

Chapter 7. Clinical Applications and Case Studies

Part 1: Integrative Physiology & Biochemistry for Physiotherapy

□ 1. Learning Objectives

By the end of this section, you should be able to:

1. Synthesize Cardiovascular, Respiratory, Musculoskeletal and Metabolic Principles

When a patient has difficulty walking or breathing, multiple systems are involved. For example:

- A weak heart (cardiovascular system) may not pump enough blood.
- Poor lung function (respiratory) can reduce oxygen delivery.
- Weak muscles or joints (musculoskeletal) may limit movement.
- Metabolic disorders like diabetes or malnutrition can reduce endurance or healing.

□ **Integration:** You'll learn to "connect the dots" between these systems to explain a patient's signs (e.g., fatigue, breathlessness) and **functional limits** (e.g., can't walk far or lift weight).

2. Translate Lab & Bedside Data into Physiotherapy Decisions

You must be able to **read and understand reports** like:

- ECG (electrocardiogram) for heart rhythm
- ABG (arterial blood gas) for oxygen & CO₂
- Creatine Kinase (CK) for muscle damage
- Glucose levels for energy and diabetes

□ **Use case:** High CK after strength training → reduce load.
Low oxygen on ABG → use breathing techniques or oxygen therapy.

3. Design Evidence-Based Intervention Plans

You'll learn to:

- Adjust **posture** for better breathing
- Plan **breathing retraining** for COPD
- Prescribe **nutrition** for muscle recovery
- Modify **loading** in rehab (e.g., after ACL surgery)

□ Everything you prescribe (exercise, breathing, diet) must **correct abnormal physiology/biochemistry** without overloading the body.

4. Employ Structured Clinical Reasoning

Use a step-by-step, logical process to decide:

- What's wrong?
- Which system is affected?
- What exercise or treatment is safe?

- When to progress or slow down?

☐ It prevents **trial-and-error therapy** and improves patient safety.

☐ 2. Integrated Framework for Clinical Reasoning - Step by Step

Step	Explanation	Link with Physiology/Biochemistry
1. History & Vitals	Note patient's heart rate (HR), blood pressure (BP), SpO ₂ , etc.	HR and BP reflect cardiac output. SpO ₂ reflects oxygen delivery. Capillary refill reflects microcirculation.
2. Movement Analysis	Look at range of motion (ROM), strength, endurance.	Shows muscle fibre type, energy pathways used, and joint status.
3. Lab/Imaging	Check tests like CK, Troponin, ABG, HbA1c, DEXA.	Understand muscle damage, glucose control, oxygen status, and bone strength.
4. Problem List	Convert findings to impairments → activity limits → participation.	Helps set therapy goals and prioritise risks.
5. Intervention Selection	Choose exercise type, intensity, nutrition, education.	Must match patient capacity and help restore function.
6. Outcome Measures	Use VO ₂ max, 6-Min Walk Test, grip strength, pain score, QoL.	Track progress over time and adjust therapy accordingly.

☐ 3. Case Studies - Integrated Explanations

☐ Case 1: Post-Heart Attack Rehab (STEMI)

Patient: 59-year-old male, heart attack 2 days ago, stent placed.

Observation	Meaning	PT Plan
HR 88, BP 128/78, CK-MB high	Heart is weak; relies on faster HR for cardiac output	Phase 1 Rehab: Light marching in place, short duration, watch HR—don't exceed 110 bpm Seated rests, monitor SpO ₂ above 94% Teach DASH diet, explain statins block cholesterol formation
Hb 11 g/dL	Less oxygen carried in blood	
LDL 162 mg/dL	High cholesterol	

☐ Case 2: COPD with Sarcopenia

Patient: 68-year-old female, severe lung disease, underweight.

Observation	Meaning	PT Plan
SpO ₂ 91%, CO ₂ 52	Blunted brain response to CO ₂ ; relies on low oxygen to breathe	Interval cycling with oxygen support, keep O ₂ in safe zone (88-92%) Blood flow restriction (BFR) training + whey protein + leucine post-exercise Omega-3 (EPA/DHA) to reduce pain & inflammation pathways
Low muscle size & grip strength	Loss of fast-twitch muscle, inflammation	
IL-6, CRP high	Inflammatory state	

☐ Case 3: Diabetes with Non-Healing Foot Ulcer

Patient: 55-year-old male, poor sugar control, low blood flow.



Observation	Meaning	PT Plan
HbA1c 9%	Poor long-term glucose control; damages collagen	Control carbs before/after exercise; monitor blood glucose
ABI 0.75	Narrow arteries; poor foot circulation	Claudication training: Walk to pain, rest, repeat – improves blood flow
Chronic ulcer	Poor healing, possible infection	High-protein diet, vit C + zinc, off-load foot, clean with pulsed lavage

Case 4: ACL Surgery Rehab (Hamstring Graft)

Patient: 24-year-old female, 6 weeks post-surgery.

