

Connections of the lower limb (*juncturae ossium extremitatis inferioris*)

Connection of the pelvic girdle

(*juncturae ossium cinguli extremitatis inferioris*)

1. Sacroiliac joint (*articulatio sacroiliaca*) (simple joint)

Articular surfaces: auricular surface of the pelvic bone (*facies auricularis ossis coxae*) and auricular surface of the sacral bone (*facies auricularis ossis sacri*)

Articular capsule: tight and attached to the margins of the articular surfaces

Additional features: anterior, interosseous and posterior sacroiliac ligaments (*ligamenta sacroiliaca anteriora, interossea and posteriora*).

Type of joint: articular surfaces are uneven, amphiarthrosis (almost immobile joint), children articular surfaces nearly flat adults uneven.

2. Pubic symphysis (*symphysis pubica*)

Articular surfaces: symphyseal surfaces of left and right pubic bone (*facies symphyseales ossis pubis dextra et sinistra*), cartilaginous discus (females 4,5cm, males 5cm).

Additional features: interpubic disc (*discus interpubicus*) from fibrous tissue, superior and inferior pubic ligaments, inferior also arcuate pubic ligament is stronger (*ligamentum pubicum superius et inferius, inferius also ligamentum arcuatum pubis*).

Type of joint: almost immobile joint.

3. Obturator membrane (*membrana obturatoria*) (syndesmosis)

stiff membrane, attachment of the muscles (mm. obturatorii)

4. Ligaments in the pelvic region (syndesmoses)

iliolumbar ligament (*ligamentum iliolumbale*), sacrospinal ligament (*ligamentum sacrospinale*), sacrotuberale ligament (*ligamentum sacrotuberale*), faciforme process (*processus falciformis*), sacrospinal ligament (*ligamentum sacrospinale*).

Greater sciatic foramen (*foramen ischiadicum majus*)

Lesser sciatic foramen (*foramen ischiadicum minus*)

Pelvic bone (*pelvis*)

Terminal line (*linea terminalis*): (promontorium – arcuate line (*linea arcuata*) – iliopubic eminence (*eminentia iliopubica*) – cranial margin of symphysis).

Greater pelvis (*pelvis major*) – cranially from terminal line (abdominal organs)

Lesser pelvis (*pelvis minor*) – caudally from terminal line (genital and urinary system)

Superior pelvic aperture (*apertura pelvis superior*) - inlet

Inferior pelvic aperture (*apertura pelvis inferior*) - outlet

Female pelvis has four planes:

1. Superior pelvic aperture, pelvic inlet (*apertura pelvis superior, aditus pelvis*)

Transverse diameter (*diameter transversa*) – 13cm

Diagonal conjugate (*conjugata diagonalis*): measurable in female *per vaginam*, between caudal margin of the symphysis and ventral surface of the promontorium – 12,5 – 13cm.

2. Width of pelvis (*amplitudo pelvis*)

rounded shape,

Oblique diameter (*diameter obliqua*): 12,5cm.

3. Narrow part of the pelvis (*angustia pelvis*): 11,5cm

4. pelvic outlet (*apertura pelvis inferior*) exitus pelvis

rhomboid shape

Direct diameter (*diameter recta*): between inferior margin of symphysis and apex of coccygeal bone – 11 -11,5cm.

Sagittal axis (length of newborn head – 11cm) of the newborn head insert to the different diameters in different planes during delivering:

1. pelvic inlet: in transverse diameter
2. amplitude: twisting (oblique diameter)
3. angustia: in direct diameter
4. pelvic outlet: in direct diameter

Diagonal conjugate (*conjugata diagonalis*): measurable in female *per vaginam*, between caudal margin of the symphysis and ventral surface of the promontorium – 12,5 – 13cm.

External diameters of pelvis:

Bispinal diameter (*distantia bispinalis*): superior anterior iliac spine of both sides (*spina iliaca anterior superior*) – 26cm

Bicristalis diameter (*distantia bicristalis*): the most lateral points on iliac crest – 29cm.

Bitrochanteric diameter (*distatia bitrochanterica*): between greater trochanters – 31cm.

Bituberal diameter (*distantia bituberalis*): between ischial tuberosities – 12cm.

External conjugate (*conjugata externa*): spinous process of L5 and superior margin of pubic symphysis (*syphysis pubica*) – 20cm (minimally 18cm).

