



Al-Mustaqbal University
Collage of Engineering
Prosthetics and Orthotics Engineering
Second Stage

ORTHOTICS I

Prof. Dr. Mohammed Hamzah Daham

2nd term – Lecture 2

2025-2026

mohammed.hamzah.daham@uomus.edu.iq

UOMU0103054

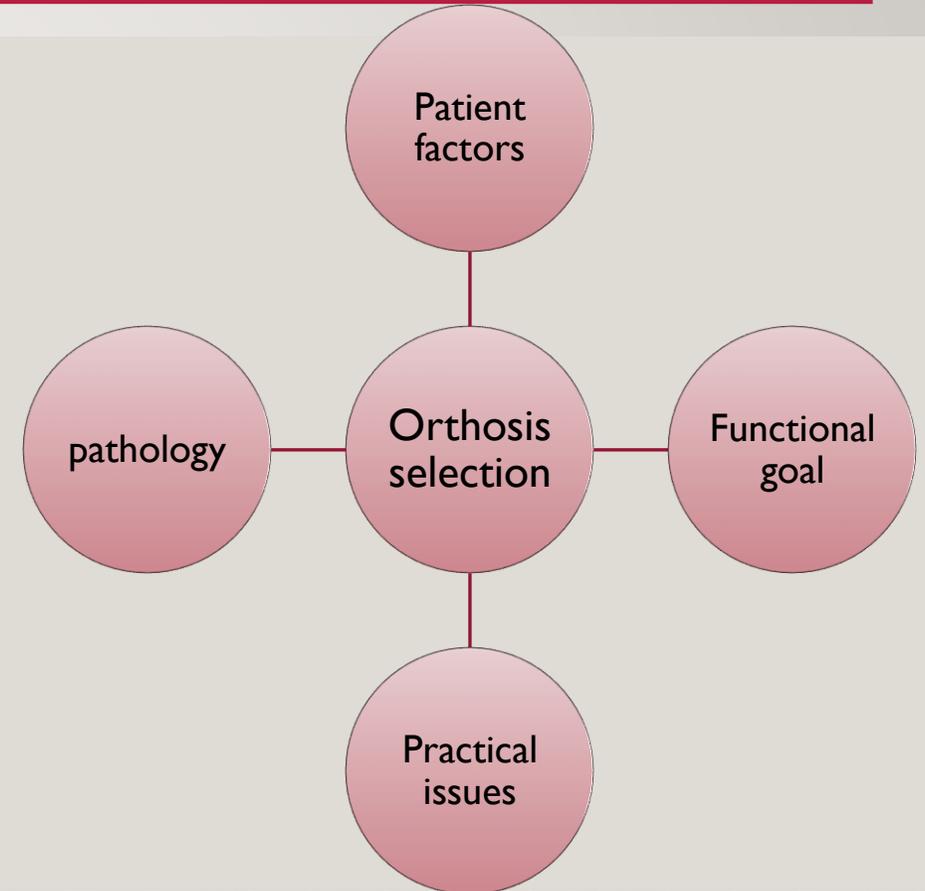
BEST ORTHOSIS AND FUNCTIONAL GAIT

ENG. HUSSEIN DHAMEER HUSSEIN



INTRODUCTION

- In clinical practice, asking “What is the best orthosis?” is common, but the correct question is: “Which orthosis is best for this patient and this goal?”
- The “best” orthosis is the one that achieves the required biomechanical control with:
 - Maximum safety and comfort
 - Minimum unnecessary restriction
 - High patient compliance

