Chapter 2. Basic Concepts in Physiotherapy Part 1. Understanding Movement and Function

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Part 1 • Understanding Movement & Function

(Kinesiology • Biomechanics)

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1 Why Study Kinesiology & Biomechanics?

Physiotherapists are movement scientists. Whether you are cueing a stroke survivor to shift weight or analysing knee-valgus in an elite basketball player, every decision rests on two foundational sciences:

Field	Core Question	Relevance to Physiotherapy
Kinesiology	*What* moves—and *how* is that movement organised?	Identifies normal vs. pathological movement patterns, guides motor-learning strategies.
Biomechanics	*Why* does it move that way—what forces, torques, tissue properties or energy exchanges are involved?	Quantifies loads, predicts injury risk, prescribes optimal exercise parameters.

The two fields are inseparable: kinesiology supplies the **qualitative map** (planes, axes, muscle actions), while biomechanics provides the **quantitative toolkit** (forces, levers, work, power).

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2 Kinesiology: The Science of Human Movement

2.1 Planes, Axes & Terminology

Plane (2-D slice)	Axis (perpendicular line)	Example Physiotherapy Task
Sagittal (left-right)	Mediolateral (ML)	Sit-to-stand, biceps curl
Frontal (coronal)	Anteroposterior (AP)	Hip abduction in side-lying
Transverse (horizontal)	Longitudinal (vertical)	Trunk rotation in PNF chopping

> **Clinical pearl:** Always coach motion **in plane** before adding multi-planar complexity; it sharpens proprioception and motor control.

2.2 Types of Motion

Motion	Definition	Common Example	PT Implication
Osteokinematics	Gross bone movement around a joint axis	Shoulder flexion 0–180°	Measured with goniometer for ROM goals
Arthrokinematics	Micro-movements between articular surfaces—roll, glide, spin	Femoral glide on tibia in knee flexion	Determines need for joint mobilisation to restore glide
Open-chain	Distal segment free	Seated knee extension	Early-stage quad strengthening
Closed-chain	Distal segment fixed	Sit-to-stand	Promotes co-contraction & proprioception

2.3 Muscle Roles & Activation Patterns

Role	Moment in Movement Cycle	Example
Agonist	Prime mover	Gluteus maximus in concentric hip extension
Antagonist	Opposes or controls agonist	Hip flexors lengthen eccentrically in same task
Synergist	Assists or stabilises	Hamstrings assist hip extension; multifidi stabilise lumbar spine
Neutraliser	Cancels unwanted motion	Pronator teres prevents biceps supination during elbow flexion

Length–Tension & Force–Velocity Concepts

- Optimal sarcomere length ≈ 2.0–2.2 µm → maximal cross-bridge overlap.
- **Concentric** force falls as velocity rises; **eccentric** force can exceed isometric by 20–60 %.
  Figure reference: Graph these relationships when teaching exercise dosing.

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3 Biomechanics: Forces, Levers & Tissue Mechanics

3.1 Newtonian Foundations

Law	Human-Movement Example	PT Application
1st (Inertia)	A limb in a cast tends toward immobility	Early assisted ROM counters inertia
2nd (F = m · a)	Heavier limb segments need higher muscle force to accelerate	Cue trunk momentum for hemiplegic gait initiation
3rd (Action–Reaction)	Ground reaction force (GRF) during gait	Orthotic design & plyometric training rely on harnessing GRF

3.2 Moments, Levers & Mechanical Advantage

Lever Class	Fulcrum–Force–Load Order	Example in Body	Clinical Insight
1st	F–A–L (See-saw)	Upper-cervical extensors vs. head weight	Small neck-extensor weakness = large posture change
2nd	F–L–A (Wheel-barrow)	Gastro-soleus in plantar-flexion when rising on toes	High force efficiency → useful for strength without tandem joint stress
3rd	A–F–L (Fishing rod)	Biceps at elbow	Most joints; favors speed & ROM over strength

- **Moment (Torque) = Force × Perpendicular distance (r)**
  In clinic: Reduce external moment arm (e.g., hold weight close) to unload early-rehab joints.

3.3 Kinetics vs. Kinematics

Measure	Unit	Instrument	Example Output
Kinematics	Degrees, $m \cdot s^{-1}$	Video analysis, inertial sensors	Velocity of knee flexion during swing phase
Kinetics	Newtons, N · m	Force plate, dynamometer	Peak ankle moment at toe-off

> **Rule-of-thumb:** Treat **kinematic deviation** (e.g., excessive hip-adduction) only if matched by **kinetic overload** (e.g., high hip-abductor moment) or pain; otherwise variation may be benign.

3.4 Tissue Load–Deformation (Stress–Strain)

Zone on Curve	Description	Rehab Relevance
Toe	Crimp straightening; low stiffness	Early passive stretch safe here

Zone on Curve	Description	Rehab Relevance
Elastic	Linear: returns to original length	Active ROM, low-load endurance
Yield & Plastic	Micro-failure; permanent length change	Collagen remodelling in prolonged stretch (e.g., contracture treatment)
Ultimate Failure	Macrofailure	Avoid: indicated by sharp pain, audible tear

- **Wolff's Law:** Bone adapts to load; progressive-impact exercise boosts BMD.
- **Davis's Law:** Soft tissues remodel along lines of stress; explains need for dynamic, multiplanar exercises post-immobilisation.

3.5 Energy, Work & Power

- **Work (J) = Force × Distance**
- **Power (W) = Work ÷ Time**
- **Mechanical efficiency** in gait ≈ 25 %; deviations (e.g., spasticity) raise metabolic cost → fatigue.

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4 From Theory to Clinic: Application Matrix

Clinical Scenario	Kinesiological Focus	Biomechanical Adjustment	Example Intervention
ACL-deficient knee	Reduce excessive anterior tibial glide	Limit shear force via hamstring co-contraction	Closed-chain squats to 60° flexion
Frozen shoulder	Restore capsular roll-glide	Gentle traction modulates joint reaction force	Grade-I/II mobilisations + pendulum swings
Elderly faller	Improve postural sway control	Increase base of support and GRF utilisation	Sit-to-stand with stagger stance on force plate
Runner with ITB syndrome	Correct hip-adduction angle	Decrease peak knee-varus moment	Gait retraining + lateral-band "monster walks"
Stroke hemiparesis	Re-teach synergy-free patterns	Manage abnormal torque coupling	Task-specific, load-progressive step training using body-weight support

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7 Learning Aids

- **Visual:** Use 3-plane models to tag muscle origins/insertions.
- **Digital:** Try smartphone apps (e.g., GaitON, MyJump2) for kinematic video feedback.
- **Kinesthetic:** Palpate moving scapula to feel upward-rotation synergy during arm lift.

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8 Summary & Take-Home Points

1. **Kinesiology** frames *what* moves; **biomechanics** explains *why* and *how much*.
2. Plane-axis literacy and lever analysis let you tailor exercise angles and loads.
3. Tissue stress-strain curves guide safe stretching, strengthening and orthotic decisions.
4. Always translate mechanical insights back into **functional, patient-centred tasks**—strength or ROM gains are valuable only when they enhance real-life performance.

Self-Reflection Task

Film your own squat from the side view. Measure:

- **Hip-knee-ankle angles** at 30°, 60° and 90° flexion (kinematics).
- Estimate **external knee moment** using body-weight and COM shift (biomechanics).
  Write a paragraph on how altering trunk angle or foot placement modulates these variables and the potential clinical use (e.g., for patellofemoral pain vs. gluteal strengthening).
