MEDICAL EDUCATION RESOURCE

Introduction and Development : Lower Limb

Introduction

The lower limb, like the upper limb, develops from limb buds and is specialized for supporting the weight of the body, standing, and locomotion. It is more stable and adapted for weight transmission rather than for mobility and manipulation. Functionally, it allows upright posture and movement, maintaining balance during walking and running.

Development of Lower Limb

- **Timing:** The lower limb bud appears about a week after the upper limb bud, around the **4th week of intrauterine life**.
- **Position:** The limb bud originates from the **lateral wall of the embryo**, opposite **lumbar and upper sacral segments (L2–S2)**.
- **Components:** It consists of a **core of mesenchyme (from somatic layer of lateral plate mesoderm)** covered by **ectoderm**.
- **Axis and Rotation:**
    - Initially, the limb buds project laterally and caudally.
    - The **preaxial (cranial)** border corresponds to the **thumb side (great toe)**, and the **postaxial (caudal)** border corresponds to the **little finger (little toe)** side.
    - During development, the **upper limb rotates laterally**, while the **lower limb rotates medially**, which explains:
        - Flexor muscles coming to lie **posteriorly** in the lower limb.

- Extensors coming to lie **anteriorly**.
- The great toe lies **medially**, unlike the thumb, which lies laterally.

Molecular Regulation of Limb Development

- **Initiation:** Controlled by molecular signaling between the **apical ectodermal ridge (AER)** and the **underlying mesenchyme**.
- **Key Genes and Molecules:**
  - **FGF (Fibroblast Growth Factors):** Especially **FGF-10**, induces limb bud formation.
  - **FGF-8:** Maintains the AER and stimulates mesenchymal proliferation.
  - **TBX4 gene:** Specifies the **hind limb** (while **TBX5** specifies the forelimb).
  - **HOX genes:** Determine the **patterning** along the proximodistal axis (shoulder to fingers/toes).
  - **SHH (Sonic Hedgehog):** From the **zone of polarizing activity (ZPA)** controls **anteroposterior axis** (thumb to little finger direction).
  - **WNT7a:** From dorsal ectoderm determines **dorsoventral patterning**.
- **Apoptosis:** Occurs in the interdigital zones, leading to the **separation of digits**.

Parts of the Lower Limb

1. **Hip region** – connects the trunk to the lower limb.
2. **Thigh** – lies between the hip and knee.

3. **Leg** – between knee and ankle.
4. **Foot** – distal segment specialized for support and locomotion.

Related Terms

- **Preaxial border:** Medial border of the limb (great toe side).
- **Postaxial border:** Lateral border of the limb (little toe side).
- **Flexor surface:** Posterior in the lower limb.
- **Extensor surface:** Anterior in the lower limb.

Parts of the Lower Limb

The lower limb is divided into **four main regions**, each containing specific bones and joints.

REGION	BONES	JOINTS
1. Gluteal region – covers side and back of pelvis	Hip bone	Hip joint
2. Thigh – between hip and knee	Femur, Patella	Knee joint

REGION	BONES	JOINTS
3. Leg (Crus) – between knee and ankle	Tibia, Fibula	Tibiofibular joints
4. Foot (Pes) – from heel to toes	Tarsus (7 bones), Metatarsus (5 bones), Phalanges (14 bones)	Ankle, Subtalar, Transverse tarsal, Tarsometatarsal, Intermetatarsal, Metatarsophalangeal, Interphalangeal joints

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Related Terms

1. **Gluteal Region**
    - Lies over the **side and back** of the pelvis.
    - **Hip (coxa):** Superolateral part seen in side view.
    - **Buttock (natis):** Rounded inferomedial part seen in back view.
    - **Hip bone:** Formed by fusion of **ilium, pubis, and ischium** at the acetabulum.
    - Two hip bones + sacrum + coccyx = **Bony pelvis**.
    - **Hip joint:** Articulation between hip bone and femur.
2. **Thigh**
    - Extends from **hip to knee**.

- Contains **femur and patella**.
- **Groin (inguinal region):** Junction between thigh and anterior abdominal wall.
- **Gluteal fold:** Upper limit of thigh posteriorly.
- **Ham/Poples:** Lower back of thigh and back of knee.

3. **Leg**
   - Lies between **knee and ankle joints**.
   - Formed by **tibia and fibula**, with **three tibiofibular joints**.
4. **Foot**
   - Has an upper **dorsal surface** and a lower **plantar surface (sole)**.
   - **Sole** is homologous to the **palm** of the hand.

> **Additional Notes**

Line of Gravity

- Passes through **cervical and lumbar vertebrae**,
  behind the hip joint,
  and **in front of knee and ankle joints**.

Weight Transmission

- In a 60 kg person:

- Each lower limb bears **30 kg at the ankle**.
- Each ankle divides it: **15 kg to heel**, **15 kg to forefoot**.
- At metatarsophalangeal joints, 15 kg divides into six parts:
  - **2 parts to great toe**, **1 part each to 2nd–5th toes**.
- Each sesamoid bone under great toe transmits **2.5 kg**.

Peculiarities of Lower Limb

1. Longest & heaviest bone — **Femur**
2. Most complex joint — **Knee joint (12 bursae)**
3. Longest muscle — **Sartorius**
4. Largest muscle — **Gluteus maximus**
5. Strongest tendon — **Tendocalcaneus (Achilles tendon)**
6. Thickest nerve — **Sciatic nerve**
7. Longest vein — **Great saphenous vein**
8. Well-developed **arches of foot**
9. Muscle with maximum heads — **Quadriceps femoris**
10. Largest sesamoid — **Patella**
11. Longest cutaneous nerve — **Saphenous nerve**

Frequently Asked Questions

1. Tabulate the parts of the lower limb along with their regions, bones, and joints.
2. Compare homologous parts of upper and lower limbs.
3. Enumerate major differences between upper and lower limbs.
4. How does the centre of gravity pass in the human body?
5. Name five peculiarities of the lower limb.
6. Why does varicose vein occur in the lower limb?
7. What are the functions of the lower limb?
8. What is the function of sesamoid bones?
9. Name the tarsal bones.
10. What is the difference between big toe and thumb?

Viva Voce (with Answers)

Q1. What is meant by the preaxial and postaxial borders of the limb?
A. Preaxial border ? Medial side (great toe); Postaxial border ? Lateral side (little toe).

Q2. Which muscles help in weight transmission during standing?
A. Mainly **gluteus maximus**, **quadriceps femoris**, **gastrocnemius**, and **soleus**.

Q3. Why is the line of gravity important?
A. It maintains balance and upright posture by passing behind the hip and in front of knee and

ankle joints.

Q4. Which bones form the medial and lateral malleolus?
A. Medial malleolus ? **Tibia**; Lateral malleolus ? **Fibula**.

Q5. Which is the largest sesamoid bone in the body?
A. Patella.

Q6. Which vein is used for long-term intravenous infusion or cardiac catheterization?
A. Great saphenous vein.

Q7. What is the functional difference between hand and foot?
A. Hand — designed for manipulation; Foot — designed for support and locomotion.

Q8. Which nerve injury leads to foot drop?
A. Common peroneal nerve injury.

Q9. Which is the longest muscle of the body?
A. Sartorius.

Q10. What is the thickest nerve in the body?
A. Sciatic nerve.