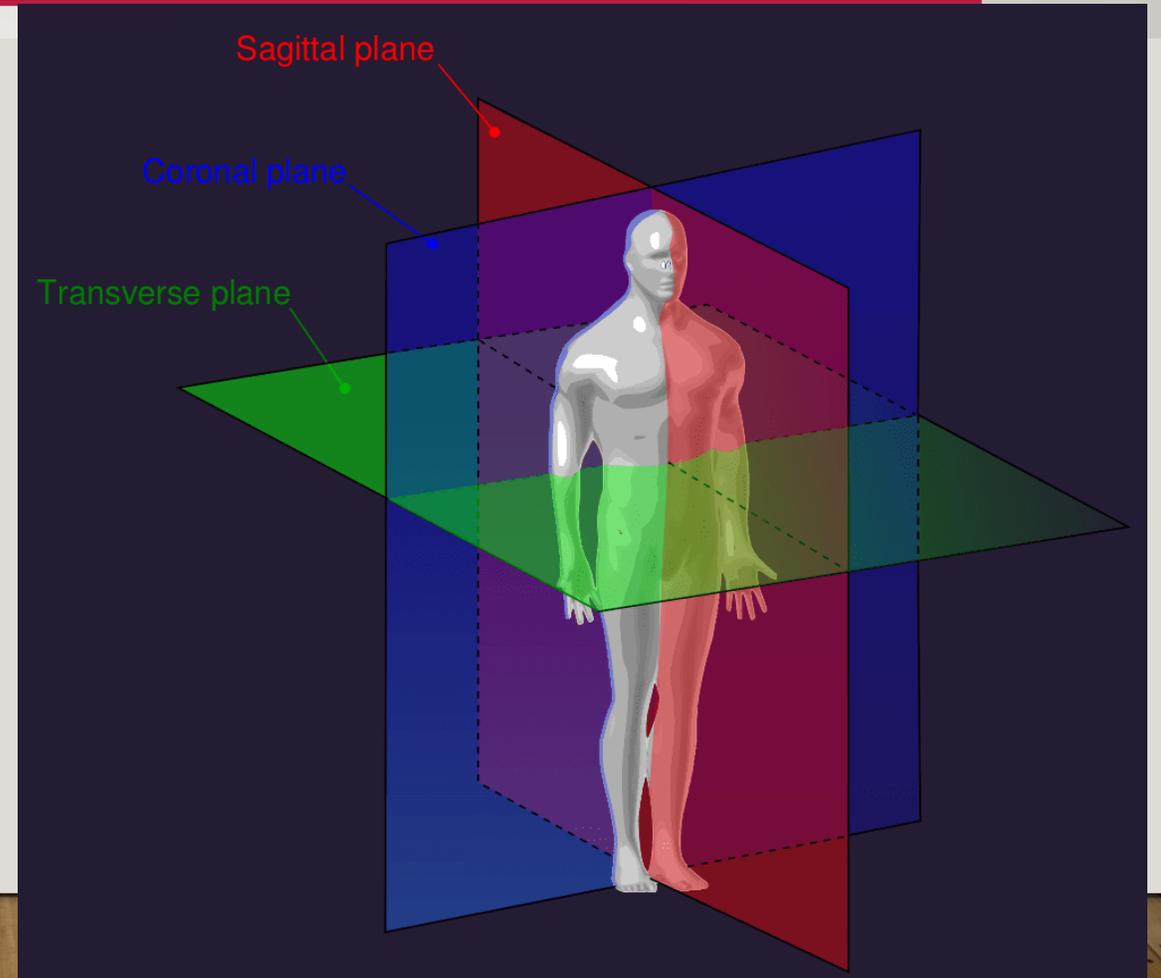


DECISION FRAMEWORK

- Patient
 - Age, weight, activity level, skin condition, cognition, compliance.
- Pathology
 - Weakness? Spasticity? ligament injury? deformity? pain?
- Purpose
 - Support (reduce pain/load), Immobilize (protect healing tissue), Control motion (limit ROM in specific plane), Correct / prevent deformity, Assist function (improve gait, prevent foot drop)
- Practicality
 - Footwear compatibility, donning/doffing, heat/sweat, cost, follow-up.

