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PAE 502

NUTRITION, GROWTH AND DEVELOPMENT

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Course code: PAE 502

Course title: Nutrition, Growth and Development

Course credit load: 3 Units

Series 1: Normal Growth and Development, Milestones, and Primitive Reflexes

- **Part 1.1: Normal Growth in Children**
  - Sub Part 1.1.1: Definition and principles of normal growth
  - Sub Part 1.1.2: Patterns of growth in weight, length, and head circumference
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Introduction

Picture a mother bringing her nine month old to a routine clinic visit, proudly reporting that her baby can now sit without support and has started babbling, while another parent expresses concern that her child of the same age is not yet doing either. Distinguishing normal variation from a genuine cause for concern depends entirely on a solid understanding of normal growth and development, the foundation on which this entire PAE 502 course, and indeed a great deal of everyday paediatric practice, is built.

The aim of this Series is to equip you with a thorough understanding of normal growth, the major domains and milestones of normal development, and the primitive reflexes present in infancy.

This Series begins with **normal growth**, before turning to **normal development** and its major domains. Next, we examine **developmental milestones**, covering gross motor and fine motor development, then language and social and personal development, before concluding with **primitive reflexes**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 1.1:** define normal growth in children,
- **SLO 1.2:** describe the general principles and patterns of normal growth,
- **SLO 1.3:** define normal development and describe its general principles,
- **SLO 1.4:** describe the major domains of child development,
- **SLO 1.5:** list the milestones of normal gross motor development by age,
- **SLO 1.6:** list the milestones of normal fine motor development by age,
- **SLO 1.7:** list the milestones of normal language development by age,
- **SLO 1.8:** list the milestones of normal social and personal development by age,
- **SLO 1.9:** define primitive reflexes and list the common primitive reflexes present in infancy, and
- **SLO 1.10:** describe the clinical significance and normal timing of appearance and disappearance of primitive reflexes.

1.1 Normal Growth in Children

1.1.1 definition and principles of normal growth

Growth is a continuous, but not constant, process

Growth is defined as a **quantitative increase** in body size and mass, reflected in measurable parameters such as **weight**, **length or height**, and **head circumference**, and represents one of the most fundamental indicators of a child's overall health and nutritional status, since growth is a sensitive process that responds relatively quickly to illness, inadequate nutrition, or psychosocial adversity.

Growth is not a **linear** process but instead proceeds at **variable rates** across different periods of childhood, with particularly rapid growth during **infancy** and again during the **pubertal growth spurt**, and comparatively slower, steadier growth during **mid-childhood**, a pattern reflecting the changing hormonal and physiological drivers of growth at each life stage.

Fill in the blank: Growth is not a linear process but proceeds at variable _____ across different periods of childhood.

1.1.2 patterns of growth in weight, length, and head circumference

A healthy **term newborn** typically weighs between **2.5 and 4.0 kilograms**, and, after an expected initial physiological weight loss of up to **10 percent** in the first few days of life, generally **regains birth weight** by around **10 to 14 days**, before gaining weight at a predictable, though gradually slowing, rate throughout infancy, with birth weight typically **doubling by around 5 months** and **tripling by around 12 months** of age.

Length increases most rapidly during infancy, with growth rate then slowing progressively through childhood before the **pubertal growth spurt**, while **head circumference**, reflecting underlying brain growth, increases most rapidly in the **first year of life**, a period during which the majority of postnatal brain growth occurs, making head circumference measurement a particularly important component of infant growth monitoring.

Fill in the blank: A newborn’s birth weight typically doubles by around _____ months of age.

1.1.3 factors regulating normal growth

Normal growth depends on an interplay of factors, including adequate **nutrition**, normal **hormonal function**, particularly **growth hormone**, **thyroid hormone**, and, later, **sex steroids**

during puberty, and normal **genetic potential**, generally estimated using **parental heights**, together with the **absence of chronic illness** or significant **psychosocial deprivation**, both of which can meaningfully impair growth even when nutrition and hormonal function are otherwise adequate.

Recognising the **relative contribution** of each of these factors is important clinically, since a child growing poorly requires a systematic evaluation considering nutritional, hormonal, genetic, and psychosocial contributors together, rather than assuming a single cause in isolation, an approach that will be developed further in later Series of this course when specific growth disorders are addressed in detail.

Fill in the blank: Genetic growth potential is generally estimated using _____ heights.

Table 1.1: Typical growth velocity across childhood.

Age period	Typical growth pattern
Infancy (0 to 12 months)	Most rapid postnatal growth; weight roughly triples by 12 months
Early to mid-childhood	Slower, steady growth rate
Puberty	Second major growth spurt, variable timing by sex

Pilot questions 1.1

1. Define growth and list the three main anthropometric parameters used to assess it. (Linked to SLO 1.1)
2. Describe the typical pattern of weight gain in the first year of life. (Linked to SLO 1.2)
3. Explain why head circumference measurement is particularly important in infancy. (Linked to SLO 1.2)
4. List three factors that regulate normal growth. (Linked to SLO 1.3)
5. Explain why parental heights are used to estimate a child's genetic growth potential. (Linked to SLO 1.3)

1.2 Normal Development in Children

1.2.1 definition and general principles of development

Development follows a predictable, if individually variable, sequence

Development refers to the progressive acquisition of **skills** and **functional abilities**, encompassing physical, cognitive, emotional, and social capacities, and, unlike growth, is a

qualitative process reflecting increasing complexity of function rather than simply increasing size, though the two processes are closely interrelated and both depend on adequate nutrition and a supportive environment.

Development generally follows a **predictable sequence**, proceeding in a **cephalocaudal** direction, from head to tail, meaning control of the head and neck is achieved before control of the trunk and limbs, and a **proximodistal** direction, from the centre of the body outward, meaning control of the shoulders is achieved before fine control of the fingers, though the **rate** at which individual children pass through this sequence varies within a normal range.

Fill in the blank: Development proceeds in a cephalocaudal direction, meaning head and neck control is achieved before _____ and limb control.

1.2.2 domains of development

Child development is conventionally divided into four major **domains**: **gross motor development**, involving control of large muscle groups for activities such as sitting, crawling, and walking, **fine motor development**, involving control of small muscle groups, particularly of the hands, for activities such as grasping and drawing, **language development**, encompassing both **receptive** understanding and **expressive** communication, and **social and personal development**, encompassing interaction with others and self-care skills.

While these domains are described separately for clarity and assessment purposes, they are, in reality, closely **interconnected**, since progress in one domain often supports or depends on progress in another, meaning a comprehensive developmental assessment should always consider **all four domains together** rather than focusing on a single domain in isolation.

Fill in the blank: The four major domains of development are gross motor, fine motor, language, and social and _____.

1.2.3 factors influencing development

Normal development depends on adequate **central nervous system integrity**, meaning the absence of significant structural brain abnormality or injury, together with adequate **sensory input**, particularly **vision** and **hearing**, since impairment in either can significantly affect the acquisition of related skills, and a **stimulating, responsive environment**, including consistent caregiver interaction, which provides the opportunities and encouragement necessary for skill practice and acquisition.

Nutrition also plays an essential role in normal development, particularly during the first years of life when brain growth and synaptic development are most active, meaning significant early

malnutrition can have lasting effects on developmental outcome even if growth itself subsequently recovers, a relationship that will be explored further when this course addresses nutrition and malnutrition specifically.

Fill in the blank: Adequate sensory input, particularly vision and _____, supports normal development.

Figure 1.2: A clinician performing a structured developmental assessment of a young child.

Pilot questions 1.2

1. Define development and distinguish it from growth. (Linked to SLO 1.3)
2. Describe the cephalocaudal and proximodistal principles of development. (Linked to SLO 1.3)
3. List the four major domains of development. (Linked to SLO 1.4)
4. Explain why the domains of development should be assessed together rather than in isolation. (Linked to SLO 1.4)
5. List three factors that influence normal development. (Linked to SLO 1.4)

1.3 Developmental Milestones: Gross Motor and Fine Motor

1.3.1 gross motor milestones in infancy

A predictable sequence from head control to independent walking

Gross motor development in infancy follows a well recognised sequence: **head control** in the prone position is generally achieved by **6 to 8 weeks**, **rolling** from front to back and back to front by around **4 to 6 months**, **sitting without support** by around **6 to 8 months**, **crawling** by around **8 to 10 months**, and **standing with support**, or **cruising**, by around **9 to 12 months**.

Independent walking is generally achieved by around **12 to 15 months**, with a genuinely wide normal range extending up to 18 months in some otherwise entirely normally developing children, meaning a single milestone falling somewhat later than the population average is not necessarily abnormal, though persistent, marked delay, or delay across multiple domains simultaneously, warrants further evaluation.

Fill in the blank: Independent sitting without support is generally achieved by around 6 to _____ months of age.

1.3.2 gross motor milestones beyond infancy

Beyond the achievement of independent walking, gross motor skills continue to develop through the toddler and preschool years, with children generally able to **run** by around **18 months**, **kick a ball** by around **2 years**, **climb stairs with alternating feet** by around **3 years**, and **hop on one foot** and **pedal a tricycle** by around **3 to 4 years**, reflecting the ongoing refinement of balance, coordination, and strength beyond the basic milestones of infancy.

By around **5 years**, most children can **skip**, **catch a ball reliably**, and demonstrate generally well coordinated, confident movement appropriate for organised physical play and early school-based physical activities, representing the culmination of this early period of gross motor skill acquisition before further refinement continues through middle childhood.

Fill in the blank: Most children can climb stairs with alternating feet by around _____ years of age.

1.3.3 fine motor milestones

Fine motor development progresses from early, relatively crude hand movements towards increasingly precise control: a **palmar grasp**, using the whole hand, develops by around **4 to 6 months**, transitioning to a more refined **pincer grasp**, using thumb and forefinger, by around **9 to 12 months**, allowing the infant to pick up small objects with increasing precision.

Beyond infancy, fine motor skills continue to develop, with children generally able to **build a tower of 2 to 3 blocks** by around **18 months**, progressing to **6 or more blocks** by around **2.5 to 3 years**, **draw a circle** by around **3 years**, and **draw a simple person** with several recognisable body parts by around **4 to 5 years**, milestones frequently used as a practical, accessible component of routine developmental assessment.

Fill in the blank: A refined pincer grasp using thumb and forefinger develops by around 9 to _____ months.

Figure 1.3: A toddler achieving the gross motor milestone of independent walking.

Pilot questions 1.3

1. List the typical age of achievement for head control, sitting, and walking. (Linked to SLO 1.5)
2. Describe the normal range for achieving independent walking. (Linked to SLO 1.5)
3. List three gross motor milestones achieved beyond infancy. (Linked to SLO 1.5)
4. Distinguish a palmar grasp from a pincer grasp and state the typical age of each. (Linked to SLO 1.6)
5. List two fine motor milestones achieved in the toddler and preschool years. (Linked to SLO 1.6)

1.4 Developmental Milestones: Language and Social/Personal Development

1.4.1 receptive and expressive language milestones

Understanding generally outpaces expression

Receptive language, the ability to understand spoken language, generally develops ahead of **expressive language**, the ability to produce speech, with infants beginning to **respond to their name** and simple, familiar words by around **6 to 9 months**, well before they are able to produce recognisable words themselves, reflecting the general principle that comprehension consistently precedes production throughout early language development.

Expressive language progresses from early **babbling**, by around **6 months**, to the first recognisable **single words** by around **12 months**, **combining two words** into simple phrases by around **18 to 24 months**, and constructing **short sentences** by around **3 years**, with vocabulary expanding rapidly, often called a **vocabulary explosion**, over the second year of life in typically developing children.

Fill in the blank: Receptive language generally develops _____ of expressive language throughout early childhood.

1.4.2 social and personal development milestones

Early social development includes the **social smile**, appearing by around **6 to 8 weeks**, representing the infant's first clearly social, reciprocal facial expression, and **stranger anxiety**, typically emerging around **6 to 9 months**, reflecting the infant's developing ability to distinguish familiar from unfamiliar people, a normal and expected developmental milestone rather than a cause for concern.

By around **12 months**, most infants engage in simple **social games**, such as waving bye-bye or playing peek-a-boo, progressing to **parallel play**, playing alongside but not directly interacting with other children, by around **2 to 3 years**, and, later, more genuinely **cooperative play**, involving shared activities and turn-taking, by around **4 years**, reflecting the gradual development of social reciprocity through early childhood.

Fill in the blank: Parallel play, in which children play alongside but not directly with each other, is typical by around 2 to _____ years.

1.4.3 self-care and personal skill milestones

Development of **self-care skills** follows a broadly predictable sequence, with children generally able to **feed themselves** with fingers by around **9 to 12 months**, use a **spoon** with increasing competence by around **15 to 18 months**, participate actively in **dressing**, such as removing simple items of clothing, by around **2 years**, and demonstrate **daytime toilet training readiness** typically between **2 and 3 years**, with considerable individual variation.

By around **4 to 5 years**, most children can **dress and undress independently**, aside from more complex fastenings such as buttons or shoelaces, and demonstrate generally **age-appropriate independence** in basic self-care, milestones that, together with those discussed across this Part of the Series, provide a comprehensive framework for structured developmental assessment.

Fill in the blank: Daytime toilet training readiness is typically achieved between 2 and _____ years of age.

Figure 1.4: An infant engaging in a reciprocal social smile with a caregiver.

Pilot questions 1.4

11. Explain why receptive language generally develops ahead of expressive language. (Linked to SLO 1.7)
12. List the typical age of first words and two-word phrases. (Linked to SLO 1.7)
13. Describe the social smile and stranger anxiety milestones and their typical timing. (Linked to SLO 1.8)
14. Distinguish parallel play from cooperative play. (Linked to SLO 1.8)
15. List two self-care milestones and their typical age of achievement. (Linked to SLO 1.8)

1.5 Primitive Reflexes

1.5.1 definition and significance of primitive reflexes

Reflexes reflect the maturity of the nervous system

Primitive reflexes are **involuntary, stereotyped motor responses** present in the healthy newborn and young infant, mediated by **subcortical** and **spinal** neural pathways rather than the higher cortical control that governs voluntary movement, and reflect the **immaturity** of the newborn nervous system at this stage of development.

As the **central nervous system matures** and higher cortical centres increasingly assume control over motor function, primitive reflexes are normally **suppressed** and disappear at predictable ages, and both the **presence** of an expected reflex at the appropriate age and its **appropriately timed disappearance** provide valuable information about the integrity and maturation of the infant's nervous system.

Fill in the blank: Primitive reflexes are mediated by subcortical and _____ neural pathways rather than higher cortical control.

1.5.2 common primitive reflexes and their timing

The **Moro reflex**, elicited by a sudden change in head position or a loud noise, produces symmetric **abduction and extension** of the arms followed by **flexion**, and a startled facial expression, and is typically present from birth, disappearing by around **4 to 6 months**. The **rooting reflex**, in which stroking the cheek causes the infant to turn towards the stimulus and open the mouth, supports early feeding and is present from birth, disappearing by around **4 months**.

The **palmar grasp reflex**, in which pressure on the palm causes the fingers to curl and grip, is present from birth and disappears by around **5 to 6 months**, while the **stepping reflex**, in which holding an infant upright with feet touching a surface elicits alternating stepping movements, is present from birth and disappears by around **2 months**, both reflecting spinal-level motor patterns present before voluntary, cortically controlled movement takes over.

Fill in the blank: The Moro reflex is typically present from birth and disappears by around 4 to _____ months.

1.5.3 clinical significance of abnormal primitive reflexes

An **absent** primitive reflex when it is expected to be present, an **asymmetric** reflex response, or a reflex that **persists beyond its normal age of disappearance**, can each indicate an underlying **neurological abnormality**, such as a **brachial plexus injury** producing an asymmetric Moro reflex, or **cerebral palsy**, in which several primitive reflexes may persist well beyond their expected age of disappearance.

For this reason, structured assessment of primitive reflexes forms a routine, valuable component of the **newborn** and **infant neurological examination**, and any child with an abnormal pattern of primitive reflexes, whether absent, asymmetric, or persistently retained, warrants careful further neurological assessment to identify or exclude an underlying cause, rather than being dismissed as a simple normal variant.

Fill in the blank: A persistently retained primitive reflex well beyond its expected age of disappearance can suggest cerebral _____.

Figure 1.5: Elicitation of the Moro reflex in a newborn infant.

Pilot questions 1.5

6. Define primitive reflexes and explain their neurological basis. (Linked to SLO 1.9)
7. Describe the Moro reflex and its typical age of disappearance. (Linked to SLO 1.10)
8. Describe the rooting reflex and its functional purpose. (Linked to SLO 1.10)

9. Describe the palmar grasp and stepping reflexes. (Linked to SLO 1.10)
10. Explain the clinical significance of an asymmetric or persistently retained primitive reflex. (Linked to SLO 1.10)

Series Summary

This Series introduced **normal growth**, its principles and typical patterns across childhood, before turning to **normal development** and its four major domains.

We then examined **developmental milestones** in detail, covering gross motor, fine motor, language, and social and personal development, before concluding with **primitive reflexes** and their clinical significance. Having worked through this Series, you should now have a thorough foundation in normal growth and development. The next Series turns to **behavioural disorders of childhood**.

Glossary of Terms

- **Growth:** a quantitative increase in body size and mass, reflected in weight, length or height, and head circumference.
- **Development:** the progressive, qualitative acquisition of skills and functional abilities across multiple domains.
- **Cephalocaudal development:** the principle that development proceeds from head to tail.
- **Proximodistal development:** the principle that development proceeds from the centre of the body outward.
- **Gross motor development:** the domain of development involving control of large muscle groups.
- **Fine motor development:** the domain of development involving control of small muscle groups, particularly of the hands.
- **Pincer grasp:** a refined grasp using the thumb and forefinger, typically developing by 9 to 12 months.
- **Social smile:** the infant's first clearly social, reciprocal facial expression, appearing by 6 to 8 weeks.
- **Stranger anxiety:** a normal developmental milestone typically emerging around 6 to 9 months.

- **Primitive reflex:** an involuntary, stereotyped motor response present in the healthy newborn, mediated by subcortical pathways.
- **Moro reflex:** a primitive reflex producing symmetric arm abduction and extension in response to a sudden stimulus.
- **Palmar grasp reflex:** a primitive reflex in which pressure on the palm causes the fingers to curl and grip.

