked by three specific bones on the sole - the calcaneus, the first metatarsal head and the fifth metatarsal head.

Without all three points at the base of this tripod being in contact with the ground, achieving a neutral foot is impossible.

In the absence of pressure in the first or fifth metatarsal head we can assume that pressure resides under the more central metatarsal heads, second and fourth (blue crosses in the diagram) or (in the case of the first metatarsal) under the hallux. *Clinical indicator: excessive points of callus around other metatarsal heads.* Any such adjustment away from the optimal three points of contact is limiting to the foot's movement potential and the patient will no longer be able to create the conditions required to pronate or supinate all of the bones in the foot.

An optimal tripod creates not only a stable base to stand on but also a broader pathway for the **Centre of Pressure** to pass through when we walk.

The less optimal the tripod, the narrower this pathway. This compromises the foot's movement and subsequently the movement of the body as it passes up through the kinetic chain. Plantar pressure in stance and gait are therefore important not just to the foot but a crucial indicator of the whole body's movement potential.

## Pronation and supination

Pronation and supination are the culminations of movement in three planes of motion (sagittal, frontal and transverse). Pronation occurs to lower the arches of the foot and create what is known as a ***mobile adaptor*** while supination forms a ***rigid lever*** as a result of the arches increasing in height.

Optimal movement of the foot is attained through the ability to both effectively pronate and supinate a foot. Pronation is therefore a critical and necessary part of the foot's motion and without it a foot is unable to find its optimal rest position. Unfortunately, pronation has a bad reputation due to the tension it places in the system and the valgus alignment it inflicts upon the body. However, it's important to state that only a foot that is stuck in pronation and unable to get out of it will suffer as a result of this tension. A foot that knows how to pronate and how to supinate out of that pronated position into a full rigid lever is in essence a healthy foot.

## Three arches

The foot has three arches: the medial longitudinal arch (MLA), the lateral longitudinal arch (LLA) and the transverse arch (TA). The MLA is often used to assess a foot's resting state and is the one most commonly referred to as the foot's 'arch'.

Whilst we are often encouraged to view higher arches as superior, it is possible that a foot with a lower arch can still have the potential to move well. It is also possible for a high arched foot to be limited in range and this ultimately can be a problem for the body as a whole, for instance a cavoid foot.

One key piece of appreciation for the arches is that in a healthy moving foot, all three arches rise and fall together.

- When the foot has access to its tripod and the three arches lower together, the foot bones are able to move into a pronation. Then when the three arches rise together, the foot bones are able to move into a supination.

When movement is compromised, medial pressure is exerted on the foot rather than nicely distributed between the three key points of contact.

**A simple assessment to see if the foot is using its tripod properly:**

When weight bearing, check to see if pressure is present under the first and fifth metatarsals by attempting to lift them off the ground

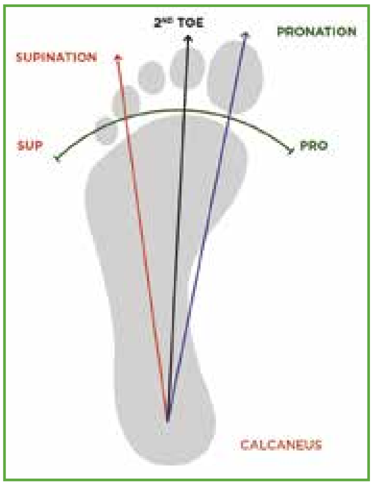
For example, in a healthy moving foot, never would the LLA rise as the MLA falls, as contact on the 5th metatarsal head would be lost. Clinical indicator: Excessive pressure/callus under the 1st MTPJ Likewise, when the first metatarsal is not in contact with the ground, sufficient plantarflexion of the first ray is compromised and a true supination cannot be achieved. Clinical indicator: Hallux limitus / Hallux abducto-valgus (HAV)

## Keystones

Like a roman arch, each of our three arches in the foot has a keystone and each keystone can be viewed as forming a triangle with each end of its arch. Its movement has a direct influence on the rest of the foot.

