

# BIOMECHANICS

ECE 331 – INTRODUCTION TO BIOMEDICAL ENGINEERING

Monday, December 22, 2025

# WHAT IS BIOMECHANICS?

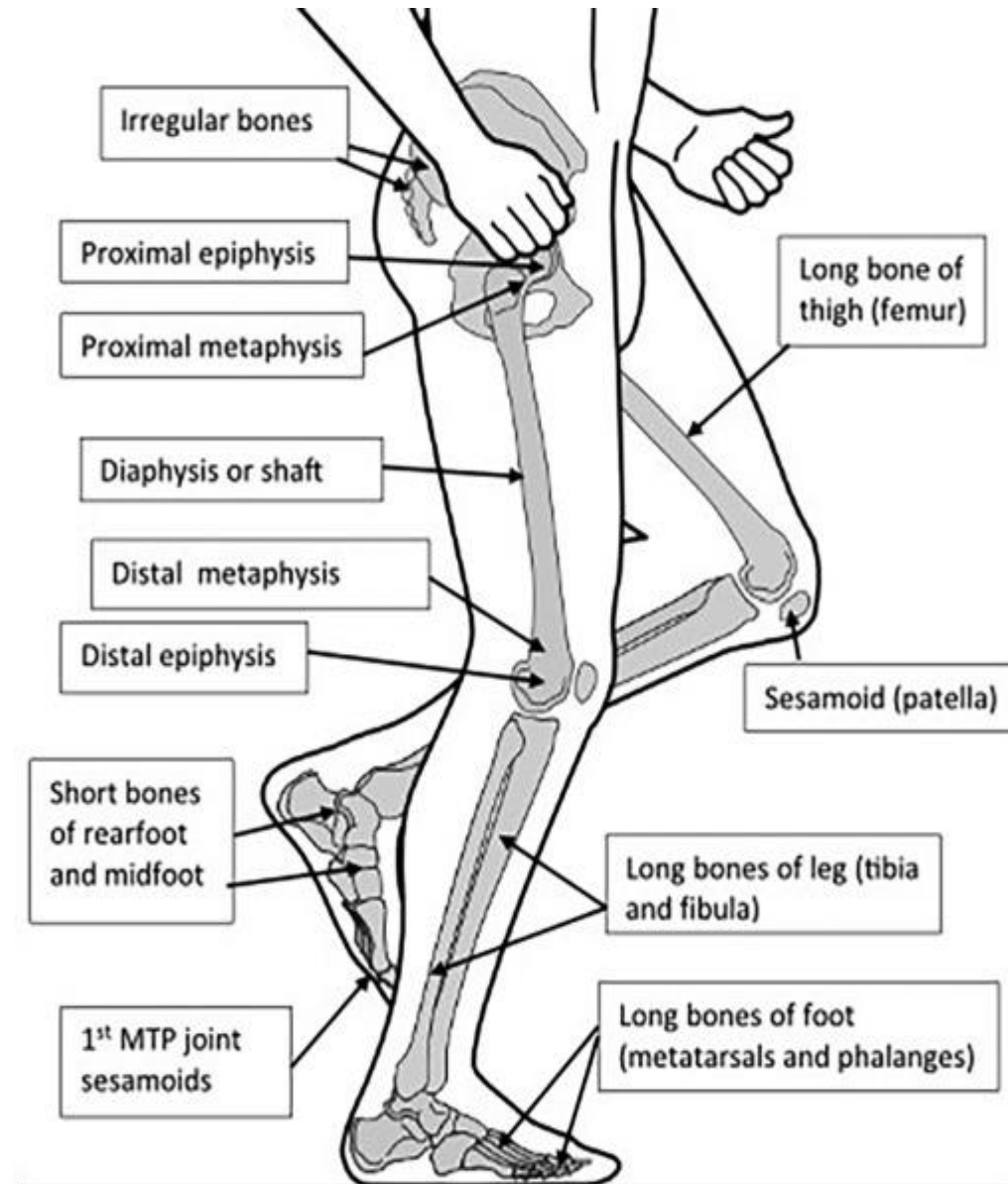
1. **Biomechanics** is the study of the structure, function and motion of the mechanical aspects of biological systems.
2. **Biomechanics** can also be defined as mechanics applied to biology, and mechanics itself is the response of bodies to forces or displacements.
3. **Biomechanics Specialist** applies mechanical principles to the human body in order to understand the mechanical influences on bone and joint health.