Concept Check Questions [Series 1]

Objective questions

- Growth is not a linear process but proceeds at variable _____ across different periods of childhood.
- A newborn's birth weight typically doubles by around _____ months of age.
- Independent sitting without support is generally achieved by around 6 to _____ months of age.
- A refined pincer grasp using thumb and forefinger develops by around 9 to _____ months.
- The Moro reflex is typically present from birth and disappears by around 4 to _____ months.

Short-answer questions

1. List three factors that regulate normal growth.
2. List the four major domains of development.
3. Describe the normal range for achieving independent walking.
4. Distinguish parallel play from cooperative play.
5. Describe the rooting reflex and its functional purpose.

Long-answer questions

- Discuss the general principles and patterns of normal growth in children. (Linked to SLO 1.1, SLO 1.2)
- Discuss the definition, principles, and domains of normal development. (Linked to SLO 1.3, SLO 1.4)
- Discuss the gross motor and fine motor milestones of early childhood. (Linked to SLO 1.5, SLO 1.6)

- Discuss the language and social/personal developmental milestones of early childhood. (Linked to SLO 1.7, SLO 1.8)
- Discuss primitive reflexes and their clinical significance. (Linked to SLO 1.9, SLO 1.10)

Answers to Concept Check Questions [Series 1]

Objective questions

- Rates.
- 5.
- 8.
- 12.
- 6.

Short-answer questions

- Nutrition, hormonal function, and genetic potential are factors regulating normal growth.
- Gross motor, fine motor, language, and social and personal development are the four domains.
- Independent walking is generally achieved by 12 to 15 months, with a normal range extending to 18 months.
- Parallel play is playing alongside but not directly with other children, while cooperative play involves shared activities and turn-taking.
- The rooting reflex causes the infant to turn towards a cheek stimulus and open the mouth, supporting early feeding.

Long-answer questions

- **Basic response:** Growth is a quantitative increase in size and mass, proceeding at variable rates across infancy, childhood, and puberty, regulated by nutrition, hormones, and genetic potential.

Value-added response: Head circumference growth is most rapid in the first year, reflecting active brain growth, making it a particularly important component of infant growth monitoring.

- **Basic response:** Development is the qualitative acquisition of skills across gross motor, fine motor, language, and social and personal domains, following cephalocaudal and proximodistal principles.

Value-added response: The four domains are interconnected and should be assessed together, since progress in one domain often supports progress in another.

- **Basic response:** Gross motor milestones progress from head control through sitting, crawling, and walking, while fine motor milestones progress from palmar grasp to pincer grasp and beyond.

Value-added response: A wide normal range exists for individual milestones, meaning a single delayed milestone is not necessarily abnormal, though delay across multiple domains warrants evaluation.

- **Basic response:** Language milestones progress from babbling to single words, two-word phrases, and short sentences, while social milestones progress from the social smile to parallel and cooperative play.

Value-added response: Receptive language consistently develops ahead of expressive language, and self-care skills develop alongside these domains through early childhood.

- **Basic response:** Primitive reflexes are involuntary, subcortically mediated responses present at birth, including the Moro, rooting, palmar grasp, and stepping reflexes, each disappearing at a predictable age.

Value-added response: An absent, asymmetric, or persistently retained primitive reflex can indicate an underlying neurological abnormality and warrants further assessment.

Answers to Pilot Questions [Series 1]

Part 1.1

1. Growth is a quantitative increase in body size; weight, length or height, and head circumference are the main parameters.
2. Weight gain is rapid in the first year, with birth weight roughly tripling by 12 months.
3. Head circumference reflects brain growth, which is most active in the first year of life.
4. Nutrition, hormonal function, and genetic potential are factors regulating growth.
5. Parental heights help estimate a child's genetically expected growth potential.

Part 1.2

1. Development is the qualitative acquisition of skills, distinct from growth, which is a quantitative increase in size.
2. Cephalocaudal development proceeds head to tail; proximodistal development proceeds centre outward.
3. Gross motor, fine motor, language, and social and personal development are the four domains.
4. The domains are interconnected, so progress in one often supports progress in another.
5. Central nervous system integrity, sensory input, and a stimulating environment influence development.

Part 1.3

1. Head control by 6 to 8 weeks, sitting by 6 to 8 months, and walking by 12 to 15 months.
2. Walking is normally achieved by 12 to 15 months, with a normal range extending to 18 months.
3. Running, kicking a ball, and climbing stairs with alternating feet are milestones beyond infancy.
4. Palmar grasp uses the whole hand by 4 to 6 months; pincer grasp uses thumb and forefinger by 9 to 12 months.
5. Building a tower of blocks and drawing a circle are fine motor milestones of the toddler and preschool years.

Part 1.4

1. Comprehension of language develops before the ability to produce speech.
2. First words appear around 12 months, and two-word phrases around 18 to 24 months.
3. The social smile appears by 6 to 8 weeks; stranger anxiety emerges around 6 to 9 months.

4. Parallel play is playing alongside others; cooperative play involves shared activity and turn-taking.
5. Self-feeding with fingers by 9 to 12 months and using a spoon by 15 to 18 months are self-care milestones.

Part 1.5

1. Primitive reflexes are involuntary, stereotyped responses mediated by subcortical and spinal pathways.
2. The Moro reflex produces symmetric arm abduction and extension, disappearing by 4 to 6 months.
3. The rooting reflex causes turning towards a cheek stimulus, supporting early feeding.
4. The palmar grasp reflex causes gripping on palm pressure; the stepping reflex produces alternating leg movements.
5. It can indicate an underlying neurological abnormality, such as brachial plexus injury or cerebral palsy.

References and Attributions [Series 1]

- Kliegman, R. M., St Geme, J. W., Blum, N. J., Shah, S. S., Tasker, R. C. and Wilson, K. M. (2020). Nelson Textbook of Pediatrics (21st ed.). Elsevier.
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- Futagi, Y., Toribe, Y. and Suzuki, Y. (2012). The grasp reflex and Moro reflex in infants: hierarchy of primitive reflex responses. International Journal of Pediatrics, 2012, 191562.

Figures, Plates, Tables, and Boxes

1. Table 1.1: Typical growth velocity across childhood. AI-generated using the prompt: "Create a clean reference table titled Growth Velocity Across Childhood, listing age period and typical growth pattern. Simple clinical reference table style with outside border."

2. Figure 1.2: A clinician performing a structured developmental assessment of a young child. AI-generated using the prompt: "A warm, realistic clinical illustration of a clinician sitting on the floor with a young child, engaging the child with simple toys during a developmental assessment, with a parent seated nearby. Single clean medical illustration, soft natural lighting, no text overlays, no multiple panels, respectful and accurate depiction."
3. Figure 1.3: A toddler achieving the gross motor milestone of independent walking. AI-generated using the prompt: "A warm, realistic illustration of a toddler taking a few independent steps across a room towards a caregiver who is kneeling with arms open, encouraging the child. Single clean illustration, soft warm lighting, no text overlays, no multiple panels, joyful and accurate depiction."
4. Figure 1.4: An infant engaging in a reciprocal social smile with a caregiver. AI-generated using the prompt: "A warm, realistic illustration of a young infant smiling up at a caregiver who is gently holding and smiling back at the baby, in soft natural light. Single clean illustration, no text overlays, no multiple panels, tender and accurate depiction."
5. Figure 1.5: Elicitation of the Moro reflex in a newborn infant. AI-generated using the prompt: "A realistic clinical illustration of a clinician gently supporting a newborn infant while eliciting the Moro reflex, showing the infant's arms symmetrically extended outward. Single clean medical illustration, soft clinical lighting, no text overlays, no multiple panels, respectful and accurate depiction."

Course code: PAE 502

Course title: Nutrition, Growth and Development

Course credit load: 3 Units

Series 2: Behavioural Disorders of Childhood

- **Part 2.1: Food Fussiness and Elimination Disorders**
  - Sub Part 2.1.1: Food fussiness in children
  - Sub Part 2.1.2: Enuresis: definition, classification, and management
  - Sub Part 2.1.3: Encopresis: definition and management
- **Part 2.2: Temper Tantrums and Head Banging**
  - Sub Part 2.2.1: Temper tantrums: definition and clinical features
  - Sub Part 2.2.2: Management of temper tantrums
  - Sub Part 2.2.3: Head banging: clinical features and management
- **Part 2.3: Breath Holding Attacks**
  - Sub Part 2.3.1: Definition and types of breath holding attacks
  - Sub Part 2.3.2: Clinical features and differential diagnosis
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- **Part 2.4: Language Delay, Disorders, and Communication Disorders**
  - Sub Part 2.4.1: Definition of language delay and language disorders
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  - Sub Part 2.4.3: Evaluation and management of language and communication disorders
- **Part 2.5: Dyslexia and Stuttering**
  - Sub Part 2.5.1: Dyslexia: clinical features
  - Sub Part 2.5.2: Management of dyslexia
  - Sub Part 2.5.3: Stuttering: clinical features and management

Introduction

In the last Series, we explored normal growth and development. We now turn to a range of common behavioural disorders encountered in everyday paediatric practice, most of which represent variations of normal development rather than serious underlying pathology, but which nonetheless cause genuine concern and distress for families. Picture a mother worried that her toddler screams and throws himself to the floor whenever he doesn't get his way, alongside a different parent concerned that her six year old still wets the bed most nights. Understanding these common behavioural disorders, and how to appropriately reassure and guide families, is the focus of this Series.

The aim of this Series is to equip you with the knowledge required to recognise and manage the common behavioural disorders of childhood, including elimination disorders, temper tantrums, head banging, breath holding attacks, and language and learning disorders.

This Series begins with **food fussiness and elimination disorders**, before turning to **temper tantrums and head banging**. Next, we examine **breath holding attacks**, then **language delay, disorders, and communication disorders**, before concluding with **dyslexia and stuttering**.

Series Learning Outcomes

At the end of this Series, you should be able to:

- **SLO 1.1:** describe food fussiness in children and its general management,
- **SLO 1.2:** define enuresis and encopresis and describe their clinical features and management,
- **SLO 1.3:** describe temper tantrums and their general management,
- **SLO 1.4:** describe head banging and its clinical significance and management,
- **SLO 1.5:** describe the types and clinical features of breath holding attacks,
- **SLO 1.6:** describe the management and prognosis of breath holding attacks,
- **SLO 1.7:** define language delay and language disorders, and describe communication disorders,
- **SLO 1.8:** describe the evaluation and management of language and communication disorders,
- **SLO 1.9:** describe the clinical features and management of dyslexia, and
- **SLO 1.10:** describe the clinical features and management of stuttering.

2.1 Food Fussiness and Elimination Disorders

2.1.1 food fussiness in children

A common, usually self-limiting toddler behaviour

Food fussiness, or **picky eating**, is extremely common in **toddlers** and preschool children, typically presenting as a **limited range of accepted foods**, reluctance to try **new foods**, a phenomenon termed **food neophobia**, and strong preferences for specific food textures, brands, or presentations, generally representing a normal, if sometimes frustrating, phase of development rather than a serious eating disorder.

Management centres on **reassurance** of the family regarding the generally benign, self-limiting nature of food fussiness, together with practical strategies such as **repeated, pressure-free exposure** to new foods, since research consistently shows that a child may need to be offered a new food many times before accepting it, avoiding **mealtime conflict**, and continuing to offer a varied diet without excessive concern, reserving further evaluation for children with associated **poor growth** or genuinely restricted intake.

Fill in the blank: Reluctance to try new foods in a young child is termed food _____.

2.1.2 enuresis: definition, classification, and management

Enuresis refers to involuntary **urination** beyond the age at which bladder control is normally expected, generally considered clinically relevant from around **5 years** of age, and is classified as **nocturnal**, occurring during sleep, or **diurnal**, occurring during waking hours, and further as **primary**, in a child who has never achieved a sustained period of dryness, or **secondary**, in a child who develops enuresis after a previous period of established dryness.

Management of enuresis depends on the specific pattern and the child's age, and generally begins with **reassurance** and simple behavioural measures, such as **fluid restriction before bedtime** and **scheduled voiding**, with **enuresis alarms** and, in some cases, **desmopressin** medication considered for persistent nocturnal enuresis in older children, while **secondary enuresis** in particular should prompt consideration of an underlying medical or psychosocial trigger requiring specific evaluation.

Fill in the blank: Enuresis is generally considered clinically relevant from around _____ years of age.

2.1.3 encopresis: definition and management

Encopresis refers to involuntary or, less commonly, voluntary passage of **stool** in inappropriate locations beyond the age at which bowel control is normally expected, and is most commonly associated with underlying **chronic constipation**, in which impacted stool leads to **overflow soiling**, meaning careful assessment for constipation is an essential first step in any child presenting with encopresis.

Management of encopresis therefore centres on treatment of any underlying **constipation**, using **laxative therapy** together with **behavioural strategies**, such as scheduled toilet sitting after meals, and **positive reinforcement**, and, since encopresis can be a source of significant **embarrassment** and **psychosocial impact** for the affected child, a sensitive, non-punitive approach that avoids blame is essential to successful management and to protecting the child's emotional wellbeing throughout treatment.

Fill in the blank: Encopresis is most commonly associated with underlying chronic _____.

Figure 2.1: A toddler displaying typical food fussiness at mealtime.

Pilot questions 2.1

1. Describe food fussiness and its typical presentation in toddlers. (Linked to SLO 2.1)

2. Describe the general management approach to food fussiness. (Linked to SLO 2.1)
3. Define enuresis and distinguish primary from secondary enuresis. (Linked to SLO 2.2)
4. Describe the general management of nocturnal enuresis. (Linked to SLO 2.2)
5. Define encopresis and describe its most common underlying cause. (Linked to SLO 2.2)

2.2 Temper Tantrums and Head Banging

2.2.1 temper tantrums: definition and clinical features

A normal, if trying, feature of toddlerhood

Temper tantrums are common, developmentally normal episodes of **emotional outburst** in young children, typically presenting with **crying**, **screaming**, **kicking**, or **throwing oneself to the floor**, usually triggered by **frustration**, being denied a request, or difficulty communicating needs effectively, and are most common between **1 and 4 years** of age, a period during which children have significant emotional drives but still limited verbal and self-regulatory capacity.

While generally a normal part of development, **frequency**, **intensity**, and **duration** of tantrums that are markedly excessive for the child's age, or tantrums that persist well beyond the typical age range, may occasionally indicate an underlying **developmental**, **behavioural**, or **communication difficulty** warranting further assessment, meaning the overall pattern and context, rather than the presence of tantrums itself, is what determines clinical significance.

Fill in the blank: Temper tantrums are most common between 1 and _____ years of age.

2.2.2 management of temper tantrums

Management of typical temper tantrums centres on **parental guidance** and reassurance regarding the normal, developmentally expected nature of this behaviour, together with practical strategies such as maintaining **calm, consistent responses**, avoiding **rewarding** tantrum behaviour by giving in to the triggering demand, and using **positive reinforcement** for appropriate behaviour, since consistent, predictable parental responses generally help reduce tantrum frequency and intensity over time.

Prevention strategies are also valuable, including ensuring the child has adequate **rest** and **regular meals**, since fatigue and hunger both lower the threshold for emotional outbursts, providing **age-appropriate choices** to reduce feelings of powerlessness, and giving **advance warning** of transitions between activities, all of which can meaningfully reduce the frequency of tantrums when applied consistently by caregivers.

Fill in the blank: Avoiding giving in to the triggering demand helps prevent inadvertently _____ tantrum behaviour.

2.2.3 head banging: clinical features and management

Head banging, a rhythmic, repetitive striking of the head against a surface, is a relatively common behaviour in young children, generally appearing between **6 months and 3 years** of age, and, in most cases, represents a **self-soothing** or self-stimulating behaviour, often occurring at times of tiredness, frustration, or before falling asleep, without any underlying pathological cause in an otherwise normally developing child.

Management of typical, benign head banging is generally **reassurance-focused**, together with simple practical safety measures such as **padding** the crib or bed to prevent injury, and the behaviour typically **resolves spontaneously** by around 3 to 4 years of age, though head banging occurring alongside other concerning features, such as significant developmental delay, self-injurious behaviour of increasing severity, or occurring in an older child, warrants further evaluation for an underlying neurodevelopmental condition.

Fill in the blank: Head banging generally appears between 6 months and _____ years of age.

Table 2.2: Comparing temper tantrums, head banging, and breath holding attacks.

Behaviour	Typical age	General management
Temper tantrums	1 to 4 years	Calm, consistent response; avoid rewarding the behaviour
Head banging	6 months to 3 years	Reassurance and safety measures such as padding
Breath holding attacks	6 months to 6 years	Reassurance; identify and manage underlying trigger

Pilot questions 2.2

1. Describe the typical clinical presentation and age range of temper tantrums. (Linked to SLO 2.3)
2. List two features that might suggest a tantrum warrants further assessment. (Linked to SLO 2.3)
3. Describe the general management strategies for temper tantrums. (Linked to SLO 2.3)
4. Describe head banging and its typical age range. (Linked to SLO 2.4)
5. Describe the general management of benign head banging. (Linked to SLO 2.4)

2.3 Breath Holding Attacks

2.3.1 definition and types of breath holding attacks

Alarming to witness, but generally entirely benign

Breath holding attacks are involuntary episodes, typically triggered by **crying** following pain, frustration, or fright, in which a young child, usually between **6 months and 6 years** of age, involuntarily **stops breathing**, sometimes progressing to brief **loss of consciousness**, and are classified into two main types according to the associated colour change: **cyanotic** and **pallid**.

Cyanotic breath holding attacks, the more common type, typically begin with **vigorous crying**, followed by breath holding in **expiration**, and **cyanosis**, or bluish discolouration, while **pallid breath holding attacks**, less common, are usually triggered by a sudden **minor injury** or fright, with **minimal or no crying**, followed by rapid **pallor**, believed to result from a **vagally mediated** reflex causing transient bradycardia, and both types may, in a minority of cases, progress briefly to loss of consciousness or, rarely, a brief convulsive movement.

Fill in the blank: Cyanotic breath holding attacks typically begin with vigorous _____, followed by breath holding in expiration.

2.3.2 clinical features and differential diagnosis

The **sequence** of a breath holding attack, a clear identifiable trigger followed by crying or absence of crying, then breath holding, colour change, and, in some cases, brief loss of consciousness with rapid, complete recovery, generally allows a confident clinical diagnosis to be made on history alone, and the **stereotyped, reproducible pattern**, together with the invariable, clear precipitating trigger, is an important distinguishing feature from other causes of paroxysmal episodes in young children.

