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).

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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 & CO_2
- 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.

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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.

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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.

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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.

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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
Hb 11 g/dL	Less oxygen carried in blood	Seated rests, monitor SpO_2 above 94%
LDL 162 mg/dL	High cholesterol	Teach DASH diet, explain statins block cholesterol formation

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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%)
Low muscle size & grip strength	Loss of fast-twitch muscle, inflammation	Blood flow restriction (BFR) training + whey protein + leucine post-exercise
IL-6, CRP high	Inflammatory state	Omega-3 (EPA/DHA) to reduce pain & inflammation pathways

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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 (PGE_2), 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)

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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.

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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.

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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**?

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4. Identify Red Flags

Some test patterns mean **emergency**:

- Very high BP or low SpO_2 → stop immediately

- Signs of internal bleeding or infection → refer urgently

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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 ≥ 55%	If EF < 40%, start with light exercise at 40–50% HRR.
	Blood Pressure	Uses cuff (manual/auto).	≤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.	≥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× 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.

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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 & SpO_2**: If SpO_2 drops during stairs, add rest breaks or oxygen support.

When to Progress

- CK and soreness are mild → can increase exercise load.
- FEV_1 improves → increase resistance in inspiratory training device.

Red Flags: When to Stop

- **New Atrial Fibrillation** on monitor
- **Metabolic Acidosis** (ABG: pH < 7.30, HCO_3^- < 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 FEV_1/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 CO_2)** → 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

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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:

1. **Lactate Graph** – A sharp rise indicates the **lactate threshold** (body shifting from aerobic to anaerobic metabolism).
2. **Blood Glucose** – May dip slightly due to muscle uptake.
3. **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.

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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 = FEV_1/FVC 0.62; FEV_1 = 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

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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)

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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.
- SpO_2 drop? → Add pacing or O_2.
- CK high? → Lower eccentric load.

□ Clean data starts with clean technique—**sampling, calibration, consent, safety** are just as important as knowledge.