Observation	Meaning	PT Plan
High CK after therapy	Mild muscle damage; needs rest	Electrical stimulation (NMES) + voluntary quad contraction
Bone tunnels healing	Graft needs load, calcium, vit D	Step-up training, vit D supplement if low
Graft turning to ligament	Needs collagen & oxygen	Bike with low resistance, iron-rich food for healing tissues

4. Clinical Integration Tips

Symptom/Lab	Which System?	What Can PT Do?
HR keeps rising	Cardiovascular, endocrine	Check over-training, meds, fluid balance
Muscle pain + high CK	Muscle injury or statin effect	Reduce exercise, ensure protein intake
SpO ₂ drops post-exercise	Lungs or low hemoglobin	Pursed-lip breathing, oxygen support

5. Self-Check Quiz (with Answers)

Q1. Which metabolic pathway limits walking in PAD and how does interval training help?

- **Anaerobic glycolysis** gets overloaded due to poor blood flow.
- Training improves mitochondrial function and promotes new blood vessels.

Q2. How do omega-3s reduce tendon pain?

- They block inflammatory molecules (PGE₂), shifting toward healing molecules like **resolvins**.

Q3. Red flags for stopping Phase-II cardiac rehab?

- ECG: ST depression >2 mm
- Biochem: Rising **Troponin T** or **CK-MB**

Q4. Why does a COPD patient desaturate more on arm exercise?

- Upper limbs have less endurance fibres → fatigue earlier → more oxygen needed.



Q5. Nutrients for ligament healing?

→ **Vitamin C** (for collagen formation) and **Copper** (for cross-linking fibres)

□ 6. Key Takeaways

- **Physiology + Biochemistry** are not separate—they work together in every treatment plan.
- As a physiotherapist, your tools are **movement, breathing, posture, and nutrition**.
- Use **structured thinking**: Identify the system → understand the mechanism → choose the right intervention.

Part 2: Assessment & Diagnostic Techniques for Physiotherapists

□ 1. Learning Objectives - Explained

By completing this section, you'll learn how to:

1. Select Suitable Lab and Bedside Tests

You'll be trained to **choose the right test** based on the patient's condition. For example:

- Is it a lung problem? → Use spirometry or ABG.
- Suspect heart issue? → ECG, BP, or echocardiography.
- Weak muscles? → CK or DEXA scan.

□ You will **not need to do every test for every patient**, but pick what is relevant for physiotherapy.

2. Understand Test Procedures and Ranges

You must know:

- **How each test works** (basic principle)
- **How to handle samples** (e.g., ABG needs arterial blood + heparin)
- **What's a normal range** (e.g., blood pressure or blood sugar)

This lets you spot what's wrong quickly.

3. Interpret Results for Therapy

Once you have the report:

- Should you **start, pause, change, or stop** your treatment?
- Do you need to **add oxygen? Reduce exercise? Refer to physician?**

4. Identify Red Flags

Some test patterns mean **emergency**:

- Very high BP or low SpO₂ → stop immediately

- Signs of internal bleeding or infection → refer urgently

□ 2. Core Diagnostic Techniques - System-wise Table

System	Test / Tool	Principle	Normal Range	Physiotherapy Meaning
Cardiovascular	ECG	Surface electrodes detect electrical signals from heart.	HR 60–100 bpm, PR 0.12–0.20 sec	If ST elevation ≥ 2 mm → STOP session. QTc > 0.47 → avoid electrical modalities.
	Echocardiography	Ultrasound reflects off valves & walls to measure EF.	EF $\geq 55\%$	If EF $< 40\%$, start with light exercise at 40–50% HRR.
	Blood Pressure	Uses cuff (manual/auto).	$\leq 120/80$ mmHg	If SBP > 220 or DBP > 110 , stop resistance training.
Respiratory	Spirometry	Measures lung function using forced breath.	FEV ₁ /FVC ≥ 0.70	Obstruction < 0.70 → use breathing retraining; FEV ₁ $< 50\%$ → low-intensity only.
	Pulse Oximetry	Uses red/infrared light to measure oxygen in blood.	$\geq 94\%$ at rest	COPD goal = 88–92%; pause therapy if SpO ₂ $< 85\%$.
	ABG	Blood test for pH, O ₂ , CO ₂ (from artery).	pH 7.35–7.45; PaO ₂ > 80	pH < 7.30 or PaCO ₂ > 60 → delay intense therapy.
Muscle & Bone	CK (Creatine Kinase)	Measures muscle damage enzyme.	Male: 40–200 U/L; Female: 20–180	$> 5\times$ baseline → reduce eccentric exercise.
	DXA Scan	Low-dose X-ray to assess bone density.	T-score ≥ -1.0 normal	T ≤ -2.5 → start with low-impact, balance exercises.
Metabolic / Endocrine	Blood Glucose	Glucose strip from finger.	70–100 fasting	> 250 post-meal or < 70 pre-exercise → modify carbs/insulin.
	HbA1c	Shows 3-month sugar control.	$< 5.7\%$ normal	If $> 8\%$, go slow with foot loading, watch for ulcers.
	Lipid Panel	Measures LDL, HDL, etc.	LDL < 100 ; HDL > 40 (M) / > 50 (F)	LDL > 190 → monitor closely during cardiac rehab.
Inflammation & Recovery	CRP / ESR	Markers of infection/inflammation.	CRP < 5 mg/L	> 10 with joint pain → check for hidden infection.
	Vitamin D	Measures 25-OH Vit D in blood.	> 30 ng/mL	< 20 → supplement before doing weight training.

