Pes Planus (Flat Feet)

Pes planus is the loss of the medial longitudinal arch of the foot. It can be flexible or rigid and it results in relative flattening of the plantar surface. The condition may be lifelong, or acquired through time, inflammation or other musculoskeletal problems. Treatment is generally only needed if the condition is new, painful or progressing, or when there is a fixed deformity or other associated problem.

Pes planus refers specifically to loss of the arch in the bony structure of the foot. People with hypertrophied plantar foot muscles (eg, lifelong barefoot walkers) might appear to have flat feet but if their bony arches are normal then they do not have pes planus.[1]

The arches of the foot

The arches add elasticity and flexibility to the foot by allowing the midfoot to spread and close. They help the foot to absorb shock and produce strength to push off and to adjust to balance and walk. They also help distribute weight evenly around the foot, and act as an energy store when running.[2]

Biomechanical analysis suggests that there are advantages and disadvantages to both high-arched and low-arched feet: the strain on the plantar fascia and metatarsals is greater in the high-arched foot, whereas strain on the calcaneus, navicular and cuboid are greater in the low-arched foot. A happy medium is perhaps ideal.[3]

Epidemiology[4, 5]

Pes planus may occur in up to 20% of adults, many of whom are flexible and have no resulting difficulties.

Pes planus is common in young children, who typically have a minimal longitudinal arch with forefoot pronation and heel valgus on weight-bearing. This is present to a greater degree in children of African ethnicity. Studies suggest around 45% of children aged 3-6 years, with around 5.5° of valgus, although the prevalence decreases with age. The prevalence of pathological pes planus in this group was less than 1%. Higher prevalence was associated with obesity and with male gender. Most children develop a normal longitudinal arch by the age of 10 years.

Effects of pes planus on foot dynamics[6]

Collapse of the medial longitudinal arch everts the calcaneus in relation to the talus, so that the foot pronates. Affected patients usually also have:

- Valgus position of the heel and forefoot (turned outwards); and
- Pronation (rolling inwards) of the midfoot, usually referred to as 'hyperpronation'.

Hyperpronation moves the transmission of force medially as the weight is transferred forwards on to the walking foot. This can stretch the soft tissues behind the medial malleolus (the posterior tibial tendon and posterior tibial nerve) which can lead to tendinopathy and nerve entrapment. The collapsed arch can also stretch the spring ligament and plantar fascia, leading to plantar fasciitis. Compensatory abduction of the forefoot, together with altered transmission of weight through the foot, can lead to hallux valgus and metatarsalgia.

Types of pes planus

- Flexible or fixed.
- Developmental, congenital or acquired.
Aetiology of pes planus\textsuperscript{[4, 6]}

Pes planus in children\textsuperscript{[7]}
- Pes planus can be part of normal development:
  - There may be ligamentous laxity, which is probably determined genetically.
  - Infants typically have a minimal arch. In neonates and toddlers there is a fat pad under the medial longitudinal arch which protects it whilst the arch develops and which resolves between the ages of 2 and 5 years. Children are almost all flat-footed when they first start to walk - intrinsic laxity and a lack of neuromuscular control compound this.
  - 45\% of children aged 3-6 years have flattening of the long arch, with forefoot pronation and heel valgus on weight bearing.
  - Most of these children spontaneously develop a strong normal arch by around the age of 10 years.
  - Obesity in children is significantly correlated with the tendency of the longitudinal arch to collapse in early childhood.\textsuperscript{[8]}
- Abnormal development of the foot, producing pes planus, may be due to:
  - Neurological problems - eg, cerebral palsy, polio.
  - Bony abnormalities - eg, tarsal coalition (fusion of tarsal bones), accessory navicular bone (a small bone which sits in the posterior tibial tendon, weakening support to the arch).
  - Ligamentous laxity - eg, Ehlers-Danlos syndrome, Marfan's syndrome
- A small proportion of flexible pes planus does not correct with growth (physiological pes planus). These can become rigid if the pes planus leads to bony changes.