# BIOMECHANICS : IMPACT ON BONE AND JOINT HEALTH

1. **Biomechanics** plays helps us to understand the forces that our bones, joints, and muscles encounter during everyday activities.
2. This understanding is crucial for orthopedic health, as improper biomechanics can lead to a host of injuries and ailments.
3. Areas of interest for orthopedic health include:
  - a) Walking and running
  - b) Lifting of objects
  - c) Reaching and pushing
  - d) Sitting and posture
  - e) Jumping and landing
4. **Biomechanics isn't just about understanding movement; it's about optimizing it. By recognizing the mechanics behind our everyday actions, we can make informed choices about footwear, ergonomics, exercise techniques, and more.**

# 1.0 IMPACT ON BONE AND JOINT :WALKING & RUNNING

- 1. Walking and running** involve a series of coordinated actions from the legs, hips, and spine. Every step generates a force that travels through the foot, up the leg, and into the pelvis and spine.
- 2. Shock absorption properties of our joints**, particularly the knees and ankles, play a vital role in dissipating the impact forces associated with each step.
- 3. Improper gait or foot alignment** can lead to problems like plantar fasciitis, shin splints, and even hip and lower back pain.



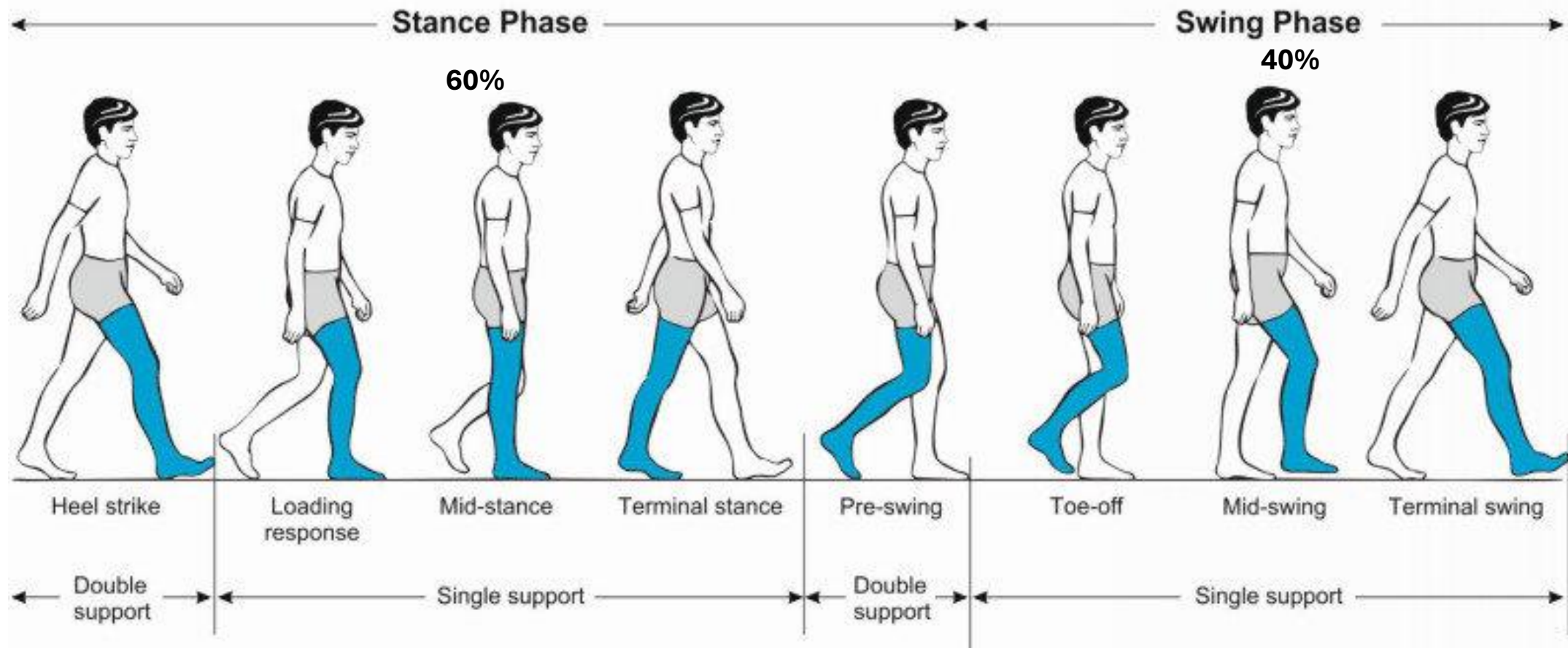
# KEY ASPECTS OF WALKING & RUNNING BIOMECHANICS

