

Arches of Foot

? Arches of Foot — Introduction

- The **arched foot** is a distinctive human feature that allows **bipedal locomotion** and efficient **weight transmission**.
- Although present from birth, arches are masked in infants due to **fat in the soles**.
- They act as **shock absorbers** and **springs** during walking and running

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Classification of Arches

1. Longitudinal Arches

- **Medial longitudinal arch**
- **Lateral longitudinal arch**

2. Transverse Arches

- **Anterior transverse arch**
- **Posterior transverse arch**

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? Medial Longitudinal Arch

- Higher, mobile, and resilient; acts as a shock absorber.
- Shaped like a **big arc of a small circle** — with more bones and joints.

Bones Forming the Arch

- **Calcaneus, talus, navicular, three cuneiforms, and first–third metatarsals.**

Ends

- **Anterior end:** Heads of 1st–3rd metatarsals.
- **Posterior end:** Medial tubercle of calcaneum.
- **Keystone: Talus** (its head supports the summit of the arch)

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Pillars

- **Anterior pillar:** Talus ? Navicular ? 3 cuneiforms ? 1st–3rd metatarsals.
- **Posterior pillar:** Medial half of calcaneum.

Main Joint

- **Talocalcaneonavicular joint.**

Supporting Structures

- **Ligamentous support:**

- *Spring (plantar calcaneonavicular) ligament* — supports head of talus.
- *Plantar aponeurosis* — acts as tie-beam.

- **Muscular support:**

- *Tibialis posterior, flexor hallucis longus, and flexor digitorum longus* (posterior sling).
- *Tibialis anterior* and *peroneus longus* act as stirrup-like supports pulling the arch upward.
- *Abductor hallucis* and *flexor digitorum brevis* act as dynamic tie-beams

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? Lateral Longitudinal Arch

- **Lower, shorter, less mobile**, and more **rigid** — transmits body weight to the ground.
- Considered a **small arc of a big circle**.

Bones

- **Calcaneus, cuboid, and 4th–5th metatarsals.**

Ends

- **Anterior:** Heads of 4th and 5th metatarsals.

- **Posterior:** Lateral tubercle of calcaneum.

- **Keystone: Cuboid**

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Pillars

- **Anterior pillar:** Cuboid and 4th–5th metatarsals.

- **Posterior pillar:** Lateral half of calcaneum.

Main Joint

- **Calcaneocuboid joint.**

Supporting Structures

- **Ligaments:** Long and short plantar ligaments; plantar aponeurosis acts as tie-beam.

- **Muscles:**

- *Flexor digitorum brevis, abductor digiti minimi, and flexor digiti minimi brevis* (tie-beams).

- *Peroneus longus, brevis, and tertius* maintain arch height

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? Anterior Transverse Arch

- Lies in **coronal plane** at the heads of metatarsals.
- **Complete arch**, which flattens slightly during weight-bearing.

Bones

- **Heads of all five metatarsals.**
- **Supported by:**
 - *Intermetatarsal ligaments* and *deep transverse metatarsal ligament*.
 - *Transverse head of adductor hallucis* binds metatarsal heads together.
 - *Peroneus longus* tendon acts as sling from lateral to medial side

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? Posterior Transverse Arch

- Lies across **bases of metatarsals and distal tarsals** (cuneiforms, cuboid).
- **Incomplete (half-dome)** — completed by opposite foot when together.

Bones

- **Navicular, three cuneiforms, cuboid, bases of metatarsals**

Support

- *Intertarsal and tarsometatarsal ligaments, dorsal interossei, flexor hallucis brevis, and peroneus longus tendon sling* maintain the curvature

?? Factors Maintaining All Arches

1. **Shape of bones** — wedge-shaped cuneiforms and metatarsal bases provide bony configuration.
2. **Intersegmental ties** — ligaments joining adjacent bones (spring, long, and short plantar ligaments).
3. **Tie-beams** — plantar aponeurosis and intrinsic muscles hold ends together.
4. **Slings** — tendons like *tibialis posterior, peroneus longus, tibialis anterior* pull the arch upward

? Functions of the Arches

1. Distribute **body weight** over heel and toes.

2. Act as **springs and shock absorbers** during locomotion.
3. **Protect** soft tissues of the sole from pressure.
4. Provide **resiliency** (medial arch) and **rigidity** (lateral arch)

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? Clinical Anatomy

- **Flat Foot (Pes Planus):** Collapse of longitudinal arches ? clumsy gait, pain, neuralgia due to pressure on plantar nerves and vessels.
- **Pes Cavus:** Exaggerated arches; seen in spastic or neurological conditions.
- **Clubfoot (Talipes Equinovarus):** Congenital deformity with inversion and plantar flexion of foot

? Factors Responsible for Maintenance of Arches

The arches of the foot are maintained by **bony, ligamentous, and muscular mechanisms** which act together for stability and elasticity.

1. Shape of the Bones (Bony Factor)

- **Transverse arch:** Maintained by wedge-shaped tarsal and metatarsal bones — the **apex of wedge points downward.**

- Bony factor is less important for longitudinal arches but contributes to the foot's concavity.