These three bones (talus, cuboid and second cuneiform) are useful to observe as the keystone's position at rest or in motion is useful for determining its role in supporting the movement potential of the foot.

### Talus




Observation of the talus can be utilised to quickly determine the resting state of the rearfoot. It's the bone that connects the foot to the rest of the body.

In neutral it would 'look along' the line of the second metatarsal. When pronating it would rotate medially to the second metatarsal and when supinated it would rotate laterally toward the outer toes. It may also be everted at rest.

### Cuboid

Narrower at the bottom than the top, the cuboid forms the central bone in the LLA and lateral border of the foot. It articulates between the calcaneus bone and the fifth metatarsal bone and performs a roll like action, flattening in a pronation and standing up tall "like a wall" in supination. Clinical indicator for restricted cuboid: Pain on the styloid process.

### 2nd Cuneiform

The second cuneiform sits in the middle of the foot at the top of the TA. Its ***triangular shape*** enables the narrowing of the foot as the foot supinates. During pronation the second cuneiform travels anterior and medially in space as it lowers to the floor and during supination it travels posterior and lateral in space as it rises upwards.

Bringing all of this together, if for example you see a resting foot that has a talus that is internally rotated, a cuboid that lies flat and a second cuneiform that lies anterior and medial to its neutral position you can see that it is pronated rather than in a neutral position. The more rigid a foot is whilst at rest, the less chance of achieving the necessary movements there are. The arch remains low, the tripod is compromised, tissues remain long and the potential for subsequent movement up the chain is limited. Clinical indicators of tissue stress: plantar fasciitis, morton's neuroma, medial compartment syndrome, tibialis posterior dysfunction.

## Finding centre in the foot

Centre is about the brain finding a rest position that allows movement equally in both directions. It is different to neutral as it implies the capacity to move to either side. It will vary from patient to patient (and over time) with true centre being the centre for a foot with optimised movement to both pronation and supination.

Any structure in the body, including the foot, must have an experience of its end ranges in order to find a central resting point between the two. Managed by the brain, the position of centre is chosen based on the bone, joint, muscle or structure's experience of the edge of its movement potential.

- True centre in the foot is only achievable when the tripod is optimised and the keystones are in the correct neutral position.
- It is the experience of both pronation and supination that enables us to determine where our own centre is.
- Treatment that allows the foot to access new joint motion will allow the brain to choose a new centre, resulting in a change in resting muscle length. Even the most rigid of feet will have the potential to access new joint motion.
- It's important to recognise for example that a right rotated pelvis impacts the centre of each foot pronating the left foot and supinating the right foot (or presenting less pronated than the left).

## Rearfoot, Forefoot and Phalanges

The next stage in using AiM to understand the motion of the foot and identify any restrictions is to use its Flow Motion ModelTM (FMM) to assess the foot in all three planes.

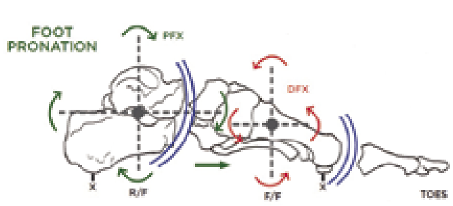
Within the FMM, the foot is divided into three sections, the rearfoot, the forefoot and the phalanges. The rearfoot includes the calcaneus and the talus, whilst the forefoot includes the midtarsal bones (excluding the cuboid) and the five long metatarsal bones.

