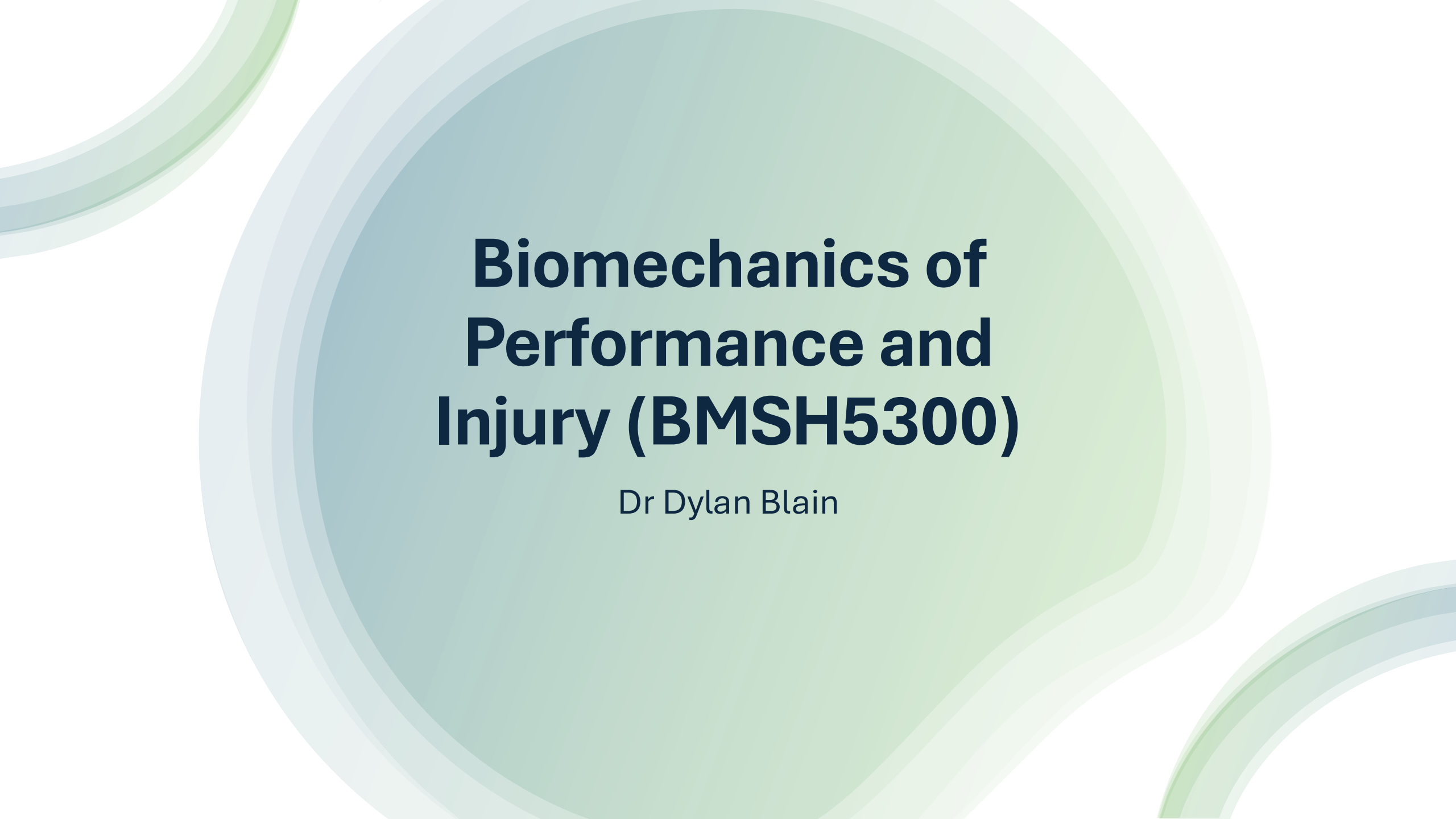




Biomechanics of Performance and Injury (BMSH5300)

Dr Dylan Blain

Objectives

- Define sport and exercise biomechanics
- Identify the goals of sport and exercise biomechanics
- Describe the methods used to achieve the goals of sport and exercise biomechanics
- Be somewhat familiar with the history and development of sport and exercise biomechanics

(continued)



Objectives

- Define mechanics
- Outline the organization of mechanics
- Define length and the units of measurement for length
- Define time and the units of measurement for time
- Define mass and the units of measurement for mass

(continued)



Why Study Biomechanics?

- Studying biomechanics will help you understand why some sport techniques work and some don't
- Goals of biomechanics
 - Improved performance and faster learning
 - Understand the cause of injury