The main **differential diagnosis** to actively consider is **epileptic seizure**, though the clear precipitating trigger, the characteristic sequence of events, and the typically brief, complete, and rapid recovery in breath holding attacks generally help distinguish it from a seizure, and **iron deficiency anaemia** should also be considered, since it has an established association with increased frequency of breath holding attacks in some affected children.

Fill in the blank: The main differential diagnosis to actively consider for breath holding attacks is epileptic _____.

2.3.3 management and prognosis of breath holding attacks

Management of breath holding attacks is largely **reassurance-focused**, since the episodes themselves, while alarming to witness, are generally **entirely benign** and do not cause lasting harm, with parents advised to remain **calm**, ensure the child is in a **safe position** during an episode, such as lying on their side, and avoid excessive attention or reward-seeking responses to the behaviour that might inadvertently reinforce its recurrence.

Where **iron deficiency** is identified on investigation, **iron supplementation** has been shown to reduce the frequency of breath holding attacks in some children, and the overall **prognosis** is excellent, with the great majority of children **outgrowing** the behaviour entirely by around **6 to 8 years** of age, without any lasting developmental or neurological consequence, information that is generally highly reassuring for anxious families.

Fill in the blank: Iron supplementation has been shown to reduce the frequency of breath holding attacks associated with iron _____.

Figure 2.3: A parent comforting a child recovering after a breath holding episode.

Pilot questions 2.3

1. Describe the two types of breath holding attacks and their typical sequence. (Linked to SLO 2.5)
2. Distinguish cyanotic from pallid breath holding attacks. (Linked to SLO 2.5)
3. Describe how breath holding attacks are distinguished from epileptic seizures. (Linked to SLO 2.5)
4. Describe the general management of breath holding attacks. (Linked to SLO 2.6)
5. Describe the prognosis of breath holding attacks. (Linked to SLO 2.6)

2.4 Language Delay, Disorders, and Communication Disorders

2.4.1 definition of language delay and language disorders

Delay versus disorder shapes the expected trajectory

Language delay refers to language development that follows the normal, expected sequence but at a **slower rate** than typical for the child's age, generally expected to **catch up** over time, particularly with appropriate support, while a **language disorder** refers to a more persistent, qualitatively **atypical** pattern of language development that is not simply explained by delay alone and is less likely to fully resolve without targeted intervention.

Distinguishing delay from disorder is not always straightforward, particularly in a young child, and often requires **ongoing assessment over time** by an appropriately trained professional, together with consideration of relevant **risk factors**, such as a family history of language difficulty, hearing impairment, or broader developmental concerns, which increase the likelihood of a genuine disorder rather than simple delay.

Fill in the blank: A language disorder refers to a persistent, qualitatively _____ pattern of language development.

2.4.2 communication disorders

Communication disorders encompass a broader category than language disorders alone, including **speech sound disorders**, affecting the clarity and accuracy of speech production, **fluency disorders**, such as stuttering, discussed in detail in the final Part of this Series, and

social communication disorders, affecting the appropriate, contextual use of language in social interaction, each requiring somewhat different assessment and management approaches.

Hearing impairment is an important and potentially **reversible or manageable** contributing factor to communication difficulty that should always be actively excluded early in the evaluation of any child with delayed or disordered language, since undetected hearing loss can otherwise be mistakenly attributed entirely to a primary language or developmental disorder, delaying appropriate, targeted intervention.

Fill in the blank: Hearing impairment should always be actively excluded early in the evaluation of a child with delayed or disordered _____.

2.4.3 evaluation and management of language and communication disorders

Evaluation of a child with suspected language delay or disorder should include a detailed **developmental history**, assessment across **all developmental domains** given the frequent overlap between language and other areas of development, formal **hearing assessment**, and, where indicated, referral to a **speech and language therapist** for detailed, structured assessment of both receptive and expressive language skills.

Management is generally **multidisciplinary**, centred on **speech and language therapy**, together with treatment of any identified underlying or contributing cause, such as hearing impairment, and **parent-focused strategies** to encourage language development at home, such as reading together and responsive, language-rich interaction, with **early intervention** consistently associated with better long-term outcomes across the range of language and communication disorders.

Fill in the blank: Management of language and communication disorders is generally _____, centred on speech and language therapy.

Figure 2.4: A speech and language therapist working with a young child.

Pilot questions 2.4

1. Distinguish language delay from language disorder. (Linked to SLO 2.7)
2. List the three categories of communication disorder. (Linked to SLO 2.7)
3. Explain why hearing impairment must be actively excluded in a child with language delay. (Linked to SLO 2.7)
4. Describe the evaluation of a child with suspected language or communication disorder. (Linked to SLO 2.8)
5. Describe the general management approach to language and communication disorders. (Linked to SLO 2.8)

2.5 Dyslexia and Stuttering

2.5.1 dyslexia: clinical features

A specific difficulty with reading, not a reflection of overall intelligence

Dyslexia is a specific **learning disorder** primarily affecting the accurate and fluent recognition of **written words**, and, by extension, **reading comprehension** and **spelling**, occurring in

children with otherwise **normal intelligence** and adequate educational opportunity, meaning dyslexia should never be assumed to reflect a child's general cognitive ability or overall potential.

Clinical features suggestive of dyslexia include **difficulty with phonological awareness**, the ability to identify and manipulate the sounds within words, **slow, effortful reading**, **frequent letter reversals** or **word substitutions** persisting beyond the age at which these are considered a normal part of early reading development, and a **discrepancy** between the child's reading ability and their broader cognitive and verbal ability, often first noticed by a parent or teacher when a child struggles significantly despite evident effort.

Fill in the blank: Dyslexia primarily affects the accurate and fluent recognition of written _____.

2.5.2 management of dyslexia

Management of dyslexia centres on **structured, evidence-based literacy intervention**, typically delivered by a **specialist educator** trained in appropriate teaching methods, focusing specifically on **phonological awareness** and **structured, systematic phonics instruction**, together with practical **classroom accommodations**, such as additional time for reading-based tasks and alternative methods of assessment where appropriate.

Early identification and intervention are consistently associated with better long-term academic and psychosocial outcomes, and equally important is ensuring the child and family understand that dyslexia reflects a **specific difficulty with reading processing**, not a lack of intelligence or effort, since a supportive, well-informed approach at home and school meaningfully protects the child's **self-esteem** and ongoing motivation to learn.

Fill in the blank: Management of dyslexia centres on structured, evidence-based _____ intervention.

2.5.3 stuttering: clinical features and management

Stuttering, or **stammering**, is a **fluency disorder** characterised by disruptions in the normal flow of speech, including **repetitions** of sounds, syllables, or words, **prolongations** of sounds, and **blocks**, in which speech is briefly interrupted entirely, and commonly first emerges between **2 and 5 years** of age, a period during which language skills are developing rapidly and some degree of normal, transient disfluency is common.

Developmental stuttering, the most common form, often **resolves spontaneously**, particularly when mild and of relatively short duration, while persistent stuttering, particularly with

associated struggle behaviour, such as visible tension or grimacing during speech attempts, or stuttering **persisting beyond 12 months**, warrants referral to a **speech and language therapist**, with management including specific **fluency-shaping techniques** and strategies to reduce **communication anxiety**, since the psychosocial impact of stuttering can be as significant as the speech disruption itself.

Fill in the blank: Stuttering commonly first emerges between 2 and _____ years of age.

Figure 2.5: A child receiving structured reading support for dyslexia.

Pilot questions 2.5

- Define dyslexia and explain why it does not reflect a child's general intelligence. (Linked to SLO 2.9)
- List two clinical features suggestive of dyslexia. (Linked to SLO 2.9)
- Describe the general management approach to dyslexia. (Linked to SLO 2.9)
- Describe the typical clinical features of stuttering. (Linked to SLO 2.10)
- List two features that should prompt referral of a stuttering child to a speech and language therapist. (Linked to SLO 2.10)

Series Summary

This Series examined the common **behavioural disorders of childhood**, beginning with **food fussiness and elimination disorders**, before turning to **temper tantrums and head banging**.

We then examined **breath holding attacks**, followed by **language delay, disorders, and communication disorders**, before concluding with **dyslexia and stuttering**. Having worked through this Series, you should now be able to recognise and manage these common behavioural presentations and appropriately reassure and guide affected families. The next Series turns to **nutrition and protein-energy malnutrition**.

Glossary of Terms

1. **Food neophobia:** reluctance to try new foods, a common feature of food fussiness in toddlers.
2. **Enuresis:** involuntary urination beyond the age at which bladder control is normally expected.
3. **Encopresis:** involuntary or voluntary passage of stool in inappropriate locations, often due to overflow from constipation.
4. **Temper tantrum:** a developmentally normal episode of emotional outburst common in young children.
5. **Head banging:** a rhythmic, repetitive striking of the head, generally a benign self-soothing behaviour in young children.
6. **Cyanotic breath holding attack:** a breath holding attack beginning with crying, followed by breath holding and cyanosis.
7. **Pallid breath holding attack:** a breath holding attack triggered by minor injury or fright, with minimal crying and pallor.
8. **Language delay:** language development following the normal sequence but at a slower rate than typical.
9. **Language disorder:** a persistent, qualitatively atypical pattern of language development.
10. **Dyslexia:** a specific learning disorder affecting accurate and fluent recognition of written words, occurring with normal intelligence.
11. **Stuttering:** a fluency disorder characterised by repetitions, prolongations, and blocks in speech.

12. **Phonological awareness:** the ability to identify and manipulate the sounds within words, central to reading development.

Concept Check Questions [Series 2]

Objective questions

6. Reluctance to try new foods in a young child is termed food _____.
7. Enuresis is generally considered clinically relevant from around _____ years of age.
8. Encopresis is most commonly associated with underlying chronic _____.
9. Cyanotic breath holding attacks typically begin with vigorous _____, followed by breath holding in expiration.
10. Dyslexia primarily affects the accurate and fluent recognition of written _____.

Short-answer questions

11. Describe the general management approach to food fussiness.
12. Describe the general management strategies for temper tantrums.
13. Distinguish cyanotic from pallid breath holding attacks.
14. List the three categories of communication disorder.
15. List two clinical features suggestive of dyslexia.

Long-answer questions

1. Discuss food fussiness, enuresis, and encopresis in children, including their management. (Linked to SLO 2.1, SLO 2.2)
2. Discuss temper tantrums and head banging, including their clinical features and management. (Linked to SLO 2.3, SLO 2.4)
3. Discuss the types, clinical features, and management of breath holding attacks. (Linked to SLO 2.5, SLO 2.6)
4. Discuss language delay, language disorders, and communication disorders, including their evaluation and management. (Linked to SLO 2.7, SLO 2.8)
5. Discuss the clinical features and management of dyslexia and stuttering. (Linked to SLO 2.9, SLO 2.10)

Answers to Concept Check Questions [Series 2]

Objective questions

6. Neophobia.
7. 5.
8. Constipation.
9. Crying.
10. Words.

Short-answer questions

11. Reassurance, repeated pressure-free exposure to new foods, and avoiding mealtime conflict.
12. Calm, consistent responses, avoiding rewarding the behaviour, and positive reinforcement of appropriate behaviour.
13. Cyanotic attacks begin with crying and cyanosis; pallid attacks have minimal crying and are followed by pallor from a vagal reflex.
14. Speech sound disorders, fluency disorders, and social communication disorders.
15. Difficulty with phonological awareness and frequent letter reversals or word substitutions.

Long-answer questions

16. **Basic response:** Food fussiness is managed with reassurance and repeated exposure; enuresis and encopresis are managed with behavioural measures and, for encopresis, treatment of underlying constipation.

Value-added response: Secondary enuresis and encopresis both warrant consideration of an underlying medical or psychosocial trigger, and a sensitive, non-punitive approach is essential.

17. **Basic response:** Temper tantrums and head banging are common, developmentally normal behaviours managed with calm, consistent parental responses and reassurance.

Value-added response: Excessive frequency or intensity, or persistence beyond the typical age range, should prompt further assessment for an underlying developmental or communication difficulty.

18. **Basic response:** Breath holding attacks are classified as cyanotic or pallid, generally diagnosed on history, and managed with reassurance and safety measures during episodes.

Value-added response: Iron deficiency should be considered and treated where present, and the prognosis is excellent, with most children outgrowing the behaviour by 6 to 8 years.

19. **Basic response:** Language delay follows the normal sequence at a slower rate, while language disorder is qualitatively atypical; communication disorders include speech, fluency, and social communication difficulties.

Value-added response: Evaluation must include hearing assessment and consideration of all developmental domains, with management centred on multidisciplinary speech and language therapy and early intervention.

20. **Basic response:** Dyslexia affects reading accuracy and fluency despite normal intelligence, managed with structured phonics-based literacy intervention.

Value-added response: Stuttering involves repetitions, prolongations, and blocks, often resolving spontaneously, though persistent stuttering with struggle behaviour warrants speech and language therapy referral.

Answers to Pilot Questions [Series 2]

Part 2.1

11. Food fussiness presents as a limited range of accepted foods and reluctance to try new foods.
12. Reassurance and repeated, pressure-free exposure to new foods are key management strategies.
13. Enuresis is involuntary urination beyond the expected age; primary enuresis means never achieving dryness, secondary means dryness was previously achieved.
14. Fluid restriction before bedtime, scheduled voiding, and, in some cases, enuresis alarms or desmopressin.
15. Encopresis is involuntary passage of stool in inappropriate locations, most commonly due to chronic constipation.

Part 2.2

1. Temper tantrums present with crying, screaming, and kicking, most common between 1 and 4 years.

2. Markedly excessive frequency or intensity for age, or persistence beyond the typical age range.
3. Calm, consistent responses, avoiding rewarding the behaviour, and positive reinforcement.
4. Head banging is rhythmic striking of the head, typically appearing between 6 months and 3 years.
5. Reassurance and safety measures such as padding the crib, since the behaviour usually resolves by 3 to 4 years.

Part 2.3

1. Cyanotic and pallid types; the sequence is a trigger followed by crying or no crying, breath holding, colour change, and recovery.
2. Cyanotic attacks begin with crying and progress to cyanosis; pallid attacks have minimal crying and progress to pallor.
3. A clear precipitating trigger and rapid, complete recovery help distinguish breath holding attacks from seizures.
4. Reassurance, ensuring safety during episodes, and avoiding excessive attention to the behaviour.
5. The prognosis is excellent, with most children outgrowing the behaviour by 6 to 8 years of age.

Part 2.4

1. Language delay follows the normal sequence at a slower rate; language disorder is a persistent, atypical pattern.
2. Speech sound disorders, fluency disorders, and social communication disorders.
3. Undetected hearing loss can be mistakenly attributed entirely to a primary language disorder, delaying appropriate treatment.
4. Developmental history, assessment across domains, hearing assessment, and speech and language therapy referral.
5. Management is multidisciplinary, centred on speech and language therapy and early intervention.

Part 2.5

1. Dyslexia is a specific reading disorder occurring with normal intelligence, not reflecting overall cognitive ability.
2. Difficulty with phonological awareness and persistent letter reversals are clinical features.

3. Structured, evidence-based literacy intervention focusing on phonological awareness and phonics.
4. Stuttering involves repetitions, prolongations, and blocks in speech, commonly emerging between 2 and 5 years.
5. Associated struggle behaviour or stuttering persisting beyond 12 months should prompt referral.

References and Attributions [Series 2]

1. Kliegman, R. M., St Geme, J. W., Blum, N. J., Shah, S. S., Tasker, R. C. and Wilson, K. M. (2020). Nelson Textbook of Pediatrics (21st ed.). Elsevier.
2. American Academy of Pediatrics (2020). Bright Futures: Guidelines for Health Supervision of Infants, Children, and Adolescents (4th ed.).
3. DiMario, F. J. (2001). Breath-holding spells in childhood. Current Problems in Pediatrics, 31(9), 253 to 268.
4. International Dyslexia Association (2021). Definition of Dyslexia.

Figures, Plates, Tables, and Boxes

- Figure 2.1: A toddler displaying typical food fussiness at mealtime. AI-generated using the prompt: "A warm, realistic illustration of a toddler sitting in a high chair, arms crossed, looking away from a plate of food, with a calm parent seated nearby. Single clean illustration, soft natural lighting, no text overlays, no multiple panels, gentle and accurate depiction."
- Table 2.2: Comparing temper tantrums, head banging, and breath holding attacks. AI-generated using the prompt: "Create a clean reference table titled Comparing Common Childhood Behavioural Presentations, listing behaviour, typical age, and general management. Simple clinical reference table style with outside border."
- Figure 2.3: A parent comforting a child recovering after a breath holding episode. AI-generated using the prompt: "A gentle, realistic illustration of a parent calmly holding and comforting a young child on their lap in a quiet room, both appearing settled and at ease. Single clean illustration, soft warm lighting, no text overlays, no multiple panels, tasteful and reassuring depiction, no depiction of the acute episode itself."

- Figure 2.4: A speech and language therapist working with a young child. AI-generated using the prompt: "A warm, realistic illustration of a speech and language therapist sitting across a small table from a young child, using colourful picture cards together in a bright therapy room. Single clean illustration, soft natural lighting, no text overlays, no multiple panels, engaging and accurate depiction."
- Figure 2.5: A child receiving structured reading support for dyslexia. AI-generated using the prompt: "A warm, realistic illustration of a specialist educator sitting beside a child at a desk, pointing to letters on a simple reading card together, in a bright, encouraging classroom setting. Single clean illustration, soft natural lighting, no text overlays, no multiple panels, supportive and accurate depiction."

