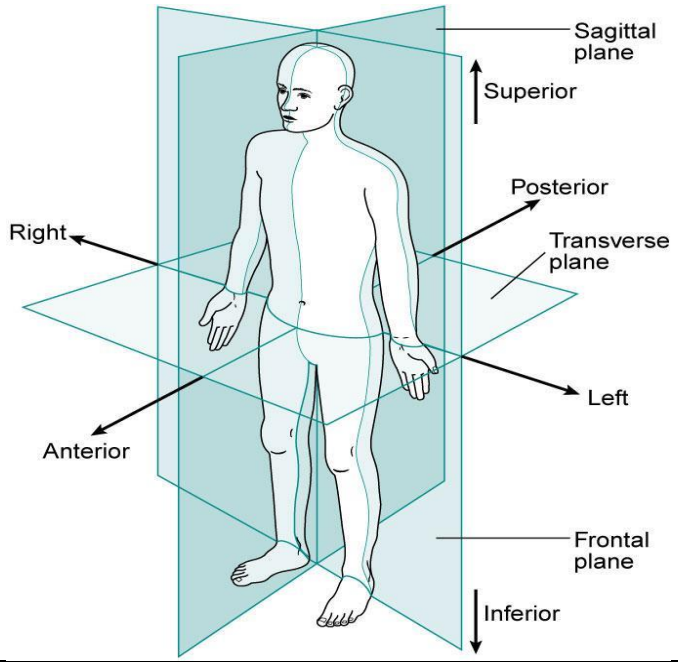
4.2 – Joint and Movement Type

4.2.1 - Outline the types of movement of synovial joints

- The musculoskeletal system is the arrangement of bones, joints and muscles that permits movement of the human body in sport and exercise
- The body segments are articulated by the synovial joints at which two or more bones meet
- Usually movement consists of rotation of one segment relative to another at the joint
- The rotation is caused by forces originating from the muscles, other parts of the body or external actors (such as gravity, sporting implements or other people)

- Synovial joints can be classified depending on how many axes of rotation the bones have

TERM	TYPE	EXAMPLE	STRUCTURE
Non-Axial	Gliding Joints	Between the carpal bones in the palm of the hand	• The bones slide in relation to each other Therefore, there are no axes of rotation in this type of joint
Uniaxial	Hinge and Pivot Joints	The elbow and the radio-ulnar joint	• There is only one axis of rotation This means that the structure of the bones at the joint restricts rotation to movement
Biaxial	Condylar and Saddle Joints	The knee and the base of the thumb	• There are two kinds of axis rotation Therefore, the ones can move in two different ways
Triaxial	Ball and Socket Joints	The shoulder and the hip	• There are three kinds of axis rotation Therefore, these bones permit the greatest movement, as they allow the limbs attached at them to move through a large volume of space



MOTION IN THE SAGITTAL PLANE	
Flexion	Closing of the joint angle around the transverse axis at the closing joint
Extension	Opening of the joint angle around the transverse axis at the joint
MOTION IN THE FRONTAL PLANE	
Abduction	Opening of the joint angle around the anteroposterior axis at the joint
Adduction	Closing of the joint angle around the anteroposterior axis at the joint
MOTION IN THE TRANSVERSE PLANE	
Medial (inward) Rotation	The anterior surface of the moving bone moves towards the medial (inside) aspect of the body
Lateral (outward) Rotation	The anterior surface of the moving bone moves towards the lateral (outside) aspect of the body

- These are the main fundamental movements that apply to all joints, as long as the structure permits movements around the appropriate axes

- **The Elbow Joint**
    - Flexes when it bends
    - Extends when it straightens
    - The structure of the joint does not permit; abduction, adduction, medial or lateral rotation

- **The Shoulder Joint**
    - Flexes when the arm is raised
    - Extends when it is lowered
    - These two movements are the opposite to what might be expected
    - Abducts when the arm is raised from the side
    - Adducts when it is lowered again

- **The Humerus (Upper Arm)**
  - Can undergo rotation around the transverse axis at the shoulder joint
  - When the elbow is kept fully extended, the hand can still go from facing anteriorly to posteriorly (medial rotation) and back again (lateral rotation)

- **When the word 'Hyper' is added to any of these terms, this usually indicates that the action is beyond 180° or back past the starting position**
  - **It is also defined as movement of a body segment into the space posterior to the body when it is in the anatomical position**
    - **Example:**
      - **Hyperextension of the shoulder**

When the arm extends in the sagittal plane and then continues past the anatomical position behind the body

