The musculoskeletal system is made up of bones, cartilage, ligaments, tendons and muscles, which form a framework for the body. Tendons, ligaments and fibrous tissue bind the structures together to create stability, with ligaments connecting bone to bone, and tendons connecting muscle to bone. There are 206 bones in the adult skeleton; male and female skeletons are almost the same, but the female skeleton has a broader pelvis to accommodate childbirth and the male skeleton is typically taller with greater bone density. The skeleton is divided into the:

- Axial skeleton – comprising the skull, vertebral column and the rib cage;
- Appendicular skeleton – consisting of the pelvic and pectoral girdles, and the upper and lower limbs (Cedar, 2012).

Coordinated movement is made possible through the combination of purposeful and synchronised movements across the relevant muscles and bones to create articulation of the joints. The configuration of the joint surface determines the movement possible. Planes of movement include flexion, extension, abduction, adduction, rotation and circumduction (Table 1).

Joints
The joints are the articulating surfaces between two bones and may be classified according to how much movement they allow:

- Synarthrosis – a fixed, unmovable joint;
- Amphiarthrosis – a joint in which some movement is possible;
- Diarthrosis – a freely movable joint (Moini, 2020).

They can also be classified according to the components that unite the bones (such as fibrous structures, cartilaginous structures and synovial structures), as shown below.

Fibrous joints
Fibrous joints are articulating surfaces linked together with tough fibrous connections. One example is the suture lines in the skull, where bones that were initially separate have become fused together (synostosis) to form one bone (Danning, 2019). As the suture line does not permit movement once fusion has occurred, this is considered to be a synarthrotic joint.

Syndesmoses are another type of fibrous joint, in which ligaments and interosseous membrane connect the joint to create a firm structure. One example is the inferior tibiofibular joint, in which...
interosseous, tibiofibular and transverse ligaments connect the distal tibia and fibula of the lower leg. Another is the radioulnar joint, where an intraosseous membrane connects the distal radius and ulnar bones of the forearm. This can also be classified as an amphiarthritic joint as it permits some movement to allow for pronation and supination of the hand and forearm.

**Cartilaginous joints**

These joints are connected by tough cartilage between the bone and can be classified as primary (synchondroses) or secondary (symphyses).

**Synchondroses**

Synchondroses are cartilaginous joints formed of hyaline cartilage, and are mainly found in the growing skeleton as the ossification centres of growing bone that will ossify over time (synostosis), such as the epiphyseal growth plate.

Cartilaginous joints are usually immobile but, in a rare condition in children and adolescents, the attachment of the epiphysis loosens, allowing the femoral head to slip down the femoral neck. This is known as a slipped upper femoral epiphysis and often presents with the child developing an unexpected limp (Robson and Syndercombe Court, 2019).

In the mature skeleton, an example of a synchondrosis is the first sternocostal joint (between the first rib and the manubrium); all other sternocostal joints are synovial.

**Symphyses**

These are permanent cartilaginous joints, in which the bones are connected through fibrocartilage; interestingly, these are all at the body’s midline (Robson and Syndercombe Court, 2019). The intervertebral discs between the vertebral bodies of the spine are an example of bones connected by fibrocartilage. These fibrous joints allow relatively limited movement individually but extensive movement can be achieved collectively across the whole spine.

Another example of a symphysis is the symphysis pubis in the pelvis, which helps maintain pelvic stability. In pregnancy, the symphysis pubis is softened by hormones to allow for expansion during delivery. This, together with the unfused bones of the baby’s skull, allows passage of the baby’s head through the birth canal.

As symphyses allow slight movement between the articulating surfaces, they are considered to be amphiarthroses.

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**Table 1. Planes of movement at the joint**

