Biomechanics

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- Bio- Life, combined with the field of mechanics (study of joints, movements).
- Study of action of forces (internal and external), and the motion of a living organism (looks at bones, tissues and organs), maths behind injury and tissue-related disease.
- **Sub-branches:**
  - Statics (state of rest/ constant motion is the field of study).
  - Dynamics (study subjected to acceleration).
  - Kinematics (study of appearance/ description of motion)- Study of size, sequencing and time of the movement, regardless of the acting forces. In sporting context, it is termed as form/ technique.
  - Kinetics (study of action of forces)- Study of internal (muscle) and external (gravity, impulse) forces.
  - Kinesiology (study of human movement)- Umbrella term for exercise physiology, athletic training, motor behaviour, biomechanics. (Pedagogy- Correct way of doing something, in the context of kinesiology, it could mean providing the right kind of training for an athlete to excel).
  - Sports medicine- Some forms of biomechanics fall under sports medicine, but not all biomechanics is sports medicine. Sports medicine is also an umbrella term for both clinical and scientific aspects of sports and exercise. Key focus- Performance + avoiding injury.
- Examples-
  - Astronauts tend to lose bone mass. A bio mechanist can work on the problem of what kind of exercise astronauts should perform when in space to minimise the impact of this.
  - Right lifting technique to prevent damage to your back/ other muscles.
  - What elements make some athletes dominate over others, despite having the same quality of training?
- Qualitative and quantitative analysis- Quantitative analysis important for additional information.
- Coaches- Analysis mostly qualitative, but they now work with experts, utilising technology like sensors to obtain more concrete information on how the athlete can improve his or her performance.

- Gait biomechanics- Your posture, and analysis of all forms of pain that an individual faces, by comparison with normal gait and hypothesising about the possible causes of deviation from the same. One indicator of normal gait- Uniform wearing of shoes.
- Sports biomechanics- Analysing the movement of an athlete till the time an action is carried out (Eg.- Till he throws a ball), and identifying what could be the possible causes of injury.
- Injury biomechanics- Possible areas of injury, a field to study the same without having to actually simulate all the scenarios using actual cars and dummies, Using computational models to create crash scenarios, using high quality dummies with well-defined organ structures to analyse the extent of damage (forces acting on the brain during a car crash, for instance).
- Cardiovascular biometrics- The way stents function, possible reasons for their failure. General causes- Oversized or undersized stents. Stents- Placed using angioplasty, where the stent is inserted and then inflated, to open the artery up and allow blood flow. Made of alloys, if oversized, it scratches the surface of the artery, it leads to thrombosis (a defence mechanism), tissue starts to grow and integrates with the stent, causing it to get clogged. Undersized stents would not allow for sufficient blood flow, as they don't open up the artery enough.
- Cadaver tissue testing- Has associated consent issues (need consent from the family of the deceased). Used to analyse the properties of tissues, stress-strain analysis.
- Experimental gait analysis- Done in large gait labs, a person on a long walkway, with a motion capture system (consisting of IR cameras), captures the entire room, creates a 3D model of the same. One example- Slipping on a forced platform, to identify when a person slips, and when they do not.
- Finite element modelling/ computational modelling- Complex simulations of things like car crashes, explosions, armour testing.
- Disease biomechanics- For instance, cerebral aneurysm (small clot that developed a long time ago because of some fall, which continues to grow over the years, and eventually rupture). Looking at ways to predict the occurrence of these things, and other issues like hip failure in the future. Can be used to test interventions and medical devices (proper stent placement, hip implant testing, dental implant stress testing).

- Arch- Ensures that the body weight is balanced and well-distributed.
  - Plantar fascia- Connected to the heel and the metatarsal.
  - Plantar fascia stretched beyond capacity when you wear heels, or if you have flat foot or high arch. Sharp heel pain experienced.
  - Calcaneal spur- Refers to this over stretching of the plantar fascia.
  - Some forms of therapy exist to relax the plantar fascia and restore it to its normal status, just like with any other muscle.
  - Another solution could be to get an insole, which corrects posture.
- Cerebral aneurysm- Creates a region with high stress within the blood vessels in the brain, which could cause rupturing, and

hence, a haemorrhage.

- Fatty liver- Caused by cholesterol rich diet, and if not taken care of, could progress to cirrhosis or cancer.
- Stitches/ sutures- Important to apply the right amount of force, to prevent overlap or gaps.
- Finite element modelling- Can study the propagation of forces across points of application, between interconnected bodies.
- Ulcers on feet- Preventing further damage to the region by creating an insole with a gap at the location of the ulcer, to prevent any form of load being placed on it. Computational model used to analyse stress and strain. Ulcer isolation insole technology.