TYPE OF JOINT	MOTION	MOVEMENT DESCRIPTION
Dorsiflexion	Flexion of the ankle joint	• These movement move the foot up and down in the sagittal plane
Plantar Flexion	Extension of the ankle joint	
Pronation	Medial rotation of the radio-ulnar joint (not the wrist joint)	• These movements allow the forearm (and the hand) to rotate • Even when the elbow is flexed to 90° from the anatomical position • Pronation would take the hand from 'palm upwards' to 'palm downwards' and vice versa for supination
Supination	Lateral rotation of the radio-ulnar joint (not the wrist joint)	
Eversion	Medial rotation at the ankle joint	• These movements involve 'rolling' of the foot and ankle, from the anatomical position • If the foot is moved so that the sole faces inwards, this is inversion • If the foot is moved so that the sole faces outwards, this is eversion
Inversion	Lateral rotation at the ankle joint	
Horizontal Abduction (Horizontal Extension)	Opening of the joint angle around the transverse plane when the body segment has already been flexed to 90°	• These actions are common at the shoulder • If the arm is flexed (raised in the sagittal plane) to 90° and then brought toward the midline of the body horizontal, this is horizontal adduction • If the arm is moved horizontally away from the midline when already
Horizontal Adduction (Horizontal Flexion)	Closing of the joint angle around the transverse plane when the body segment has already been flexed to 90°	

		flexed to 90°, this is horizontal abduction

TERM	EXPLANATION	EXAMPLE	TYPE OF MOVEMENT	OCCURRENCE IN
Circumduction	'Circling' of a body segment at a joint	Moving the arm in a circle around the shoulder Cricketer bowling	• Combination of hyperextension, abduction, extension and adduction Circumduction may include other movements in the circling action depending on the direction, axis of rotation and the particular joint	• Shoulder • Hip • Wrist • Ankle • Thumb Requires at least a biaxial joint
Pronation and Supination Of the foot	The movements are often used by sports medicine practitioners when describing motion of the foot at the ankle joint	• Walking • Running	**PRONATION** • Combines dorsiflexion, eversion and abduction of the ankle and foot **SUPINATION** • Plantarflexion, inversion and adduction	**PRONATION** • Just after landing in walking or running as the body's weight is absorbed **SUPINATION** • During push-off in walking or running as the ankle is used to propel the person forward and upward • Not all individuals demonstrate pronation on landing, however it depends on their body structure and their movement technique

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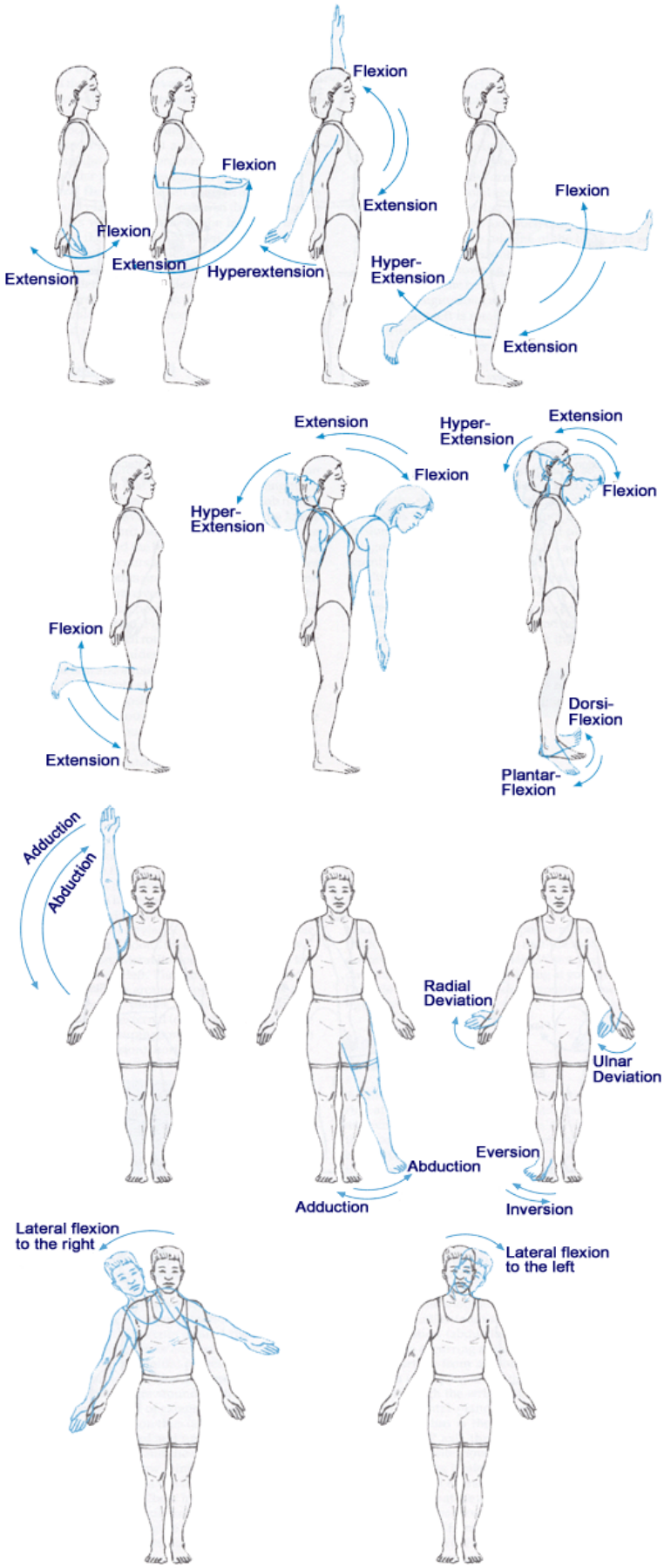
Flexion
Extension
Flexion
Extension
Flexion
Extension
Hyperextension
Flexion
Extension
Hyper-
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Flexion
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Flexion
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Extension
Extension
Flexion
Flexion
Extension
Dorsi-
Flexion
Plantar-
Flexion
Adduction
Abduction
Radial
Deviation
Ulnar
Deviation
Abduction
Adduction
Eversion
Inversion
Lateral flexion
to the right
Lateral flexion
to the left