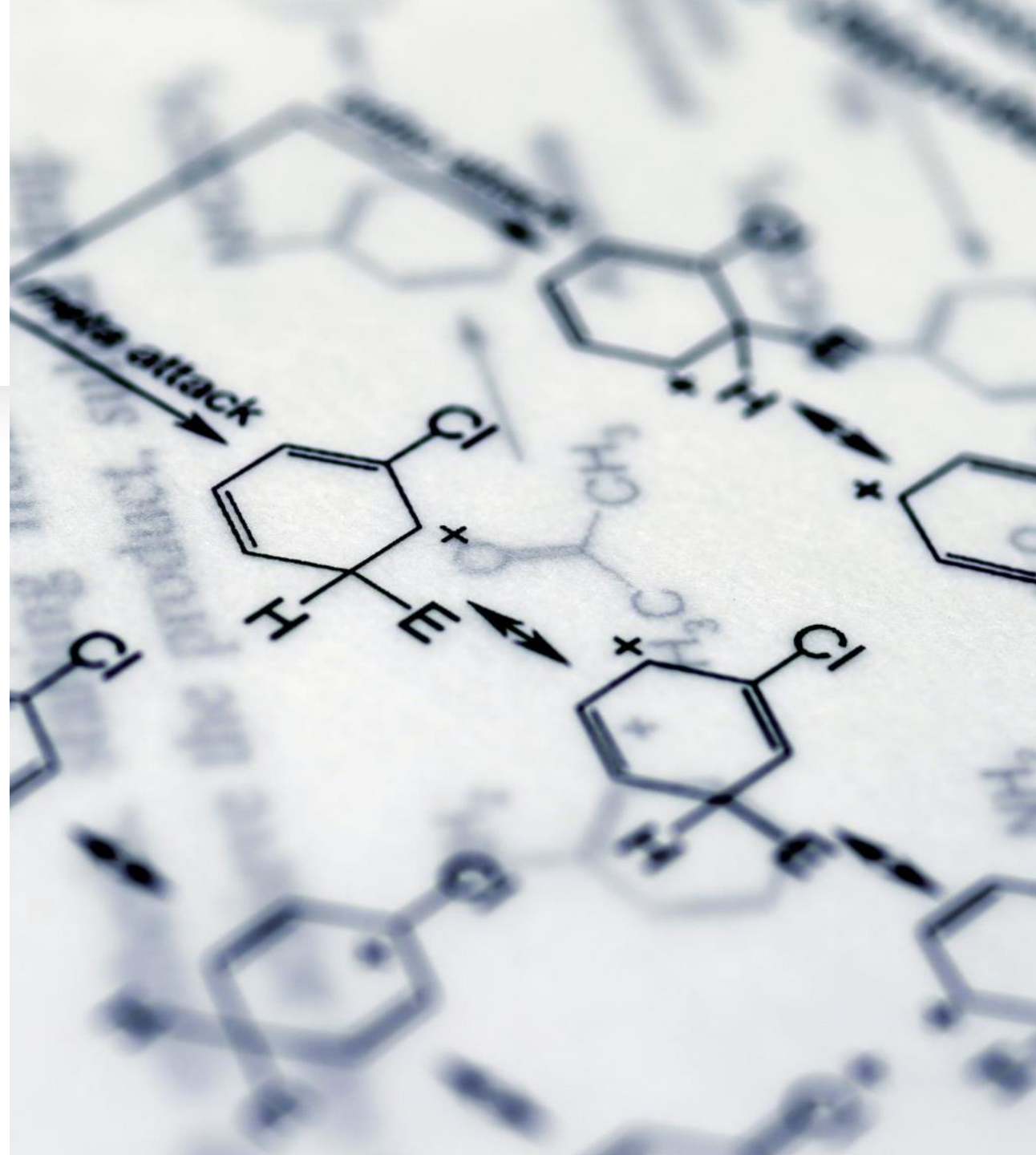


What Is Biomechanics?

- Bio = living or biological systems
- Mechanics = analysis of forces and their effects
- Biomechanics is the study of the structure and function of biological systems by means of the methods of mechanics.

—Herbert Hatze, 1974

- The study of forces and their effects on living systems



What is Biomechanics?

- “the study and analysis of human movement patterns in sport”
(Bartlett, 2014)

Sport and Exercise Biomechanics



**Study of forces and their effects
on humans in exercise and sport**



**Goals of sport and exercise
biomechanics**

Performance improvement

Injury prevention

Performance Improvement

Coaches, teachers, trainers

- Correct actions of an athlete, student or client to improve execution or safety of a skill or exercise

Researcher

- Discover a new, more effective or safer technique for performing a skill or exercise
- *(continued)*

Performance Improvement (*continued*)



Equipment improvement

Refine equipment to better match
performance demands
Swimsuits, clap skates, javelin



Training improvement

Analysis of strength demands in an activity
Gymnastics, figure skating, pole vaulting

Injury Prevention and Rehabilitation



Reduce impact forces in gymnastics



Reduce elbow loading in tennis



Decrease the incidence of concussion

Suggest technique and rule changes



Equipment design improvements

Better helmets and footwear

History of Sport Biomechanics

Aristotle

De motu animalium

Mechanics of human and animal motion

Etienne Jules
Marey

Used a variety of instruments to measure force and motion

Analysis of track and field athletes at 1900 Olympics

(continued)

History of Sport Biomechanics (*continued*)

Archibald V.
Hill

Mechanics and energetics of sprinting in the 1920s

1930s

Wallace Fenn, Thomas Cureton, and Arthur Steindler studied the mechanics of gait and swimming and created first biomechanics textbook
(*continued*)

History of Sport Biomechanics (*continued*)

John Bunn: emphasized mechanics over anatomy
Scientific Principles of Coaching

1950s

1960s

International biomechanics seminars first held
Journals established
(continued)

History of Sport Biomechanics (*continued*)

1970s

- International Society of Biomechanics
- American Society of Biomechanics

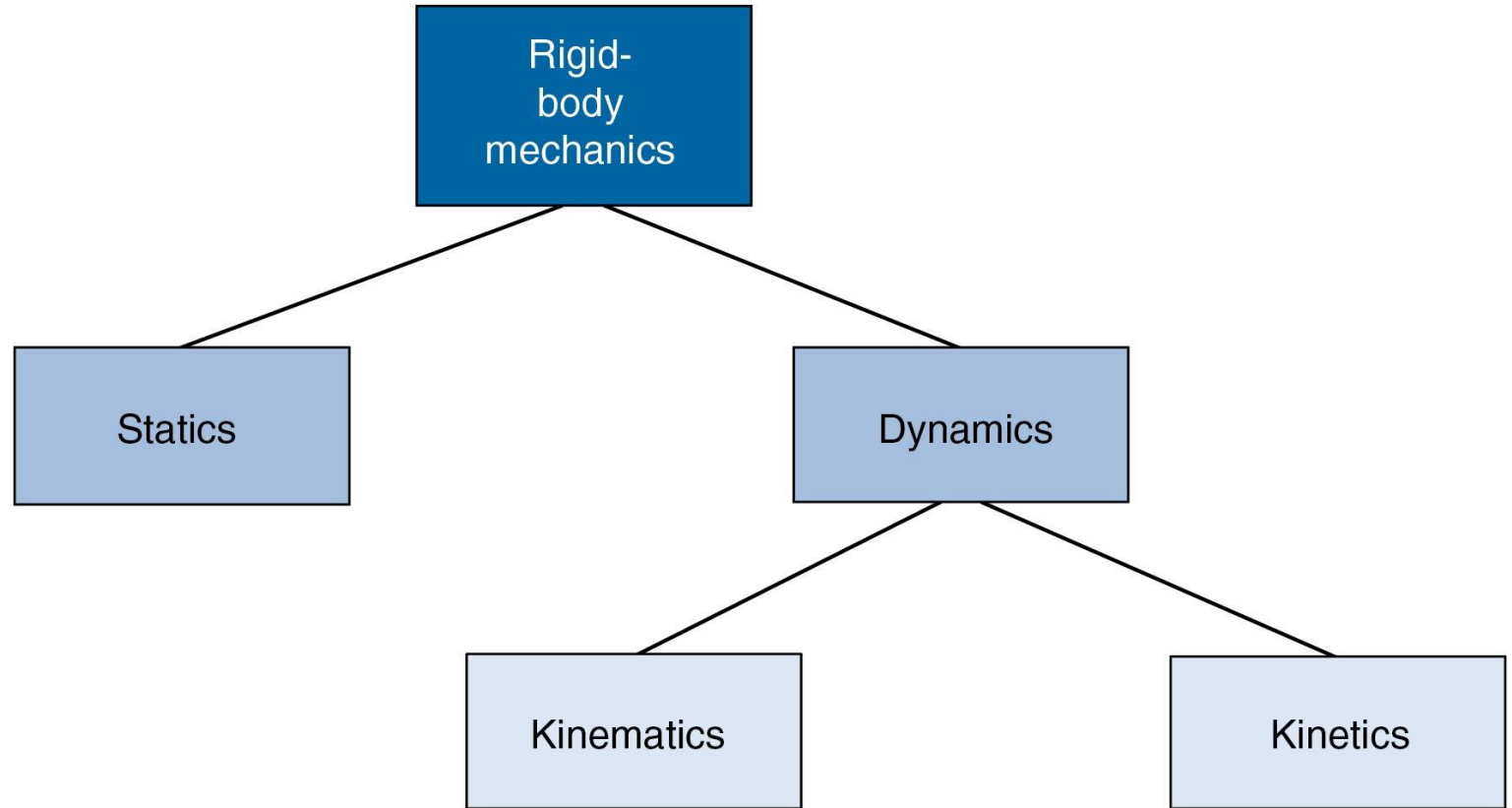
Late 20th and early 21st centuries

- Widespread availability of commercial software and instrumentation
- Recognition of potential contribution to all levels of skill