Physiological pes planus in adults
Around 20\% of adults have pes planus, most of whom lack physiological arch development, probably due to ligamentous laxity. The majority have a flexible foot and no symptoms. However, if there is also heel cord contracture, there may be symptoms (see ‘Contributing factors’, below).\textsuperscript{[4]}

Acquired pes planus in adults\textsuperscript{[1, 7, 9, 10]}
This may be due to reduced arch strength, increased load, or a combination of the two.

Factors which reduce arch strength
- Dysfunction of the tibialis posterior tendon - a common and important cause, which develops due to age-related degeneration, inflammation, hypertension, diabetes, obesity, chronic injuries and, occasionally, traumatic rupture. The tibialis posterior tendon is the primary dynamic stabiliser of the foot. Its contraction causes plantar flexion and inversion, elevation of the foot arch and locking of the midtarsal joints. This allows efficient working of the gastrocnemius during walking.
- Tear of the spring ligament (rare).
- Tibialis anterior rupture (rare).
- A neuropathic foot - eg, from diabetes, polio, or other neuropathies.
- Age-related degenerative changes in foot and ankle joints:
  - Inflammatory arthropathy - eg, rheumatoid arthritis.
  - Osteoarthritis.
  - Fractures.
  - Bony abnormalities - eg, tarsal coalition.
- Other bony abnormalities - eg, rotational deformities, tibial abnormalities, coalition (fusion) of tarsal bones, equinus deformity.
- Ligamentous laxity - eg, familial, Marfan's syndrome, Ehlers-Danlos syndrome, Down's syndrome.

Factors which increase load
- Footwear: shoes which limit toe movement; high heels (barefoot walking may be protective.) Greater foot pronation occurs when wearing shoes than when walking barefoot. Shoes elevate the calcaneus, shorten the Achilles tendon and effectively splint the foot, thereby limiting muscle contraction during ambulation. Extensive observational data suggest that wearing shoes in childhood is detrimental to the development of a normal longitudinal arch and that shoeless populations have less chronic foot pain.
A tight Achilles tendon or calf muscles (heel cord contracture): these may help to cause pes planus, or may contribute to symptoms such as foot pain when there is existing pes planus.

- Obesity: obese individuals have an altered gait with more extensive rearfoot eversion. Heavier body weight results in higher plantar pressures, with the largest effect under the longitudinal arch and metatarsal heads.

- Pregnancy: there is evidence that the endocrine changes of pregnancy (which increase ligamentous laxity) may predispose to collapse of the foot arches in women who are also obese.\[^{11}\]

- Other factors causing foot pronation - eg, hip abductor weakness and genu valgum.

Presentation and assessment

History

Patients typically present with noticeable pes planus, parental concern, or foot pain.

In children

- Age-appropriate history of concerns and motor development.
- History of the pes planus including any changes.
- Developmental history, particularly motor development (floppiness as a baby, age at first walking, walking development, stumbling, regression, in-toeing).
- Symptoms: walking/running ability and any foot pain.
- Older children: level of physical activity, sports participation or avoidance.
- Musculoskeletal history - exercise-related pain suggestive of benign joint hypermobility syndrome
- Past medical history: other diseases.
- Family history of flat feet or of conditions associated with soft tissue abnormalities.

In adults

- Establish whether the pes planus is new and whether it is symmetrical.
- Ask whether there is foot pain.
- Note whether there is alteration of gait.
- Ask whether there any other lower limb symptoms or recent history - eg, knee pain, Achilles tendonitis, plantar fasciitis.
- Past medical history: consider injuries, other related disease (neurological, rheumatological, musculoskeletal).
- Note occupation and physical activity.
- If pes planus is new, asymmetrical or painful, ask about symptoms of tibialis posterior dysfunction, which are:
  - Pain or swelling behind the medial malleolus and along the instep.
  - Change in foot shape.
  - Decreasing walking ability and balance.
  - Ache on walking long distances.

