PART 1: BASIC PRINCIPLES OF BIOMECHANICS

FICS INTERNATIONAL FEDERATION OF SPORTS CHIROPRACTIC

A simple guide to pick up on Normal and Abnormal biomechanical limb behaviour:

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*Main source of referencing acquired from:

- Hyde, T. E. and Gengenbach, M. S. (2007), Conservative Management of Sports Injuries, 2nd ed, Massechusetts, Jones and Bartlett.
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Unit Content

BASIS CONCEPTS

- Joint anatomy and types diarthrodial joints
- Joint Function
  - Kinematic chains
- Arthrokinematics

MUSCLE AND TENDON PHYSIOLOGY

- Muscle physiology and biomechanics
- Common injuries
- Injury grading
- Related Sports and Rehab

LIGAMENT PHYSIOLOGY

- Common injuries
- Injury grading
- Related Sports and Rehab

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Basics of biomechanics

Before we go into the details of joints and anatomy we need to know the fundamentals of:

- Anatomical Positioning
- Axes of rotation
- Anatomy of a synovial joint

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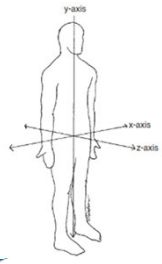
Axes of Rotation



Characterised by 3 Lines that dissect the body.

- X-axis: Lateral (Transverse)
- Y-axis: Vertical
- Z-Axis: Frontal (Transverse)

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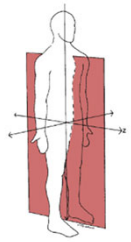
Anatomical Positioning



Sagittal Plane:

- Divides the body into left and right halves.
- Demarcated by the Y and Z axes.
- Movements of flexion and extension move through this plane.

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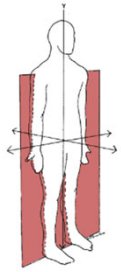
Anatomical Positioning



Coronal Plane:

- Divides the body into Anterior(Ventral) and Posterior (Dorsal) halves.
- Demarcated by the Y and X axes.
- Movements of Abduction and Adduction move through this plane.

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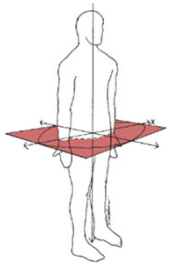
Anatomical Positioning



Transverse Plane:

- Divides the body into Superior and Inferior halves.
- Demarcated by the X and Z axes.
- Movements of rotation move through this plane.

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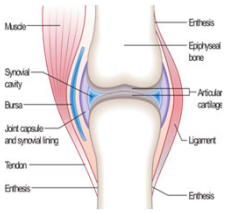
Anatomy of a typical diarthrodial Joint

AKA: Synovial Joints.

- Characterized by the free moving ends (Epiphyses) encapsulated within a synovial lined joint space.
- The articular surfaces are free to move relative to each other because of no connective tissue directly connecting the surfaces.
- The shape of the joint surfaces dictate the motion potential of the joints.



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Joint Function

- The structure of the joints of the human body reflect the functions that the joints are designed to serve.
- The demand on the limb or segment that needs to move will dictate the type, shape and size of joint needed.
- As the joints become larger and have more range of motion (ROM) the less stable the joint is. Therefore we will see more stabilizing factors in some joints and less range of motion in others.
- This can be seen as an example in the Shoulder joint (Glenohumeral Joint) where there is an extensive range of motion but at the sacrifice of stability.
- The rotator cuff muscles and the Rotator interval capsule have to apply different forces in order to stabilise the shoulder as accessory stabilizers for the joint.

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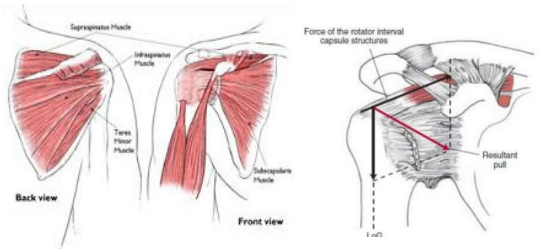
Joint Function: Example of joint stabilization



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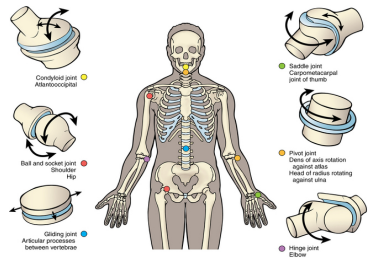
Types of typical diarthrodial Joints



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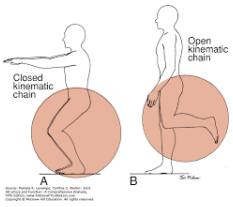
Kinematic Chains



- A series of rigid links that are interconnected by joints which allow the limb to move in a predictable manner.
- It can either be **Open** or **Closed**
- **Open Kinematic Chain:** one joint is able to move independently to the proximal joints and has a freedom to move in space.
- **Closed Kinematic Chain:** when the distal end of a limb is fixed but the segments are able to move. There is no net change in limb position but movement has occurred.