1. **Biomechanics of walking and running** involves the movement of the foot and lower extremity bones, and the coordination of many joints and muscles.
2. **Running** is defined as a gait in which there is an aerial phase, a time when no limbs are touching the ground.
3. **Key aspects of walking biomechanics are:**
  - a) **Gait cycle** is made up of two phases (stance and swing), which are further divided into several sub-phases. The stance phase takes up 60% of the gait cycle.
  - b) **Foot** provides traction, balance, and propulsion and adapt to uneven surfaces.
  - c) **Joints:** major joints of the lower extremity are the hip, knee, and ankle. The hip joint is a ball-and-socket joint that can rotate in all directions. The knee joint is a hinge joint that allows for flexion and extension.
  - d) **Muscle activation:** The body's muscle activation levels, joint range of motion, and joint forces are all increased during running compared to walking.



# HUMAN GAIT CYCLE

1. **Human gait** depends on a complex interplay of major parts of the nervous, musculoskeletal and cardiorespiratory systems.
2. **Individual gait pattern** is influenced by age, personality, mood and sociocultural factors.

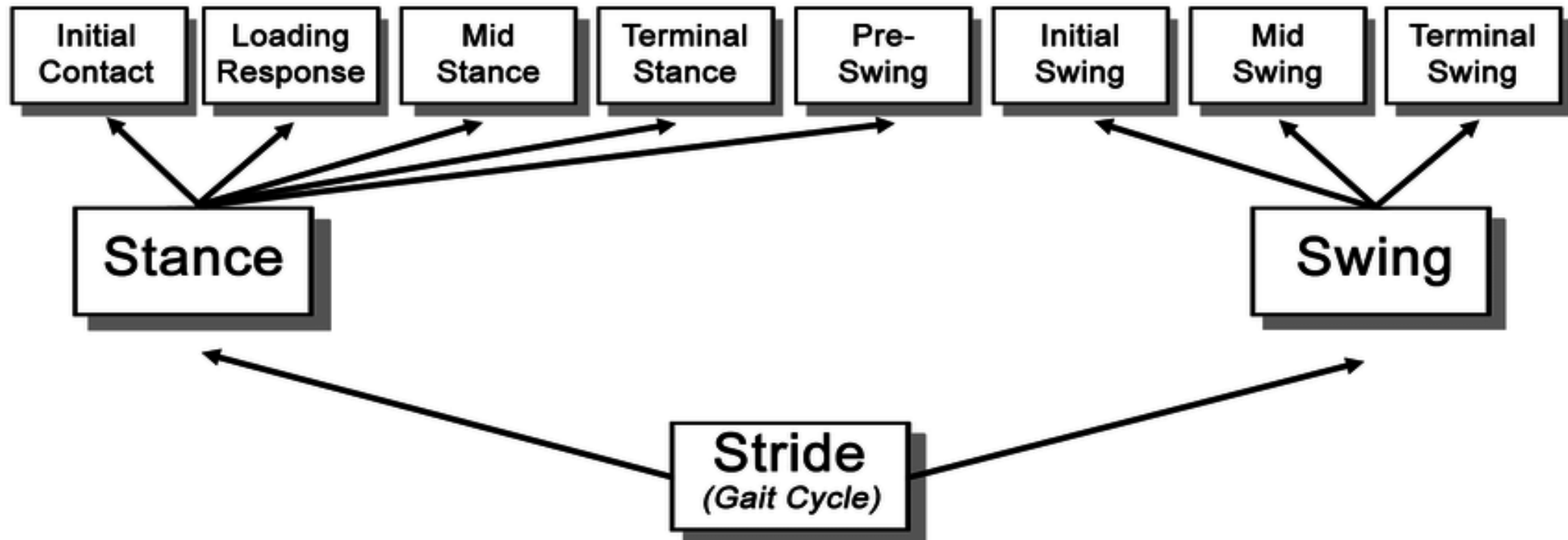
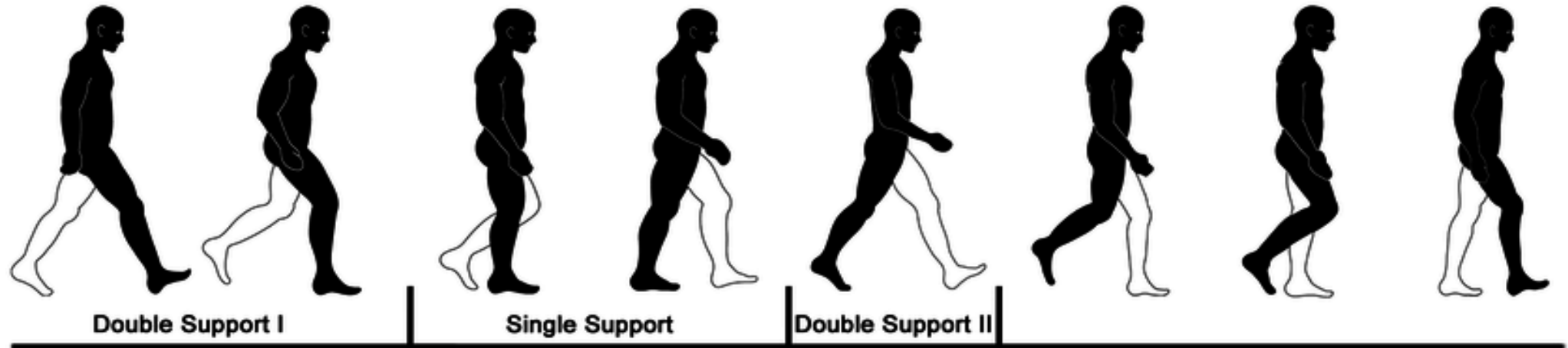