□ Tip: All lab results should be matched with symptoms and functional assessments.

□ 3. Linking Tests with Therapy Decisions

□ Readiness & Safety Screens

- **ECG:** E.g., if PR interval is prolonged (0.22s), but heart rhythm is normal → low-level mobilisation is safe.
- **BP & SpO₂:** If SpO₂ drops during stairs, add rest breaks or oxygen support.

□ When to Progress

- CK and soreness are mild → can increase exercise load.
- FEV₁ improves → increase resistance in inspiratory training device.



□ Red Flags: When to Stop

- **New Atrial Fibrillation** on monitor
- **Metabolic Acidosis** (ABG: pH < 7.30, HCO₃⁻ < 18)
- **Orthostatic Hypotension**: BP drops >20 mmHg with fainting

□ Recovery & Nutrition Decisions

- Low **Albumin (<3.5 g/dL)** = poor wound healing → consult dietitian.
- Low **Iron/Ferritin (<30 ng/mL)** = weak oxygen delivery → delay aerobic sessions.

□ 4. Practical Tips for Physiotherapists

- **CK peak**: Wait 24 hrs after heavy eccentric session to measure accurately.
- **ABG position**: Patient should sit upright for 5 minutes before drawing blood.
- **BP Cuff**: Wrong size → false readings. Cuff should cover 40% of upper arm.
- **Don't react to one value**: Look at **trend**. A single borderline troponin doesn't stop therapy—but a rising trend does.

□ 5. Case-Based Mini Interpretations

Scenario	Meaning	Action
Post-Stroke : ABG → PaCO ₂ 30, pH 7.48	Respiratory alkalosis	Teach paced breathing, add speaking valve
Runner + Shin Pain : Vit D = 18 ng/mL	Vit D deficient, Ca normal	Add 2000 IU/day D3, continue pool rehab
ICU Patient : CK = 6000, fever 40°C	Risk of muscle breakdown (rhabdomyolysis)	Delay rehab; start fluid therapy

□ 6. Self-Check Quiz (with Explanations)

1. **Which pattern shows FEV₁/FVC > 0.8 + reduced FVC?**
→ **Restrictive**. These patients breathe rapidly and shallowly. Use small-volume interval training.
2. **CK = 1100 U/L, 48 hr post-exercise, no symptoms. Safe to progress?**
→ No. >5× normal or >1000 U/L = **deload**, rest, add recovery strategies.
3. **ABG in Cheyne-Stokes (CHF)?**
→ **Hypocapnia (low CO₂)** → Respiratory alkalosis
4. **Why check INR before chest percussion?**
→ INR > 2.5 = **risk of bleeding** from mechanical techniques.
5. **Blood tests for muscle recovery readiness?**
→ **Albumin ≥ 3.5 g/dL** (nutrition)
→ **Testosterone or IGF-1** (anabolic hormones)

7. Key Take-Home Points

- Lab data isn't just for doctors. As a physiotherapist, you use it to guide **movement, breathing, posture, and recovery**.
- Think in systems: **cardio, respiratory, muscle, metabolic**—every test tells you how to modify therapy.
- Always match **lab results** with **clinical signs** and **functional ability**.

Part 3: Practical Labs & Hands-On Exercises

This section gives you **practical experience** in understanding how physiology and biochemistry connect with real-life physiotherapy applications. Each lab simulates a clinical condition or response, and you will *observe, measure, interpret,* and *act like a clinician*. Let's walk through it step by step.

