

## The Spine

The vertebral column (backbone or spine) is a column of 24 vertebrae, the sacrum, intervertebral discs, and the coccyx situated in the dorsal aspect of the torso, separated by spinal discs. It houses the spinal cord in its spinal canal. Viewed laterally the vertebral column presents several curves, which correspond to the different regions of the column, and are called cervical, thoracic, lumbar, and pelvic.

The cervical curve, convex forward, begins at the apex of the odontoid (*tooth-like*) process, and ends at the middle of the second thoracic vertebra; it is the least marked of all the curves.

The thoracic curve, concave forward, begins at the middle of the second and ends at the middle of the twelfth thoracic vertebra. Its most prominent point behind corresponds to the spinous process of the seventh thoracic vertebra. This curve is known as a *tt curve*.

The lumbar curve is more marked in the female than in the male; it begins at the middle of the last thoracic vertebra, and ends at the sacrovertebral angle. It is convex anteriorly, the convexity of the lower three vertebrae being much greater than that of the upper two. This curve is described as a *lordotic curve*.

The pelvic curve begins at the sacrovertebral articulation, and ends at the point of the coccyx; its concavity is directed downward and forward.

The thoracic and pelvic curves are termed primary curves, because they alone are present during fetal life. The cervical and lumbar curves are *compensatory* or *secondary*, and are developed after birth, the former when the child is able to hold up its head (at three or four months) and to sit upright (at nine months), the latter at twelve or eighteen months, when the child begins to walk.

Individual vertebrae are named according to region and position, from superior to inferior:

- Cervical – 7 vertebrae (C1-C7)
  - C1 is known as "atlas" and supports the head, C2 is known as "axis"
  - Possesses bifid spinous processes, which is absent in C7
  - Small-bodied
- Thoracic – 12 vertebrae (T1-T12)
  - Distinguished by the presence of costal facets for the articulation of the heads of ribs
  - Body is intermediate in size between the cervical and lumbar vertebrae
- Lumbar – 5 vertebrae (L1-L5)
  - Has a large body
  - Does not have costal facets nor transverse process foramina
- Sacral – 5 (fused) vertebrae (S1-S5)
- Coccygeal – 4 (3-5) (fused) vertebrae (Tailbone)

## The Pelvis

The pelvis is the bony structure located at the base of the spine (properly known as the caudal end). It is part of the appendicular skeleton. Each os coxae (hipbone) consists of three bones: the ilium, ischium, and the pubis. The ilium is the largest and upper most part, the ischium is the posterior-inferior (back-lower) part, and the pubis is the anterior (front) part of the hipbone. The two hipbones are joined anteriorly at the symphysis pubis and posteriorly to the sacrum. The pelvis incorporates the socket portion of the hip joint for each leg (in bipeds) or hind leg (in quadrupeds). It forms the lower limb (or hind-limb) girdle of the skeleton.

## Pelvic cavity

The pelvic cavity is a body cavity that is bounded by the bones of the pelvis and which primarily contains reproductive organs, the urinary bladder, and the rectum. The lesser pelvis (or "true pelvis") only includes structures inferior to the pelvic brim. The greater pelvis (or "false pelvis") is the expanded portion of the cavity situated above and in front of the pelvic brim. The sacrum is a large, triangular bone at the base of the spine and at the upper and back part of the pelvic cavity, where it is inserted like a wedge between the two hip bones.

The hip bones are divided into 5 areas, which are:

- The sacrum: This is a bone at the base of the vertebral column that is created by the fusion of 5 vertebrae. It attaches to the ilium on the sides. It also provides a point of muscle attachment for back muscles.
- The coccyx (also called the tail bone): This is a small vestigial bone that attaches to the base of the sacrum. It is created from the fusion of up to 5 small vertebrae.
- The ilium: This is the largest area of the hip bones. It consists of 2 large broad plates, one on each side, which serve to support the internal organs, and to provide attachment for muscles of the back, sides, and buttocks. The hip joint of the femur is part of the ilium.
- The ischium: The ischium consists of 2 broad curves of bone, one on each side, which lie below the ilium, and are attached to the pubis in the front and the ilium in the back. The ischium serves as a place of attachment for muscles. When a person's butt hurts from sitting on a hard surface, it is the result of the sharp ischium pressing on the buttocks.
- The pubis: The pubis is the front-most area of the hip bones. It attaches to the ilium on the sides and the ischium on the bottom. It provides structural support, and serves as a place of attachment for the muscles of the inner thigh.

## Movements

Seven different kinds of movements are possible in the hip joint:

- Flexion and extension on or from the spine or on or from the thigh
- Abduction and adduction of the femur
- Internal (medial) and external (lateral) rotation of the pelvis, thigh or spine
- Circumduction of the femur or pelvis

A synovial joint that can produce movement around more than one axis is called a multiaxial joint.