To observe these sections, we break them down plane by plane. By understanding what should happen, we can then

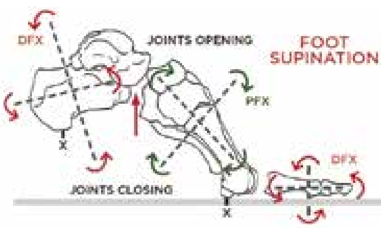
## Sagittal plane foot motion (side view)

| Pronation | Supination |
|---|---|
| • The Calcaneus tilts forwards with the pressure moving anteriorly under the heel bone - plantarflexion of the rearfoot bones.<br>• The lowering of the arch is representative of a forefoot dorsiflexion.<br>• As the rearfoot plantarflexes and the forefoot dorsiflexes, all three arches lower together.<br>• The second cuneiform is guided anteriorly.<br>• The articulation of the dorsiflexing metatarsals is to slide upwards inside the metatarsal phalangeal joints (MTPJ) and create a plantarflexion of the toes.<br>• This plantarflexion of the phalanges is insufficient for them to press down into the floor and lift the met heads up thus promoting the tripod. | • As the muscles contract from their lengthened position, the direction of movement in the bones is reversed.<br>• The plantar tissues pull the calcaneus toward the toes and the metatarsal heads back towards the heel bone causing a dorsiflexion of the rearfoot and a plantarflexion of the forefoot as the arch rises upwards, shortening the foot.<br>• The second cuneiform is guided posteriorly.<br>• This enables the distal part of the forefoot at the metatarsal heads to lower firmly into the ground, thus maintaining grounded contact of the tripod.<br>• The toes respond to the plantarflexing forefoot as the metatarsals slide downwards in the MTPJ facilitating a dorsiflexion of the toe.<br>• The result is an increase in arch height and a shorter rigid foot. |
| **The outcome of motion is that:**<br>• The bones begin to open the joint spaces on the plantar surface.<br>• The foot becomes longer as where joints open, muscles lengthen. | **The outcome of motion is that:**<br>• The bones begin to close the joint spaces on the plantar surface<br>• The foot becomes shorter as where joints close, muscles are contracting. |

The act of lowering the arches is priming the tissue for contraction from an eccentrically loaded position in order to contract or spring back in the opposite supinatory direction. The resultant increase in arch height from the tissue contraction and closing of the joint spaces builds to create a full supination and the rigid lever that is used for optimum propulsion.




*Pronation S plane*

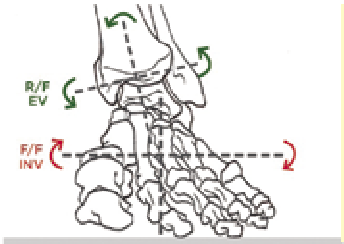



*Supination S plane*

| | Rearfoot | Forefoot | Phalanges |
|---|---|---|---|
| **Pronation** | PFX | DFX | PFX |
| **Supination** | DFX | PFX | DFX |

## Frontal plane foot motion (front view)

| Pronation | Supination |
|---|---|
| • The calcaneus tilts medially into eversion and encourages the pressure in the rearfoot to travel medial.<br>• Both the talus and the calcaneus move in the same direction of eversion, however the talus bone everts to a lesser degree than the calcaneus.<br>• The cuboid everts and flattens along with the calcaneal eversion.<br>• To avoid losing fifth metatarsal head contact as the weight-bearing rearfoot everts, a forefoot inversion must occur to maintain the tripod.<br>• The inverted forefoot is akin to a varus forefoot which will look like a flat foot when placed on the floor.<br>• The phalanges move oppositely to the forefoot, enabling the nail bed to keep facing upwards to the sky and minimise frontal plane roll. | • Contraction of muscles such as posterior tibialis and soleus draws pressure to the lateral side of the calcaneus and inverts the rearfoot.<br>• The calcaneal inversion pushes the talus back up toward neutral and beyond.<br>• The cuboid inverts to stand "tall like a wall".<br>• To avoid losing first metatarsal head contact as the rearfoot inverts, the forefoot must evert to maintain this critical contact point.<br>• The everted forefoot is akin to a valgus forefoot which forms a supinated foot when placed on the floor.<br>• The phalanges move oppositely to the forefoot, enabling the nail bed to keep facing upwards to the sky and minimise frontal plane roll. |




*Pronation F plane*

| | Rearfoot | Forefoot | Phalanges |
|---|---|---|---|
| **Pronation** | EV | INV | EV |
| **Supination** | INV | EV | INV |

Rearfoot eversion coupled with forefoot inversion with the tripod on the ground describes how the foot pronates in the frontal plane. The pronating foot is known as a mobile adaptor and you will notice how the foot spreads through the transverse arch.