Overview of Practical Labs

Lab No.	Title & Systems	What You'll Learn	Safety Alerts
1	Finger-stick Glucose & Lactate Test	How carbs and lactate behave during exercise	Use sterile lancets; no test for patients with bleeding disorders
2	Serum CK & Muscle Soreness	How to track muscle damage after strength training	Use clean venepuncture or dried spot cards; infection control
3	Spirometry & Talking Test	Assess lung function and ventilatory threshold	Don't test patients with unresolved pneumothorax
4	Sub-max Cardio Test	Estimate aerobic fitness using HR and VO ₂	Watch out for heart/orthopedic risks
5	EMG & Handgrip Fatigue	Measure muscle activity and fatigue pattern	Clean skin; avoid electrical interference
6	Salivary α -Amylase Stress Response	Measure autonomic stress biomarker	No food/gum before test; biohazard safety
7	Urinalysis Before/After Exercise	Understand hydration and kidney response	Use privacy screens; dispose samples properly
8	Indirect Calorimetry (optional)	Track oxygen use and fuel preference	Disinfect mask, monitor CO ₂ levels, HEPA filter use

Example Explained: Lab 1 - Finger-stick Glucose & Lactate During Cycling

Goal: Understand how energy substrates (glucose & lactate) change with rising intensity of exercise.

What you'll need:

- Glucometer with strips
- Handheld lactate analyzer
- Cycle ergometer (stationary bike)
- Alcohol swabs and lancets
- RPE (Rating of Perceived Exertion) scale
- Sharps disposal box
- Data sheet for logging results



□ Procedure:

Step	What to Do	What to Record
Warm-up	Pedal at 25 watts for 3 minutes	Heart rate (HR), RPE
Exercise	Increase resistance by 25 watts every 2 min until RPE = 15 or SpO ₂ < 90%	At each stage: HR, BP, Blood glucose, Blood lactate
Cool-down	Pedal slowly for 5 mins	Lactate after 5 minutes

□ Data Interpretation:

- Lactate Graph** - A sharp rise indicates the **lactate threshold** (body shifting from aerobic to anaerobic metabolism).
- Blood Glucose** - May dip slightly due to muscle uptake.
- HR-Work Plot** - Should be **linear** in fit individuals.

□ Clinical Relevance:

Imagine training a diabetic client—by observing when their blood sugar dips or lactate spikes, you can adjust workout intensity to avoid **hypoglycaemia** or fatigue.

□ 2. Data Handling & Interpretation Tasks

Here's how you interpret real data:

Test Result	What It Means	Action You Take
CK = 1250 U/L with soreness 6/10	Significant muscle micro-damage	Avoid more eccentric exercise till CK < 500 and DOMS ≤ 3
Spirometry = FEV₁/FVC 0.62; FEV₁ = 48%	Moderate obstructive lung issue (like COPD)	Start Pursed-Lip Breathing (PLB) and Inspiratory Muscle Training (IMT)
RER = 1.05 at 150 watts	Carbohydrate is dominant fuel	Advise pre-session carb intake; good for explosive power workouts

□ 3. Group Mini-Projects - Real Clinical Simulations

Project	Roles You Can Take	Final Outcome
Inflammation & Nutrition	ELISA Test Operator (CRP), Diet Tracker, Data Analyst	Make a poster showing how omega-3 supplements reduce inflammation
Hydration Science	Urine checker, Weight monitor, Sweating rate calculator	Create a hydration plan (e.g., drink 12 mL/kg/hour to maintain hydration)

□ 4. Safety & Ethical Must-Dos

Before any hands-on session:

- Take **informed consent** and fill **PAR-Q+** (Physical Activity Readiness Questionnaire).
- Follow **universal precautions**—gloves, masks, hand hygiene.
- **Calibrate** all devices before use. Note serial numbers.
- **Supervisor with ACLS** (Advanced Cardiac Life Support) must be available during cardio labs.
- **De-brief** participants: give results + suggest doctor visit if abnormal findings.



□ 5. Practical Self-Check Quiz (With Answers)

1. **What two values are needed to convert oxygen usage to calories burned?**
→ RER (Respiratory Exchange Ratio) and energy equivalent per liter of oxygen at that RER
2. **Why use RMS for EMG fatigue study?**
→ It gives a *clean, averaged signal over time*, unlike raw EMG which fluctuates too much.
3. **What can falsely increase salivary amylase at rest?**
→ Caffeine, chewing gum, citric lozenges.
4. **Lab precaution to prevent haemolysis during CK testing?**
→ Use 21G needle, invert tube gently—*no shaking!*
5. **Is urine SG = 1.030 always dehydration post-workout?**
→ **False.** It may be **temporary** from exercise → check body weight & urine color too.

□ 6. Final Key Learnings

- Practical tests transform theory into reality—you actually **see how physiology behaves in a body under stress or exercise.**
- Always link what you measure to what you'll do:
 - Glucose drop? → Adjust carbs.
 - SpO₂ drop? → Add pacing or O₂.
 - CK high? → Lower eccentric load.
- Clean data starts with clean technique—**sampling, calibration, consent, safety** are just as important as knowledge.