Examination\[^{6}\]

- Observe the pes planus:
  - With the patient standing, look at the feet from above and behind and all sides, note when non-weight-bearing, when weight-bearing and when walking. Loss of the arch is visible in pes planus, with the medial side of the foot close to the ground. Look at the feet from behind - with pes planus the heel moves outwards (valgus) and the toes may also be pointed outwards.

- Assessment of the foot:
  - Establish whether the foot is flexible:
    - Ask the patient to stand on tiptoe. With flexible pes planus, this will reveal the arch, and the heel will move inwards (varus position).
    - Evaluate ankle dorsiflexion and plantarflexion and rearfoot, midfoot and forefoot ranges of motion.
    - Assess the Achilles tendon - less than 10° of dorsiflexion suggests Achilles tendon contracture.
    - Look at the shoes: flexible flat feet may cause rapid and uneven shoe wear.
Look for signs of tibialis posterior dysfunction:[12]
- Ask the patient to do 10 unsupported heel raises (stand on one foot on tiptoe, unsupported).
  Patients with tibialis posterior dysfunction will be unable to do this.
- Further assessment of tibialis posterior dysfunction is detailed in the reference below.[12]

Assess related problems, if relevant - eg, neuropathy or arthritis.
General examination of the musculoskeletal system. Look for evidence of generalised joint laxity, using the Beighton Score.[13]
- Observe gait.

Investigations[4, 12, 14]
The paediatric flat foot proforma is an instrument for assessing for pes planus in mid-childhood, although as yet there is no clear and evidence-based treatment algorithm.[15] However, overall there is no standardised evaluative framework and the condition is confused by multiple classifications, most of which look at the arch, feet position and foot flexibility. Usual assessment methods are X-rays, footprints and visual observations.

In some cases, standing foot X-rays may be useful to show the degree of deformity:
- Standing lateral view shows the longitudinal arch and talo-navicular joint.
- Standing AP view shows the degree of heel valgus (talo-calcaneal angle).

Management[14, 16]

Treatment in children
The treatment of paediatric flexible pes planus is controversial; there is clear consensus that the condition reduces with ages and that most children are asymptomatic. Few paediatric flat feet are symptomatic but they are often unnecessarily treated.

Where foot orthoses are indicated, generic appliances are usually sufficient. Customised orthoses should be reserved for:
- Children with foot pain and arthritis.
- Unusual morphology.
- Unresponsive cases.

Surgery is rarely indicated for children unless the pes planus is rigid. There is a need for a standardised assessment, classification and management approach.

Treatment in adults
In many cases, pes planus does not require treatment. Most flexible flat feet are asymptomatic.

- The arch may develop spontaneously in children aged under 10 years with flexible pes planus and no other relevant condition.
- In adults, pes planus which has been present a long time, is flexible, bilateral, painless, and is not progressing, does not require treatment.

Symptomatic and inflexible pes planus may require treatment. Initial options include activity modification, footwear and orthoses, exercises and medication (non-steroidal anti-inflammatory drugs (NSAIDs)). Comorbidities should be identified and managed. When treatment is required and non-surgical treatment options have failed then surgery is considered. Consider referral or treatment if:
- Pes planus is fixed, new, asymmetrical or progressing.
- Where there is foot pain.
- If the patient has another disease which may be contributing (eg, neuropathy, inflammatory arthritis).
- There is tibialis posterior dysfunction. This should be treated in its own right; treatment may involve rest, NSAIDs, orthotics or surgery.[12]
Non-surgical treatment\[^{[4, 6]}\]

- Exercise for flat feet - both barefoot walking and prescribed activities have been used.
- Heel cord stretching, to stretch and lengthen the Achilles tendon and posterior calf muscles, as a tight Achilles tendon tends to pronate the foot. The patient should be instructed as follows:
  - Stand facing a wall with hands on the wall at about eye level. Put the leg you want to stretch about a step behind your other leg.
  - Keeping the back heel on the floor, bend the front knee until you feel a stretch in the back leg.
  - Hold the stretch for 15-30 seconds. Repeat 2-4 times. Do this exercise 3-4 times a day.