Gender differences

- The female pelvis is larger and broader than the male pelvis which is taller, narrower, and more compact. Ala ossis illi is in male more in sagittal plane in females more in frontal plane.
- The iliac crests are higher and more pronounced in males, making the male false pelvis deeper and more narrow than in females.
- Ischial tuberosities are in females more distant than in males.
- Symphysis is higher in males and the angle between the inferior pubic rami is acute (70 degrees) in men, but obtuse (90-100 degrees) in women. Accordingly, the angle is called subpubic angle in men and pubic arch in women. Additionally, the bones forming the angle/arch are more concave in females but straight in males.
- The female inlet is larger and oval in shape, while the male sacral promontory projects further (i.e. the male inlet is more heart-shaped).
- The male sacrum is long, narrow, more straight, and has a pronounced sacral promontory. The female sacrum is shorter, wider, more curved posteriorly, and has a less pronounced promontory.
- Greater sciatic notch is broader in females, in males is narrow.
- Superior ramus of pubic bone is in females longer.
- Obturator foramen is in females triangular and in males oval.

Connections of the free part of the lower limb (*juncturae ossium extremitatis inferioris liberae*)

1. Hip joint (*articulatio coxae*)

Articular surfaces: lunate articular surface in acetabulum (*facies lunata*), acetabular pillow (*pulvinar acetabuli*) and head of the femur (*caput femoris*).

Articular capsule: attached to the margins of acetabulum on the femur reaches anteriorly to the intertrochanteric line (*linea intertrochanterica*) and posteriorly medially away from the trochanteric fossa (*fossa trochanterica*) that is outside of capsule.

Additional features: acetabular lip (*labrum acetabulare*), transverse acetabular ligament (*ligamentum transversum acetabulare*), iliofemoral ligament (*ligamentum iliofemorale*), pubofemoral ligament (*ligamentum pubofemorale*), ischiofemoral ligament (*ligamentum ischiofemorale*), orbicular zone (*zona orbicularis*) formed by pubofemoral and ischiofemoral ligaments, ligament of the head of the femur (*ligamentum capitis femoris*), iliopectine bursa (*bursa iliopectinea*).

Type of joint: ball and socket (spheroidal) but with limited movements - *enarthrosis*, movements are possible to all directions (three degrees of freedom of movements).

2. Knee joint (*articulatio genus*) – compound joint

Articular surfaces:

a) medial femoral condyle (*condylus femoris medialis*) and medial articular surface on the proximal end of the tibia (*facies articularis medialis*)

b) lateral femoral condyle (*condylus femoris lateralis*) and lateral articular surface on the proximal end of the tibia (*facies articularis lateralis*)

c) articular surface of the patella (*facies articularis patellae*) and patellar surface of femur (*facies patellaris femoris*)

Articular capsule: is solid and spacious and is attached 1-1,5cm from margins of articular surfaces. Synovial membrane is placed on the cruciate ligaments (*ligamenta cruciata*) and anteriorly from them protrudes towards to the patella as (*plica synovialis patellae*). Caudally from patella is inserted between the fibrous and synovial membrane (*corpus adiposum genus*). Infrapatellar synovial plica (*plica synovialis infrapatellaris*), (*plicae alares*).

Additional features: medial meniscus (*meniscus medialis*) (attach to the area intercondylaris anterior et posterior) - semicircular fuses with joint capsule and through with medial collateral ligament is less movable than lateral meniscus (*meniscus lateralis*) – almost circular (attach to the lateral intercondylar tubercle), tendon of quadriceps femoris muscle, patellar ligament (*ligamentum patellae*), medial and lateral patellar retinaculum (*retinaculum patellae mediale et laterale*), collateral tibial and fibular ligaments (*ligamentum collaterale tibiale et fibulare*), oblique popliteal ligament (*ligamentum popliteum obliquum*), anterior and posterior cruciate ligaments (*ligamenta cruciata – anterior et posterior*), suprapatellar, praepatellar and subcutaneous praepatellar bursae (*bursa suprapatellaris, praepatellaris, praepatellaris subcutanea*),

Type of joint: compound joint, hinge joint (monoaxial), flexio, extension, in small flexion slight external and internal rotation is possible.