Organization of Mechanics

- Rigid-body mechanics: objects assumed to be perfectly rigid, simplifying analysis
- Deformable-body mechanics: objects deform when loaded, related to training and injury
- Fluid mechanics: mechanics in liquids and gasses (water and air)
- Relativistic mechanics: Einstein's theory of relativity
- Quantum mechanics: quantum theory

The Branches of Rigid-Body Mechanics



Rigid-Body Mechanics

Statics

- Mechanics of objects at rest or moving at constant velocity
 - Acceleration equals 0
 - No unbalanced force or torque acts on the object

Dynamics

- Mechanics of objects in accelerated motion
- Speeding up or slowing down
 - Acceleration not equal to 0
 - Unbalanced forces and torques act on the object

Dynamics

Kinematics

- Description of motion:
How far? How fast?
What direction?
- Sequencing of joint actions

Kinetics

- Deals with the forces that cause or tend to cause changes in motion: pushes and pulls, turning effect of a force, loading of an object

Units of Measurement in Biomechanics

Length

- Position in space or change in position (how far)
- An important performance measure for shot-put, high jump
- A Critical component of success for golf, baseball
- An important dimension in athletes: height
- Meter (kilometer = 1,000 m; cm = 1/100 m)

1 m = 3.28 feet

(continued)

Units of Measurement in Biomechanics (*continued*)

Time

- Duration of an event
- Important performance measure: races
- Critical component of success: reaction time
- Important dimension in rules: game time, time outs
- Second (s)

(continued)

Units of Measurement in Biomechanics (*continued*)

Mass and inertia

- Resistance to changing motion (inertia)

Greater inertia, greater resistance to speeding up or slowing down

- Mass: quantity of matter in an object

- Mass quantifies inertia

More massive an object, greater object's inertia

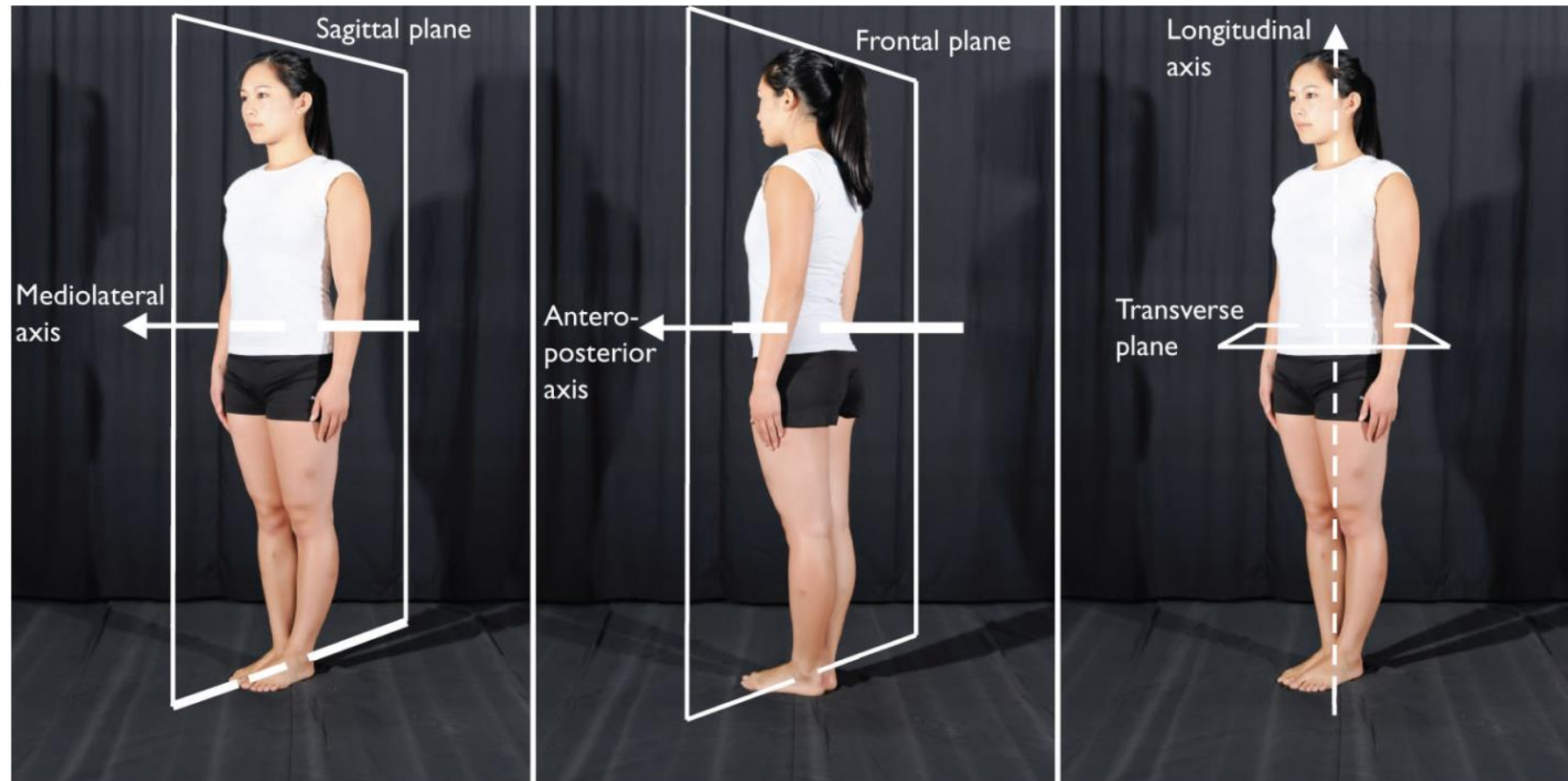
- Kilogram (kg)

Qualitative Biomechanical Analysis

Defining Human Movements

Planes of Movement	Sagittal, frontal, transverse
Axis of Movement	Mediolateral (frontal), anteroposterior (sagittal), longitudinal.
Postures	Fundamental, anatomical