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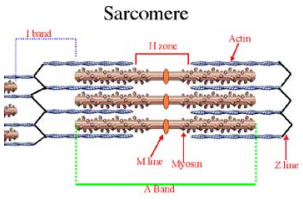
Muscle and Tendon Physiology

The smallest contractile unit of the muscle is a **Sarcomere.**

- Composed of actin and myosin.
- Sarcoplasmic reticulum provides Ca^{2+} to create a polar bond to actin and the myosin heads to mediate muscle contraction.



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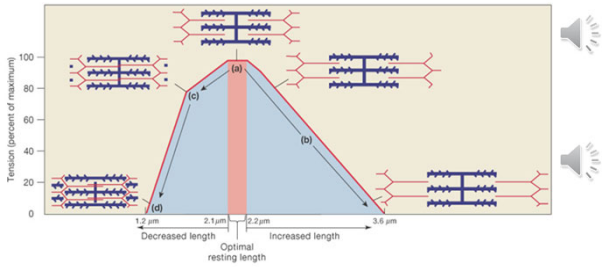
Muscle and Tendon - Length Tension Relationships



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Types of muscle inhibition

Active Inhibition

- Muscle Contracts to the point where it is unable to move the limb any further due to soft tissue obstruction.
- The Muscle is still able to generate contraction force. *(d)

Passive Inhibition

- The muscle is unable to contract eccentrically as the limb is stretched beyond the anatomical limits of the sarcomere.
- The muscle is unable to initiate contraction unless the length is reduced. *(b)

*REFER TO THE DIGRAM ON SLIDE 14 WITH REFERENCE TO POINTS (d) AND (b).

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Muscle physiology and biomechanics

- Muscles are our power houses and our movers of the body.
- Because of this they tend to fatigue easily and can potentially get injured.
- By looking at the behaviour of the muscle in contraction we are able to determine when a muscle is injured, underperforming due to altered mechanics and general muscle pain syndromes such as DOMS.
- Muscle testing is a simple and effective method of assessing muscle behaviour and potential injury.

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Factors that affect Muscle Strength

Motor-Unit Summation

- The more motor units the muscle uses to contract, the more summative contraction can be achieved.
- We see this in explosive forceful contractions such as that in sprinting.

Increase Rate Coding

- Increasing the rate of fire in each specific motor unit increases the total rate of recovery and re-contraction of the muscle.
- This is seen in gradual build up muscle contraction such as applying weight in weightlifitng.

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Factors Affecting Muscle Tension

The amount of tension achieved in a motor unit is primarily dictated by:

- The number of muscle fibres in that unit.
- The size of the fibres. (i.e. the larger the fibres the more tension that can be generated).
- Specific tension per cross-sectional area.
  - Smaller slow twitch fibres generate approximately 1.73Kg tension per cm^2.
  - Larger fast twitch fibres generate 2.23Kg tension per cm^2.

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Common injuries

Muscle Strains:

- These are the most common and most feared for any athlete.
- May occur due to overuse:
  - E.g.: Repetitive motion such as pitching in baseball
- OR Forceful overload in a sport activity
  - E.g.: hamstring strain during the launch off the plate in long jump.

Graded 1 – 3

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Muscle Strains Graded:

GRADE 1:	GRADE 2:	GRADE 3
Minor or microscopic tissue damage: • Painful for the patient. • Usually experience a severe cramp or spasm. • Not usually palpable • 7 – 10 days normal recovery back to 100%	**Moderate or Macroscopic (partial thickness tear) muscle tissue damage:** • Extremely painful for the patient • Muscle cramp or spasm • Palpable muscle tear and can be measured via U/S. • Rehabilitation required 10-21 days normal recovery 80% - 100% return of normal muscle function depending on thickness of the tear.	**Severe Maximal (full thickness tear) tissue damage:** • Patient does not feel pain initially due to loss of tension. • Physical muscle deformity. • Muscle sheath or fascia may still maintain attachment to tendon. • Surgery and rehabilitation required: 3 weeks to 6 months recovery.

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Tendonitis/Tendonosis

These are inflammatory conditions that affect the tendons directly:

Most common Mechanism's of Injury (MOI) is due to overuse or increased leverage on the tendons in Racket and instrument based sports.