The hip joint is a synovial joint formed by the articulation of the rounded head of the femur and the cup-like acetabulum of the pelvis. It is classified as a ball and socket joint. It forms the primary connection between the bones of the lower limb and the axial skeleton of the trunk and pelvis. Both joint surfaces are covered with a strong but lubricated layer called articular hyaline cartilage. The cuplike acetabulum forms at the union of three pelvic bones and the joint may not be fully ossified (the process of forming bone) under the age of 25 years. The depth of the acetabulum is increased by a fibrocartilaginous rim called a labrum that grips the head of the femur and secures it in the joint. The acetabulum is oriented inferiorly, laterally and anteriorly. The magnitude of inferior orientation can be assessed using a line connecting the lateral rim of acetabulum and center of femoral head. This line forms an angle with vertical known as center edge angle or angle of Wiberg. The magnitude of anterior orientation is referred as angle of acetabular anteversion.

The large head of the femur is completely covered in hyaline cartilage except for a small area called the fovea or pit. This is the site of attachment for an intracapsular ligament (called the ligamentum teres) that attaches directly from the head of the femur to the acetabulum. The head of the femur is attached to the shaft by a thin neck region that is often prone to fracture in the elderly, which is mainly due to the degenerative effects of osteoporosis.

## **Capsule**

The strong but loose fibrous capsule of the hip joints permits the hip joint to have the second largest range of movement (second only to the shoulder) and yet support the weight of the body, arms and head. The capsule is attached proximally to the entire periphery of the acetabulum beyond the acetabular labrum. The capsule covers the femoral head and neck like a sleeve and attaches to the base of neck. The capsule has two sets of fibers: longitudinal and circular. The circular fibers form a collar around the femoral neck called the zona orbicularis. The longitudinal retinacular fibers travel along the neck and carry blood vessels. As the line of gravity falls posterior to the axis of the hip joint, the combined weight of the body seeks to extend the hip joint in normal standing and make the trunk fall backwards to the ground. To resist the stretching action on the anterior joint capsule in normal upright posture, the hip has two very strong anterior ligaments.

## **Ligaments**

The hip joint is reinforced by three main ligaments.

- At the front of the joint, the strong iliofemoral ligament attaches from the pelvis to femur. This Y-shaped ligament is also known as the ligament of Bigelow. This ligament seeks to resist excessive extension of the hip joint. It is often considered to be the strongest ligament in the human body.
- The pubofemoral ligament attaches across the front of the joint from the pubis bone of the pelvis to the femur. This ligament is oriented more inferiorly than the iliofemoral

ligament and reinforces the inferior part of the hip joint capsule. It also blends with the medial parts of the iliofemoral ligament.

- The posterior of the hip joint capsule is reinforced by the ischiofemoral ligament that attaches from the ischial part of the acetabular rim to the femur.

There is also a small ligament called ligamentum teres or the ligament of the head of the femur. The ligament is a triangularly shaped band with its base on both sides of peripheral edge of acetabular notch. This structure is not that important as a ligament but can often be vitally important as a conduit of a small artery to the head of the femur. This arterial branch is not present in everyone but can become the only blood supply to the bone in the head of the femur when the neck of the femur is fractured or disrupted by injury in childhood.

### **Blood supply and nerve supply of the hip joint**

The hip joint is supplied with blood from the medial circumflex femoral and lateral circumflex femoral arteries, which are both usually branches of the deep artery of the thigh (profunda femoris), but may also arise directly from the femoral artery. There is also a small contribution from a small artery in the ligament of the head of the femur which is a branch of the posterior division of the obturator artery, which becomes important to avoid avascular necrosis of the head of the femur when the blood supply from the medial and lateral circumflex arteries are disrupted (e.g. through fracture of the neck of the femur along their course).

The hip has two anatomically important anastomoses, the cruciate and the trochanteric anastomoses. These exist between the femoral artery or profunda femoris and the gluteal vessels.

The hip joint is supplied by a number of nerves (proprioception, nociception, etc...) including the femoral nerve, the obturator nerve, superior gluteal nerve, and the nerve to quadratus femoris.

The muscles that cause movement in the hip can be divided into five groups according to their orientation around the hip joint:

- the *extensors group* includes gluteus maximus and hamstrings
- the *lateral rotator group* includes obturator internus and externus, gemellus superior and inferior, quadratus femoris and piriformis
- the *adductor group* includes pectineus, adductor brevis, longus and magnus.
- the *flexor group* includes iliopsoas, rectus femoris, tensor fascia lata and sartorius
- the *abductor group* include gluteus medius and minimus.

These muscles produce flexion, extension, lateral rotation, medial rotation, abduction, and adduction.

Many of the hip muscles are responsible for more than one type of movement in the hip, as different areas of the muscle act on tendons in different ways.

## The Hip Joint

The hip is a ball-and-socket joint where the head of the femur (Thigh bone) articulates with the cuplike acetabulum of the pelvic bone. The acetabulum fits tightly around the head of the femur. The ball is normally held in the socket by very powerful ligaments that form a complete sleeve around the joint (the joint capsule). The capsule has a delicate lining (the synovium). The head of the femur is covered with a layer of smooth cartilage which is a fairly soft, white substance. The socket is also lined with cartilage. This cartilage cushions the joint, and allows the bones to move on each other with very little friction.

An x-ray of the hip joint usually shows a "space" between the ball and the socket because the cartilage does not show up on x-rays. In the normal hip this "joint space" is approximately 1/4 inch wide and fairly even in outline.