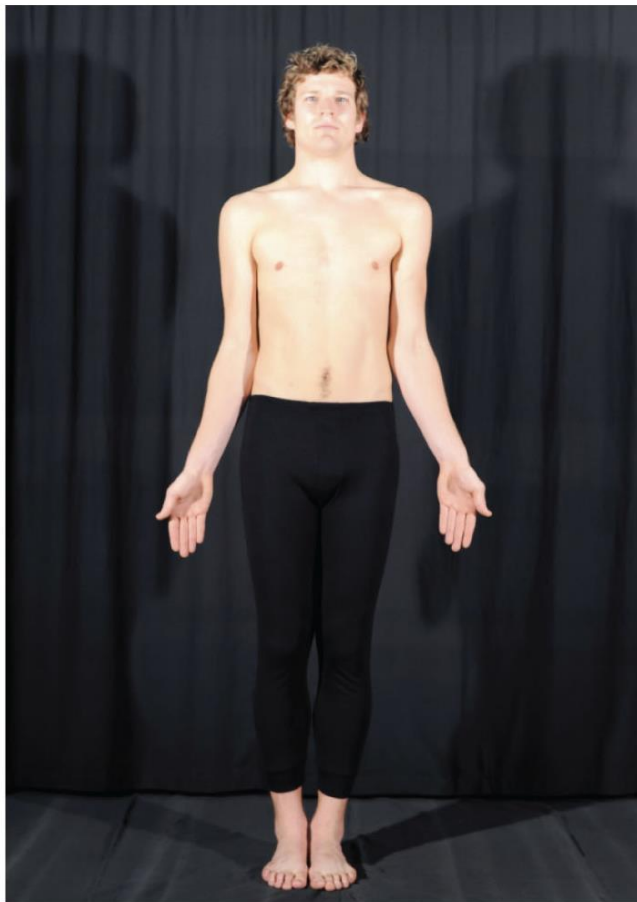
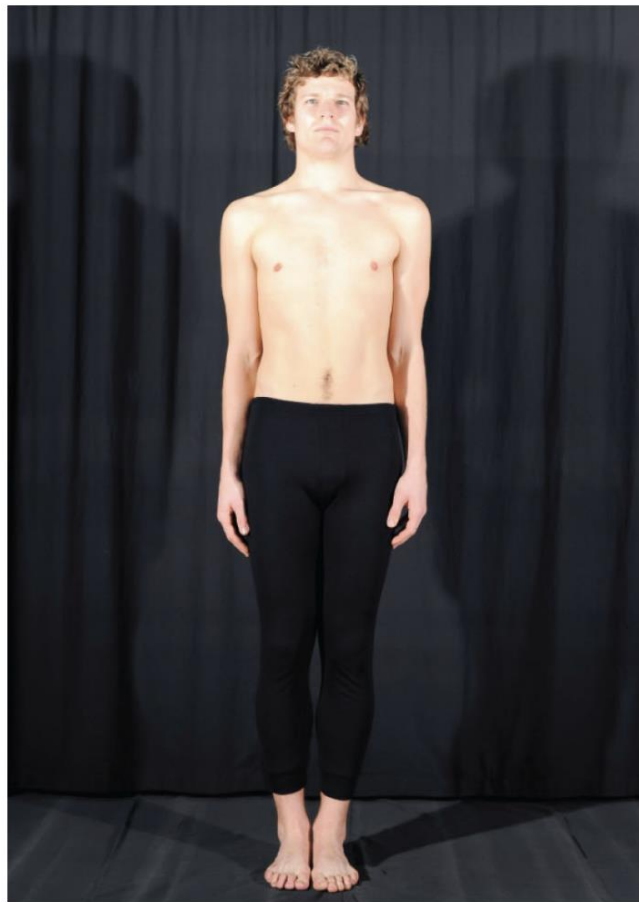
Planes & axis of movement &



Tasks

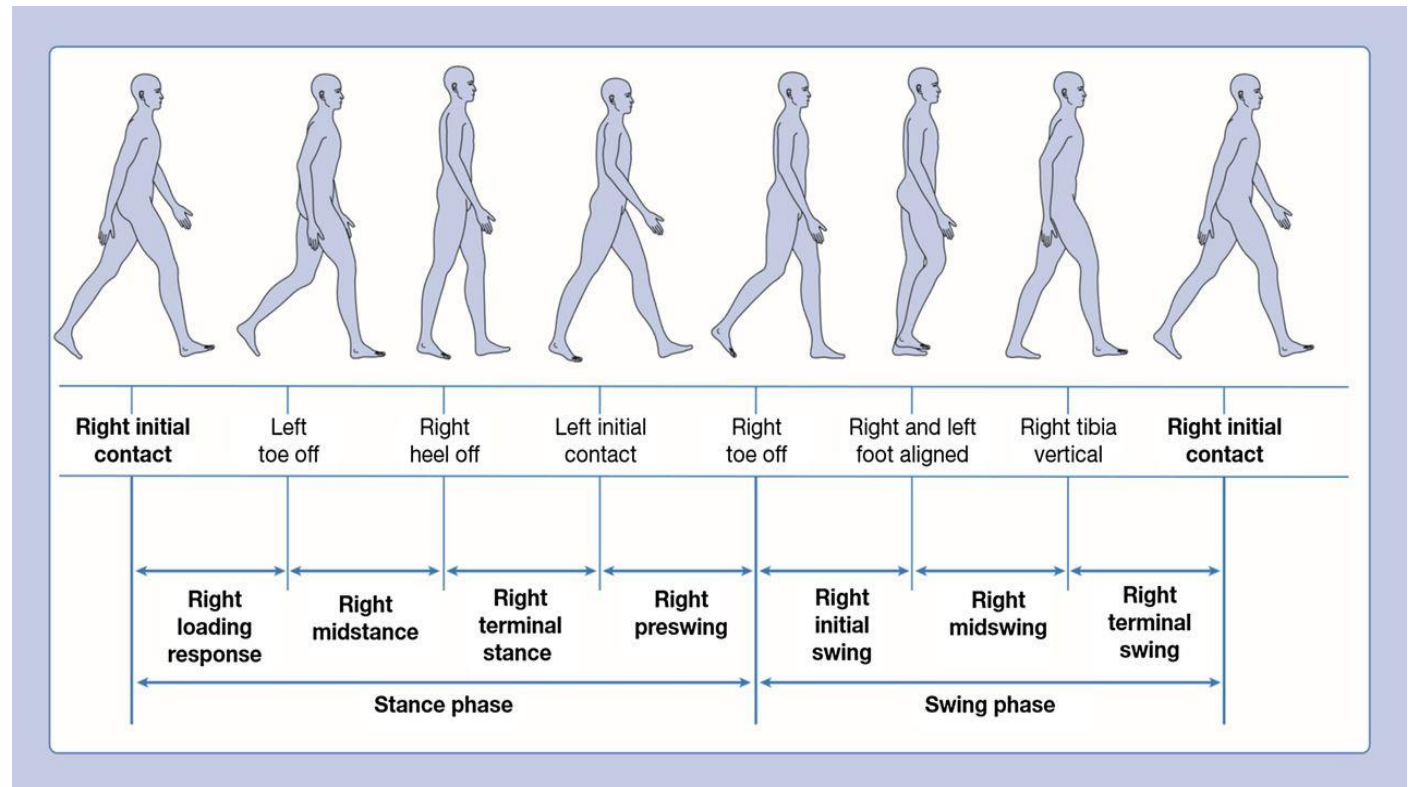
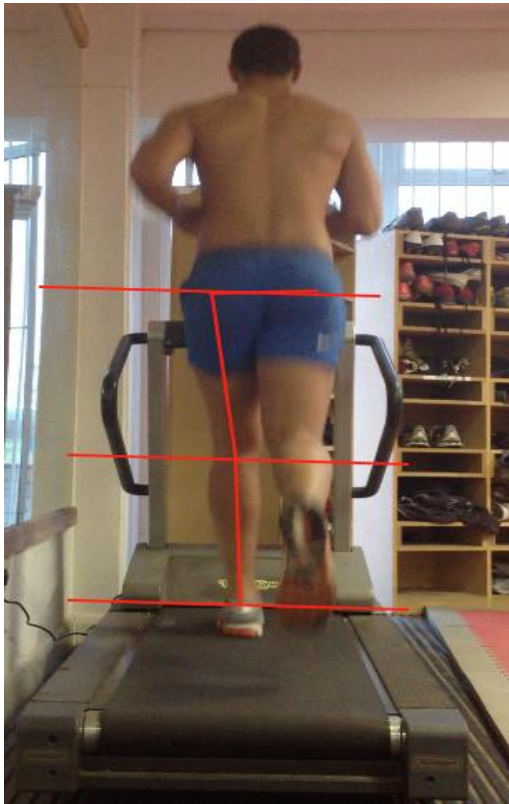
- Identify a movement that occurs in the Sagittal plane.
- Identify a movement that occurs in the transverse plane.
- Identify a movement that occurs around the antero-posterior axis.