Range of Motion (ROM) depends on 4 factors;

1. The shape of the surfaces of the articulating bones in the joints
2. The position and length of the restraining ligaments
3. The effects of the muscles and tendons at the joint
4. The amount of soft tissue (skin, fat, muscle) at the joint

4.2.2 – Outline the types of muscle contraction

- When muscles contract, the ends of the muscles are drawn towards the centre of the body due to the sliding filaments
    - However muscles can move the body segments by varying the force of contraction and where the muscles line of action is relative to the joint

TERM	DESCRIPTION
Concentric Contraction	• If the ends of the muscle are actually drawn together; this will result in the movement of one or more body segments • If the rotational effect of the force (torque or moment) from the muscle is greater than that of the resistance to be overcome Segment weight, external weight, other muscles, other person
Isometric Contraction	If the muscle contracts, but the rotational effect of the muscle force (muscle torque or moment) is exactly equal to that it provided by the resistance, then the muscle will not physically shorten although it will be contracted
Eccentric Contraction	• If the muscle is contracting but the rotation effect of the muscle force (muscle torque or moment) is less than that of the resistance, then the ends of the muscles actually get further apart, even though the muscle is still contracting • This is because the muscle is not relaxed, but is not contracting strongly enough (and / or not in a suitable position) to overcome or balance the resistance • The lengthening of the muscle while still contracting is thought to break the actin-myosin bonds mechanically, this means that greater muscle forces and torques can be produced than in concentric contraction Fewer motor units are recruited for the same muscle force and there is also a lower oxygen cost for eccentric contractions than concentric contraction of the same muscle
Isotonic Contraction	• The force remains constant during the movement of the body segment affected by the muscle • The muscle will usually change due to the change in joint angle and therefore the angle of pull of the muscle relative to the joint will also change • This means that the force in the muscle will usually change throughout the the range of motion, even if the external resistance is constant **Lifting a constant weight – Includes CONCENTRIC & ECCENTRIC CONTRACTIONS**
Isokinetic Motion	• When a muscle contract so that the body segment to which it is attached moves at a constant speed around the joint • This type of movement is very rare in sport and exercise (most movements have an acceleration phase and a deceleration phase) • Usually requires complex equipment to ensure the segment rotational speed is constant • This type of motion is useful to rehabilitation when a therapist wants to make sure the speed of a limb is not excessive Just because the body segment moves at a constant rotational speed, it can not be assumed that the muscle is contracting at a constant speed due to the different angles of pull through the range of motion

4.2.3 - Explain the concept of reciprocal inhibition

- **Reciprocal Inhibition (RI)**
  - Is exercise attempts to achieve the simultaneous relaxation of one muscle by the the contraction of its antagonist muscle
    - In reality other muscles are involved both in the contraction and the ensuing relaxation

  - When an agonist contracts to move a body segment, it is usual for the antagonist (the muscle with the opposite concentric contraction action) to relax

    - **This means that the agonist is not being opposed by any muscle torque acting in the opposite direction to that of the motion = <u>RECIPROCAL INHIBITION REFLEX</u> = An automatic action controlled by neurons**

      - When the agonist motor neuron is stimulated, the motor neuron to the antagonist is inhibited, preventing it from contracting strongly
        - During sport and exercise, the signals are very important to ensure maximum torque around the joints when the agonist muscles contract

  - Antagonist muscles contract eccentrically
    - In most movements this would be counterproductive as the antagonist muscles would be producing a torque in the opposite direction to motion
      - Thus, lowering the net torque around the joint