WHAT IT CONTROLS

- Orthoses are often chosen by the motions they control.
- Sagittal plane: flexion/extension
- Frontal plane: varus/valgus control
- Transverse plane: rotation control

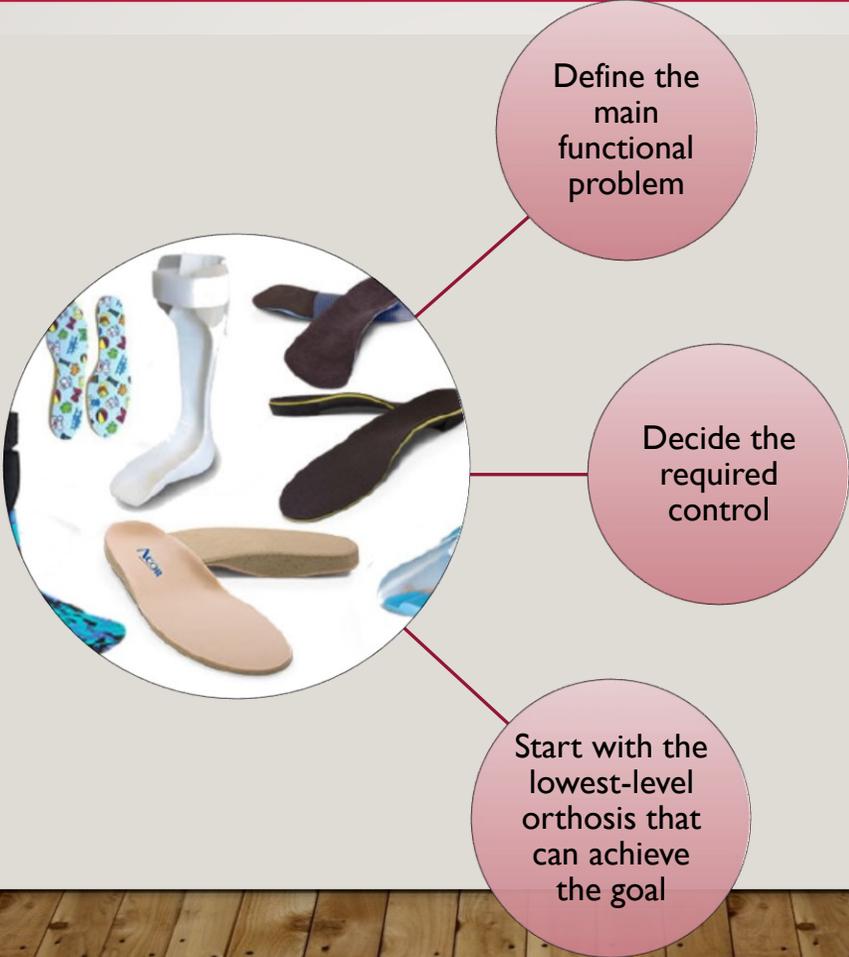


MATCH TO THE GOAL

- Immobilize Fracture / post-op protection → Rigid brace / immobilizer
- Assist movement Foot drop → PLS AFO or carbon AFO (depends on strength & control)
- Control deformity Progressive contracture risk → Night splint / serial casting + orthosis
- Reduce pain/load → Unloader brace



A SIMPLE SELECTION ALGORITHM



EFFECTIVE ORTHOSIS

- An orthosis is most comfortable and effective when:
 1. The forces are distributed over large surface areas to minimize pressure on skin and soft tissue.
 2. The forces are applied in such a way that a large moment arm reduces the amount of force needed to control the joint.
 3. The sum of the primary force and opposing counterforces of each control system equals zero.

CONT.

- Principles Underlying Control Systems in Orthotic Design:

1. Pressure = Force/Area
2. Torque = Force \times distance
3. Control direction of primary force
direction of counter-forces
4. Equilibrium Σ forces = 0