Postures



Gait Analysis

The study of human motion and posture to enhance walking or running performance and to reduce the occurrence of injury



Use of Gait Analysis

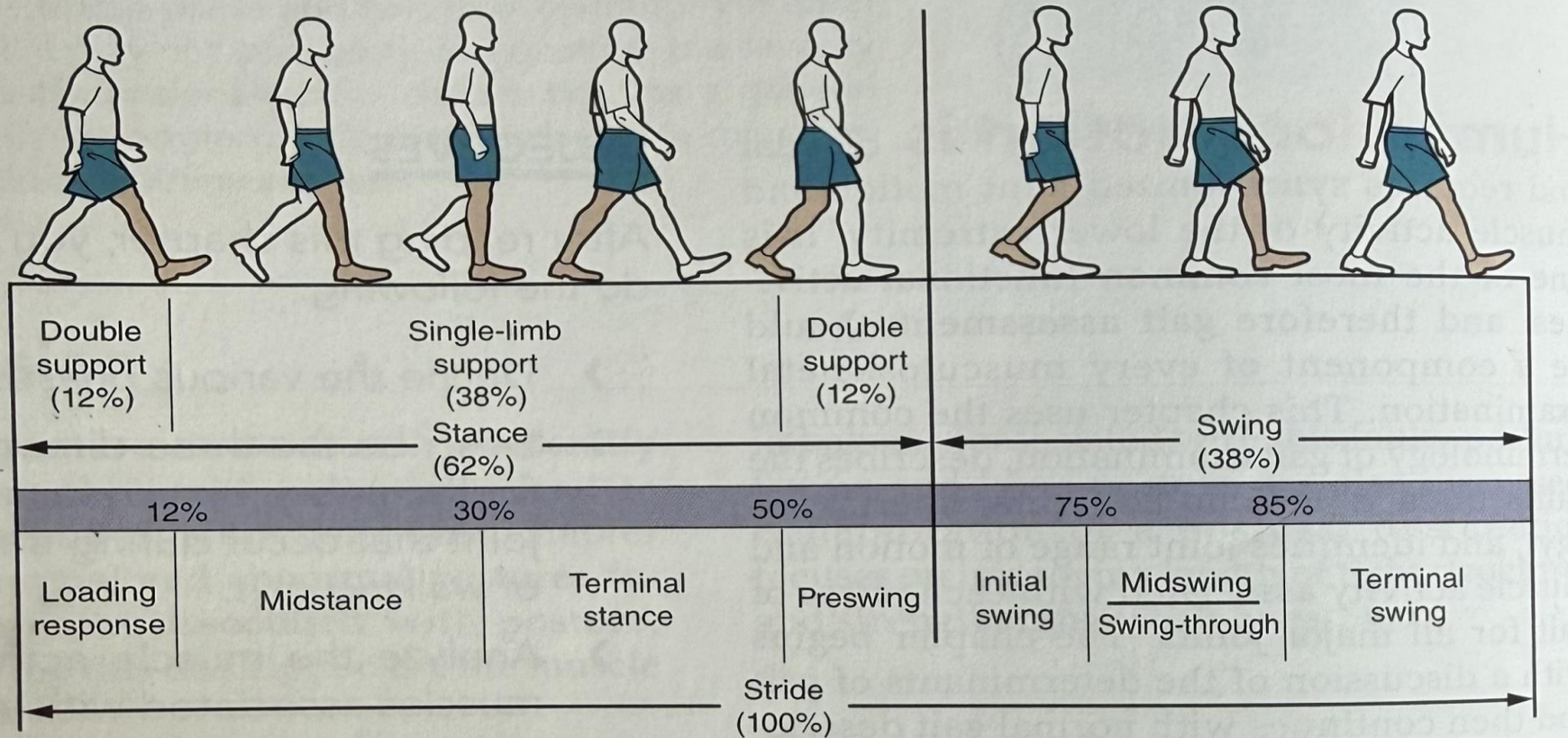
Improve posture, walking and running technique / performance.

Reduce hypokinetic health conditions.

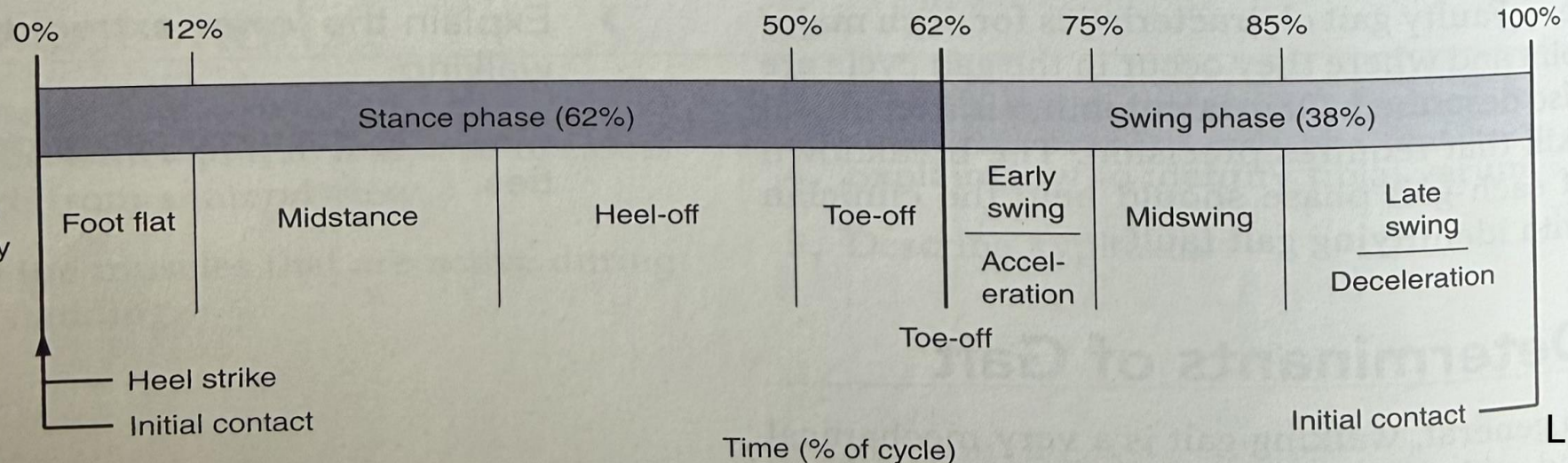
Reduce likelihood of developing musculoskeletal strategies compensatory.