2. Intersegmental Ties (Ligamentous Factor)

Ligaments connecting segments of the arch prevent separation:

- **Spring ligament (plantar calcaneonavicular):** Maintains the **medial longitudinal arch**.
- **Long and short plantar ligaments:** Maintain the **lateral longitudinal arch**.
- **Interosseous ligaments and intermetatarsal ligaments:** Support **transverse arches**.

3. Tie Beams (Bowstrings)

Structures that connect the two ends of the arch and resist flattening:

- **Plantar aponeurosis:** Prevents flattening of longitudinal arches.
- **Muscles of the first layer of sole** (abductor hallucis, flexor digitorum brevis) act as tie-beams.
- **Adductor hallucis (transverse head):** Acts as tie-beam for transverse arch.

4. Slings (Suspensory Factors)

Muscular tendons that pull the arch upwards:

- **Medial longitudinal arch:**
 - *Tibialis posterior, flexor hallucis longus, and flexor digitorum longus.*

- **Lateral longitudinal arch:**

- *Peroneus longus* and *peroneus brevis*.

- **Both arches:**

- *Tibialis anterior* and *peroneus longus* act like a **stirrup**, pulling the midfoot upward.

- **Transverse arches:**

- Maintained by *peroneus longus* (running across the sole) and *tibialis posterior*.

? Functions of the Arches

1. Weight Distribution:

- Transfers body weight to heel and heads of metatarsals (mainly 1st and 5th).
 - Lateral border bears lesser weight due to its arch shape.

2. Spring Action:

- Medial longitudinal arch acts like a spring aiding in walking and running.

3. Shock Absorption:

- Cushions the impact of stepping and jumping.

4. Protection:

- Concavity of the sole protects soft tissues, vessels, and nerves.

5. Functional Differences:

- **Medial arch:** Resilient and elastic.
- **Lateral arch:** Rigid and stable.

? Summary

- The **foot arches** include two longitudinal (medial and lateral) and two transverse (anterior and posterior).
- The **medial longitudinal arch** is the most prominent and clinically significant — affected in *pes planus* (flat foot) and *pes cavus* (high arch).
- **Ligamentous and muscular supports** are essential for maintaining the arches during weight-bearing and locomotion.

?? Comparison: Medial vs Lateral Longitudinal Arch

FEATURE	MEDIAL LONGITUDINAL ARCH	LATERAL LONGITUDINAL ARCH
Height & Mobility	Higher, more mobile, resilient	Lower, rigid, transmits weight
Function	Acts as shock absorber	Provides stability for weight transmission

FEATURE	MEDIAL LONGITUDINAL ARCH	LATERAL LONGITUDINAL ARCH
Bones	Calcaneus, talus, navicular, three cuneiforms, 1st–3rd metatarsals	Calcaneus, cuboid, 4th–5th metatarsals
Keystone	Head of talus	Cuboid
Anterior End	Heads of 1st–3rd metatarsals	Heads of 4th–5th metatarsals
Posterior End	Medial tubercle of calcaneum	Lateral tubercle of calcaneum
Main Joint	Talocalcaneonavicular joint	Calcaneocuboid joint
Ligamentous Support	Spring ligament	Long and short plantar ligaments
Tie-Beams	Plantar aponeurosis (medial part), abductor hallucis, flexor digitorum brevis (medial part)	Plantar aponeurosis (lateral part), abductor digiti minimi, flexor digitorum brevis (lateral part)
Muscular Slings	Tibialis posterior, FHL, FDL	Peroneus longus and brevis
Suspension (Stirrup)	Tibialis anterior + Peroneus longus	Tibialis anterior + Peroneus longus
Character	Elastic and spring-like	Stable and weight-bearing

Clinical Anatomy — Arches of the Foot

1. Flat Foot (Pes Planus)

- **Definition:** Collapse or loss of the medial longitudinal arch ? sole becomes flat and touches the ground.

- **Types:**

- **Congenital:** Due to tarsal bone malformation.
- **Acquired:** Common; results from **weakening of ligaments and intrinsic foot muscles** (especially plantar aponeurosis).

- **Causes:**

- Excessive standing, obesity, rickets, pregnancy, poorly fitting shoes, or paralysis of tibialis posterior.

- **Features:**

- Medial border of foot touches the ground.
- Foot appears broader and everted.
- Pain and fatigue after walking or standing.

- **Complications:**

- Strain on ligaments, callosities on sole, valgus deformity of heel.

- **Treatment:**

- Arch supports, proper footwear, physiotherapy, surgical correction in severe cases.

2. Pes Cavus (High-Arched Foot)

- **Definition:** Exaggerated height of the medial longitudinal arch.

- **Causes:**

- Neurological disorders (spastic paralysis, poliomyelitis, Charcot–Marie–Tooth disease).

- **Features:**

- Toes are flexed, heel and metatarsal heads bear excessive weight.
 - Painful callosities under metatarsal heads.

- **Clinical importance:**

- Loss of normal shock absorption ? frequent ankle sprains.