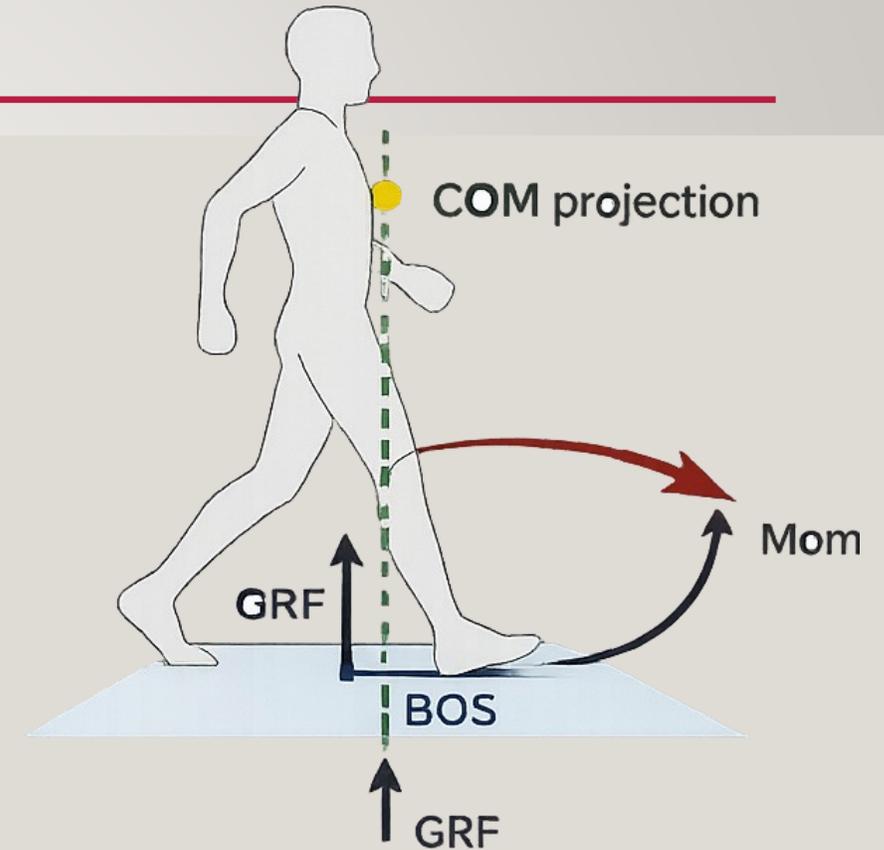


FUNCTIONAL GAIT

- Functional gait = ability to walk with:
 - Adequate speed
 - Good balance
 - Sufficient endurance
 - Low risk of injury
 - Ability to perform daily tasks (turning, stairs, uneven surfaces)

THE CORE MECHANICAL PROBLEM

- Walking is essentially the controlled motion of the center of mass (COM) relative to the base of support (BOS) while generating forward progression.
- Stability requirement: keep COM projection within/near BOS (especially during single support).
- Progression requirement: generate net forward impulse while controlling limb clearance.



Moment = Force x moment arm
Impulse = Force x time

DETERMINANT I: STABILITY (COM–BOS CONTROL)