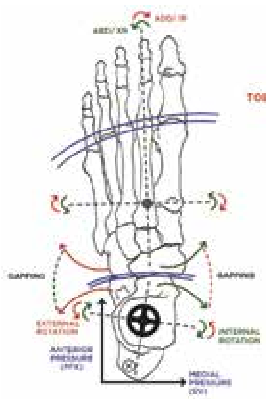
Once again the lowering of the TA and the spreading of the forefoot is adding length to multiple tissues in the foot such as tibialis posterior, tibialis anterior, FHL and adductor hallucis. These tissues are then primed for contraction (you may recall AiM's rule that muscles lengthen before they contract). The subsequent contraction is again to create the opposite shape in the foot. The outcome of this action raises the arches, coupled with the forefoot plantarflexion and forms the rigid lever as the foot shortens and narrows in supination.

## Transverse plane foot motion (Top down view)

AiM describes the talus as "The driver of the Bus" as it acts as a steering wheel in the transverse plane. The talus bone rotates internally and externally and has a knock on effect on the foot, the tibia and fibula and the rest of the body.

PIC?

| Pronation | Supination |
|---|---|
| • The calcaneus internally rotates as the pressures move anterior and medial.<br>• The talus is guided forward and medially into the concave receptacle of the navicular bone and begins its internal rotation.<br>• The second cuneiform is guided medially<br>• Rear foot internal rotation (adduction) is met with forefoot abduction (external rotation) as the joints along the medial border of the foot are encouraged to open.<br>• Joints open on the medial border and close on the lateral border.<br>• The toes follow the forefoot as they rest on the ground fulfilling their role in the tripod. | • Contraction of muscles such as posterior tibialis and soleus draws pressure to the lateral side of the calcaneus and inverts the rearfoot.<br>• The calcaneal inversion pushes the talus back up toward neutral and beyond.<br>• The cuboid inverts to stand "tall like a wall".<br>• To avoid losing first metatarsal head contact as the rearfoot inverts, the forefoot must evert to maintain this critical contact point.<br>• The everted forefoot is akin to a valgus forefoot which forms a supinated foot when placed on the floor.<br>• The phalanges move oppositely to the forefoot, enabling the nail bed to keep facing upwards to the sky and minimise frontal plane roll. |



*Foot T plane*

| T-Plane | Rearfoot | Forefoot | Phalanges |
|---|---|---|---|
| **Pronation** | IR | ABD | Follows Forefoot ABD |
| **Supination** | XR | ADD | Follows Forefoot ADD |

Tissues such as FHL, Flexor Hallucis Brevis and Extensor Hallucis Longus that run along the medial border are all lengthened in a pronation and contract back from their lengthened position to generate a supination in the transverse plane. The outcome of the supination is to close the joints on the medial border and facilitate an external rotation of the rearfoot and the leg to activate the extensor chain in the body.

| | PRONATION | | | SUPINATION | | |
|---|---|---|---|---|---|---|
| | **S-Plane** | **F-plane** | **T-Plane** | **S-plane** | **F-plane** | **T-plane** |
| **Rearfoot** | PFX | EV | IR | DFX | INV | XR |
| **Forefoot** | DFX | INV | ABD | PFX | EV | ADD |
| **Phalanges** | PFX | EV | ABD | DFX | INV | ADD |

**Two foot shapes**
There are only two optimal foot shapes that the foot should be able to access:

**Pronation shape – mobile adaptor**
- Foot lengthens and widens.
- Joints gap on the medial border and the plantar surface.

**Supination shape – Rigid Lever**
- Foot shorted and narrows.
- Joints gap on the lateral border and dorsal surface.

## Movement solutions

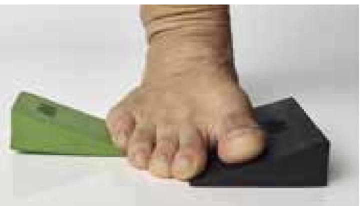
The AiM wedges were originally based on the concepts used when making orthotics; the orthotics original purpose was to help the foot gain access to a neutral position on its tripod.