<table>
<thead>
<tr>
<th>Movement</th>
<th>Description</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>Bending the joint: decreases the angle between the bones</td>
<td>Elbow joint Flexion Extension</td>
</tr>
<tr>
<td>Extension</td>
<td>Straightening the limb (continuing the extension past the anatomical straight line may be described as hyperextension)</td>
<td></td>
</tr>
<tr>
<td>Abduction</td>
<td>Movement away from the midline</td>
<td>Abduction</td>
</tr>
<tr>
<td>Adduction</td>
<td>Movement towards the midline</td>
<td>Adduction</td>
</tr>
<tr>
<td>Rotation</td>
<td>Movement around a longitudinal axis</td>
<td>Rotation</td>
</tr>
<tr>
<td>Circumduction</td>
<td>Movement in a circular motion</td>
<td>Circumduction</td>
</tr>
<tr>
<td>Pronation</td>
<td>For example, turning the palm of the hand downwards</td>
<td>Supination Pronation</td>
</tr>
<tr>
<td>Supination</td>
<td>For example, turning the palm of the hand upwards</td>
<td></td>
</tr>
<tr>
<td>Opposition</td>
<td>Movement of the thumb across the palm to touch the tips of the fingers on the same hand</td>
<td>Opposition</td>
</tr>
<tr>
<td>Inversion</td>
<td>Turning the sole of the foot inwards</td>
<td></td>
</tr>
<tr>
<td>Eversion</td>
<td>Turning the sole of the foot outwards</td>
<td></td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Joint type</th>
<th>Description</th>
<th>Example</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planar</td>
<td>Two flat or slightly curved articulating surfaces that slide against each other, allowing a side-to-side and back-and-forth movement</td>
<td>Intercarpal joints, Intertarsal joints, Vertebral facets</td>
<td><img src="image1" alt="Plane Joint" /></td>
</tr>
<tr>
<td>Hinge</td>
<td>Typically has convex part of one bone that sits inside the concave part of another and allows a uni-axial movement, such as flexion and extension</td>
<td>Elbow, Ankle, Knee</td>
<td><img src="image2" alt="Hinge joint" /></td>
</tr>
<tr>
<td>Pivot</td>
<td>One bone pivots around another to create a rotational movement around a single axis</td>
<td>Atlantoaxial joint between C1 (atlas) and C2 (axis) of the spine, Radialulnar joint between the radius and the ulnar, allowing them to pronate and supinate the hand</td>
<td><img src="image3" alt="Pivot joint" /></td>
</tr>
<tr>
<td>Condyloid</td>
<td>An ovoid convex part sits in the ellipsoidal cavity of the other bone, which permits flexion/extension, abduction/adduction and circumduction</td>
<td>Radiocarpal joint of the wrist, Metacarpophalangeal joints in the hand</td>
<td><img src="image4" alt="Condylar joint" /></td>
</tr>
<tr>
<td>Saddle</td>
<td>Allows articulation through reciprocal reception as the bones have concave-convex surfaces that interlock. Permits flexion/extension, abduction/adduction and circumduction</td>
<td>Carpometacarpal joint of the thumb</td>
<td><img src="image5" alt="Saddle joint" /></td>
</tr>
<tr>
<td>Ball and socket</td>
<td>The spheroid structure (ball) sits in the socket of another bone. This allows multiaxial movement and has the greatest range of movement. The depth of the socket and the fibrocartilaginous labrum are the limiting factors for motion</td>
<td>Glenohumeral, Acetabulofemoral (hip)</td>
<td><img src="image6" alt="Ball and socket joint" /></td>
</tr>
</tbody>
</table>

**Synovial joints**

Synovial joints are designed to allow free movement of the joint and are classified as diarthroses. Characterised by a gap between the articulating bones, they are held in close proximity by a joint capsule. Contraction of the infrastructure of muscles around the joint maintains movement, while stability is maintained through the use of soft tissue structures, such as ligaments, labra, fat pads and menisci (Danning, 2019).

The joint has an outer fibrous capsule that encapsulates the entire joint and is attached to the periosteum, allowing movement, maintaining tensile strength and helping to prevent dislocation. Inside the capsule are sensory nerve fibres, which detect pain and identify the joint’s position (Moini, 2020). The capsule’s inner layer is highly vascularised and innervated by slow/
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small nerve fibres that, if stimulated, may cause a diffuse burning or aching sensation (Danning, 2019). This layer also contains the synovial membrane (synovium), which is composed of synoviocytes of which there are two types:
- Type A – mediate cytokine release and are involved in generating an immune response (Robson and Syndercombe Court, 2019);
- Type B – produce the synovial fluid.

**Synovial fluid**
The synovial fluid helps protect the joint from mechanical injury and contains hyaluronic acid and lubricin (Danning, 2019). In a healthy joint, the synovial fluid is very viscous and clear, and is either colourless or a pale straw colour. Water is able to enter the joint very easily during inflammation but, once it mixes with hyaluronic acid, it cannot leave as quickly (Robson and Syndercombe Court, 2019). Over time, although it may only take a few hours for the joint to swell, it can take a few days for that swelling to subside.

The synovial fluid may become infected by a haematogenous (blood-borne) spread of bacteria, extension of an adjacent infection or direct inoculation following trauma or an invasive procedure. This is known as septic arthritis and can damage the synovium or cartilage.

**Rheumatoid arthritis**
This is an autoimmune inflammatory arthropathy that affects the synovium. It occurs more often in smokers and is three times more common in women than men (Ralston and McInnes, 2014). Clinical onset is characterised by the abnormal production of cytokines and inflammatory mediators such as interleukin 1, interleukin 6, interleukin 15 and tumour necrosis factor (Ralston and McInnes, 2014). This causes the synovium to become inflamed and hypertrophied so the synovial villi become thickened and fuse together to form a pannus. The pannus invades the surrounding tissue (such as the cartilage, ligaments and joint capsule), which can lead to progressive destruction of the joint (Danning, 2019).