Course code: PAE 502

Course title: Nutrition, Growth and Development

Course credit load: 3 Units

Series 3: Nutrition and Protein-Energy Malnutrition

1. **Part 3.1: Nutritional Needs of Normal Children**
    1. Sub Part 3.1.1: Nutritional requirements of infants
    2. Sub Part 3.1.2: Complementary feeding
    3. Sub Part 3.1.3: Nutritional needs of older children
2. **Part 3.2: Protein-Energy Malnutrition: Classification and Pathophysiology**
    1. Sub Part 3.2.1: Definition and classification of protein-energy malnutrition
    2. Sub Part 3.2.2: Clinical classification: marasmus, kwashiorkor, and marasmic-kwashiorkor
    3. Sub Part 3.2.3: Pathophysiology of protein-energy malnutrition
3. **Part 3.3: Marasmus**
    1. Sub Part 3.3.1: Clinical features of marasmus
    2. Sub Part 3.3.2: Complications and assessment of marasmus
    3. Sub Part 3.3.3: General principles of management of marasmus
4. **Part 3.4: Kwashiorkor and Severe Acute Malnutrition Management**
    1. Sub Part 3.4.1: Clinical features of kwashiorkor
    2. Sub Part 3.4.2: Principles of management of severe acute malnutrition
    3. Sub Part 3.4.3: Outpatient management and prevention of relapse
5. **Part 3.5: Micronutrient Deficiencies**
    1. Sub Part 3.5.1: Vitamin A deficiency
    2. Sub Part 3.5.2: Iron and zinc deficiency
    3. Sub Part 3.5.3: Iodine deficiency and general prevention of micronutrient deficiencies

Introduction

In the last Series, we explored the common behavioural disorders of childhood. We now turn to nutrition, one of the most fundamental determinants of child health, growth, and development. Picture a well nourished toddler thriving on a varied, age-appropriate diet, alongside a severely malnourished infant with visible wasting and oedema, admitted for urgent nutritional rehabilitation. Understanding normal nutritional needs, and recognising and managing protein-energy malnutrition and micronutrient deficiencies, is the focus of this Series, and, as emphasised throughout this course, attendance at the nutrition clinic remains a compulsory, hands-on component of learning this material.

The aim of this Series is to equip you with the knowledge required to understand the nutritional needs of normal children, and to recognise and manage protein-energy malnutrition, including marasmus and kwashiorkor, and common micronutrient deficiencies.

This Series begins with the **nutritional needs of normal children**, before turning to the **classification and pathophysiology of protein-energy malnutrition**. Next, we examine **marasmus**, then **kwashiorkor and severe acute malnutrition management**, before concluding with **micronutrient deficiencies**.

Series Learning Outcomes

At the end of this Series, you should be able to:

6. **SLO 1.1:** describe the nutritional needs of normal infants and children,
7. **SLO 1.2:** describe recommended infant and young child feeding practices,
8. **SLO 1.3:** define and classify protein-energy malnutrition,
9. **SLO 1.4:** describe the pathophysiology of protein-energy malnutrition,
10. **SLO 1.5:** describe the clinical features of marasmus,
11. **SLO 1.6:** describe the management of marasmus,
12. **SLO 1.7:** describe the clinical features of kwashiorkor,
13. **SLO 1.8:** describe the principles of management of severe acute malnutrition,
14. **SLO 1.9:** describe the common micronutrient deficiencies and their clinical features, and
15. **SLO 1.10:** describe the prevention and management of micronutrient deficiencies.

3.1 Nutritional Needs of Normal Children

3.1.1 nutritional requirements of infants

Requirements are highest, relative to size, in early infancy

Infants have proportionally **higher energy and nutrient requirements** relative to body weight than older children or adults, reflecting their **rapid growth rate**, particularly in the first six months of life, and requirements for specific nutrients, including **protein**, **iron**, and **calcium**, are correspondingly elevated during this period of intense growth and development.

Exclusive breastfeeding is recommended for the first **6 months** of life, providing complete nutrition for most healthy term infants, together with important **immunological** and other health benefits for both infant and mother, and, where breastfeeding is not possible or is contraindicated, an appropriate **infant formula** provides a suitable alternative source of complete nutrition during this period.

Fill in the blank: Exclusive breastfeeding is recommended for the first _____ months of life.

3.1.2 complementary feeding

Complementary feeding, the introduction of foods and liquids alongside continued breastfeeding, should begin at around **6 months** of age, when breast milk alone is no longer sufficient to meet the infant's growing nutritional needs, particularly for **iron** and **zinc**, and should progress gradually from soft, pureed foods to more varied textures as the infant's oral motor skills develop.

Complementary foods should be **nutrient-dense**, appropriately **age-adjusted** in texture and consistency, and introduced with attention to **food safety** and **hygiene**, and breastfeeding should ideally continue **alongside** complementary feeding up to **2 years** of age or beyond, since breast milk continues to provide valuable nutrition and immunological protection well beyond the first six months.

Fill in the blank: Complementary feeding should begin at around _____ months of age.

3.1.3 nutritional needs of older children

Beyond infancy, children require a **balanced diet** providing adequate **energy**, **macronutrients**, including protein, carbohydrate, and fat, and **micronutrients**, with specific requirements varying by **age**, **sex**, and **level of physical activity**, and dietary diversity, including regular intake of **fruits**, **vegetables**, **protein sources**, and **whole grains**, supports both adequate growth and long-term health.

Particular attention to **iron** and **calcium** intake is important in later childhood and adolescence, given the significant increases in **blood volume** and **bone mineralisation** respectively during

periods of rapid growth, particularly puberty, discussed in detail in a later Series of this course, meaning nutritional guidance should be tailored to the child's specific developmental stage rather than applying a single approach uniformly across all ages.

Fill in the blank: Particular attention to iron and _____ intake is important during periods of rapid growth such as puberty.

Figure 3.1: A mother breastfeeding her infant.

Pilot questions 3.1

1. Explain why infants have proportionally higher nutritional requirements than older children. (Linked to SLO 3.1)
2. Describe the recommendation for exclusive breastfeeding. (Linked to SLO 3.1)
3. Define complementary feeding and state when it should begin. (Linked to SLO 3.2)
4. Describe the key principles of appropriate complementary feeding. (Linked to SLO 3.2)
5. List two micronutrients requiring particular attention during periods of rapid growth in later childhood. (Linked to SLO 3.3)

3.2 Protein-Energy Malnutrition: Classification and Pathophysiology

3.2.1 definition and classification of protein-energy malnutrition

A spectrum from mild to severe, acute to chronic

Protein-energy malnutrition, abbreviated **PEM**, refers to a spectrum of nutritional disorders resulting from inadequate intake of **energy**, **protein**, or both, relative to the body's requirements, and remains a significant cause of childhood morbidity and mortality in many low resource settings, including parts of Nigeria, often compounded by coexisting infection and micronutrient deficiency.

PEM is classified by **severity**, using **anthropometric indices** such as **weight-for-height**, **weight-for-age**, and **mid-upper arm circumference**, discussed in detail in the next Series of this course, into **mild**, **moderate**, and **severe** malnutrition, and by **duration**, into **acute malnutrition**, reflecting recent nutritional deficit, and **chronic malnutrition**, or **stunting**, reflecting longstanding, cumulative nutritional deficit affecting linear growth.

Fill in the blank: PEM is classified by duration into acute malnutrition and chronic malnutrition, also called _____.

3.2.2 clinical classification: marasmus, kwashiorkor, and marasmic-kwashiorkor

Severe PEM is further classified clinically into three recognised patterns: **marasmus**, characterised predominantly by severe **wasting** without significant oedema, reflecting predominantly **energy deficiency**, **kwashiorkor**, characterised by **bilateral pitting oedema**, historically attributed predominantly to **protein deficiency** though the underlying pathophysiology is now understood to be more complex, and **marasmic-kwashiorkor**, a combined pattern showing features of both.

These three clinical patterns, discussed in detail in the following Parts of this Series, are not entirely distinct disease entities but rather represent **overlapping presentations** along a shared underlying spectrum of severe malnutrition, and the specific pattern a given child presents with is influenced by factors including the **relative balance** of energy and protein deficiency, the **duration** of malnutrition, and individual **metabolic adaptation**.

Fill in the blank: Kwashiorkor is characterised by bilateral pitting _____.

3.2.3 pathophysiology of protein-energy malnutrition

In response to inadequate energy intake, the body initially mobilises **glycogen stores**, followed by **fat stores** through **lipolysis**, and, as malnutrition progresses and these reserves are depleted, **muscle protein breakdown** occurs to provide amino acids for essential metabolic processes, producing the characteristic **muscle wasting** seen in severe malnutrition, particularly marasmus.

In kwashiorkor, additional mechanisms are believed to contribute to the characteristic **oedema**, including **reduced serum albumin**, lowering plasma **oncotic pressure**, alongside **increased capillary permeability** and disturbances in **free radical** handling, though the precise pathophysiology remains an area of ongoing research, and the marked variability in which children develop kwashiorkor versus marasmus under apparently similar nutritional deprivation remains only partially understood.

Fill in the blank: As malnutrition progresses, muscle protein breakdown occurs to provide _____ for essential metabolic processes.

Table 3.2: Classification of protein-energy malnutrition by clinical pattern.

Pattern	Key feature	Predominant deficiency
Marasmus	Severe wasting without oedema	Predominantly energy deficiency
Kwashiorkor	Bilateral pitting oedema	Historically attributed to protein deficiency
Marasmic-kwashiorkor	Combined wasting and oedema	Mixed picture

Pilot questions 3.2

1. Define protein-energy malnutrition. (Linked to SLO 3.4)
2. Distinguish acute malnutrition from chronic malnutrition, or stunting. (Linked to SLO 3.4)
3. List the three clinical patterns of severe protein-energy malnutrition. (Linked to SLO 3.4)
4. Describe the sequence of metabolic adaptation in a child with inadequate energy intake. (Linked to SLO 3.4)
5. Describe the proposed mechanisms contributing to oedema in kwashiorkor. (Linked to SLO 3.4)

3.3 Marasmus

3.3.1 clinical features of marasmus

The body consuming its own reserves to survive

Marasmus presents with severe **wasting**, characterised by marked loss of **subcutaneous fat** and **muscle bulk**, giving the child an **emaciated**, aged appearance, together with **loose, wrinkled skin**, particularly noticeable over the buttocks and thighs, and a relatively **prominent head** in proportion to a markedly thinned body, reflecting the severity of tissue wasting elsewhere.

Affected children are typically **alert** and often demonstrate a **ravenous appetite**, in contrast to the more common apathy seen in kwashiorkor, discussed in the next Part of this Series, and may show signs of significant **dehydration**, given frequently associated diarrhoeal illness, together with **hypothermia** and **hypoglycaemia**, both important complications requiring active monitoring and correction during initial management.

Fill in the blank: Children with marasmus are typically alert and often demonstrate a _____ appetite.

3.3.2 complications and assessment of marasmus

Children with marasmus are at significant risk of **hypothermia**, given the loss of insulating subcutaneous fat, **hypoglycaemia**, given depleted glycogen and fat reserves, and **infection**, given significantly **impaired immune function** in the setting of severe malnutrition, meaning any unwell child with marasmus should be actively assessed for an underlying or complicating infection rather than attributing all clinical features to malnutrition alone.

Assessment should include careful **anthropometric measurement**, discussed in detail in the next Series, together with examination for **signs of dehydration**, **infection**, and specific **micronutrient deficiencies**, discussed later in this Series, since severe malnutrition rarely occurs in isolation and is frequently accompanied by coexisting deficiencies requiring simultaneous identification and correction.

Fill in the blank: Children with marasmus have significantly impaired _____ function, increasing infection risk.

3.3.3 general principles of management of marasmus

Management of marasmus follows the general principles of **severe acute malnutrition management**, discussed in detail in the following Part of this Series, beginning with

stabilisation, addressing immediately life-threatening complications such as hypoglycaemia, hypothermia, dehydration, and infection, before **cautious nutritional rehabilitation**, since overly rapid refeeding carries a genuine risk of **refeeding syndrome**, a potentially serious metabolic complication.

Nutritional rehabilitation proceeds gradually, using specifically formulated **therapeutic feeds**, with careful monitoring of **weight gain**, **clinical status**, and specific **biochemical parameters** throughout the recovery process, and successful management requires close **multidisciplinary** involvement, together with attention to the underlying **social and economic factors** that contributed to the child's malnutrition in the first place, to prevent relapse after discharge.

Fill in the blank: Overly rapid refeeding in severe malnutrition carries a genuine risk of refeeding _____.

Figure 3.3: A child receiving therapeutic feeding as part of nutritional rehabilitation for marasmus.

Pilot questions 3.3

1. Describe the characteristic clinical appearance of a child with marasmus. (Linked to SLO 3.5)

2. Distinguish the typical appetite and alertness of a child with marasmus from kwashiorkor. (Linked to SLO 3.5)
3. List three important complications to actively monitor for in marasmus. (Linked to SLO 3.5)
4. Describe the general phases of management of severe malnutrition. (Linked to SLO 3.6)
5. Explain why nutritional rehabilitation must proceed cautiously rather than rapidly. (Linked to SLO 3.6)

3.4 Kwashiorkor and Severe Acute Malnutrition Management

3.4.1 clinical features of kwashiorkor

Oedema can mask the underlying severity of wasting

Kwashiorkor is characterised by the defining feature of **bilateral pitting oedema**, typically beginning in the **feet and lower limbs** and, in more severe cases, extending to involve the face and generalised body oedema, together with **skin changes**, including **flaky paint dermatosis**, areas of hyperpigmentation and desquamation, and **hair changes**, including **hypopigmentation** and increased fragility.

Affected children are frequently **apathetic** and **irritable**, in contrast to the alertness typically seen in marasmus, and may have a relatively **preserved appearance of subcutaneous fat**, particularly over the face, sometimes producing a deceptively **well nourished appearance**, termed **moon face**, that can mask the true severity of the underlying nutritional deficit if oedema is not specifically recognised and assessed.

Fill in the blank: Bilateral pitting oedema in kwashiorkor typically begins in the feet and lower _____.

3.4.2 principles of management of severe acute malnutrition

Management of **severe acute malnutrition**, whether presenting as marasmus, kwashiorkor, or the combined marasmic-kwashiorkor pattern, follows a structured, staged approach, beginning with **initial stabilisation**, addressing hypoglycaemia, hypothermia, dehydration, electrolyte imbalance, and infection, using **cautious fluid management**, since standard rapid rehydration protocols used in well nourished children can precipitate dangerous **fluid overload** in a severely malnourished child.

Following stabilisation, **nutritional rehabilitation** proceeds using specifically formulated therapeutic feeds, initially **F-75**, a lower energy, stabilisation-phase formula, transitioning to **F-100** or **ready-to-use therapeutic food**, higher energy formulations designed to support rapid catch-up growth once the child is medically stable, with **micronutrient supplementation**, discussed further in the next Part of this Series, provided throughout.

Fill in the blank: Initial nutritional rehabilitation in severe malnutrition uses a lower energy formula called F-_____.

3.4.3 outpatient management and prevention of relapse

Children with **uncomplicated severe acute malnutrition**, without significant medical complications or appetite loss, can often be managed as **outpatients** using **ready-to-use therapeutic food**, an energy-dense, micronutrient-fortified paste that does not require refrigeration or preparation, allowing effective community-based management and considerably reducing the burden on inpatient facilities in high-prevalence settings.

Prevention of relapse after successful nutritional rehabilitation requires attention to the underlying **social**, **economic**, and **food security** factors that contributed to the episode of malnutrition, together with **nutritional education** for the family, ongoing **growth monitoring**, and, where relevant, **linkage to broader social support services**, since addressing the immediate nutritional deficit alone, without addressing these underlying contributing factors, frequently results in relapse.

Fill in the blank: Uncomplicated severe acute malnutrition can often be managed as _____ using ready-to-use therapeutic food.

Figure 3.4: A community health worker assessing a child's feet for bilateral pitting oedema.

Pilot questions 3.4

- Describe the characteristic clinical features of kwashiorkor. (Linked to SLO 3.7)
- Explain why kwashiorkor can present with a deceptively well nourished appearance. (Linked to SLO 3.7)
- Describe the initial stabilisation phase of severe acute malnutrition management. (Linked to SLO 3.8)
- Distinguish F-75 from F-100 or ready-to-use therapeutic food. (Linked to SLO 3.8)
- Describe the general approach to preventing relapse after nutritional rehabilitation. (Linked to SLO 3.8)

3.5 Micronutrient Deficiencies

3.5.1 vitamin A deficiency

A leading preventable cause of childhood blindness

Vitamin A deficiency remains an important cause of preventable childhood **blindness** and increased susceptibility to **infection** in many low resource settings, with early clinical features

including **night blindness**, difficulty seeing in low light conditions, progressing, in more severe or prolonged deficiency, to **xerophthalmia**, dryness and characteristic changes of the conjunctiva and cornea, including **Bitot's spots**, and, in advanced cases, **corneal ulceration** and permanent visual loss.

Given its considerable public health importance, **routine vitamin A supplementation** is recommended in many high-risk settings as a preventive measure, and vitamin A is additionally given as part of the management of **measles**, discussed earlier in this course, since deficiency significantly worsens the severity and complication risk of that specific infection.

Fill in the blank: Early clinical features of vitamin A deficiency include night _____.

3.5.2 iron and zinc deficiency

Iron deficiency, the most common micronutrient deficiency worldwide, causes **microcytic, hypochromic anaemia**, presenting with **pallor**, **fatigue**, and, in more severe cases, **impaired cognitive development**, particularly when deficiency occurs during critical periods of early brain development, and is frequently multifactorial in origin, including inadequate dietary intake, chronic blood loss, such as from intestinal parasites discussed earlier in this course, and increased requirements during periods of rapid growth.

Zinc deficiency contributes to **growth faltering**, **impaired immune function** with increased susceptibility to infection, particularly diarrhoeal illness, and characteristic **skin changes** in severe deficiency, and **zinc supplementation** is specifically recommended as part of the management of acute diarrhoea, as discussed in an earlier course, reflecting its dual role as both a preventive and therapeutic intervention in this context.

Fill in the blank: Iron deficiency causes a microcytic, _____ anaemia.

3.5.3 iodine deficiency and general prevention of micronutrient deficiencies

Iodine deficiency is the most common preventable cause of **intellectual impairment** worldwide, since adequate iodine is essential for normal **thyroid hormone synthesis**, discussed in an earlier course, and, when severe and occurring during pregnancy or early childhood, can result in **irreversible neurodevelopmental impairment**, together with visible **goitre** in less severe, chronic deficiency.

Prevention of micronutrient deficiencies at a population level relies principally on **food fortification**, such as **iodised salt** and vitamin A or iron fortified staple foods, together with **targeted supplementation programmes** for specific high-risk groups, and promotion of **dietary diversity**, with these population-level strategies generally proving more sustainable and cost-

effective than relying solely on individual clinical treatment of established deficiency once it has already occurred.

Fill in the blank: Iodine deficiency is the most common preventable cause of intellectual _____ worldwide.

Figure 3.5: A child receiving a dose of oral vitamin A supplementation.