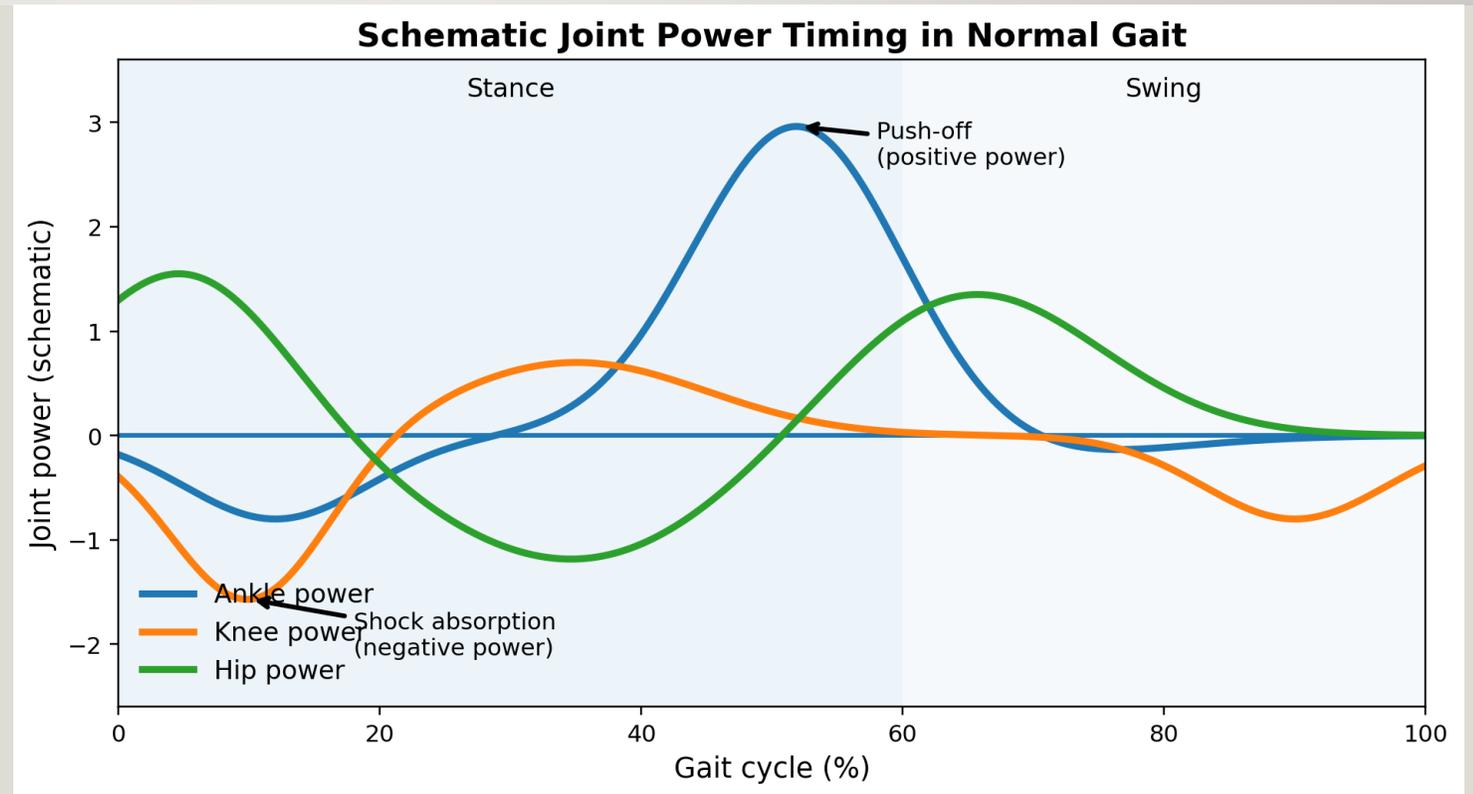
- Functional stability depends on:
- Step width / BOS size
- COM lateral excursion
- Trunk control + hip abductors
- Sensory feedback (vision, vestibular, proprioception)
- Mechanical interpretation: A wider BOS increases the margin for COM control but may increase energy cost.
- Weak hip abductors → pelvic drop → COM shifts → unstable single support.

DÉTERMINANT 2: EXTERNAL FORCES & JOINT MOMENTS (GRF)

- The ground reaction force (GRF) is the main external force in gait.
- The GRF creates external joint moments about ankle/knee/hip.
- Key mechanics: External moment \approx GRF \times moment arm (perpendicular distance to joint center)
- If GRF passes anterior to the knee \rightarrow external extension moment; if posterior \rightarrow external flexion moment.

DETERMINANT 3: JOINT POWER & WORK (ENERGY TRANSFER)

- Functional gait needs the right power timing: $\text{Power} = \text{joint moment} \times \text{angular velocity}$
- Muscles absorb/produce work to control limb and propel the body.
- Negative power = muscles absorb energy to control and stabilize.
- Positive power = muscles generate energy for propulsion and limb advancement.



DETERMINANT 4: ENDURANCE & FITNESS

- Even with good mechanics, without endurance: patient cannot walk longer distances.
- limited community ambulation early fatigue → poor stability → falls
- Factors: cardiopulmonary capacity, muscle endurance.

WHY ORTHOSES IMPROVE FUNCTIONAL GAIT

- Orthoses can improve functional gait by:
 - Changing GRF line of action → changes external moments (stability)
 - Providing stiffness to reduce muscle demand
 - Controlling ROM to prevent collapse or improve clearance