In anatomy, the hip is the bony projection of the femur which is known as the greater trochanter, and the overlying muscle and fat. The hip joint, scientifically referred to as the acetabulofemoral joint, is the joint between the femur and acetabulum of the pelvis and its primary function is to support the weight of the body in both static (e.g. standing) and dynamic (e.g. walking or running) postures.

### The three types of muscle:

- Skeletal muscle or "voluntary muscle" is anchored by tendons to bone and is used to affect skeletal movement such as locomotion and in maintaining posture. Though this postural control is generally maintained as a subconscious reflex, the muscles responsible react to conscious control like non-postural muscles. An average adult male is made up of 40–50% of skeletal muscle and an average adult female is made up of 30–40% (as a percentage of body mass).<sup>[citation needed]</sup>
- Smooth muscle or "involuntary muscle" is found within the walls of organs and structures such as the esophagus, stomach, intestines, bronchi, uterus, urethra, bladder, blood vessels, and even the skin (in which it controls erection of body hair). Unlike skeletal muscle, smooth muscle is not under conscious control.
- Cardiac muscle is also an "involuntary muscle" but is more akin in structure to skeletal muscle, and is found only in the heart.

Cardiac and skeletal muscles are "striated" in that they contain sarcomeres and are packed into highly-regular arrangements of bundles; smooth muscle has neither. While skeletal muscles are arranged in regular, parallel bundles, cardiac muscle connects at branching, irregular angles (called intercalated discs). Striated muscle contracts and relaxes in short, intense bursts, whereas smooth muscle sustains longer or even near-permanent contractions.

### Skeletal muscle is further divided into several subtypes:

- Type I, slow oxidative, slow twitch, or "red" muscle is dense with capillaries and is rich in mitochondria and myoglobin, giving the muscle tissue its characteristic red color. It can carry more oxygen and sustain aerobic activity.
- Type II, fast twitch muscle, has three major kinds that are, in order of increasing contractile speed:<sup>[2]</sup>
  - Type IIa, which, like slow muscle, is aerobic, rich in mitochondria and capillaries and appears red.
  - Type IIx (also known as type IIc), which is less dense in mitochondria and myoglobin. This is the fastest muscle type in humans. It can contract more quickly and with a greater amount of force than oxidative muscle, but can sustain only short, anaerobic bursts of activity before muscle contraction becomes painful (often incorrectly attributed to a build-up of lactic acid). N.B. in some books and articles this muscle in humans was, confusingly, called type IIB.<sup>[3]</sup>
  - Type IIb, which is anaerobic, glycolytic, "white" muscle that is even less dense in mitochondria and myoglobin. In small animals like rodents this is the major fast muscle type, explaining the pale color of their flesh.

## "Strength" in human muscles

Since three factors affect muscular strength simultaneously and muscles never work individually, it is misleading to compare strength in individual muscles, and state that one is the "strongest". But below are several muscles whose strength is noteworthy for different reasons.

- In ordinary parlance, muscular "strength" usually refers to the ability to exert a force on an external object—for example, lifting a weight. By this definition, the masseter or jaw muscle is the strongest. The 1992 Guinness Book of Records records the achievement of a bite strength of 4337 N (975 lbf) for 2 seconds. What distinguishes the masseter is not anything special about the muscle itself, but its advantage in working against a much shorter lever arm than other muscles.
- If "strength" refers to the force exerted by the muscle itself, e.g., on the place where it inserts into a bone, then the strongest muscles are those with the largest cross-sectional area. This is because the tension exerted by an individual skeletal muscle fiber does not vary much. Each fiber can exert a force on the order of 0.3 micronewton. By this definition, the strongest muscle of the body is usually said to be the quadriceps femoris or the gluteus maximus.
- A shorter muscle will be stronger "pound for pound" (i.e., by weight) than a longer muscle. The myometrial layer of the uterus may be the strongest muscle by weight in the human body. At the time when an infant is delivered, the entire human uterus weighs about 1.1 kg (40 oz). During childbirth, the uterus exerts 100 to 400 N (25 to 100 lbf) of downward force with each contraction.
- The external muscles of the eye are conspicuously large and strong in relation to the small size and weight of the eyeball. It is frequently said that they are "the strongest muscles for the job they have to do" and are sometimes claimed to be "100 times stronger

than they need to be." However, eye movements (particularly saccades used on facial scanning and reading) do require high speed movements, and eye muscles are exercised nightly during rapid eye movement sleep.

- The statement that "the tongue is the strongest muscle in the body" appears frequently in lists of surprising facts, but it is difficult to find any definition of "strength" that would make this statement true. Note that the tongue consists of sixteen muscles, not one.
- The heart has a claim to being the muscle that performs the largest quantity of physical work in the course of a lifetime. Estimates of the power output of the human heart range from 1 to 5 watts. This is much less than the maximum power output of other muscles; for example, the quadriceps can produce over 100 watts, but only for a few minutes. The heart does its work continuously over an entire lifetime without pause, and thus does "outwork" other muscles. An output of one watt continuously for eighty years yields a total work output of two and a half gigajoules.