Pilot questions 3.5

1. Describe the clinical features of vitamin A deficiency, from early to advanced stages. (Linked to SLO 3.9)
2. Explain the relevance of vitamin A supplementation in the management of measles. (Linked to SLO 3.9)
3. Describe the clinical features of iron deficiency and zinc deficiency. (Linked to SLO 3.9)
4. Describe the consequences of severe iodine deficiency, particularly in pregnancy and early childhood. (Linked to SLO 3.10)
5. Describe the general population-level strategies for preventing micronutrient deficiencies. (Linked to SLO 3.10)

Series Summary

This Series examined **nutrition**, beginning with the nutritional needs of normal children, before turning to the **classification and pathophysiology of protein-energy malnutrition**.

We then examined **marasmus** and **kwashiorkor**, together with the principles of severe acute malnutrition management, before concluding with the common **micronutrient deficiencies** and their prevention. Having worked through this Series, you should now be able to understand normal nutritional needs and recognise and manage protein-energy malnutrition and micronutrient deficiencies. The next Series turns to **anthropometry, growth charts, and factors affecting growth**.

Glossary of Terms

6. **Exclusive breastfeeding:** feeding an infant only breast milk, recommended for the first 6 months of life.
7. **Complementary feeding:** the introduction of foods and liquids alongside continued breastfeeding, beginning around 6 months.
8. **Protein-energy malnutrition:** a spectrum of nutritional disorders resulting from inadequate intake of energy, protein, or both.
9. **Stunting:** chronic malnutrition reflecting longstanding, cumulative nutritional deficit affecting linear growth.
10. **Marasmus:** severe malnutrition characterised predominantly by severe wasting without significant oedema.
11. **Kwashiorkor:** severe malnutrition characterised by bilateral pitting oedema.
12. **Refeeding syndrome:** a potentially serious metabolic complication of overly rapid nutritional rehabilitation.
13. **F-75:** a lower energy therapeutic feed used in the initial stabilisation phase of severe malnutrition management.
14. **Ready-to-use therapeutic food:** an energy-dense, micronutrient-fortified paste used for outpatient management of severe acute malnutrition.
15. **Xerophthalmia:** dryness and characteristic changes of the conjunctiva and cornea due to vitamin A deficiency.

16. **Bitot's spots:** characteristic conjunctival changes seen in vitamin A deficiency.
17. **Iodine deficiency:** the most common preventable cause of intellectual impairment worldwide.

Concept Check Questions [Series 3]

Objective questions

11. Exclusive breastfeeding is recommended for the first _____ months of life.
12. Kwashiorkor is characterised by bilateral pitting _____.
13. Overly rapid refeeding in severe malnutrition carries a genuine risk of refeeding _____.
14. Initial nutritional rehabilitation in severe malnutrition uses a lower energy formula called F-_____.
15. Iron deficiency causes a microcytic, _____ anaemia.

Short-answer questions

1. Define complementary feeding and state when it should begin.
2. List the three clinical patterns of severe protein-energy malnutrition.
3. Distinguish the typical appetite and alertness of a child with marasmus from kwashiorkor.
4. Distinguish F-75 from F-100 or ready-to-use therapeutic food.
5. Describe the clinical features of vitamin A deficiency, from early to advanced stages.

Long-answer questions

6. Discuss the nutritional needs of normal infants and children, including recommended feeding practices. (Linked to SLO 3.1, SLO 3.2)
7. Discuss the classification and pathophysiology of protein-energy malnutrition. (Linked to SLO 3.3, SLO 3.4)
8. Discuss the clinical features and management of marasmus. (Linked to SLO 3.5, SLO 3.6)
9. Discuss the clinical features of kwashiorkor and the principles of severe acute malnutrition management. (Linked to SLO 3.7, SLO 3.8)
10. Discuss the common micronutrient deficiencies and their prevention. (Linked to SLO 3.9, SLO 3.10)

Answers to Concept Check Questions [Series 3]

Objective questions

11. 6.
12. Oedema.
13. Syndrome.
14. 75.
15. Hypochromic.

Short-answer questions

16. Complementary feeding is the introduction of foods alongside continued breastfeeding, beginning around 6 months.
17. Marasmus, kwashiorkor, and marasmic-kwashiorkor are the three clinical patterns.
18. Marasmus children are typically alert with a ravenous appetite, while kwashiorkor children are often apathetic and irritable.
19. F-75 is a lower energy stabilisation formula; F-100 and RUTF are higher energy formulas for catch-up growth.
20. Early features include night blindness, progressing to xerophthalmia, Bitot's spots, and, in advanced cases, corneal ulceration.

Long-answer questions

21. **Basic response:** Infants have proportionally high nutritional needs met by exclusive breastfeeding for 6 months, followed by complementary feeding alongside continued breastfeeding.

Value-added response: Older children require a balanced, diverse diet with particular attention to iron and calcium during periods of rapid growth such as puberty.

22. **Basic response:** Protein-energy malnutrition is classified by severity and duration, and clinically into marasmus, kwashiorkor, and marasmic-kwashiorkor patterns.

Value-added response: Pathophysiology involves progressive mobilisation of glycogen, fat, and then muscle protein, with additional mechanisms such as reduced albumin contributing to oedema in kwashiorkor.

23. **Basic response:** Marasmus presents with severe wasting, an alert child, and a ravenous appetite, managed through staged stabilisation and cautious nutritional rehabilitation.

Value-added response: Important complications include hypoglycaemia, hypothermia, and infection, requiring active monitoring throughout management.

24. **Basic response:** Kwashiorkor presents with bilateral pitting oedema, skin and hair changes, and apathy, with severe acute malnutrition managed through staged stabilisation and rehabilitation using F-75 then F-100 or RUTF.

Value-added response: Uncomplicated cases can be managed as outpatients using RUTF, and relapse prevention requires addressing underlying social and economic contributing factors.

25. **Basic response:** Vitamin A, iron, zinc, and iodine deficiencies each cause specific clinical syndromes, from night blindness to anaemia to intellectual impairment.

Value-added response: Prevention relies principally on food fortification and targeted supplementation programmes, generally more sustainable than treating established deficiency alone.

Answers to Pilot Questions [Series 3]

Part 3.1

1. Infants have a rapid growth rate, increasing their relative energy and nutrient needs.
2. Exclusive breastfeeding is recommended for the first 6 months of life.
3. Complementary feeding is introducing foods alongside breastfeeding, beginning around 6 months.
4. Complementary foods should be nutrient-dense, age-appropriate in texture, and hygienically prepared.
5. Iron and calcium require particular attention during periods of rapid growth such as puberty.

Part 3.2

1. PEM is a spectrum of disorders from inadequate intake of energy, protein, or both.
2. Acute malnutrition reflects recent deficit; chronic malnutrition, or stunting, reflects longstanding deficit affecting linear growth.
3. Marasmus, kwashiorkor, and marasmic-kwashiorkor are the three clinical patterns.

4. Glycogen stores are mobilised first, followed by fat stores, then muscle protein breakdown.
5. Reduced serum albumin, increased capillary permeability, and free radical disturbances are proposed mechanisms.

Part 3.3

1. Marasmus presents with severe wasting, loose wrinkled skin, and a prominent head relative to a thin body.
2. Marasmus children are typically alert with a ravenous appetite, unlike the apathy of kwashiorkor.
3. Hypothermia, hypoglycaemia, and infection are important complications to monitor for.
4. Management proceeds through stabilisation followed by cautious nutritional rehabilitation.
5. Rapid refeeding risks refeeding syndrome, a serious metabolic complication.

Part 3.4

1. Bilateral pitting oedema, flaky paint dermatosis, and hair changes are characteristic of kwashiorkor.
2. Relatively preserved facial fat can produce a moon face appearance masking the underlying severity.
3. Stabilisation addresses hypoglycaemia, hypothermia, dehydration, electrolyte imbalance, and infection.
4. F-75 is used in stabilisation; F-100 or RUTF are used for catch-up growth once stable.
5. Addressing underlying social, economic, and food security factors, plus education and growth monitoring, prevents relapse.

Part 3.5

1. Night blindness progressing to xerophthalmia, Bitot's spots, and corneal ulceration in advanced deficiency.
2. Vitamin A deficiency worsens measles severity and complication risk, so supplementation is given as part of measles management.
3. Iron deficiency causes microcytic anaemia and fatigue; zinc deficiency causes growth faltering and impaired immunity.
4. Severe iodine deficiency in pregnancy and early childhood can cause irreversible neurodevelopmental impairment.
5. Food fortification, such as iodised salt, and targeted supplementation programmes are key prevention strategies.

References and Attributions [Series 3]

- Kliegman, R. M., St Geme, J. W., Blum, N. J., Shah, S. S., Tasker, R. C. and Wilson, K. M. (2020). Nelson Textbook of Pediatrics (21st ed.). Elsevier.
- World Health Organization (2013). Guideline: Updates on the Management of Severe Acute Malnutrition in Infants and Children. WHO Press.
- World Health Organization (2009). Infant and Young Child Feeding: Model Chapter for Textbooks for Medical Students and Allied Health Professionals. WHO Press.
- World Health Organization (2009). Global Prevalence of Vitamin A Deficiency in Populations at Risk 1995 to 2005. WHO Press.

Figures, Plates, Tables, and Boxes

- Figure 3.1: A mother breastfeeding her infant. AI-generated using the prompt: "A warm, respectful illustration of a mother breastfeeding her infant while seated comfortably in a quiet room, gentle expression on both faces. Single clean illustration, soft natural lighting, no text overlays, no multiple panels, tasteful and accurate depiction."
- Table 3.2: Classification of protein-energy malnutrition by clinical pattern. AI-generated using the prompt: "Create a clean reference table titled Clinical Patterns of Protein-Energy Malnutrition, listing pattern, key feature, and predominant deficiency. Simple clinical reference table style with outside border."
- Figure 3.3: A child receiving therapeutic feeding as part of nutritional rehabilitation for marasmus. AI-generated using the prompt: "A gentle, respectful clinical illustration of a healthcare worker feeding a young child a small cup of therapeutic milk formula in a nutrition ward setting. Single clean medical illustration, soft clinical lighting, no text overlays, no multiple panels, dignified and accurate depiction, avoiding graphic depiction of severe wasting."
- Figure 3.4: A community health worker assessing a child's feet for bilateral pitting oedema. AI-generated using the prompt: "A realistic, respectful clinical illustration of a community health worker gently examining a young child's foot with a caregiver present nearby, in a simple clinic setting. Single clean medical illustration, soft clinical lighting, no text overlays, no multiple panels, dignified and accurate depiction."
- Figure 3.5: A child receiving a dose of oral vitamin A supplementation. AI-generated using the prompt: "A warm, realistic clinical illustration of a healthcare worker gently giving a young child a small capsule of oral vitamin A supplement, with a caregiver holding the child supportively. Single clean medical illustration, soft warm lighting, no text overlays, no multiple panels, respectful and accurate depiction."

Course code: PAE 502

Course title: Nutrition, Growth and Development

Course credit load: 3 Units

Series 4: Anthropometry, Growth Charts, and Factors Affecting Growth

1. **Part 4.1: Technical Skills of Anthropometry: Weight and Length or Height**
    1. Sub Part 4.1.1: Measuring weight in infants and children
    2. Sub Part 4.1.2: Measuring length in infants
    3. Sub Part 4.1.3: Measuring height in older children
2. **Part 4.2: Technical Skills of Anthropometry: Head Circumference and Mid-Upper Arm Circumference**
    1. Sub Part 4.2.1: Measuring head circumference
    2. Sub Part 4.2.2: Measuring mid-upper arm circumference
    3. Sub Part 4.2.3: Common errors in anthropometric measurement
3. **Part 4.3: Growth Charts: Use and Value**
    1. Sub Part 4.3.1: Types of growth charts
    2. Sub Part 4.3.2: Plotting and interpreting growth charts
    3. Sub Part 4.3.3: The clinical value of growth charts
4. **Part 4.4: Factors Affecting Growth and Development**
    1. Sub Part 4.4.1: Genetic and biological factors
    2. Sub Part 4.4.2: Nutritional and environmental factors
    3. Sub Part 4.4.3: Psychosocial factors affecting growth and development
5. **Part 4.5: Failure to Thrive: Causes and Evaluation**
    1. Sub Part 4.5.1: Definition and classification of failure to thrive
    2. Sub Part 4.5.2: Causes of failure to thrive
    3. Sub Part 4.5.3: Evaluation of a child with failure to thrive

Introduction

In the last Series, we explored nutrition and protein-energy malnutrition. We now turn to the practical technical skills required to actually measure and monitor a child's growth, together with the many factors that can influence it. Picture a nurse carefully weighing and measuring an infant at a routine clinic visit, plotting the results on a growth chart, and noticing a concerning flattening of the child's growth trajectory over recent months. Developing accurate anthropometric technique, and understanding how to use and interpret growth charts, is the focus of this Series, together with the broader factors that influence growth and the evaluation of a child failing to thrive.

The aim of this Series is to equip you with the technical skills of anthropometry, the ability to use and interpret growth charts, an understanding of the factors affecting growth and development, and the evaluation of a child with failure to thrive.

This Series begins with the **technical skills of anthropometry**, covering weight and length or height, before turning to further anthropometric measurements, including **head circumference and mid-upper arm circumference**. Next, we examine the **use and value of growth charts**, then the **factors affecting growth and development**, before concluding with **failure to thrive**.

Series Learning Outcomes

At the end of this Series, you should be able to:

6. **SLO 1.1:** describe the technique of measuring weight in infants and children,
7. **SLO 1.2:** describe the technique of measuring length and height,
8. **SLO 1.3:** describe the technique of measuring head circumference and mid-upper arm circumference,
9. **SLO 1.4:** describe common errors in anthropometric measurement and how to avoid them,
10. **SLO 1.5:** describe the types of growth charts and their use,
11. **SLO 1.6:** describe the value and interpretation of growth charts,
12. **SLO 1.7:** list the genetic and biological factors affecting growth and development,
13. **SLO 1.8:** list the environmental and psychosocial factors affecting growth and development,
14. **SLO 1.9:** define failure to thrive and describe its classification, and
15. **SLO 1.10:** describe the causes and evaluation of failure to thrive.

4.1 Technical Skills of Anthropometry: Weight and Length or Height

4.1.1 measuring weight in infants and children

Correct technique and equipment both matter

Weight should be measured using a properly **calibrated scale**, appropriate for the child's age, with **infants and young children unable to stand** weighed on an electronic **infant scale**, undressed or in minimal clothing, since even light clothing can meaningfully affect the recorded weight in a small infant, while **older children** capable of standing independently can be weighed on a standard standing scale.

The scale should be **zeroed** before each measurement, and, for a wriggling infant, the **average** of several readings, or a specific **tare** function subtracting the weight of a caregiver holding the infant, can improve accuracy, with the final measurement recorded to the nearest **appropriate precision**, generally **10 grams** for infants and **100 grams** for older children, and always **documented immediately** to avoid transcription error.

Fill in the blank: The scale should be _____ before each weight measurement.

4.1.2 measuring length in infants

Length, used for children **under 2 years** of age or unable to stand independently, is measured with the child **lying supine** on a specialised **length board**, with a fixed headboard and a movable footboard, requiring **two examiners** for accuracy: one to hold the child's head against the fixed headboard with the **Frankfurt plane** correctly aligned, and the other to gently straighten the child's legs and bring the movable footboard to rest firmly against the soles of the feet.

Common sources of **measurement error** include failure to fully straighten the child's knees, incorrect head positioning, and the footboard not being held firmly perpendicular to the length board, all of which can meaningfully affect the recorded measurement, meaning consistent, correct technique, ideally with two properly trained examiners, is essential for obtaining an accurate and reproducible length measurement.

Fill in the blank: Length measurement in infants requires two examiners and a specialised length _____.

4.1.3 measuring height in older children

Height, used for children **2 years and older** capable of standing independently, is measured using a **stadiometer**, with the child standing **barefoot**, heels together, back straight against the

vertical measuring surface, and the head positioned in the **Frankfurt plane**, a horizontal line running from the lower border of the eye socket to the upper margin of the ear canal, ensuring a standardised, reproducible head position.

The child should be encouraged to **stand as tall as possible** with a gentle upward stretch, and the movable headpiece brought down to rest firmly, but without excessive pressure, on the crown of the head, with the measurement recorded to the nearest **0.1 centimetre**, and, as with length measurement, correct **positioning** and consistent technique are essential to obtain a reliable, reproducible result.

Fill in the blank: Height is measured with the head positioned in the _____ plane, a horizontal line from the eye to the ear canal.

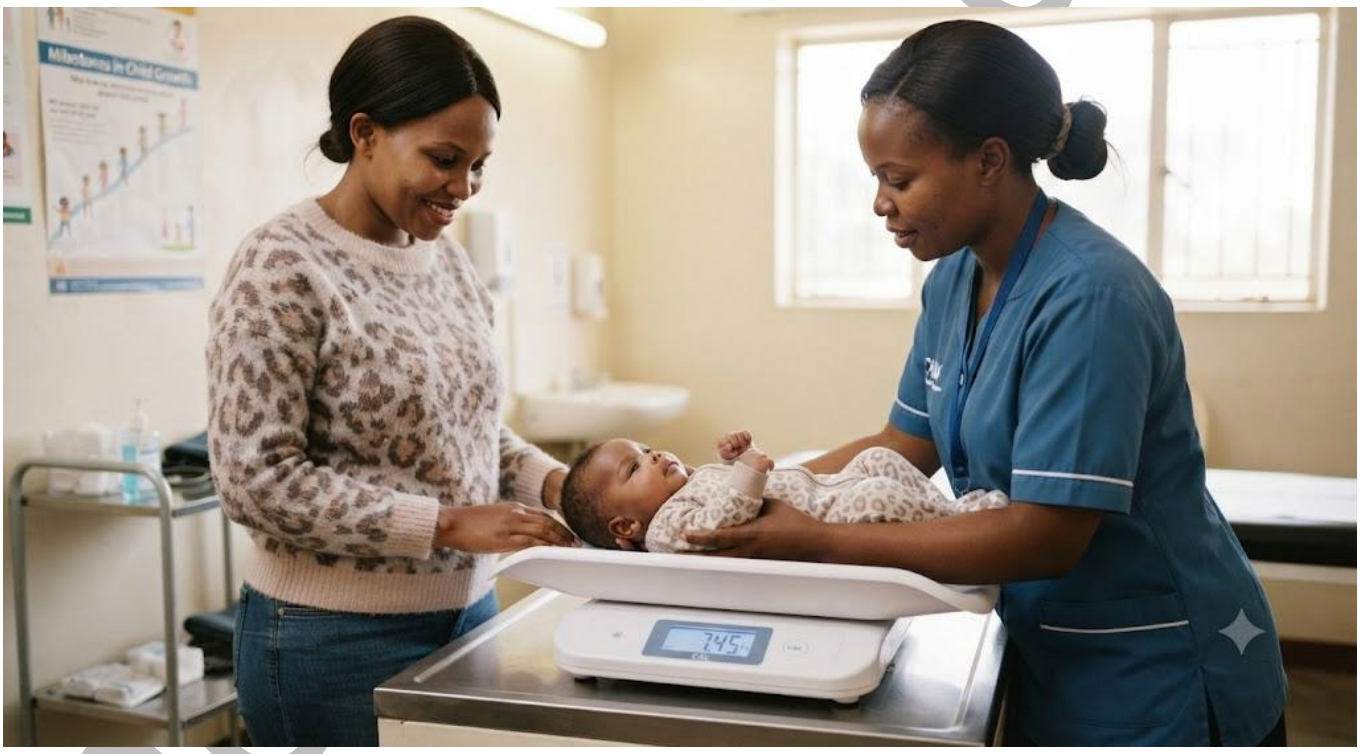

Figure 4.1: A healthcare worker weighing an infant on an electronic infant scale.