3. Connections of the shin bones (*juncturae tibiofibulares*)

A. Tibiofibular articulation (*articulatio tibiofibularis*)

Articular surfaces : articular surfaces of the head of the fibula (*facies articularis capitis fibulae*) and articular fibular surface of the tibia (*facies articularis fibularis tibiae*).

Articular capsule: is short and stiff, and attached to the margins of articular surfaces.

Additional features: ligament of the head of the fibula (*ligamentum capitis fibulae*).

Type of joint: plane joint, small movements anteriorly and posteriorly.

B. Interosseous membrane of the shin bones (*membrana interossea cruris*)

Stiff membrane attached to the interosseous margins of the tibia and fibula, attachments of some muscles and course of nerves and vessels.

C. Tibiofibular syndesmosis (*syndesmosis tibiofibularis*) (**syndesmosis !!**)

Distal end of the fibula is inserted in fibular notch (*incisura fibularis tibiae*) **it is not joint !!!!**

Connection by strong ligaments anterior and posterior tibiofibular ligaments (*ligamentum tibiofibulare anterius et posterius*).

Movements: small movements but in case of tearing of ligaments it is not possible to

Joints of the foot (*articulationes pedis*)

A. Talocrural joint (*articulatio talocruralis*) :

Articular surfaces : inferior articular surface of tibia (*facies articularis inferior tibiae*), articular surface of medial malleolus (*facies articularis malleoli medialis*), articular surface of lateral malleolus (*facies articularis malleoli lateralis*) and talar trochlea (*trochlea tali*).

Articular capsule: is attached to the articular margins, anterior and posterior part is lax and on side is reinforced by strong ligaments.

Additional features:

Medial collateral ligament, deltoid ligament (*ligamentum collaterale mediale, ligamentum deltoideum*) has four parts: tibionavicular part (*pars tibionavicularis*) to navicular bone, anterior tibiotalar part (*pars tibiotalaris anterior*) to anterior part of talus, tibiocalcaneal part (*pars tibiocalcanea*) to sustentaculum tali and posterior tibiotalar part (*pars tibiotalaris posterior*) to posterior part of talus.

Lateral part has three ligaments: anterior talofibular ligament (*ligamentum talofibulare anterius*) to collum tali, calcaneofibular ligament (*ligamentum calcaneofibulare*) between lateral malleolus and lateral surface of the calcaneus, posterior talofibular ligament (*ligamentum talofibulare posterius*) between lateral malleolar fossa (*fossa malleoli lateralis*) and posterior talar process (*processus posterior tali*).

Type of the joint: trochlear joint, hinge joint, plantar and dorsal flexion, trochlea tali is narrower proximally slight side to side movements are possible.

B. Intertarsal joints (*articulationes intertarsales*)

▪ **Subtalar joint (*articulatio subtalaris*)**

Articular surfaces: posterior calcaneal surface of talus and posterior talar surface of calcaneus (*facies articularis calcanea posterior tali et facies articularis talaris posterior calcanei*).

Articular capsule: short and attached to the articular margins.

Additional features: lateral and medial talocalcaneal ligaments (*ligamentum talocalcaneum laterale et mediale*), interosseous talocalcaneal ligament (*ligamentum talocalcaneum interosseum*).

▪ **Talocalcaneonavicular joint (*articulatio talocalcaneonavicularis*) (compound joint)**

Articular surfaces: anterior and medial calcaneal surface of talus and anterior and medial talar surface of calcaneus (*facies articularis calcanea anterior et media tali et facies articularis talaris anterior et media calcanei*) and head of talus (*caput tali*) with navicular bone (*os naviculare*).

Articular capsule: is very thin and common for all parts attach to the margins of articular surfaces.

Additional feature:

Plantarly: plantar calcaneonavicular ligament (*ligamentum calcaneonaviculare plantare*).

Dorsally: dorsal calcaneonavicular ligament (*ligamentum calcaneonaviculare dorsale*) part of the bifurcate ligament (*ligamentum bifurcatum*), talonavicular ligament (*ligamentum talonaviculare*), interosseous talocalcaneal ligament (*ligamentum talocalcaneare interosseum*),

Both joints represent mechanical unit with possible movements according to the axis that goes through tarsal sinus (*sinus tarsi*), pronatio and supinatio (internal and external rotation).

▪ **Calcaneocuboid joint (*articulatio calcaneocuboidea*)**

Articular surfaces: cuboid articular surface of calcaneus (*facies articularis cuboidea*) and proximal articular surface of cuboid bone.