  - Example:
    - During the upward phase of bicep curls, the biceps brachii muscle contracts concentrically and the triceps brachii is still relaxed

  - Occasionally it is necessary for both agonist and antagonist to contract at the same time

  - Example:
    - To control balance or make a joint 'stiffer' when learning a task
      - This is called co-activation and in this case reciprocal inhibition is overridden by the voluntary nervous system

AGONIST	ANTAGONIST
Anterior Deltoid	Levator Scapula
Biceps	Triceps
Deltoids	Latissimus Dorsi
Forearm Flexors	Forearm Extensors
Hip Adductor	Gluteus Medius
Iliopsoas	Gluteus Maximus
Pectoralis Major	Trapezius Rhomboids
Quadriceps	Hamstrings
Rectus Abdominis	Hamstrings When knees are extended
Tibialis Anterior	Gastrocnemius When knee is extended
Tibialis Anterior	Soleus When knee is flexed

AGONIST

- Muscle contracts concentrically to move the bone relative to the joint
    - The muscle shortens and the muscle torque is greater than any resistance torque
    - There are different levels of agonist: prime, assistant or emergency
    - Example:
        - Lifting a weight (elbow flexion) during a bicep curl
            - The prime mover or agonist would be the biceps brachii (the large muscle on the anterior surface of the upper arm)
            - The assistant movers would be the brachialis (a smaller muscle on the anterior surface of the elbow) and the brachioradialis (the muscle that runs from above the elbow to the wrist on the anterior surface of the forearm)

ANTAGONIST

- If a muscle contacts eccentrically, then it is often acting as an antagonist for the joint action
- This means it acts in the opposite direction to its usual concentric function and gets longer even though it is contracting
    - Example:
        - When lowering the weight during a bicep curl (elbow extension)
            - The biceps brachii and the other two muscles act as antagonists to slow the descent (if the muscles relaxed, the weight would simply fall due to gravity
                - **NOTE:**
                - The tricep brachii (the muscle on the posterior surface of the upper arm) does not contract in this action
                - This would simply 'throw' the weight to the floor as the elbow would be extended actively at speed rather than under control

4.2.4 - Analyse movements in relation to joint action and muscle contraction

FIXATOR (stabilizer)

- When muscles contract, both ends are drawn towards the middle of the muscle
- However if only one end of the muscle is required to move a body segment, then the body segment to which the other end of the muscle is attached (usually the other segment of the joint) must be kept stationary
- Therefore, this will require at least one other muscle to contract (usually isometrically) to prevent this segment from moving so that the agonist may move the desired segment
    - **This is one of the main ideas behind the principle of core stability - the muscles of the core must be strong so they can hold the trunk of the body steady while the agonists or antagonists move the limbs**

SYNERGISTS (neutralizer)

- Most muscles have more than one action at a joint
    - Example:
        - When the biceps brachii contracts

            - It flexes the elbow joint
            - It supinates the radio-ulnar joint
                - One or both of the pronator muscles would be used if supination was not desired when the biceps brachii contracts
    - Synergists contract (usually isometrically) to prevent unwanted actions of the agonists or antagonists when undergoing movement
        - If a limb is being moved in the opposite direction to a resistance force (gravity) the agonists are undergoing concrete
        - However if a limb is moving in the same direction as the resistance force (but under control) an eccentric contraction is being performed by the antagonists
        - If no movement is apparent, but the other muscles are contracting, then isometric contraction is likely to be occurring

4.2.5 - Explain delayed onset muscle soreness (DOMS) in relation to eccentric and concentric muscle contractions

- Muscle soreness is a common response to an acute bout of hard exercise, particularly unfamiliar exercises
    - Example:
        - A session of weightlifting for someone who has not performed resistance training for a long period of time
- Soreness usually dissipates 24 - 72 hours after the exercise
- **DOMS results primarily from eccentric muscle action and has a number of causes including:**
    - **Structural muscle damage**
    - **Over training**
    - **Minute tears in the muscle tissue**
    - **Pressure changes that produce fluid retention in the tissues surrounding the muscle**
    - **Muscle spasms**
    - **Overstretching and tearing of the connective tissue attached to the muscle**
    - **Acute inflammation**
        - A combination of these factors
- Muscle soreness may be due to a variety factors, but one of the most common is the sub-cellular damage (and the associated inflammation) that becomes apparent 1 or 2 days after exercise
    - Related to exercise which has large amounts of eccentric exercise
        - Example:
            - Running downhill
                - The quadricep muscles contract eccentrically at the knee to control body weight

- DOMS is prevented and minimized by reducing the eccentric component of muscle action and the most effective method of treating DOMS is:
    - Light exercise
    - Massages
    - Ice baths
    - Warming down and cooling down after exercise
    - Start training at low intensity and gradually increasing the intensity