Improve pain free movement.

Rancho
Los Amigos
terminology

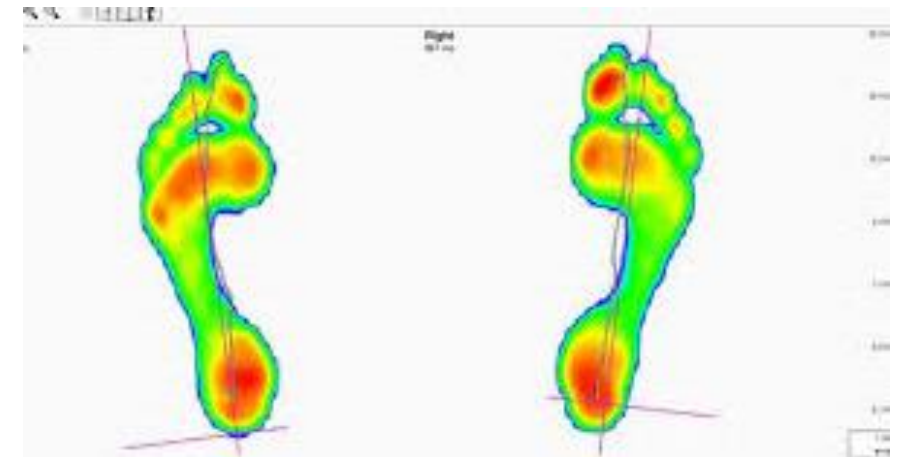
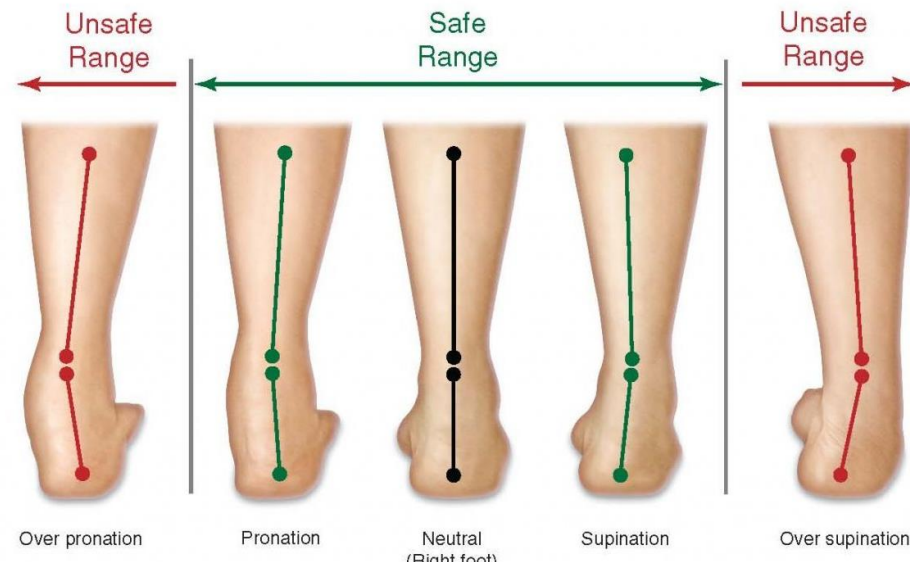
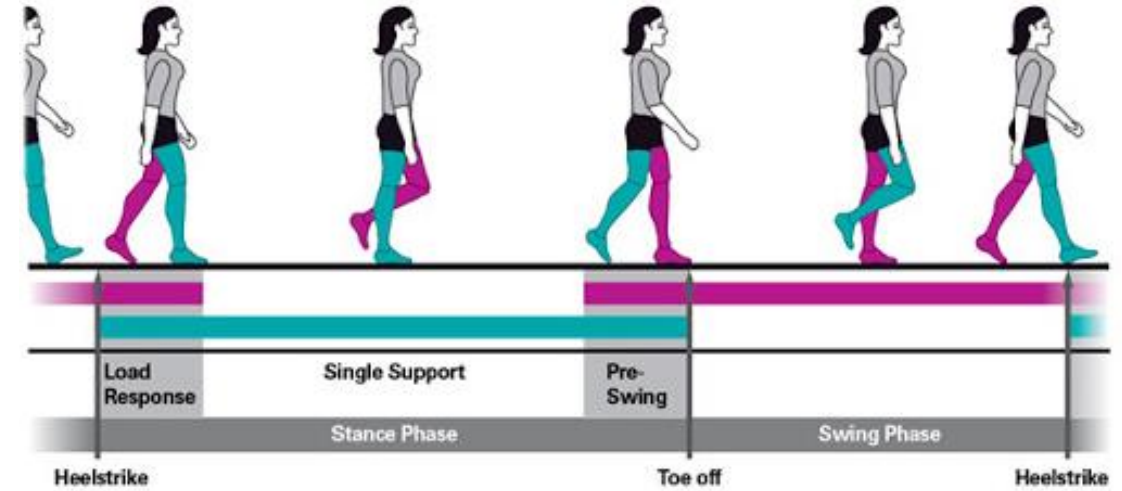
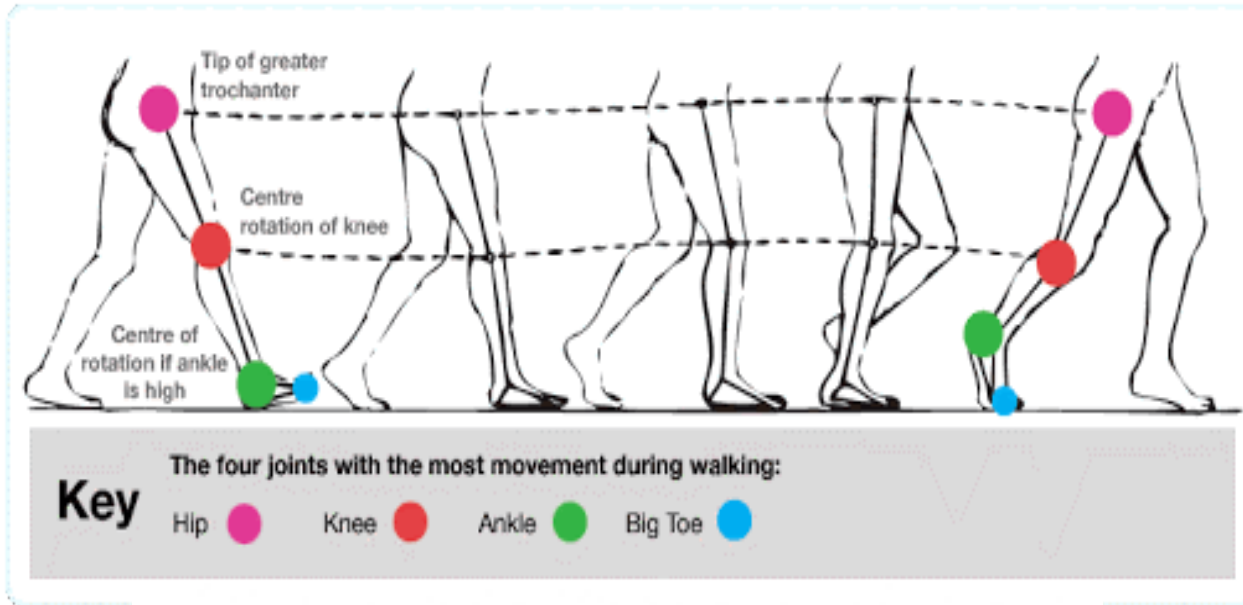