3. Clubfoot (Talipes Equinovarus)

- **Definition:** Congenital deformity where the foot is **plantarflexed (equinus)**, **inverted (varus)**, and **adducted**.

- **Cause:**

- Abnormal intrauterine position or defective muscle balance between invertors and evertors.

- **Features:**

- Sole faces medially; child walks on the lateral border of foot.

- **Treatment:**

- Early manipulation, plaster correction, or surgical release.

4. Claw Foot

- **Definition:** Hyperextension at metatarsophalangeal joints with flexion at interphalangeal joints.

- **Cause:**

- Weakness or paralysis of small muscles of foot (as in leprosy, diabetic neuropathy).

- **Clinical Feature:**

- Toes resemble claws; difficulty in walking.

- **Treatment:**

- Orthopedic correction and physiotherapy.

5. Hallux Valgus

- **Definition:** Lateral deviation of the great toe at the metatarsophalangeal joint.

- **Cause:**

- Tight footwear, genetic predisposition, flat foot.

- **Clinical Importance:**

- Medial deviation of first metatarsal, formation of **bunion (bursa)** over the joint ? painful swelling.

- **Treatment:**

- Corrective footwear or surgical correction.

6. Plantar Fasciitis and Calcaneal Spur

- **Plantar Fasciitis:** Inflammation of plantar aponeurosis ? severe heel pain, especially on first step in morning.

- **Calcaneal Spur:**

- Bony outgrowth at calcaneal tuberosity where aponeurosis attaches.
 - Often accompanies chronic plantar fasciitis.

- **Treatment:**

- Rest, heel padding, physiotherapy, corticosteroid injection.

7. Flatfoot in Children (Physiological)

- Due to fatty cushion masking the arch; **usually corrects by age 6–7 years** as intrinsic muscles strengthen.

8. Fallen Arches in Adults

- Seen in **teachers, soldiers, or waiters** due to prolonged standing.

- Chronic pain over the sole; managed with arch supports and exercises.

? Facts to Remember — Arches of the Foot

1. The **foot acts as a spring and shock absorber**, distributing weight during locomotion.
2. There are **two longitudinal arches** (medial and lateral) and **two transverse arches** (anterior and posterior).
3. The **medial longitudinal arch** is the **highest, most mobile, and most important**.
4. The **lateral longitudinal arch** is **lower and rigid**, transmitting weight to the ground.
5. **Talus** acts as the **keystone** of the medial arch; **cuboid** acts as the keystone of the lateral arch.
6. **Spring ligament** supports the head of talus and maintains medial arch.
7. **Long and short plantar ligaments** maintain lateral arch.
8. **Plantar aponeurosis** acts as a tie-beam for both longitudinal arches.
9. **Tibialis anterior and peroneus longus** form a **stirrup sling** supporting both arches.
10. The **transverse arches** are maintained by wedge-shaped bones, ligaments, interosseous muscles, and peroneus longus tendon.
11. **Flat foot** results from collapse of the medial arch due to ligament and muscle weakness.
12. **Pes cavus** is the exaggerated form of the medial arch, commonly neurological in origin.

13. The **arches protect plantar vessels, nerves, and muscles** from direct pressure.
14. **Resiliency of the medial arch and rigidity of the lateral arch** provide both spring and stability.
15. During walking, **arches flatten slightly during stance** and **recoil during toe-off**, ensuring smooth locomotion.
16. The **transverse arch** is completed by both feet when standing together.
17. **Children's flat foot** is often physiological and self-correcting.
18. **Adults' flat foot** may lead to pain, valgus deformity, and fatigue.
19. **Arch supports and strengthening exercises** are key to management of foot deformities.
20. Proper **footwear and posture** are essential for maintaining normal arch structure.

Clinicoanatomical Problem — Arches of the Foot

A young adult was **disqualified from army recruitment** because of **flat feet**.

Questions:

1. What are flat feet?
2. Name the factors maintaining the medial longitudinal arch of the foot.

Answer:

- When the **medial border of the foot** fails to show its normal **upward concavity**, the condition is termed a **flat foot (pes planus)**.

- If such a person places a **wet foot on the ground**, the entire sole makes an imprint — unlike the arched footprint of a normal foot.
- A **flat foot** person cannot run efficiently because of reduced elasticity and shock absorption in the sole. Hence, such individuals are often **unfit for military service**, where running performance is essential

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Factors maintaining the medial longitudinal arch:

1. Shape of bones:

- Specially the **talus** and **calcaneus**, which form the bony configuration of the arch.

2. Ligamentous supports:

- **Spring (plantar calcaneonavicular) ligament**

- **Deltoid ligament**

- **Plantar aponeurosis** acting as a tie-beam

3. Short muscles:

- **Abductor hallucis**

- **Flexor hallucis brevis**

- **Dorsal interossei**

4. Long tendons:

- **Flexor hallucis longus (FHL)**

- **Tibialis posterior**

- **Tibialis anterior**

- **Peroneus longus**

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Clinical Relevance:

- In **flat foot**, loss of arch support causes **pain, muscle fatigue**, and **valgus deformity** of the heel.
- **Arch supports, physiotherapy, and corrective footwear** can relieve symptoms.