Articular capsule: thin and attached to the articular margins.

Additional features: plantar calcaneocuboid ligament (*ligamentum calcaneocuboideum plantare*) long plantar ligament (*ligamentum plantare longum*), calcaneocuboid ligament (*ligamentum calcaneocuboideum*) is second part of bifurcate ligament (*ligamentum bifurcatum*).

Type of joint: saddle joint but movements are limited by other joints subtalar joint, axis of movements is in sinus tarsi.

Chopart's articulation (joint), transverse tarsal joint (*articulatio tarsi transversa*):

joint fissure between head of talus (*caput tali*) and navicular bone (*os naviculare*) and between calcaneus and cuboid bone (*os cuboideum*). Opening of this fissure in case of exarticulation is by cutting the bifurcate ligament.

▪ **Cuneonavicular joint (*articulatio cuneonavicularis*)**

Articular surfaces: distal articular surface of navicular bone (*os naviculare*) and proximal articular surfaces of cuneiform bones (*ossa cuneiformia*).

Additional features: plantar and dorsal cuneonavicular ligaments (*ligamenta cuneonavicularia plantaria et dorsalia*), articular fissure is connected with articular fissure of intermetatarsal joints, common articular capsule if enforced by dorsal, plantar and interosseous intercuneiform ligaments (*ligamenta intercuneiformia dorsalia, plantaria et interossea*).

▪ **Cuneocuboid joint (*articulatio cuneocuboidea*)**

Articular surfaces: articular surface on medial side of cuboid bone and lateral articular surface of lateral cuneiform bone.

Additional features: dorsal, plantar and interosseous cuneocuboid ligaments (*ligamenta cuneocuboidea- dorsale, plantare, interosseum*).

▪ **Intermetatarsal joint (*articulatio intermetatarsalis*)**

C. Tarsometatarsal joints (articulationes tarsometatarsales) (Lisfrank's joint)

Articular surfaces: three parts

- a) Medial cuneiform bone with base of I. metatarsal bone
- b) Intermediate and lateral cuneiform bone with II. and III. metatarsal bones
- c) Cuboid bone with IV. and V. metatarsal bones

Articular capsule: thin and attached to the articular margins.

Additional feature: dorsal, plantar and interosseous tarsometatarsal ligaments (*ligamenta tarsometatarsalia dorsalia, plantaria et interossea*).

Movements: slight movements during loading of plantar arch.

Lisfrank's joint: place of articulation of toe.

D. Metatarsophalangeal joints (*articulationes metatarsophalangeales*)

Articular surfaces: heads of metatarsal bones and bases of proximal phalanges.

Articular capsule: is attached to margins of the articular surfaces.

Additional features: fibrous cartilages increase articular fossa – *laminae fibrocartilagineae plantares*, deep transverse metatarsal ligament (*ligamentum metatarsale transversum profundum*), collateral ligaments (*ligamenta collateralia*), sesamoid bones (*ossa sesamoidea*) in first metatarsophalangeal joint.

Type of joint: ball and socket, flexion, extension, abduction and adduction movements restricted by collateral ligaments.

E. Interphalangeal joints (*articulationes interphalangeae pedis*)

Articular surfaces: *trochlea phalangis* of the proximal phalanx, basis of distal phalanx.

Articular capsule: is attached to margins of the articular surfaces.

Additional features: fibrous cartilages increase articular fossae – *laminae fibrocartilagineae plantares*. Articular capsules are reinforced by the strong collateral ligaments (*ligg. collateralia*), tendons of extensors.

Type of joint: hinge joint (*articulatio trochlearis*), movements – flexion and extension.

Arches of the foot

The bones of the foot do not lie in a horizontal plane. Instead, they form longitudinal and transverse arches relative to the ground, which absorb and distribute downward forces from the body during standing and moving on different surfaces.

Longitudinal arch

Medially: talus, navicular bone, cuneiform bones, I. – III. metatarsal bones

Laterally: calcaneus, cuboid bone, IV- and V. metatarsal bones.

Medial arch is over the lateral arch

Transverse arch

Ossa cuneiformia

Arches are kept by ligaments and muscles.

Function: protection of soft parts of *planta pedis* before pressure (long standing), weight bearing points are tuber calcanei, heads I. and V. metatarsal bones.

Flat foot – *pes planus*.