Traditional
terminology



Louden et al. (2013)

Measurements



Video Analysis

Record gait in the sagittal plane in the frontal plane

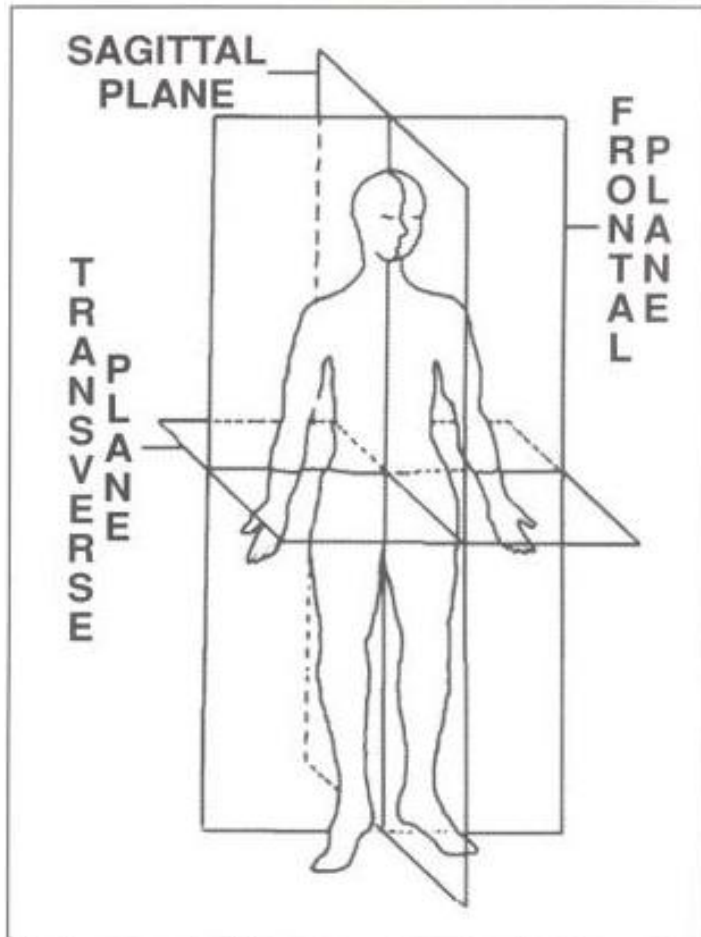
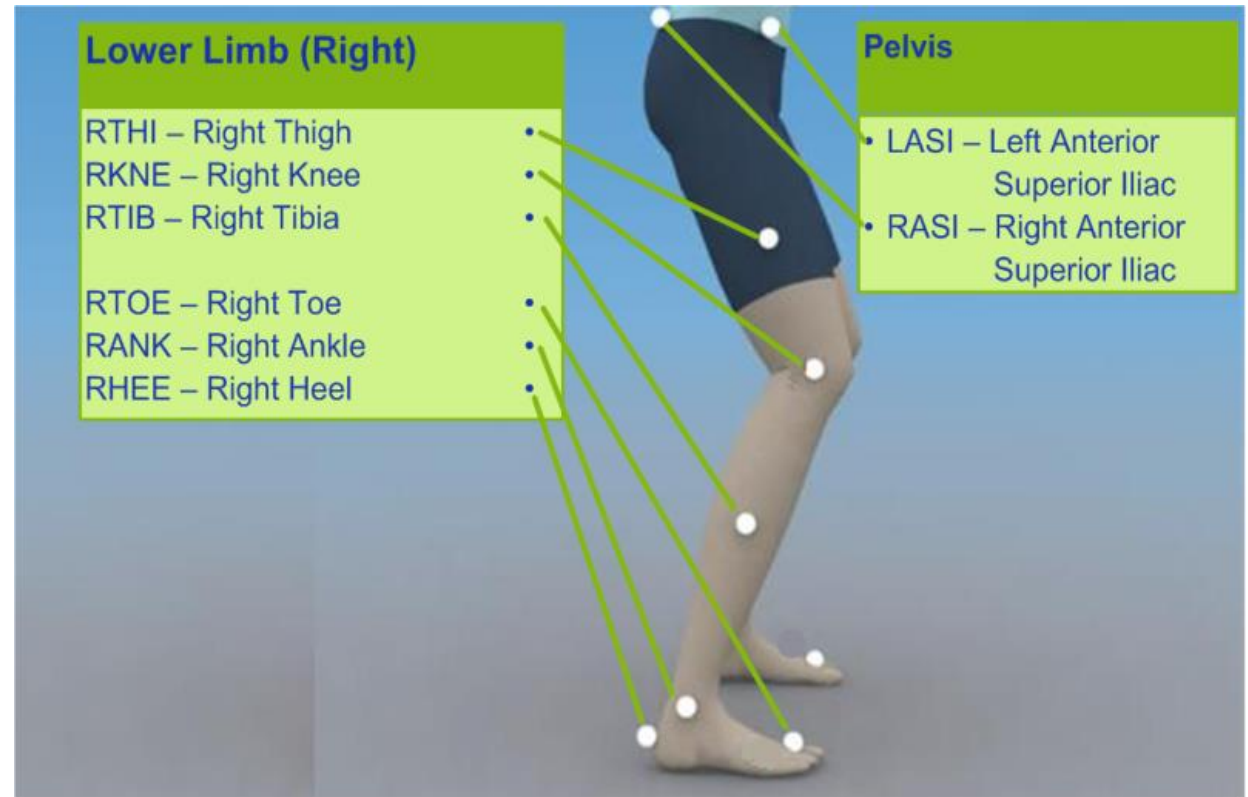


