Chapter 6. Integration of Body Systems & Their Functional Significance

1 Learning Objectives

By the end of this chapter you will be able to …

1. **Define homeostasis, allostasis and feedback loops** and explain why no single body system can preserve internal stability unaided.
2. **Describe anatomico-physiological link-points** between at least five systems central to physiotherapy.
3. **Analyse multi-system clinical scenarios** and derive safe, evidence-based intervention plans.
4. **Design integrated assessment batteries** that screen for cross-system contraindications and monitor treatment efficacy.

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2 Concept Foundations

Concept	Concise Definition	Detailed Physiotherapy Context
Homeostasis	Dynamic internal equilibrium maintained within tight limits	Regulating core temperature, pH and blood glucose during a 30-min treadmill session
Allostasis	Changing baseline set-points to accommodate acute or chronic stress	Training-induced resting bradycardia; chronic pain raising sympathetic tone
Feedback loop	Sensor → Integrator → Effector circuitry; *negative* (restores balance) or *positive* (amplifies)	Baroreflex prevents orthostatic hypotension when a stroke survivor transfers supine → sit

Key Point: In rehabilitation we aim to **harness** adaptive feedback (e.g., Wolff's law for bone) while **avoiding maladaptation** (e.g., over-training syndrome).

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3 High-Impact System Pairings

Interacting Systems	Mechanism of Coupling	Functional Significance for PT
Cardiovascular ↔ Respiratory	*Fick Principle* – $VO_2 = CO \times (a\text{-}v)O_2$ diff	Prescribes aerobic intensity; guides post-operative incentive-spirometry dosage
Neuromuscular ↔ Skeletal	Motor-unit activation stresses bone; osteoblasts remodel under load	Progressive resistance combats sarcopenic osteoporosis
Endocrine ↔ Metabolic ↔ MSK	Insulin, cortisol, testosterone govern protein synthesis/glucose uptake	Scheduling exercise around insulin peaks prevents hypoglycaemia; anabolic window optimisation
Renal ↔ CV	RAAS alters plasma volume & BP	Haemodialysis patients: monitor pre-/post-treatment BP before gait training
Immune/Lymphatic ↔ Integumentary	Inflammation & lymph drainage drive tissue repair	Manual lymph drainage hastens wound closure and restores ROM post-burn

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4 Integrated Clinical Vignettes

Case	Systems Interplay	PT Assessment & Interventions
A. Post-MI + Moderate COPD	CV pump reserve limited; ventilatory inefficiency ↑ work of breathing	• Baseline vitals, 6-MWT, SpO_2 • Low-load cycle-ergometry with interval pacing (RPE 11-13) • Diaphragmatic & pursed-lip breathing to off-load accessory muscles

Case	Systems Interplay	PT Assessment & Interventions
B. SCI (T6) + Orthostatic Hypotension	Neurogenic sympathetic loss ↓ vascular tone; CV preload falls	• Tilt-table progression 15° → 70° over sessions • Compression stockings & abdominal binder • Education on AD triggers and beta-blocker effect masking tachycardia
C. Elderly T2DM + Osteoporosis	Endocrine dysglycaemia impairs collagen cross-linking; bone mineral density low	• Pre-exercise capillary glucose check (avoid < 100 mg/dL) • WBV platform + progressive resistance (8-10 RM) three times/week • Foot inspection & footwear advice to protect integument

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5 Systems-Integration Flow (Therapeutic Exercise Example)

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scssCopyEdit↑ Skeletal-muscle contraction
      │
      ├─► Metabolic demand ↑ (ATP, O₂, glucose)
      │         │
      │         ├─► CV output ↑ (HR, SV)
      │         │
      │         └─► Respiratory ventilation ↑ (TV, RR)
      │
      ├─► Catecholamine surge (Endocrine)
      │         │
      │         └─► Glycogenolysis + lipolysis → fuel supply
      │
      ├─► Heat production ↑
      │         │
      │         └─► Integumentary vasodilation + sweating
      │
      └─► Fluid redistribution
                └─► Renal & CV adjust plasma volume via RAAS
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Therapeutic Insight: Exceeding one node's tolerance (e.g., inadequate hydration → renal strain) cascades failure across the network, underscoring the need for graded, periodised loading.

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6 Integrated Assessment Matrix

Parameter	Primary System	Secondary Influence	PT Tool / Frequency
HR, BP, ECG	CV	Neuro (autonomic), Endocrine	Continuous telemetry during high-risk rehab phases
SpO_2, Ventilatory Pattern	Resp	CV, Neuro	Pulse-ox each session; observe paradoxical breathing
Blood Glucose (DM only)	Endocrine	CV, MSK	Pre-/post-exercise finger-stick
Girth / Bio-impedance	Lymphatic	CV, Integ	Weekly in post-mastectomy upper limb
Dermatome/Myotome	Neuro	MSK	Baseline and PRN for radiculopathy symptoms

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7 Self-Check Quiz (with Answers)

1. **Why can beta-blockers mask autonomic dysreflexia symptoms in high-level SCI?**

Answer: Beta-blockers blunt sympathetic cardiac responses (tachycardia, hypertension). Autonomic dysreflexia relies on detecting these signs; suppression delays recognition and management, increasing risk of cerebrovascular events.

2. **During aquatic therapy, how do the renal and cardiovascular systems react to hydrostatic pressure?**
   Answer: Central blood volume increases → atrial stretch → atrial natriuretic peptide release → diuresis & natriuresis (renal) while CV system adapts with ↑ stroke volume and ↓ HR (Bainbridge reflex).
3. **Match the hormone to its physiotherapy effect**
   a) **Parathyroid hormone** — stimulates osteoclasts, so excessive levels weaken bone → need low-impact loading;
   b) **Epinephrine** — raises HR & contractility, enhancing short-term exercise capacity;
   c) **Insulin-like growth factor-1** — promotes muscle protein synthesis, supporting hypertrophy training.
4. **True/False:** Lymph-oedema management is purely a local integumentary intervention.
   Answer: *False.* It also depends on lymphatic vessel function (immune system), muscle pump (MSK), and CV venous return; systemic fluid shifts influence outcomes.
5. **Give two reasons why deconditioning after bed-rest is a multi-system issue.**
   Answer: (i) CV deconditioning ↓ VO_2 max and orthostatic tolerance; (ii) MSK losses in muscle mass & bone density; additionally respiratory, endocrine (insulin resistance) and neural proprioceptive declines occur, all reducing rehab capacity.

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8 Practical / Lab Activities

Activity	Integration Targets	Expected Competence Gain
Tilt-Table + Telemetry	CV-Neuro-Renal	Manage orthostatic hypotension protocol safely
Spiro-Cycle Test	CV-Resp-Endocrine	Interpret gas-exchange data to set HIIT zones
Systems Mapping Workshop	All	Draw 360° diagram linking pathology to PT goals

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9 Key Take-Home Messages

1. **Systems integration underpins every rehabilitation response**—no isolated “muscle” or “lung” training truly exists.
2. **Multi-system assessment** detects red-flags early and individualises dosage.
3. Effective physiotherapists are **load managers & homeostasis guardians**, guiding the body to adapt, not fail.
4. **Communication of cross-system findings** with the healthcare team enhances safety and outcome tracking.