# DIFFERENCES BETWEEN BIOMECHANICS OF WALKING & RUNNING

**Biomechanics of walking and running differ** in a number of ways, including:

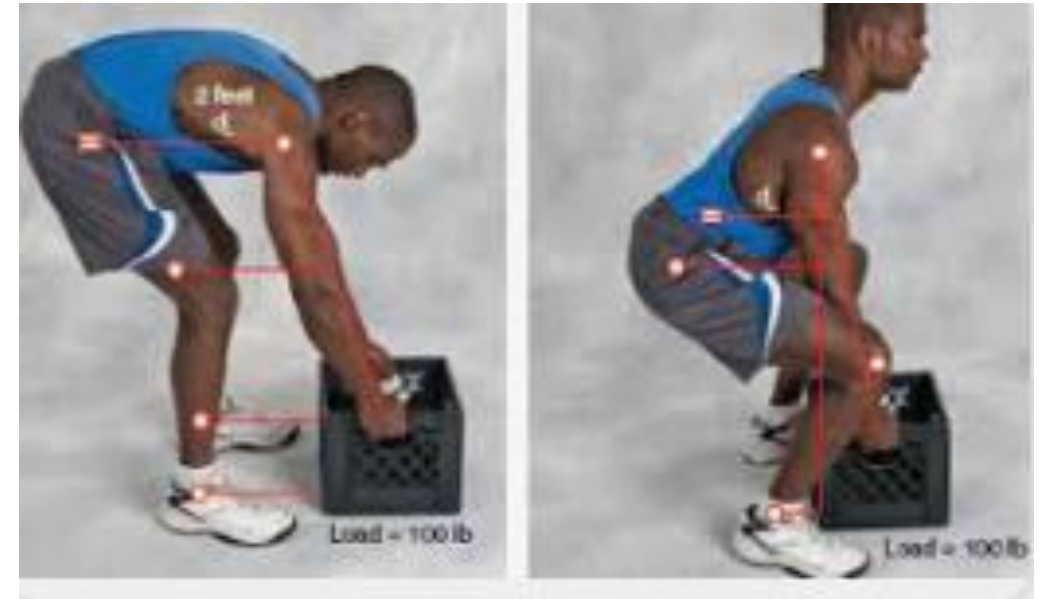
1. **Stance phase:** The stance phase is shorter in running than in walking. In walking, the stance phase is 62% of the gait cycle, while in running it's 31%.
2. **Contact time:** Running has shorter contact times than walking.
3. **Peak forces:** Running has higher peak forces than walking.
4. **Muscle activity:** Running requires more muscle activity than walking.
5. **Joint range of motion:** Running requires more joint range of motion than walking.
6. **Center of gravity:** The body lowers its center of gravity by flexing the hips and knees, and dorsiflexing at the ankle.
7. **Ground reaction force:** The ground reaction force (GRF) at the center of pressure (CoP) can increase to 250% of body weight during running.
8. **Double float phase:** Running has a double float phase, where both feet are off the ground at the beginning and end of the swing phase.

# HUMAN GAIT CYCLE (STRIDE)



## 2.0 LIFTING OF OBJECTS

1. The **biomechanics of lifting of objects** involves a harmony of muscle contractions and joint movements.
2. **Proper lifting technique** emphasizes the use of the legs and core muscles, reducing strain on the lower back.
3. **Poor lifting mechanics** is a common cause of lower back injuries, often due to excessive stress on the lumbar vertebrae and the associated soft tissues.