- Orthotics (inserts or insoles, often custom-made):
  - These usually contain a heel wedge to correct calcaneovalgus deformity, and an arch support. In patients with fixed pes planus or arthropathy, customised insoles may help relieve symptoms.
  - No high-level evidence supports the use of foot orthoses for flexible pes planus in adults, although low-level evidence suggests that foot orthoses improve pain and reduce rearfoot eversion, and there is slightly better evidence that they improve foot biomechanics when walking. Further research is needed.\[^{[17]}\]
  - Arch supports used without correcting heel cord contracture can make symptoms worse.

- Reduce contributing factors:\[^{[1]}\]
  - Wear shoes with low heels and wide toes.
  - Lose weight if appropriate.
  - Do exercises to strengthen foot muscles - walking barefoot (if appropriate), toe curls (flexing toes) and heel raises (standing on tiptoe).

Surgery\[^{[4, 6, 14]}\]

The goals of surgery are pain reduction/resolution and realignment of the foot.

Common indications for surgery are:

- Cerebral palsy with an equinovalgus foot, to prevent progression and breakdown of the midfoot. Subtalar fusion is effective in ambulatory patients, although there is a high recurrence rate.\[^{[18]}\]
- Rigid and painful pes planus.
- To prevent progression - eg, with a Charcot joint.
- Tibialis posterior dysfunction, where non-surgical treatment has been unsuccessful.

Possible surgical procedures include:

- Soft tissue reconstructive procedures - eg:
  - Achilles tendon lengthening.
  - Reconstruction of the tibialis posterior tendon.

- Arthroereisis (a controversial procedure involving insertion of a spacer into the sinus tarsi to reduce pronation of the subtalar joint).
- Reconstructive osteotomies - rearfoot, midfoot or forefoot, depending on alignment - eg, calcaneal osteotomy, to re-align the hindfoot.
- Arthrodesis:
  - Subtalar arthrodesis.
  - Triple arthrodesis - usually a salvage for failed surgical treatment.

Complications and prognosis

Physiological pes planus

It is generally accepted that physiological pes planus is unlikely to cause significant foot problems.\[^{[4, 6]}\]
However, some authors suggest that excessive foot pronation may contribute to the development of foot pain and foot problems such as:

- Tibialis posterior dysfunction (because hyperpronation stretches this tendon).
- Hallux valgus (because more weight is borne by the medial metatarsals when the foot hyperpronates).
- Metatarsalgia (for the same reason).
- Plantar fasciitis.
- Knee pain: one study found that off-the-shelf foot orthoses were beneficial for patello-femoral pain.\(^{[19]}\)
- Another study suggested that foot deformity may be linked to greater disability from knee osteoarthritis.\(^{[20]}\)
- Pes planus may reduce the shock-absorbing features of the foot, potentially contributing to low back pain, although it may be protective against metatarsal stress fracture.\(^{[4]}\)

The role of pes planus in these problems has not been proved.

**Symptomatic or rigid pes planus**\(^{[21]}\)

Depending on the cause, pes planus can deteriorate, with loss of the longitudinal arch leading to collapse of the midfoot. With deterioration, a flexible foot can become rigid and/or painful. This can cause significant difficulties with walking and may require surgery.

Situations where deterioration is likely without treatment include:

- Neuropathy - eg. with a Charcot joint there may be rapid and progressive loss of the arch.\(^{[6]}\)
- Tibialis posterior dysfunction.
- Cerebral palsy.\(^{[4]}\)

**Further reading & references**

- Hyperpronation and foot pain; the physician and sportsmedicine 32;8 (August 2004)
- Pes planus/flat foot; Wheelless’ Textbook of Orthopaedics
- Flat foot; The Foot and Ankle Clinic

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