Pilot questions 4.1

1. Describe the correct technique for weighing an infant. (Linked to SLO 4.1)
2. Explain why the scale should be zeroed before each measurement. (Linked to SLO 4.1)
3. Describe the correct technique for measuring length in an infant, including the role of the two examiners. (Linked to SLO 4.2)

4. Describe the correct technique for measuring height in an older child. (Linked to SLO 4.3)
5. Define the Frankfurt plane and explain its relevance to height and length measurement. (Linked to SLO 4.3)

4.2 Technical Skills of Anthropometry: Head Circumference and Mid-Upper Arm Circumference

4.2.1 measuring head circumference

A window into brain growth, best measured with care

Head circumference is measured using a **flexible, non-stretchable tape measure**, positioned around the widest part of the head, passing over the most prominent part of the **forehead**, or **glabella**, anteriorly, and the most prominent part of the back of the head, or **occipital protuberance**, posteriorly, with the tape held **firmly but not tightly** to avoid compressing the soft tissue.

Multiple measurements should be taken and the **largest value** recorded, since this most accurately reflects the true maximum head circumference, and head circumference is a particularly important measurement in **infancy**, discussed in earlier Series of this course, given its close relationship to underlying brain growth and its value in the early detection of conditions such as **microcephaly** or **hydrocephalus**.

Fill in the blank: Head circumference measurement should record the _____ of multiple readings taken.

4.2.2 measuring mid-upper arm circumference

Mid-upper arm circumference, abbreviated **MUAC**, is measured at the **midpoint** between the tip of the shoulder, or **acromion**, and the tip of the elbow, or **olecranon**, on the **left arm**, which should be relaxed and hanging naturally by the child's side, with the tape wrapped snugly around the arm without compressing the underlying soft tissue.

MUAC is a particularly valuable, simple **screening tool** for **acute malnutrition** in children between **6 and 59 months** of age, since it requires minimal equipment, is quick to perform, and correlates well with mortality risk, making it especially useful in **community-based screening**

programmes and resource-limited settings where more complex anthropometric equipment may not be readily available.

Fill in the blank: Mid-upper arm circumference is measured at the midpoint between the acromion and the _____.

4.2.3 common errors in anthropometric measurement

Common sources of error across all anthropometric measurements include **inadequately calibrated or maintained equipment**, **incorrect positioning** of the child, **rounding or approximating** measurements rather than recording the precise value obtained, and **transcription errors** when recording results, all of which can meaningfully affect the accuracy and clinical usefulness of the resulting data, particularly when tracking a child's growth trajectory over time.

Minimising these errors requires **regular equipment calibration and maintenance**, **standardised technique** consistently applied by all staff taking measurements, adequate **training** and periodic **retraining** of personnel, and, wherever possible, **double-checking** unexpected or unusual results before acting on them clinically, since an isolated, implausible measurement is more likely to reflect measurement error than a genuine, sudden change in the child's growth.

Fill in the blank: An isolated, implausible measurement is more likely to reflect measurement _____ than a genuine sudden change.

Figure 4.2: A healthcare worker measuring a child's mid-upper arm circumference with a MUAC tape.

Pilot questions 4.2

1. Describe the correct technique for measuring head circumference. (Linked to SLO 4.3)
2. Explain why the largest of multiple head circumference readings is recorded. (Linked to SLO 4.3)
3. Describe the correct technique for measuring mid-upper arm circumference. (Linked to SLO 4.3)
4. Explain why MUAC is a valuable screening tool in resource-limited settings. (Linked to SLO 4.3)
5. List two common sources of error in anthropometric measurement and how to minimise them. (Linked to SLO 4.4)

4.3 Growth Charts: Use and Value

4.3.1 types of growth charts

Different charts answer different clinical questions

Growth charts plot a child's anthropometric measurements against **age-** and **sex-specific reference standards**, most commonly the **World Health Organization Child Growth Standards**, and different chart types are used depending on the specific parameter being assessed, including **weight-for-age**, **length or height-for-age**, **weight-for-length or height**, and **head circumference-for-age**, each providing distinct and complementary clinical information.

Weight-for-age reflects a combination of both recent and longer-term nutritional status and is influenced by both weight and height, while **weight-for-height** more specifically reflects **acute** nutritional status, since it is independent of the child's absolute age, and **height-for-age** reflects **chronic** nutritional status or **stunting**, meaning interpreting a child's growth requires considering the specific chart type in the context of the clinical question being asked.

Fill in the blank: Weight-for-height more specifically reflects _____ nutritional status.

4.3.2 plotting and interpreting growth charts

Growth charts display curved lines representing specific **percentiles** or **z-score** lines, indicating how a given measurement compares with the reference population of children of the same age and sex, and a single measurement should be interpreted in the context of these reference lines, though a single point in time provides considerably **less information** than observing the **trend** of serial measurements over time.

Serial plotting allows assessment of a child's **growth trajectory**, or **velocity**, and a child consistently tracking along a similar percentile or z-score line over time is generally reassuring, even if that particular line is somewhat below the population average, whereas a child **crossing percentile lines downward**, indicating a flattening or reversal of expected growth, is a more concerning finding warranting further evaluation regardless of the child's absolute position on the chart.

Fill in the blank: A child consistently crossing percentile lines _____ on a growth chart is a concerning finding warranting evaluation.

4.3.3 the clinical value of growth charts

Growth charts serve several important clinical purposes: they allow **early identification** of growth faltering or excessive weight gain, provide a valuable, visual tool for **communicating** growth-related information with families in an accessible way, and allow **objective monitoring** of a child's response to any nutritional or medical intervention over time, since the visual trend

often communicates a child's clinical trajectory more clearly than isolated numerical values alone.

Growth charts also have important **limitations**, since they represent a **reference population** and do not, by themselves, diagnose a specific underlying cause for an abnormal growth pattern, meaning an abnormal finding on a growth chart should always prompt further clinical evaluation, discussed in the final Part of this Series in the specific context of failure to thrive, rather than being interpreted as a diagnosis in itself.

Fill in the blank: Growth charts represent a reference population and do not, by themselves, _____ an underlying cause.

Table 4.3: Common types of growth charts and their primary clinical use.

Chart type	Primary clinical use
Weight-for-age	Combined reflection of recent and longer-term nutritional status
Weight-for-height/length	Reflects acute nutritional status, independent of age
Height/length-for-age	Reflects chronic nutritional status, or stunting
Head circumference-for-age	Reflects brain growth, particularly important in infancy

Pilot questions 4.3

- List the main types of growth charts used in paediatric practice. (Linked to SLO 4.5)
- Distinguish weight-for-age from weight-for-height in terms of what each reflects. (Linked to SLO 4.5)
- Explain why serial growth measurements provide more information than a single measurement. (Linked to SLO 4.6)
- Describe the clinical significance of a child crossing percentile lines downward. (Linked to SLO 4.6)
- Describe the limitations of growth charts. (Linked to SLO 4.6)

4.4 Factors Affecting Growth and Development

4.4.1 genetic and biological factors

Genetics sets the potential, other factors determine how close a child gets

Genetic factors, reflected in **parental heights** and family growth patterns, establish a child's underlying **growth potential**, while specific **genetic conditions** and **chromosomal abnormalities**, discussed in an earlier course, can significantly affect growth through various mechanisms, and **intrauterine factors**, including **placental function** and maternal health during pregnancy, influence **birth size** and can have lasting effects on subsequent postnatal growth.

Hormonal factors, including **growth hormone**, **thyroid hormone**, and, during puberty, **sex steroids**, discussed in an earlier course in the context of specific endocrine disorders, are essential biological regulators of normal growth, and **chronic illness**, affecting virtually any organ system, can impair growth through mechanisms including increased metabolic demand, reduced nutrient absorption, or chronic inflammation.

Fill in the blank: Genetic factors, reflected in parental heights, establish a child's underlying growth _____.

4.4.2 nutritional and environmental factors

Nutrition is among the most significant modifiable determinants of growth, as discussed extensively earlier in this Series, and **environmental factors**, including access to **safe water**, adequate **sanitation**, and a generally **hygienic living environment**, influence growth both directly and indirectly, since recurrent **infections**, more common in poor environmental conditions, place additional metabolic demands on the child and can impair nutrient absorption.

Socioeconomic factors, including household **income**, parental **education**, particularly maternal education, and broader **food security**, significantly influence a child's access to adequate nutrition and healthcare, meaning growth is genuinely best understood as the product of a complex, interconnected set of biological, nutritional, and environmental factors rather than any single factor considered in isolation.

Fill in the blank: Recurrent infections, more common in poor environmental conditions, place additional _____ demands on the child.

4.4.3 psychosocial factors affecting growth and development

Psychosocial deprivation, including inadequate **caregiver responsiveness**, insufficient **stimulation**, and, in severe cases, **neglect**, can significantly impair both growth and development, sometimes producing a condition termed **psychosocial** or **non-organic failure to thrive**, discussed further in the next Part of this Series, in which a child fails to grow adequately despite the apparent absence of an identifiable organic medical cause.

This relationship between **psychosocial environment** and physical growth underscores the importance of a **holistic assessment** of any child with a growth concern, considering the family and social context alongside biological and nutritional factors, since addressing an underlying psychosocial contributor is often just as essential to successful management as addressing any organic or nutritional cause identified.

Fill in the blank: Inadequate caregiver responsiveness and neglect can contribute to psychosocial, or non-organic, failure to _____.

Figure 4.4: A caregiver engaging warmly and responsively with a young child.

Pilot questions 4.4

1. List three genetic or biological factors affecting growth. (Linked to SLO 4.7)
2. Explain how recurrent infection can impair growth. (Linked to SLO 4.8)
3. List two socioeconomic factors influencing a child's growth. (Linked to SLO 4.8)
4. Define psychosocial, or non-organic, failure to thrive. (Linked to SLO 4.8)
5. Explain why a holistic assessment is important when evaluating a child with a growth concern. (Linked to SLO 4.8)

4.5 Failure to Thrive: Causes and Evaluation

4.5.1 definition and classification of failure to thrive

A description of a growth pattern, not a diagnosis in itself

Failure to thrive describes a pattern of **inadequate weight gain** or **weight loss** in an infant or young child, generally defined using specific anthropometric criteria such as weight persistently **below a defined percentile or z-score threshold**, or, more informatively, a **downward crossing of percentile lines** over serial measurements, reflecting the general principle, discussed earlier in this Series, that growth trajectory over time is more clinically informative than any single measurement.

Failure to thrive is traditionally classified into **organic**, resulting from an identifiable underlying **medical condition**, **non-organic**, or **psychosocial**, resulting predominantly from environmental or caregiving factors without an identifiable organic cause, and **mixed**, involving a combination of both organic and non-organic contributing factors, a classification that, while conceptually useful, should not be applied too rigidly, since many cases involve overlapping contributors.

Fill in the blank: Failure to thrive is traditionally classified into organic, non-organic, and _____ categories.

4.5.2 causes of failure to thrive

Organic causes of failure to thrive are wide-ranging and can be broadly grouped by mechanism into **inadequate intake**, such as poor feeding technique or oromotor dysfunction, **inadequate absorption**, such as coeliac disease or cystic fibrosis, **excessive nutrient loss**, such as chronic diarrhoea or vomiting, and **increased metabolic demand**, such as chronic infection, congenital heart disease, or malignancy, each requiring a distinct diagnostic approach.

Non-organic causes relate predominantly to the **feeding environment** and broader **caregiving context**, including inadequate **feeding knowledge** or technique, insufficient **food availability** due to poverty or food insecurity, and significant **psychosocial adversity** within the family, including parental mental illness, substance use, or neglect, meaning a thorough psychosocial history is just as essential as a thorough medical history when evaluating failure to thrive.

Fill in the blank: Organic causes of failure to thrive can be grouped into inadequate intake, inadequate absorption, excessive loss, and increased metabolic _____.

4.5.3 evaluation of a child with failure to thrive

Evaluation of a child with failure to thrive should begin with a **detailed history**, including **feeding history**, **birth and antenatal history**, review of **systems** for symptoms suggestive of an underlying organic cause, and a careful **psychosocial history**, together with **plotting of all available growth measurements**, ideally including historical data, to accurately characterise the child's growth trajectory over time.

Examination should be thorough, assessing for signs of an underlying organic cause together with general observation of the **parent-child interaction**, and **investigations** should be **targeted** according to specific findings from the history and examination, rather than an indiscriminate, broad screening panel, since a structured, stepwise approach generally identifies the underlying cause more efficiently and avoids unnecessary investigation of a child who may simply require improved feeding support and follow up.

Fill in the blank: Investigations for failure to thrive should be _____ according to specific findings, rather than broad and indiscriminate.

Figure 4.5: A clinician reviewing a child's growth chart with a caregiver during a failure to thrive evaluation.

Pilot questions 4.5

6. Define failure to thrive and describe how it is generally identified using growth measurements. (Linked to SLO 4.9)
7. Distinguish organic from non-organic failure to thrive. (Linked to SLO 4.9)
8. List two organic causes of failure to thrive by mechanism. (Linked to SLO 4.10)
9. List two non-organic contributing factors to failure to thrive. (Linked to SLO 4.10)
10. Describe the general approach to evaluating a child with failure to thrive. (Linked to SLO 4.10)

Series Summary

This Series developed the **technical skills of anthropometry**, covering the correct measurement of weight, length or height, head circumference, and mid-upper arm circumference, before turning to the **use and value of growth charts**.

We then examined the **factors affecting growth and development**, before concluding with the **causes and evaluation of failure to thrive**. Having worked through this Series, you should now be able to accurately measure and interpret a child's growth and evaluate a child with growth concerns. The next Series turns to **puberty, adolescence, and over nutrition**.

Glossary of Terms

11. **Frankfurt plane:** a standardised horizontal head position used during height and length measurement.
12. **Mid-upper arm circumference:** a simple anthropometric measurement used to screen for acute malnutrition.
13. **WHO Child Growth Standards:** the widely used international reference standards for plotting child growth.
14. **Weight-for-height:** a growth chart parameter reflecting acute nutritional status, independent of age.
15. **Height-for-age:** a growth chart parameter reflecting chronic nutritional status, or stunting.

16. **Growth velocity:** the rate of change in a growth parameter over time, assessed through serial measurements.
17. **Failure to thrive:** a pattern of inadequate weight gain or weight loss in an infant or young child.
18. **Organic failure to thrive:** failure to thrive resulting from an identifiable underlying medical condition.
19. **Non-organic failure to thrive:** failure to thrive resulting predominantly from environmental or caregiving factors.
20. **Psychosocial deprivation:** inadequate caregiver responsiveness or stimulation that can impair growth and development.
21. **Percentile:** a value indicating how a measurement compares with a reference population of children of the same age and sex.
22. **Stadiometer:** a device used to measure standing height in children capable of standing independently.

Concept Check Questions [Series 4]

Objective questions

1. The scale should be _____ before each weight measurement.
2. Mid-upper arm circumference is measured at the midpoint between the acromion and the _____.
3. Weight-for-height more specifically reflects _____ nutritional status.
4. Genetic factors, reflected in parental heights, establish a child's underlying growth _____.
5. Failure to thrive is traditionally classified into organic, non-organic, and _____ categories.

Short-answer questions

6. Describe the correct technique for measuring length in an infant.
7. Explain why MUAC is a valuable screening tool in resource-limited settings.
8. Distinguish weight-for-age from weight-for-height in terms of what each reflects.
9. Define psychosocial, or non-organic, failure to thrive.
10. List two organic causes of failure to thrive by mechanism.

Long-answer questions

11. Discuss the technique of measuring weight, length, and height in children. (Linked to SLO 4.1, SLO 4.2)
12. Discuss the technique of measuring head circumference and mid-upper arm circumference, and common measurement errors. (Linked to SLO 4.3, SLO 4.4)
13. Discuss the types, use, and interpretation of growth charts. (Linked to SLO 4.5, SLO 4.6)
14. Discuss the genetic, biological, environmental, and psychosocial factors affecting growth and development. (Linked to SLO 4.7, SLO 4.8)
15. Discuss the classification, causes, and evaluation of failure to thrive. (Linked to SLO 4.9, SLO 4.10)

Answers to Concept Check Questions [Series 4]

Objective questions

1. Zeroed.
2. Olecranon.
3. Acute.
4. Potential.
5. Mixed.

Short-answer questions

6. The infant lies supine on a length board, with one examiner holding the head and the other straightening the legs and positioning the footboard.
7. MUAC requires minimal equipment, is quick to perform, and correlates well with mortality risk.
8. Weight-for-age reflects combined recent and longer-term status; weight-for-height reflects acute status independent of age.
9. Failure to thrive resulting predominantly from environmental or caregiving factors without an identifiable organic cause.
10. Inadequate intake and inadequate absorption are examples of organic causes by mechanism.

Long-answer questions

11. **Basic response:** Weight is measured on a calibrated scale, length on a length board with two examiners, and height on a stadiometer with correct Frankfurt plane positioning.

Value-added response: Consistent technique and equipment calibration are essential to obtain accurate, reproducible measurements suitable for tracking growth over time.

12. **Basic response:** Head circumference is measured with a non-stretchable tape at the widest point, and MUAC at the midpoint of the upper arm, both requiring careful technique to avoid error.

Value-added response: Common errors include poor equipment calibration, incorrect positioning, and transcription mistakes, minimised through training and double-checking unusual results.