Most common forms:

- Tennis Elbow (Lateral Epicondylitis)
- Golfer's Elbow (Medial Epicondylitis)
- Jumper's Knee (Patella Tendonitis)

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Tendon Strains Graded:

GRADE 1:	GRADE 2:	GRADE 3
Minor or microscopic tissue damage: • Painful for the patient. • Not usually palpable • 7 – 10 days normal recovery back to 100%	**Moderate or Macroscopic (partial thickness tear) tissue damage:** • Extremely painful for the patient • Palpable deficit in tendon. • Rehabilitation required. • COMMONLY CALLED ENTHESOPATHY	**Severe Maximal (full thickness tear/ Avulsion) tissue damage:** • Associated with avulsion at the ENTHESIS (Tendon insertion) of the bone. Surgery and or casting and rehabilitation required: 3 weeks to 6 months recovery.

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Common Injuries

Delayed Onset Muscle Soreness (DOMS):

- The products of collagen breakdown from intense rapid training may act as chemotactic agents, and inflammatory markers causing macrophages to travel into the muscle tissue and begin an inflammatory response.
- Macrophages are nonspecific phagocytes and break down imperfect and normal cells thus causing tissue damage.
- Hydroxyproline (OHP) is a urine marker for early onset DOMS.
- If DOMS is severe enough that it affects large amounts of tissue, the degradation will be seen by a rise of Creatine Kinase (CK) and may lead to Rhabdomyolysis if untreated.

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Common Injuries

Treatments:

- Cryotherapy
- Regular Stretching
- Ultrasound
- Light, Low Resistance Exercise
- Hyperbaric therapy
- Compression
- Massage
- Drugs:
  - NSAIDS (COX 1/COX 2)

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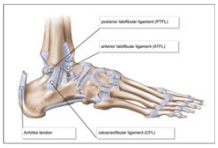
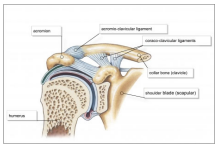
LIGAMENT PHYSIOLOGY

- The Ligaments are the primary Restraints and guides for the joints.
- Provide the main line of support for normal joint motion.
- Last line of defense for joint hyperextension and instability.
- Subject to continuous loading and are most affected by 'creep'.





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Common Injuries

Ligament sprains:

- Commonly due to joint malposition during a weight bearing exercise.
- Most common is inversion sprain in the ankle commonly in running and in stop-start sports such as netball and basketball.

Joint hyperextension and instability:

- Overload of the ligaments may induce capsular stretching.

Joint Dislocation:

- Commonly in contact sports due to force of impact.
- Commonly happens in juvenile level sports are most common.

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Ligament Sprains Graded:

GRADE 1:	GRADE 2:	GRADE 3
Minor or microscopic tissue damage: • Painful for the patient. • Usually experience acute moderate swelling and minor haematoma formation. • Not usually palpable. • Joint stability is usually maintained but may have minor instability, masked by exaggerated apprehension. • 7 – 10 days normal recovery back to 100%. • Weight bearing and proprioception is affected.	**Moderate or Macroscopic partial thickness tear:** • Extremely painful for the patient. • Large significant swelling and haematoma. • Muscle cramp or spasm may mask instability but the instability is seen easily. With the naked eye. • Pressure and weight bearing is unbearable for the patient. Proprioception is affected. • Immobilization is required.	**Severe Maximal (full thickness tear) tissue damage:** • Patient does not feel pain initially due to loss of tension. • Gross joint instability is commonly seen may also see repetitive joint dislocation. • Proprioception is completely disrupted and may affect voluntary joint control. • Surgery is commonly required with rehabilitation.

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Related Sports and Rehab

Refer to "Conservative Management of Sports Injuries" text book for all methods and indications for rehabilitation techniques:

Hyde, T. E. and Gengenbach, M. S. (2007), Conservative Management of Sports Injuries, 2nd ed, Massechusetts, Jones and Bartlett.

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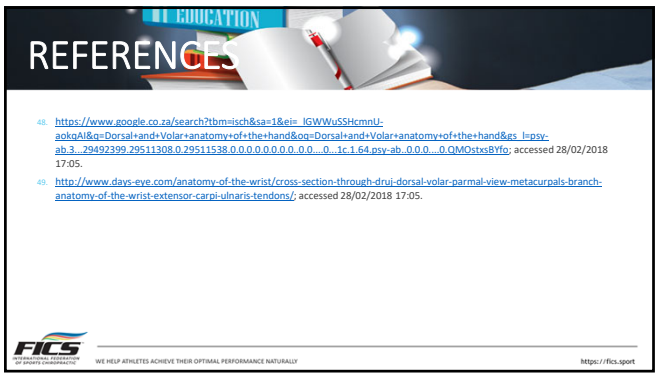

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