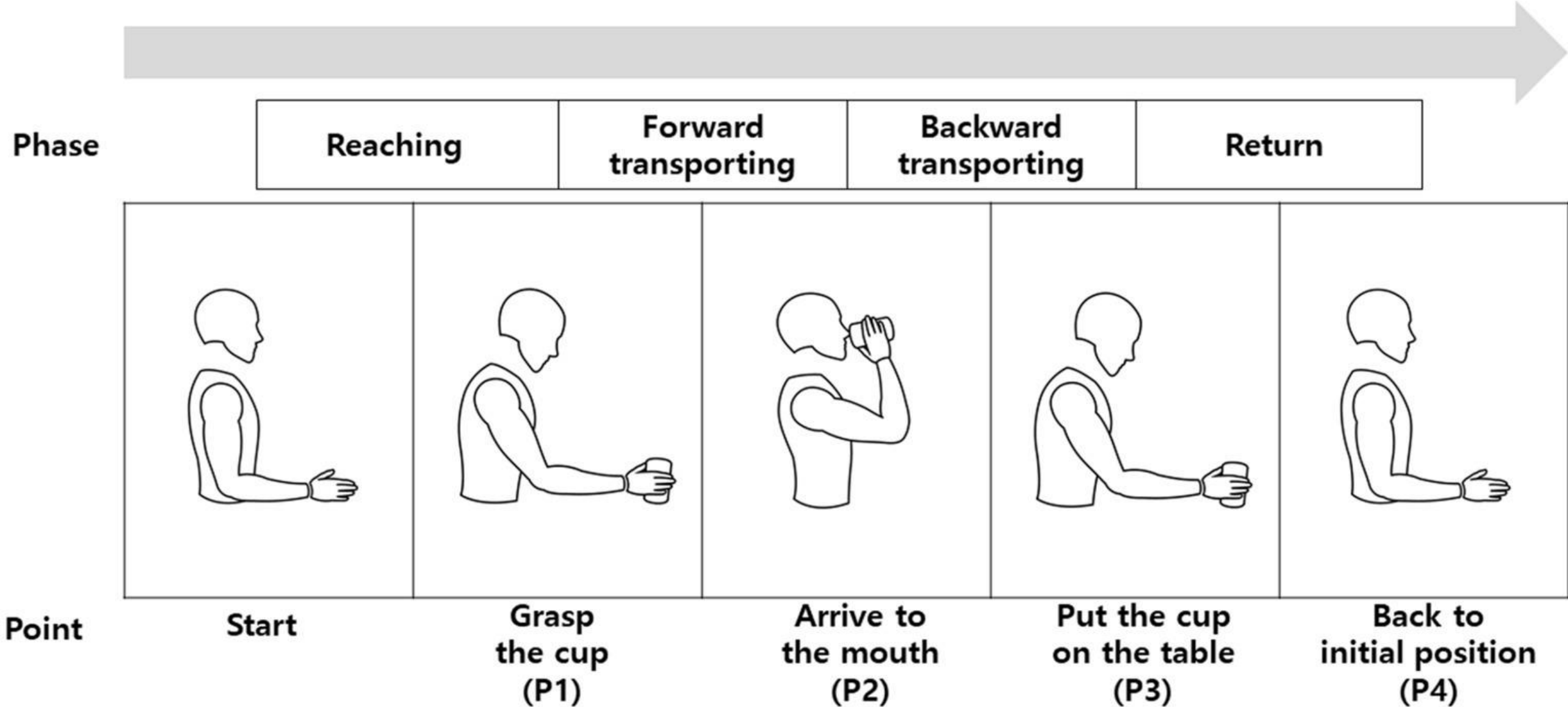


## 3.0 REACHING & PUSHING

1. **Biomechanics of reaching** involves the coordinated movement of the shoulder, elbow, wrist, trunk, and hip to accurately place the hand at a desired location. The upper limb can be thought of as a linkage system, with the hand as the main effector and the shoulder, elbow, and wrist working together to position it in space.
2. **Reaching and Pushing** involves movements that involve reaching out (like grabbing a jar from a high shelf) or pushing (like opening a heavy door) engage the shoulder joint, one of the most mobile and complex joints in the human body.
3. **Rotator cuff muscles** play a pivotal role in stabilizing the shoulder during these activities.
4. **Overextension, or repetitive stress** without adequate muscle support, can result in rotator cuff injuries or shoulder impingement.



# BIOMECHANICS OF REACHING



## 4.0 BIOMECHANICS OF SITTING & POSTURE

1. **Biomechanics of sitting and posture studies** how your body weight is distributed and how your posture affects your spine and muscles
2. **Biomechanics of sitting** involves the activation and relaxation of muscles, and the stress on different bones in the body.
3. The **spine, back, and pelvis** are the parts of the body most studied for sitting posture.
4. **In our increasingly sedentary lifestyles**, understanding the biomechanics of sitting is crucial.
5. **Proper lumbar support and alignment** prevent prolonged stress on the vertebral discs.



Graphic by Mario Lendvai

## 5.0 JUMPING & LANDING

- 1. Biomechanics of jumping and landing** is the study of the forces, motions, and musculoskeletal dynamics involved in jumping and landing. It can help to improve performance and reduce the risk of injury.
- 2. Jumping and Landing engages** powerful muscles in the legs and require synchronization of multiple joints.
- 3. Knees**, for instance, have significant forces during landing. Proper landing techniques, with knees slightly bent and aligned, can prevent excessive lateral forces that may lead to injuries like ACL tears.