13. **Basic response:** Growth charts include weight-for-age, weight-for-height, height-for-age, and head circumference-for-age, each reflecting different aspects of nutritional or growth status.

Value-added response: Serial plotting to assess growth trajectory is more informative than a single measurement, with downward percentile crossing being a particularly concerning finding.

14. **Basic response:** Growth is influenced by genetic potential, hormonal function, nutrition, and environmental factors including sanitation and infection burden.

Value-added response: Psychosocial factors, including caregiver responsiveness, can also significantly affect growth, sometimes producing non-organic failure to thrive.

15. **Basic response:** Failure to thrive is classified as organic, non-organic, or mixed, identified through inadequate weight gain or downward percentile crossing on serial measurements.

Value-added response: Evaluation combines detailed history, examination, and targeted investigation guided by specific findings rather than indiscriminate testing.

Answers to Pilot Questions [Series 4]

Part 4.1

1. Weigh the child undressed or in minimal clothing on a calibrated, appropriately sized scale.
2. Zeroing ensures the recorded weight reflects only the child, not any residual reading.
3. One examiner holds the head against the headboard while the other straightens the legs and positions the footboard.
4. The child stands barefoot with heels together, back straight, in the Frankfurt plane, against a stadiometer.
5. The Frankfurt plane is a horizontal line from the eye to the ear canal, ensuring standardised head position.

Part 4.2

1. Head circumference is measured with a non-stretchable tape around the widest point of the head.
2. The largest reading most accurately reflects the true maximum head circumference.
3. MUAC is measured at the midpoint between the acromion and olecranon on the relaxed left arm.
4. It requires minimal equipment, is quick, and correlates well with mortality risk.
5. Poor equipment calibration and incorrect positioning are common errors, minimised through training and calibration.

Part 4.3

1. Weight-for-age, weight-for-height, height-for-age, and head circumference-for-age are main chart types.
2. Weight-for-age reflects combined status; weight-for-height reflects acute status independent of age.
3. Serial measurements show growth trajectory, which is more informative than a single point in time.
4. Downward percentile crossing suggests flattening or reversal of expected growth, warranting evaluation.
5. Growth charts do not diagnose an underlying cause and must be interpreted alongside clinical evaluation.

Part 4.4

- Genetic potential, hormonal function, and intrauterine factors are genetic or biological factors.
- Recurrent infection increases metabolic demand and can impair nutrient absorption.
- Household income and parental education are socioeconomic factors influencing growth.
- Psychosocial failure to thrive is growth failure predominantly due to environmental or caregiving factors.
- A holistic assessment ensures psychosocial and biological contributors are both considered.

Part 4.5

1. Failure to thrive is inadequate weight gain, identified by measurements below a threshold or downward percentile crossing.
2. Organic failure to thrive has an identifiable medical cause; non-organic relates to environmental or caregiving factors.
3. Inadequate intake and increased metabolic demand are organic causes by mechanism.
4. Insufficient food availability and psychosocial adversity are non-organic contributing factors.
5. Evaluation combines detailed history, examination, growth chart review, and targeted investigation.

References and Attributions [Series 4]

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- Jaffe, A. C. (2011). Failure to thrive: current clinical concepts. Pediatrics in Review, 32(3), 100 to 108.

Figures, Plates, Tables, and Boxes

- Figure 4.1: A healthcare worker weighing an infant on an electronic infant scale. AI-generated using the prompt: "A realistic clinical illustration of a healthcare worker gently placing a calm infant onto a flat electronic infant scale in a clinic setting, with a caregiver standing supportively nearby. Single clean medical illustration, soft clinical lighting, no text overlays, no multiple panels, respectful and accurate depiction."
- Figure 4.2: A healthcare worker measuring a child's mid-upper arm circumference with a MUAC tape. AI-generated using the prompt: "A realistic clinical illustration of a healthcare worker gently wrapping a coloured MUAC measuring tape around a young child's upper arm in a community clinic setting. Single clean medical illustration, soft clinical lighting, no text overlays, no multiple panels, respectful and accurate depiction."
- Table 4.3: Common types of growth charts and their primary clinical use. AI-generated using the prompt: "Create a clean reference table titled Common Types of Growth Charts and Their Clinical Use, listing chart type and primary clinical use. Simple clinical reference table style with outside border."
- Figure 4.4: A caregiver engaging warmly and responsively with a young child. AI-generated using the prompt: "A warm, realistic illustration of a caregiver sitting on the floor playing gently with a young child using simple toys, both smiling, in a modest, homely room. Single clean illustration, soft natural lighting, no text overlays, no multiple panels, tender and accurate depiction."
- Figure 4.5: A clinician reviewing a child's growth chart with a caregiver during a failure to thrive evaluation. AI-generated using the prompt: "A realistic clinical illustration of a clinician and a caregiver sitting together at a desk, looking at a growth chart on paper, with a young child seated nearby. Single clean medical illustration, soft clinical lighting, no text overlays, no multiple panels, respectful and accurate depiction."

Course code: PAE 502

Course title: Nutrition, Growth and Development

Course credit load: 3 Units

Series 5: Puberty, Adolescence, and Over Nutrition

1. **Part 5.1: Physiology of Puberty**
    1. Sub Part 5.1.1: The hormonal basis of puberty
    2. Sub Part 5.1.2: Normal timing and sequence of puberty
    3. Sub Part 5.1.3: Staging of pubertal development
2. **Part 5.2: Pubertal Disorders: Precocious and Delayed Puberty**
    1. Sub Part 5.2.1: Definition and classification of precocious puberty
    2. Sub Part 5.2.2: Evaluation and management of precocious puberty
    3. Sub Part 5.2.3: Delayed puberty
3. **Part 5.3: Adolescence and Its Problems**
    1. Sub Part 5.3.1: Physical and psychological changes of adolescence
    2. Sub Part 5.3.2: Risk-taking behaviour and health concerns in adolescence
    3. Sub Part 5.3.3: Approaching adolescent healthcare
4. **Part 5.4: Over Nutrition: Definition and Assessment**
    1. Sub Part 5.4.1: Defining overweight and obesity in children
    2. Sub Part 5.4.2: Epidemiology and causes of over nutrition
    3. Sub Part 5.4.3: Clinical assessment of over nutrition
5. **Part 5.5: Associated Problems of Over Nutrition and Management**
    1. Sub Part 5.5.1: Metabolic and cardiovascular complications of over nutrition
    2. Sub Part 5.5.2: Other associated problems of over nutrition
    3. Sub Part 5.5.3: Prevention and management of over nutrition

Introduction

In the last Series, we explored anthropometry, growth charts, and factors affecting growth, including failure to thrive. We now turn to the opposite end of the growth and nutrition spectrum in some respects, beginning with puberty and adolescence, and concluding this course with over nutrition. Picture a twelve year old girl anxious about breast development appearing earlier than her classmates, alongside a ten year old boy whose weight has been steadily climbing well above the healthy range on his growth chart. Understanding normal puberty, its disorders, the broader challenges of adolescence, and the growing problem of childhood over nutrition, is the focus of this final Series of the course.

The aim of this Series is to equip you with the knowledge required to understand normal puberty and its disorders, recognise the challenges of adolescence, and assess and manage over nutrition and its associated problems.

This Series begins with the **physiology of puberty**, before turning to **pubertal disorders**, specifically precocious and delayed puberty. Next, we examine **adolescence and its problems**, then the **definition and assessment of over nutrition**, before concluding with its **associated problems and management**.

Series Learning Outcomes

At the end of this Series, you should be able to:

6. **SLO 1.1:** describe the physiology and normal timing of puberty,
7. **SLO 1.2:** describe the staging of normal pubertal development,
8. **SLO 1.3:** define and describe precocious puberty,
9. **SLO 1.4:** define and describe delayed puberty,
10. **SLO 1.5:** describe the physical, psychological, and social problems of adolescence,
11. **SLO 1.6:** describe risk-taking behaviours and health concerns relevant to adolescence,
12. **SLO 1.7:** define overweight and obesity in children,
13. **SLO 1.8:** describe the assessment of over nutrition,
14. **SLO 1.9:** describe the associated problems of over nutrition, and
15. **SLO 1.10:** describe the prevention and management of over nutrition.

5.1 Physiology of Puberty

5.1.1 the hormonal basis of puberty

A dormant axis reawakens to trigger puberty

Puberty is initiated by **reactivation** of the **hypothalamic-pituitary-gonadal axis**, which is active during early fetal life and infancy but becomes relatively **quiescent** during mid-childhood, until, at the onset of puberty, the **hypothalamus** begins pulsatile secretion of **gonadotropin-releasing hormone**, stimulating the **pituitary gland** to secrete **luteinising hormone** and **follicle-stimulating hormone**, which in turn stimulate the **gonads** to produce **sex steroids**.

The precise **trigger** for reactivation of this axis remains incompletely understood, though it involves complex interactions between **genetic**, **nutritional**, and **environmental** factors, and the resulting rise in sex steroids, **oestrogen** in females and **testosterone** in males, drives the physical changes of puberty, together with the **pubertal growth spurt** and eventual **epiphyseal closure**, which brings linear growth to an end.

Fill in the blank: Puberty is initiated by reactivation of the hypothalamic-pituitary-_____ axis.

5.1.2 normal timing and sequence of puberty

In **girls**, puberty typically begins between **8 and 13 years** of age, with **breast development**, or **thelarche**, generally the first visible sign, followed by **pubic hair development**, or **pubarche**, and, later, **menarche**, the onset of menstruation, occurring on average around **2 to 2.5 years** after the onset of breast development, with the pubertal growth spurt occurring relatively **early** in the sequence.

In **boys**, puberty typically begins somewhat later, between **9 and 14 years** of age, with **testicular enlargement** generally the first visible sign, followed by **pubic hair development**, **penile growth**, and **voice deepening**, with the pubertal growth spurt occurring relatively **later** in the sequence than in girls, contributing to the characteristic difference in average timing of peak height velocity between the sexes.

Fill in the blank: Puberty in girls typically begins between 8 and _____ years of age.

5.1.3 staging of pubertal development

Tanner staging, the standard clinical system for describing pubertal development, classifies **breast development** and **genital development** into **five stages**, from Stage 1, representing the pre-pubertal state, to Stage 5, representing full adult development, with **pubic hair development** staged separately using a parallel five-stage system, allowing a standardised, structured description of an individual child's pubertal progress.

Tanner staging is clinically valuable for **monitoring** the normal progression of puberty over time, for identifying **precocious** or **delayed** puberty, discussed in the next Part of this Series, when staging falls outside the expected age range, and for correlating physical development with other clinical parameters, such as **bone age** and **growth velocity**, providing an objective, reproducible framework for pubertal assessment.

Fill in the blank: Tanner staging classifies breast and genital development into _____ stages.

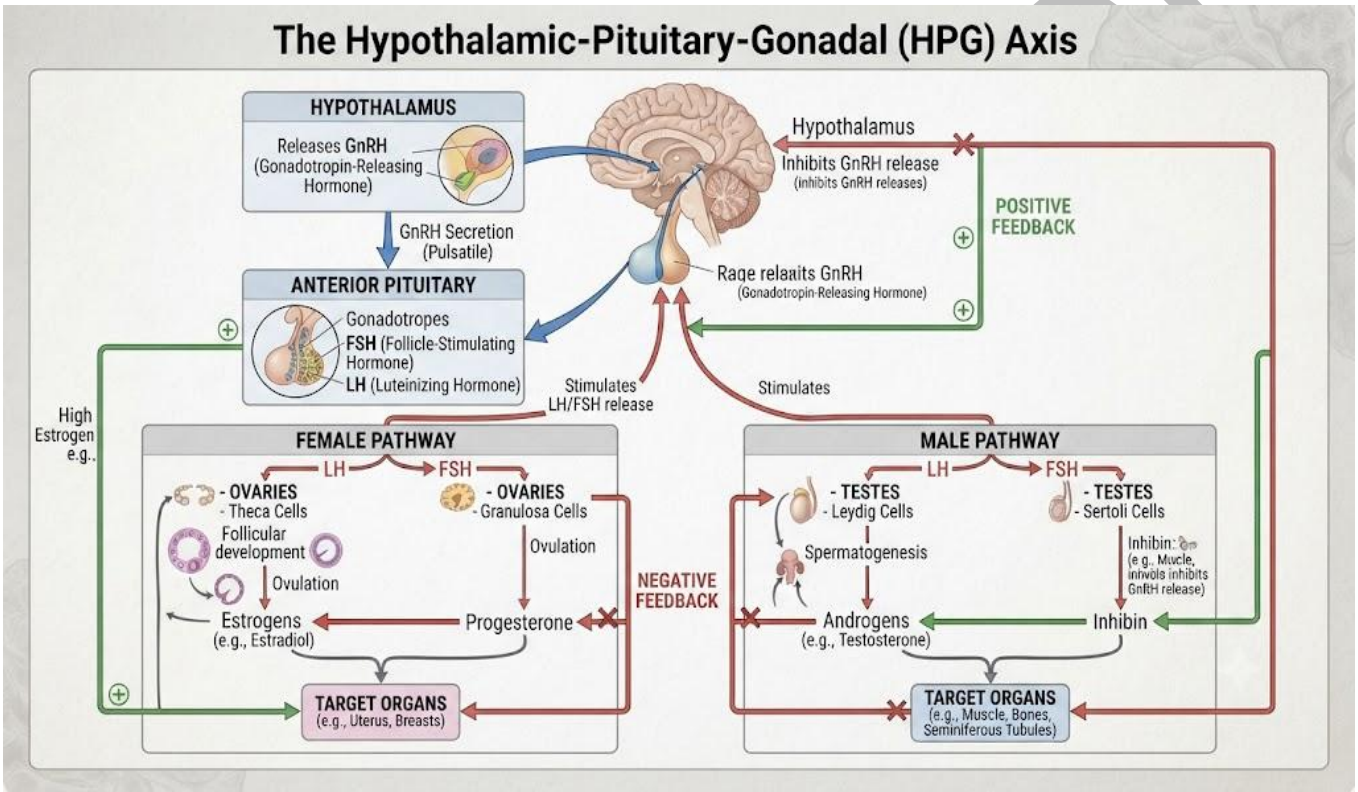

Figure 5.1: The hypothalamic-pituitary-gonadal axis that drives puberty.

Pilot questions 5.1

1. Describe the hormonal axis responsible for initiating puberty. (Linked to SLO 5.1)
2. Describe the normal sequence and timing of puberty in girls. (Linked to SLO 5.2)
3. Describe the normal sequence and timing of puberty in boys. (Linked to SLO 5.2)
4. Describe the Tanner staging system. (Linked to SLO 5.2)
5. Explain the clinical value of Tanner staging. (Linked to SLO 5.2)

5.2 Pubertal Disorders: Precocious and Delayed Puberty

5.2.1 definition and classification of precocious puberty

Timing, not just presence, defines the abnormality

Precocious puberty is generally defined as the onset of pubertal changes before **8 years** of age in girls or **9 years** of age in boys, and is classified into **central**, or **gonadotropin-dependent**, precocious puberty, resulting from premature activation of the normal hypothalamic-pituitary-gonadal axis, and **peripheral**, or **gonadotropin-independent**, precocious puberty, resulting from an independent source of sex steroid production not driven by the normal axis.

Central precocious puberty is more common in **girls**, and in the majority of affected girls no specific underlying cause is identified, termed **idiopathic**, while in **boys**, central precocious puberty more frequently has an identifiable underlying cause, such as a **central nervous system lesion**, meaning the likelihood of finding a specific underlying cause differs meaningfully by sex, influencing the intensity of investigation typically pursued.

Fill in the blank: Precocious puberty is generally defined as onset before 8 years in girls or _____ years in boys.

5.2.2 evaluation and management of precocious puberty

Evaluation of suspected precocious puberty includes **Tanner staging**, **bone age assessment**, since advanced bone age relative to chronological age is characteristic, **hormonal testing**, including **basal** and, where indicated, **stimulated gonadotropin levels**, and, where central precocious puberty is confirmed, **brain imaging**, particularly in boys, given the higher likelihood of an identifiable central nervous system cause in this group.

Management of **central precocious puberty** typically uses **gonadotropin-releasing hormone agonist** therapy, which paradoxically suppresses the axis with continuous, rather than pulsatile, stimulation, halting further pubertal progression, while management of **peripheral precocious puberty** is directed at the specific underlying cause, since GnRH agonist therapy is not effective when the axis itself is not the source of the abnormal sex steroid production.

Fill in the blank: Management of central precocious puberty typically uses gonadotropin-releasing hormone _____ therapy.

5.2.3 delayed puberty

Delayed puberty is generally defined as the absence of any pubertal changes by **13 years** of age in girls or **14 years** of age in boys, and, like precocious puberty, is classified by underlying mechanism, including **constitutional delay of growth and puberty**, the most common cause, representing a normal variant in which puberty simply begins later than average, often with a **family history** of similarly delayed puberty in a parent.

Other causes of delayed puberty include **hypogonadotropic hypogonadism**, resulting from inadequate pituitary gonadotropin secretion, and **hypergonadotropic hypogonadism**, resulting from primary gonadal failure, such as in **Turner** or **Klinefelter syndrome**, discussed in an earlier course, with evaluation and management guided by identifying the specific underlying category and cause, and constitutional delay generally requiring reassurance and observation rather than active intervention.

Fill in the blank: The most common cause of delayed puberty is constitutional delay of growth and _____.

Table 5.2: Comparing precocious and delayed puberty.

Feature	Precocious puberty	Delayed puberty
Definition threshold (girls)	Onset before 8 years	No pubertal changes by 13 years
Definition threshold (boys)	Onset before 9 years	No pubertal changes by 14 years
Most common cause	Idiopathic central precocious puberty (girls)	Constitutional delay of growth and puberty
Key investigation	Bone age, gonadotropin levels	Bone age, gonadotropin levels, family history

Pilot questions 5.2

- Define precocious puberty and distinguish central from peripheral precocious puberty. (Linked to SLO 5.3)
- Describe the evaluation of a child with suspected precocious puberty. (Linked to SLO 5.3)
- Describe the management of central precocious puberty. (Linked to SLO 5.3)
- Define delayed puberty. (Linked to SLO 5.4)
- Describe constitutional delay of growth and puberty. (Linked to SLO 5.4)

5.3 Adolescence and Its Problems

5.3.1 physical and psychological changes of adolescence

A period of rapid change across every domain

Adolescence is a period of significant **physical**, **psychological**, and **social** transition, encompassing the physical changes of puberty already discussed, together with ongoing **cognitive development**, including increasing capacity for **abstract thinking** and **future planning**, and significant **psychological development**, including the emerging formation of **personal identity** and increasing **independence** from parents and family.