The AiM methodology seeks to re-educate the foot to re-experience any of the joint motions detailed above that are absent from its day to day function while also encouraging access to the tripod on the ground.

To do this they use specifically designed wedges:

- **to influence the bones in a direction of motion (eversion, inversion etc)**
- **to bring the ground up toward the first and fifth metatarsals in the absence of contact; and**
- **to relax the tissues and create the opportunity for new joint motion.**

Increasing the foot's contact area and directly influencing the foot's motion in such a way encourages bones to movepreviously access.  This in turn enables the brain to establish a new centre in the foot, reorganising it's resting position and dynamic potential.



***Bilateral forefoot tripod***

***The AIM wedges were originally based on the concepts used when making orthotics; the orthotics original purpose was to help the foot gain access to a neutral position on its tripod.***

In essence, appropriate use of the wedges gives permission to the foot to move again. With a wider base:

- **the foot is able to access more movement at individual joint**
- **there is an increased amount of opposition between the rearfoot and forefoot structures; and**
- **there is more awareness in the ligaments and tendons that span these joints, with a critical response in the soft tissue to the movement.**

This experience of new movement is important to the body and brain's perception of itself and is critical for its future progression.

## Conclusion

*In the first article a couple of AiM's key rules were highlighted: 'Muscles lengthen before they contract' and 'Joints ACT: muscles REACT'. We can now see how these rules play out in the foot. Additionally, there is a third key rule – "Everything orbits around centre", the underlying concepts of which I touched on earlier.*

*Bringing this all together with a specific example, you will recall that the three keystones represent pivotal points in the three arches and together their resting position can be seen to determine the foot's resting posture.*

*When the talus is internal, the cuboid lies flat and the second cuneiform is anterior and medial. The foot will be flatter and appear pronated. It will have limited access into further pronation and also into supination with reduced overall movement potential. This foot will not be in true pronation when you assess it in all three planes. Joints will be open on the base and along the medial border. There may be some compromise to some of the other joints, the whole foot may be everted (no opposition between forefoot and rearfoot) and the tripod sub-optimal.*

*To help rectify this, we need the talus to externally rotate back to centre, the cuboid to stand tall "like a wall" and the second cuneiform to travel in a posterior lateral direction. Together, this involves a supinatory motion requiring the muscles we have discussed to contract from their lengthen pronated state).*

*If muscles lengthen **BEFORE** they contract, in order to generate an unconscious supination in the foot, we need to first teach the flat foot to pronate well.*

*The wedges provide the tripod contact necessary to guide bones in the appropriate direction whilst weight bearing. This action of guiding the joints into pronation triggers a muscular response (**Joints ACT: Muscles REACT**). In particular, triggering an eccentric lengthening in the muscles required for foot supination.*

*Due to the corrected nature of the movement, all bones now enter their end range in three dimensions simultaneously and all of the tissues experience maximal length before contracting back from this lengthened position to form a supination and guiding the keystones back towards their neutral position. This lifts all three arches together while maintaining the tripod on the ground.*

*Once this has been established and the foot has more integrity on its tripod and more access to its movement, it is then possible to complete the experience of teaching the foot how to fully pronate and supinate, thus allowing it to reorganise itself into a new centre.*

*The interesting thing about working with a foot when weight-bearing is that you instantly get to see the knock on effect of movement in the foot throughout the kinetic chain. If two feet are not able to function the same, there will be structural adaptations throughout the body and the tension and compression changes that occur throughout the system are a hotbed for the provision of symptomatic problems.*

***The next article will discuss the knock on effect of the foot's available motion to the rest of the body, how it influenced the development of the Flow Motion ModelTM and how, by using structure, AiM provides answers to the many symptoms we are confronted with in clinic every day.***