Gait analysis- Study of human locomotion (walking, running)

- Walking- Series of gait cycles, one gait cycle is called a stride.
- Tasks of the gait cycle-
  - Weight acceptance- Most demanding. Place your foot down, accepting your body weight/ transferring it onto a limb that just swung forward (unstable alignment). Shock absorption, moving forward.
  - Single limb support- One limb must support the entire body weight, while providing stability to the trunk/ torso, while moving forward.
  - Limb advancement- Requires foot clearance from the floor, as the limb moves to a position in front of the body.
- Need to understand proper gait, to be able to follow it, and hence avoid the assortment of health problems that arise due to loss of the ability to walk.
  - Gait cycle altered by any form of injury/ dysfunction. People with obesity, diabetes, stroke- Impeded ability to walk, hence, altered gait cycle.
  - Sports rehab- To accurately detect and interpret deviations, and correct them to alleviate pain and enhance performance, particularly for rehabilitation professions (for people who went to space- to reduce loss of bone mass, injured sportspersons and accident victims).
  - Walking patterns- Typically vary from individual to individual.
  - Gait alters in order to reduce the pain due to any ailments that an individual might be facing. Affected by musculoskeletal problems, cardiovascular and pulmonary problems and mental health disorders.
  - Analysis required to identify the kind of insole that a person requires to correct their gait.

Normal walking requirements-

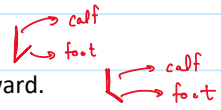
- Equilibrium- Ability to assume and maintain an upright posture and balance.
- Locomotion- Ability to initiate and maintain rhythmic stepping.
- Musculoskeletal integrity- Normal bone, joint and muscle function and structure.
- Neurological control- Ability to send and receive messages to regulate movement. For instance, the inner ear regulates balance, and if you have some form of ear pain/blockage, you also feel dizzy/ off balance while walking.

Gait cycle- **Important, will come in exam (learn the diagram from slides)**

- Stance phase- Foot is in contact with the ground. Also termed as the propulsion phase.
  - Weight acceptance phase-
    - Heel strikes the ground, initial contact. First bone to touch the ground- Calcaneus/ heel bone.
    - Loading response- The body starts to load onto the heel planted on the ground. Important for shock absorption, weight bearing.
  - Single limb support-
    - Mid stance- The load starts to shift from the heel towards the rest of the foot. Most of the muscles and joints are in neutral position. This foot hits the ground completely and the other foot gets raised, so the load bearing is on one limb.
    - Terminal stance- The foot is about to be raised to enter into swing phase, only the front in contact with ground.
- Swing phase- Foot is not in contact with the ground. Limb advancement stage.
  - Pre swing- Foot is just about enter the swing phase (kind of intermediate between the stance and swing phases). Takes off from the ground.
  - Initial swing- Foot starts to be raised and swings to progress movement.
  - Mid swing- Foot is mid-air, in the middle of the swing.
  - Terminal swing- Swing about to end, heel strike about to begin again.

Causative factors of the gait cycle (muscle and joint activity)- **Values of angles of rotation in slides not to be memorised**

- Pelvic forward rotation just before the heel strike, hip flexion also occurs.
- Pelvic rotation in the direction opposite to the foot that is entering initial contact. Rotation towards left means that the right foot is in initial contact phase. Also holds true for the loading response and the terminal stance.
- Ankle rotation-
  - Dorsiflex- Toes point upward.
  - Plantarflex- Toes point downward.



- Running speeds-
  - High speed- Front foot runners. Pressure on toes.
  - Optimum- Mid foot runners.

- Slow- Hind foot runners.

Gait pathologies- Deviations from normal gait patterns, resulting from-

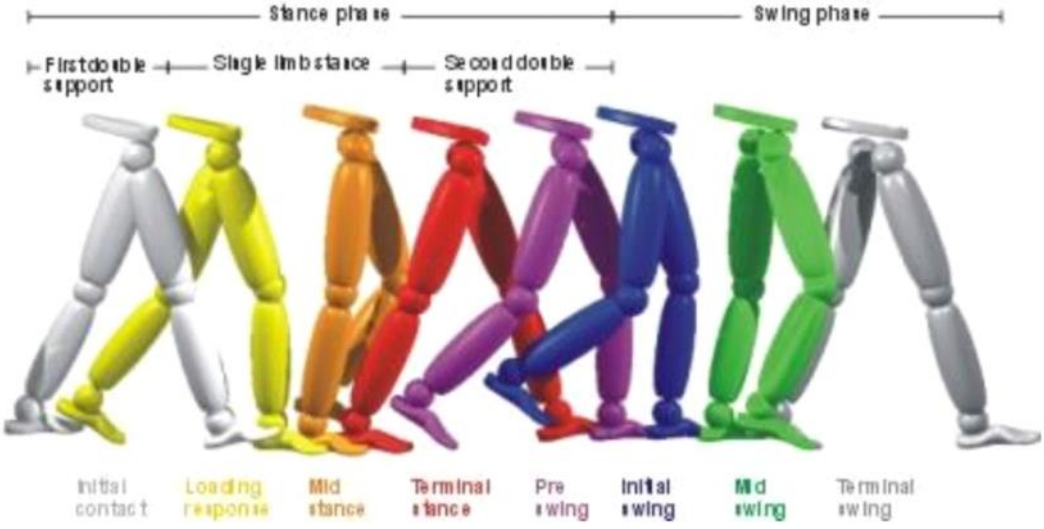
- Pain (heels/ faulty shoes)
- Injury/ surgery (restricted range of movement)
- Weakness, balance deficits.