Rheumatoid arthritis can also affect periarticular structures, including tendon sheaths and bursas, as well as having extra-articular manifestations.

**Osteoarthritis**
The articulating surfaces in synovial joints are coated with approximately 2–3mm of hyaline cartilage, which provides a smooth surface and reduces friction during movement. This helps distribute the weight across the joint, reducing friction and damage to the bone surface (Robson and Syndercombe Court, 2019).

Osteoarthritis is a degenerative condition involving focal loss of the articular cartilage, so the cartilage becomes less efficient at protecting the ends of the bone (Ralston and McInnes, 2014). Over time, this can cause bony surfaces to rub together on movement, causing pain and audible crepitus. As the bone attempts to compensate for the loss of articular cartilage, it produces new bone to try and stabilise the joint. This results in bone thickening under the remaining cartilage (sclerosis) and formation of osteophytes at the joint margins, which can reduce the range of movement of the joint.

**Supporting ligaments**
Synovial joints are designed to permit movement while, at the same time, maintaining balance, strength and stability. They vary in structure and the type of movement they permit – Table 2 summarises the different types.

The stability of the joint depends on its shape, the number and position of supporting ligaments around it, their strength and the tension they exert (Tortora and Derrickson, 2009). Supporting ligaments are described according to their position in relation to the capsule (extra-capsular or intracapsular). Excessive tension on ligaments, such as moving the joint beyond its functional range of movement, can cause them to stretch and may mean they sprain or tear. Ligament damage can compromise joint stability and function.

Prolonged disuse of the joint, for example due to immobilisation in a cast or through bed rest, often gives reduced flexibility of the ligaments and tendons, as well as muscular atrophy (Tortora and Derrickson, 2009). This may lead to reduced mobility of joints and difficulties with functional activity.

**Muscle**
There are three types of muscle in the body:
- Smooth;
- Cardiac;
- Skeletal.

Unlike skeletal muscle, smooth and cardiac muscles are not under voluntary control (Soames and Palastanga, 2019). Skeletal muscle is innervated by the somatic...
Bursitis (housemaid’s knee) and olecranon bursitis are fluid-filled sacs located at sites where there may be shearing forces, such as when muscles and tendons pass over, or around the edge of, bone – for example, in the shoulder (subacromial bursa) or the hip (trochanteric bursa) (Robson and Syndercombe Court, 2019). Bursas allow structures to glide smoothly over each other, reducing friction during movement. On occasion, they may become inflamed and painful due to infection, movement. When skeletal muscle receives a signal from the somatic (motor) nerve, it shortens, pulling one bone towards the other. As one muscle in the pair contracts, the other muscle relaxes; the process is then reversed to straighten the bone joint. Skeletal muscle requires four key properties:

- Contractility – so it contracts to produce forces sufficient to move bone.
- Extensibility – ensuring it is able to stretch without being damaged.
- Elasticity – allowing it to return to its resting state after being stretched or contracted.
- Excitability – so it is able to respond to a stimulus (action potential).

The neuromuscular junction is the chemical synapse formed between the nerve fibre and the muscle fibre. The nerve into the synapse between the muscle and the nerve fibre releases acetylcholine, which acts as a chemical neurotransmitter to convey the electrical impulse from the nerve to the receptors in the muscle. During surgery, the neuromuscular junction is an important site for drug action, as blocking the acetylcholine receptors provides a neuromuscular blockade that causes muscle paralysis. Skeletal muscle performs best when it is used regularly, and the use of targeted training or exercise can improve its endurance and power. Likewise, loss of muscle mass (atrophy), such as a decrease in muscle size and strength, may occur due to inactivity or factors such as poor nutrition or chronic illness. Although ageing, and the accompanying reduction in mobility, can reduce the quality of the connective tissue and cause ligaments to lose some of their flexibility (Robson and Syndercombe Court, 2019), it is important to optimise musculoskeletal health by maintaining a healthy diet and continuing physical activity to the best of a person’s ability (Rowe et al., 2019).

**Conclusion**

Muscles and joints are an important part of the musculoskeletal system. The structure of articulating surfaces and the type of connective tissues play a significant role in the range and plane of movement permitted at the joint. Skeletal muscles are responsible for movement and posture, and work best when used regularly to prevent atrophy. Pathology affecting the joints can have a significant impact on function and range of movement – understanding how pathology affects the musculoskeletal system allows practitioners to address signs and symptoms, and proactively promote musculoskeletal health.

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**References**