Figure 1: The Anatomical Planes



Phases of the Gait Cycle

Stance Phase

initial contact

loading (flat foot)

Mid Stance

Terminal Stance (heel off)

Pre-swing (Toe off)

Swing Phase

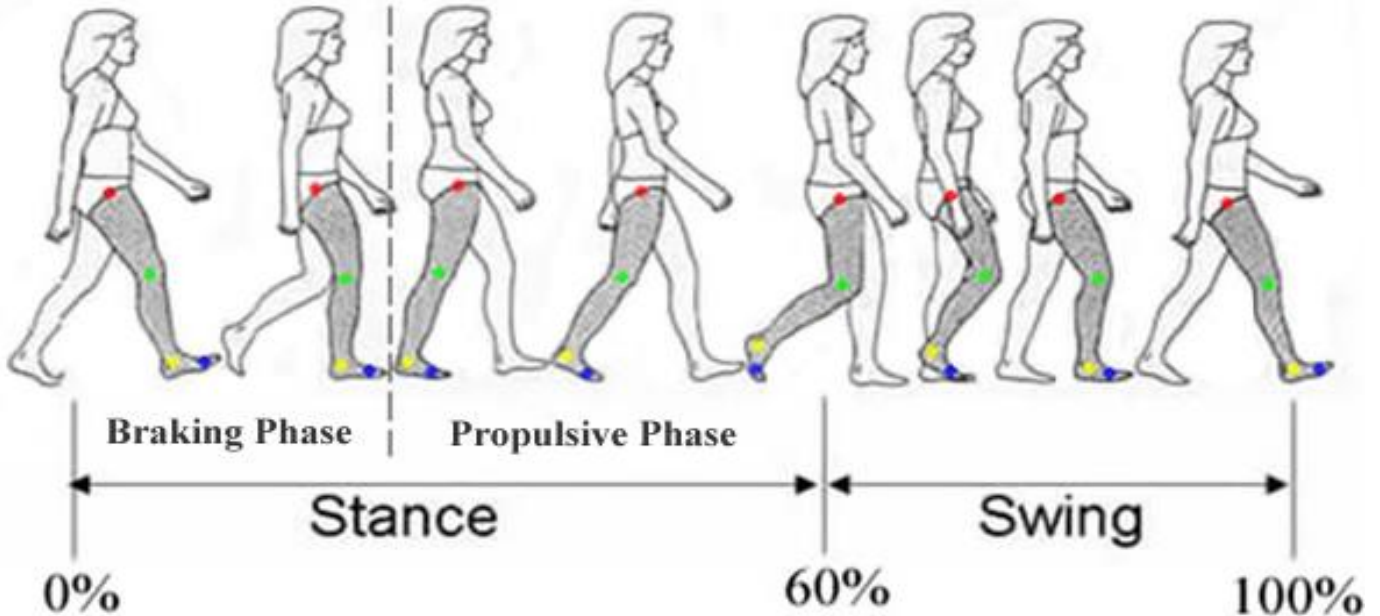
Initial swing (Accelⁿ)

Mid-swing (Toe Off)

Terminal Swing (Deccelⁿ)

• Hip • Ankle
• Knee • MTP

Gait Cycle



Rear View Analysis

Inversion v Eversion

Risk of injury

Overuse

Efficiency of impact forces

Changes due to wearing
trainers

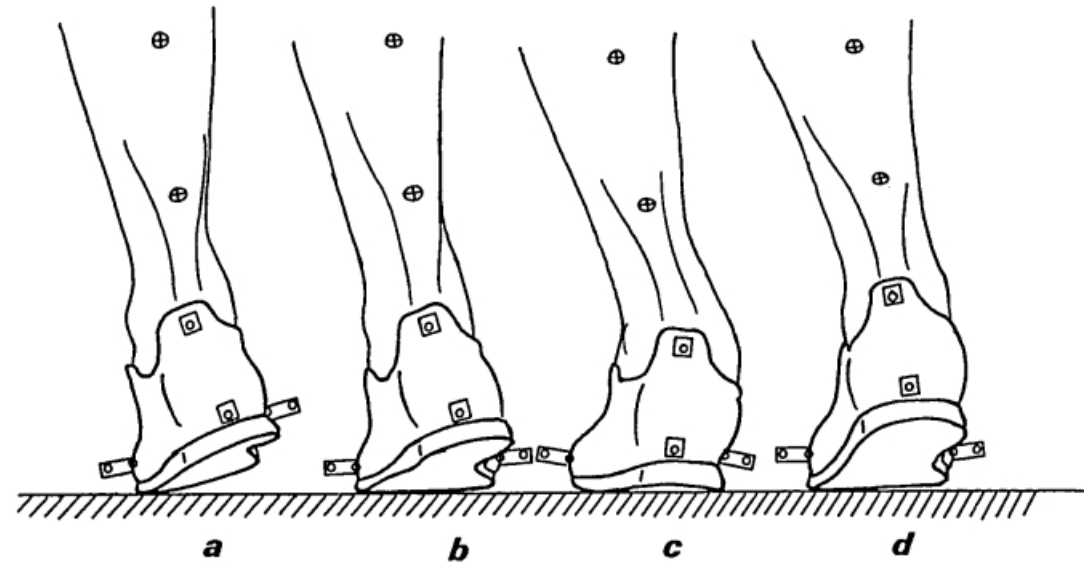
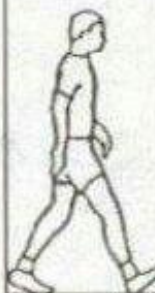
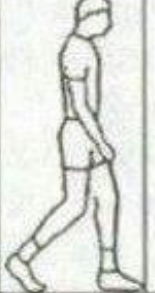
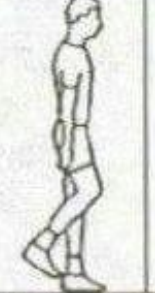


Figure 1—Various phases of forefoot running: (a) touchdown, (b) forefoot eversion and torsion, (c) rearfoot pronation, and (d) takeoff.

Measures used to Evaluate Gait

- Stride length
- Stride time
- Cadence
- Speed
- Foot / ankle impact angle
- Hip impact angle
- Leg strength
- Joint ROM
- Pelvis angle
- Stride base

Stance (60%)					Swing (40%)			
Initial Contact	Loading Response	Mid-stance	Terminal stance	Pre-swing	Initial swing	Mid-swing	Terminal swing	
								
Hip	30° flexion	Extending to 5° flexion	Extending to neutral	10° of hyper extension	Neutral extension	20° Flexion iliopsoas	30° Flexion	30° Flexion
Knee	Full extension	15° Flexion	Extending to neutral	Full extension	35° Flexion	60° Flexion	From 60° to 30° flexion	Extension to 0°
Ankle	Neutral heel first	15° Plantar flexion	From plantar flexion to 10° Dorsi flexion	Neutral with tibia stable and heel off prior to initial contact of opposite foot	20° Plantar flexion	10° Plantar flexion	Neutral	Neutral

Tasks – Walking Gait analysis task sheet