Compare normal components of gait with the stance and swing of the individual whose gait is being analysed. Compare the gait of left and right sides when determining the gait pattern. Motion analysis software used for the same (check online for the same).

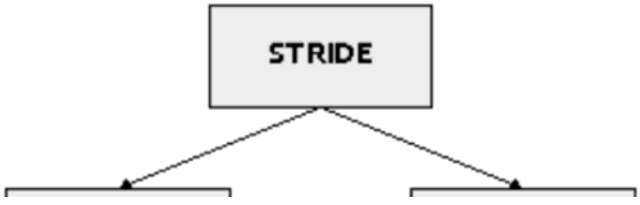
Gait Cycle or Stride

- A single gait cycle or stride is defined:
  - Period when 1 foot contacts the ground to when that same foot contacts the ground again
  - Each stride has 2 phases:
    - Stance Phase
      - Foot in contact with the ground
    - Swing Phase
      - Foot NOT in contact with the ground

A Single Gait Cycle or Stride



Gait Flow Chart



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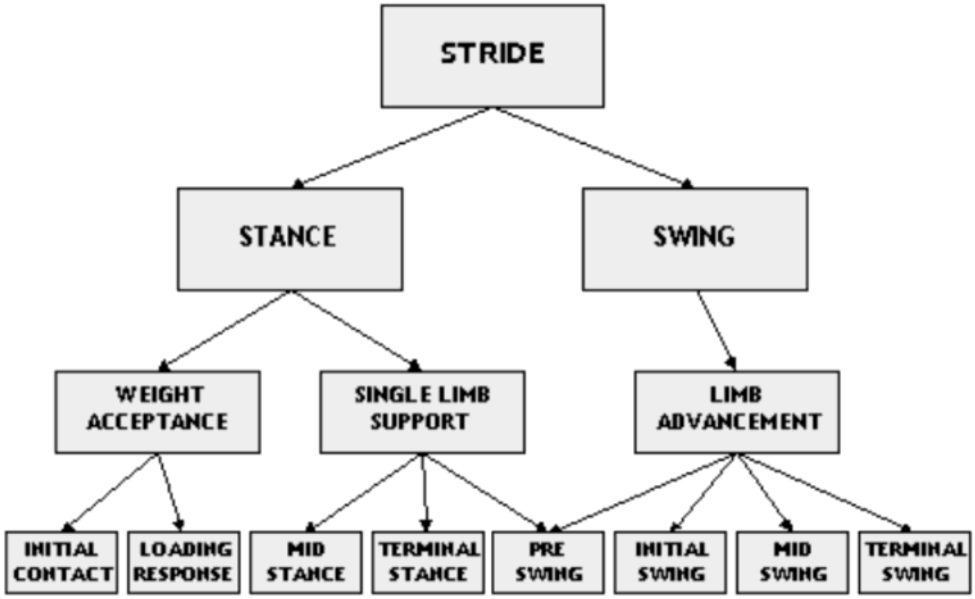

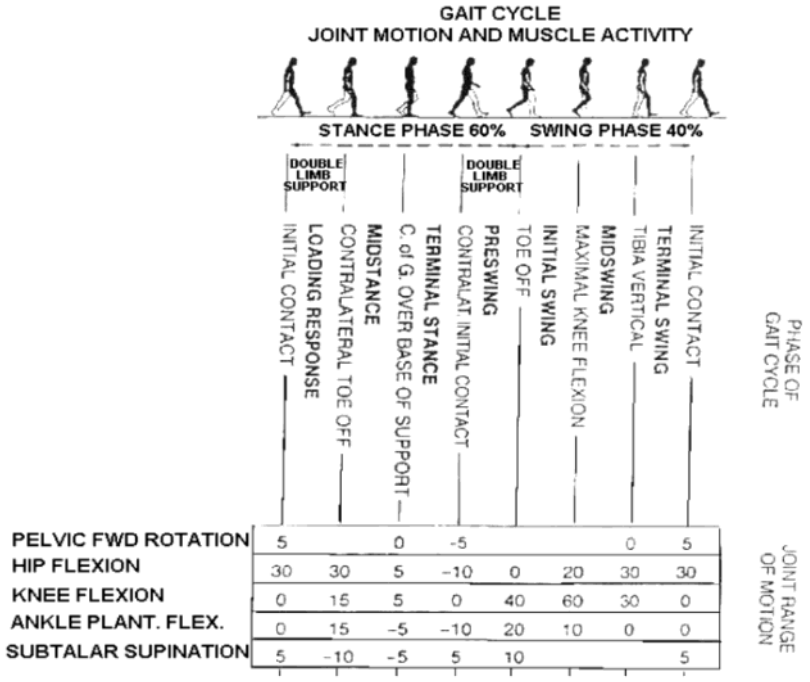

FEM for gait analysis- Gives a view of the stresses and strains at different points on the foot. Beneficial for identifying potential arch issues and rectifying them, by changing the stress-strain distribution across the food. This is useful is reducing the occurrence of ailments like ulcers, or other injuries due to improper distribution of load across the foot during walking.