This period of rapid change can bring genuine **psychological challenges**, including heightened **self-consciousness** about physical appearance and pubertal timing relative to peers, increased vulnerability to **mood disturbance**, and significant sensitivity to **peer relationships** and **social acceptance**, meaning healthcare providers working with adolescents should approach this age group with particular sensitivity to these normal, but sometimes intense, developmental pressures.

Fill in the blank: Adolescence involves increasing capacity for abstract thinking and future _____.

5.3.2 risk-taking behaviour and health concerns in adolescence

Risk-taking behaviour is a recognised, if concerning, feature of adolescence, reflecting a combination of ongoing **neurodevelopmental maturation**, particularly of brain regions governing **impulse control**, and strong **peer influence**, and can manifest as experimentation with **substance use**, including alcohol and tobacco, **risky sexual behaviour**, and other behaviours carrying genuine potential for immediate or longer-term harm.

Common **health concerns** in adolescence include **mental health conditions**, particularly **depression** and **anxiety**, which frequently first emerge or become clinically apparent during this period, **eating disorders**, and **unintentional injury**, including road traffic accidents, which remains a leading cause of death in this age group globally, meaning adolescent healthcare should routinely and proactively address these areas rather than focusing solely on physical health concerns.

Fill in the blank: Unintentional injury, including road traffic accidents, remains a leading cause of _____ in adolescence globally.

5.3.3 approaching adolescent healthcare

Effective engagement with adolescents in a healthcare setting requires attention to **confidentiality**, within appropriate, clearly explained limits, since adolescents are more likely to disclose sensitive information, such as substance use or sexual activity, when they trust that this information will generally be kept private, and a **respectful, non-judgemental approach**, treating the adolescent as an increasingly independent, capable individual rather than solely through their parent or caregiver.

HEADSS and similar structured psychosocial assessment frameworks, covering Home, Education and employment, Activities, Drugs, Sexuality, and Suicide or depression, provide a systematic approach to identifying relevant risk factors and health concerns during an adolescent consultation, helping ensure important areas are not inadvertently overlooked during a routine visit that might otherwise focus predominantly on a specific presenting physical complaint.

Fill in the blank: The HEADSS framework provides a structured approach to adolescent _____ assessment.

Figure 5.3: A clinician having a confidential, supportive conversation with an adolescent.

Pilot questions 5.3

1. Describe the physical and psychological changes characteristic of adolescence. (Linked to SLO 5.5)
2. Explain the neurodevelopmental basis of risk-taking behaviour in adolescence. (Linked to SLO 5.6)
3. List three common health concerns in adolescence. (Linked to SLO 5.6)
4. Explain why confidentiality is particularly important in adolescent healthcare. (Linked to SLO 5.6)
5. Describe the HEADSS framework and its purpose. (Linked to SLO 5.6)

5.4 Over Nutrition: Definition and Assessment

5.4.1 defining overweight and obesity in children

Definitions rely on age- and sex-specific reference standards

Over nutrition refers to an excess of nutrient intake relative to requirements, most commonly manifesting as **overweight** or **obesity**, and, unlike in adults, where fixed **body mass index**, or **BMI**, thresholds are used, children's BMI must be interpreted using **age- and sex-specific reference charts**, since a healthy BMI value changes considerably with age throughout childhood.

Overweight in children is generally defined as a BMI-for-age at or above the **85th percentile**, and **obesity** as a BMI-for-age at or above the **95th percentile**, using appropriate national or international reference standards, with **severe obesity**, defined using even higher thresholds, associated with a correspondingly greater risk of the specific complications discussed later in this Series.

Fill in the blank: Overweight in children is generally defined as a BMI-for-age at or above the _____ percentile.

5.4.2 epidemiology and causes of over nutrition

The **prevalence** of childhood overweight and obesity has been rising in many parts of the world, including urban areas of Nigeria, reflecting broader societal shifts towards **energy-dense, nutrient-poor diets**, reduced **physical activity**, and increasingly **sedentary lifestyles**, including

increased **screen time**, alongside genetic and, in a minority of cases, specific medical or endocrine contributors.

While a small proportion of childhood obesity results from an identifiable underlying **medical cause**, such as certain genetic syndromes or endocrine disorders, the great majority of cases are attributable to a sustained **energy imbalance**, in which habitual energy intake exceeds energy expenditure over time, reflecting the complex interplay of individual, family, and broader environmental factors that influence a child's diet and activity patterns.

Fill in the blank: The great majority of childhood obesity cases are attributable to a sustained energy _____.

5.4.3 clinical assessment of over nutrition

Assessment of a child with suspected over nutrition should include accurate **anthropometric measurement**, as discussed in the previous Series, with BMI plotted on an appropriate **age- and sex-specific chart**, together with a detailed **dietary history**, assessment of **physical activity** levels and **screen time**, and a **family history** of obesity and related conditions such as type 2 diabetes and cardiovascular disease.

Clinical examination should also actively screen for **signs of an underlying medical cause** in atypical presentations, such as significant **short stature** alongside obesity, which is unusual in simple over nutrition and instead suggests an endocrine or genetic cause warranting further evaluation, together with screening for early **complications** of obesity, discussed in detail in the final Part of this Series.

Fill in the blank: Significant short stature alongside obesity is unusual in simple over nutrition and suggests an underlying _____ or genetic cause.

Figure 5.4: A clinician measuring a child's height and weight to assess BMI.

Pilot questions 5.4

6. Define overweight and obesity in children using BMI percentile thresholds. (Linked to SLO 5.7)
7. Explain why fixed adult BMI thresholds cannot be used in children. (Linked to SLO 5.7)
8. Describe the general causes of the rising prevalence of childhood obesity. (Linked to SLO 5.8)
9. Describe the key components of clinical assessment of a child with suspected over nutrition. (Linked to SLO 5.8)
10. Explain why short stature alongside obesity is a concerning finding. (Linked to SLO 5.8)

5.5 Associated Problems of Over Nutrition and Management

5.5.1 metabolic and cardiovascular complications of over nutrition

Consequences that once seemed exclusive to adulthood

Childhood obesity is associated with an increased risk of **insulin resistance** and, in some children, established **type 2 diabetes**, discussed in an earlier course, together with **dyslipidaemia** and **hypertension**, both important, modifiable risk factors for later **cardiovascular disease**, meaning the metabolic consequences of childhood obesity are not confined to childhood itself but carry significant implications for long-term adult health.

Non-alcoholic fatty liver disease is an increasingly recognised complication of childhood obesity, reflecting fat accumulation within the liver, and can progress, in a proportion of affected children, to more significant liver inflammation and, rarely, fibrosis over time, underscoring the genuinely wide-ranging metabolic impact of sustained over nutrition beyond the more immediately visible physical changes.

Fill in the blank: Non-alcoholic fatty _____ disease is an increasingly recognised complication of childhood obesity.

5.5.2 other associated problems of over nutrition

Beyond metabolic complications, childhood obesity is associated with **orthopaedic problems**, including **slipped capital femoral epiphysis** and **genu valgum**, or knock knees, reflecting the mechanical burden of excess weight on the developing skeleton, and **obstructive sleep apnoea**, resulting from soft tissue narrowing of the upper airway, which can itself further impair growth and behaviour if unrecognised.

Significant **psychosocial consequences** are also common, including **low self-esteem**, **social stigma** and **bullying**, and increased risk of **depression** and **anxiety**, meaning the impact of childhood obesity extends well beyond physical health alone, and management, discussed in the next sub-Part, should always address these psychosocial dimensions alongside the physical and metabolic aspects of the condition.

Fill in the blank: Obstructive sleep apnoea in obese children results from soft tissue narrowing of the upper _____.

5.5.3 prevention and management of over nutrition

Management of childhood over nutrition centres on **family-based lifestyle intervention**, addressing **dietary quality**, reducing intake of energy-dense, nutrient-poor foods, increasing **physical activity**, and reducing **sedentary behaviour**, including screen time, with the whole family, rather than the child in isolation, generally engaged in these changes to support sustainable behaviour change and avoid singling out or stigmatising the affected child.

Prevention at a population level includes public health measures promoting **healthy school food environments**, **safe spaces for physical activity**, and broader public awareness of healthy eating and activity patterns, and, for children with significant complications or severe obesity not responding to lifestyle measures alone, referral to **specialist paediatric obesity services** may be appropriate, though this represents a small minority of cases overall, with family-based lifestyle change remaining the foundation of management for the great majority of affected children.

Fill in the blank: Management of childhood over nutrition centres on _____-based lifestyle intervention.

Figure 5.5: A family enjoying an active outdoor game together.

Pilot questions 5.5

11. List two metabolic complications of childhood obesity. (Linked to SLO 5.9)
12. Describe non-alcoholic fatty liver disease as a complication of childhood obesity. (Linked to SLO 5.9)
13. List two orthopaedic or respiratory complications of childhood obesity. (Linked to SLO 5.9)
14. Describe the psychosocial consequences of childhood obesity. (Linked to SLO 5.9)
15. Describe the general approach to management and prevention of childhood over nutrition. (Linked to SLO 5.10)

Series Summary

This Series examined the **physiology of puberty** and its normal timing and staging, before turning to **precocious and delayed puberty**.

We then examined **adolescence and its associated problems**, before turning to the **definition and assessment of over nutrition**, and concluding with its **associated problems and management**. Having worked through this Series, and indeed this course, you should now be equipped with a comprehensive understanding of normal growth and development, nutrition, and the common disorders affecting children across these areas.

Glossary of Terms

1. **Hypothalamic-pituitary-gonadal axis:** the hormonal axis whose reactivation initiates puberty.
2. **Tanner staging:** the standard clinical system for describing pubertal development in five stages.
3. **Thelarche:** the onset of breast development, typically the first visible sign of puberty in girls.
4. **Menarche:** the onset of menstruation.
5. **Precocious puberty:** onset of pubertal changes before 8 years in girls or 9 years in boys.
6. **Constitutional delay of growth and puberty:** the most common cause of delayed puberty, representing a normal variant.
7. **HEADSS:** a structured psychosocial assessment framework used in adolescent healthcare.
8. **Overweight:** a BMI-for-age at or above the 85th percentile in children.
9. **Obesity:** a BMI-for-age at or above the 95th percentile in children.
10. **Non-alcoholic fatty liver disease:** fat accumulation within the liver, an increasingly recognised complication of childhood obesity.
11. **Slipped capital femoral epiphysis:** an orthopaedic complication of childhood obesity affecting the hip joint.
12. **Obstructive sleep apnoea:** upper airway narrowing during sleep, a complication associated with childhood obesity.

Concept Check Questions [Series 5]

Objective questions

6. Puberty is initiated by reactivation of the hypothalamic-pituitary-_____ axis.
7. Precocious puberty is generally defined as onset before 8 years in girls or _____ years in boys.
8. The most common cause of delayed puberty is constitutional delay of growth and _____.
9. Overweight in children is generally defined as a BMI-for-age at or above the _____ percentile.
10. Non-alcoholic fatty _____ disease is an increasingly recognised complication of childhood obesity.

Short-answer questions

11. Describe the normal sequence and timing of puberty in girls.
12. Describe the Tanner staging system.
13. Describe constitutional delay of growth and puberty.
14. List three common health concerns in adolescence.
15. List two orthopaedic or respiratory complications of childhood obesity.

Long-answer questions

1. Discuss the physiology, timing, and staging of normal puberty. (Linked to SLO 5.1, SLO 5.2)
2. Discuss the definition, evaluation, and management of precocious and delayed puberty. (Linked to SLO 5.3, SLO 5.4)
3. Discuss the physical, psychological, and social problems of adolescence, and the approach to adolescent healthcare. (Linked to SLO 5.5, SLO 5.6)
4. Discuss the definition, causes, and assessment of over nutrition in children. (Linked to SLO 5.7, SLO 5.8)
5. Discuss the associated problems and management of childhood over nutrition. (Linked to SLO 5.9, SLO 5.10)

Answers to Concept Check Questions [Series 5]

Objective questions

1. Gonadal.
2. 9.
3. Puberty.
4. 85th.
5. Liver.

Short-answer questions

6. Breast development first, followed by pubic hair development, then menarche around 2 to 2.5 years later.
7. Tanner staging classifies breast and genital development, and pubic hair development, into five stages.
8. A normal variant in which puberty begins later than average, often with a family history, requiring reassurance rather than intervention.
9. Depression and anxiety, eating disorders, and unintentional injury are common health concerns.
10. Slipped capital femoral epiphysis and obstructive sleep apnoea are orthopaedic and respiratory complications.

Long-answer questions

11. **Basic response:** Puberty is initiated by reactivation of the hypothalamic-pituitary-gonadal axis, with characteristic sequences and timing differing between girls and boys, staged using the Tanner system.

Value-added response: Tanner staging allows objective monitoring of pubertal progress and correlation with bone age and growth velocity.

12. **Basic response:** Precocious puberty is classified as central or peripheral, evaluated with staging, bone age, and hormonal testing, and managed with GnRH agonist therapy for central cases.

Value-added response: Delayed puberty is most commonly constitutional, but hypogonadotropic and hypergonadotropic hypogonadism must also be considered based on the clinical picture.

13. **Basic response:** Adolescence involves significant physical, cognitive, and psychological change, with risk-taking behaviour reflecting neurodevelopmental maturation and peer influence.

Value-added response: Confidentiality and a structured framework such as HEADSS support effective, sensitive engagement with adolescent patients across key areas of concern.

14. **Basic response:** Over nutrition is defined using age- and sex-specific BMI percentiles, generally resulting from sustained energy imbalance, assessed through anthropometry and history.

Value-added response: Atypical features such as short stature alongside obesity should prompt evaluation for an underlying medical cause rather than assuming simple over nutrition.

15. **Basic response:** Childhood obesity is associated with metabolic, orthopaedic, respiratory, and psychosocial complications, managed through family-based lifestyle intervention.

Value-added response: Population-level prevention strategies and, in select severe cases, specialist referral complement family-based management as the foundation of care.

Answers to Pilot Questions [Series 5]

Part 5.1

1. The hypothalamic-pituitary-gonadal axis, through GnRH, LH, and FSH, drives puberty.
2. Breast development occurs first, followed by pubic hair development, then menarche around 2 to 2.5 years later.
3. Testicular enlargement occurs first, followed by pubic hair development, penile growth, and voice deepening.
4. Tanner staging classifies breast and genital development into five stages, with pubic hair staged separately.
5. It allows standardised monitoring of pubertal progress and correlation with bone age and growth.

Part 5.2

1. Precocious puberty is onset before 8 years (girls) or 9 years (boys); central involves the normal axis, peripheral does not.
2. Evaluation includes Tanner staging, bone age, hormonal testing, and imaging where indicated.
3. GnRH agonist therapy is used to suppress the axis and halt further pubertal progression.
4. Delayed puberty is absence of pubertal changes by 13 years (girls) or 14 years (boys).
5. It is a normal variant where puberty begins later than average, often with a family history.

Part 5.3

- Puberty, cognitive development, identity formation, and increasing independence characterise adolescence.
- Ongoing maturation of impulse control brain regions combined with strong peer influence drives risk-taking.
- Mental health conditions, eating disorders, and unintentional injury are common health concerns.
- Adolescents disclose sensitive information more readily when they trust it will be kept confidential.
- HEADSS structures assessment across Home, Education, Activities, Drugs, Sexuality, and Suicide/depression.

Part 5.4

- Overweight is BMI-for-age at or above the 85th percentile; obesity is at or above the 95th percentile.
- A healthy BMI value changes considerably with age throughout childhood, unlike in adults.
- Energy-dense diets, reduced physical activity, and increased screen time contribute to rising prevalence.
- Anthropometric measurement, dietary history, activity assessment, and family history are key components.
- It is unusual in simple over nutrition and suggests an underlying endocrine or genetic cause.

Part 5.5

1. Insulin resistance and dyslipidaemia are metabolic complications of childhood obesity.
2. Fat accumulation within the liver, which can progress to inflammation and, rarely, fibrosis.

3. Slipped capital femoral epiphysis and obstructive sleep apnoea are examples.
4. Low self-esteem, social stigma, bullying, and increased risk of depression and anxiety.
5. Family-based lifestyle intervention addressing diet and activity, with specialist referral for severe cases.

References and Attributions [Series 5]

- Kliegman, R. M., St Geme, J. W., Blum, N. J., Shah, S. S., Tasker, R. C. and Wilson, K. M. (2020). Nelson Textbook of Pediatrics (21st ed.). Elsevier.
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- World Health Organization (2021). Adolescent Health. WHO Press.
- Styne, D. M. et al. (2017). Pediatric obesity: an Endocrine Society clinical practice guideline. Journal of Clinical Endocrinology and Metabolism, 102(3), 709 to 757.

Figures, Plates, Tables, and Boxes

- Figure 5.1: The hypothalamic-pituitary-gonadal axis that drives puberty. AI-generated using the prompt: "Create a professional educational diagram titled The Hypothalamic-Pituitary-Gonadal Axis, showing the hormonal pathway from hypothalamus to pituitary to gonads. Clean clinical educational diagram style, single illustration, no text-heavy panels."
- Table 5.2: Comparing precocious and delayed puberty. AI-generated using the prompt: "Create a clean reference table titled Precocious versus Delayed Puberty, comparing definition thresholds, common causes, and key investigations. Simple clinical reference table style with outside border."
- Figure 5.3: A clinician having a confidential, supportive conversation with an adolescent. AI-generated using the prompt: "A warm, realistic illustration of a clinician sitting across from an adolescent in a quiet consultation room, engaged in a calm, supportive conversation. Single clean medical illustration, soft natural lighting, no text overlays, no multiple panels, respectful and accurate depiction."
- Figure 5.4: A clinician measuring a child's height and weight to assess BMI. AI-generated using the prompt: "A realistic clinical illustration of a clinician measuring a

child's height against a wall-mounted stadiometer in a clinic room, with the child standing calmly. Single clean medical illustration, soft clinical lighting, no text overlays, no multiple panels, respectful and accurate depiction."

- Figure 5.5: A family enjoying an active outdoor game together. AI-generated using the prompt: "A warm, realistic illustration of a family, including a child and both parents, playing an active game together outdoors in a park, all smiling and engaged. Single clean illustration, bright natural daylight, no text overlays, no multiple panels, joyful and accurate depiction."