Hong Kong Reference Framework for Preventive Care for Children in Primary Care Settings

Module on Physical Growth

2019

基層醫療
PRIMARY CARE

Acknowledgments

The Department of Health gratefully acknowledges the invaluable support and contribution of the

Advisory Group on Hong Kong Reference Framework for Preventive Care for Children in Primary Care Settings

in the development of this Module.

The on-going updating and development of new modules under this reference framework is supported by the **Advisory Group on Hong Kong Reference Framework for Preventive Care for Children in Primary Care Settings** since 2016. The Department of Health gratefully acknowledges the invaluable support and contribution of Members of this Advisory Group.

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Content

Chapter 1. Assessment of growth parameters

1.1 Timing of assessment

Assessment of a child's growth usually involves serial measurements of weight and height throughout infancy and childhood. Growth monitoring aims at detecting either reduced or accelerated states of growth and related treatable disorders.[1]

Accurate assessment of physical growth in children is an essential element of paediatric care and the clue for further investigation of disease or nutritional intervention. Head circumference measurement, especially within the first 3 years, may identify neurologic abnormalities and malnutrition.[2,3] It should be measured in children from birth to three years old at health maintenance visits. The head circumference of older children with neurologic or developmental complaints should also be assessed at each visit. Height, weight, and body mass index (BMI) measurements reflect the child's nutritional status. Length/height and weight should be measured at each periodic well-child visit. These measurements should be compared with growth standards for the appropriate reference population.

1.2 Environment for measurement

A suitable environment should be provided for **weight and height** measurement:

- Maintain a comfortable temperature during measurement, for example, by using heater fan and radiator.
- Ensure privacy by using curtains or partitions.
- Provide proper instructions by clinic staff / signage on the ways in measurement.
- Observe safety issues:
  (i) Babies/children should never be left unattended.
  (ii) A proper size of the weight balance basket is needed to hold the baby.
- Follow infection control measures: proper cleaning of the equipment after use, proper disposal of used napkins, availability of hand washing facilities, etc.

1.3 Equipment for measuring growth parameters

1.3.1 Infant

- **Body Weight:** electronic infant weighing scale
- **Body Length:** a length board (sometimes called an infantometer) which should be placed on a flat, stable surface such as a table. It consists of a measuring tape, a fixed head-board at right angle to the tape, and a smoothly-moving foot-board perpendicular to the tape. A measuring mat can also be used. It is a portable and non-stretchable plastic roll-up mat used for measuring the supine length of an infant. It consists of measuring scale, fixed head piece and sliding foot positioner. It gives the accuracy to the nearest 0.5 cm.
- **Head Circumference:** measuring tape

1.3.2 Children

- **Body Weight:** calibrated beam balance or electronic scale. Avoid using bathroom scales that are spring-loaded because they tend to be unreliable.
- **Body Height:** stadiometer (height measurer)/measuring rod. A stadiometer consists of a vertical board with an attached metric ruler with an easily moveable horizontal headboard that can be brought into contact with the most superior part of the head.

1.4 Techniques of measurement

1.4.1 Supine Length[4,5]

World Health Organization (WHO) recommends measuring the recumbent length if a child is less than 2 years old.

Procedures

- The measurement should be carried out with the clinic assistant or the caretaker.
- Check that the child's shoes, socks, and hair ornaments have been removed. Undo braids if they will interfere with the measurement.
- Cover the length board with a thin cloth or soft paper for hygiene and for the child's comfort.
- Ask the caretaker to lay the child on his back with his head against the fixed headboard. Align the child's head snugly against the top bar of the frame. Quickly position the head so that an imaginary vertical line from the ear canal

to the lower border of the eye socket is perpendicular to the board. (The child's eyes should be looking straight up.) Ask the caretaker to move behind the headboard and hold the head in this position.

- Check that the child lies straight along the board and does not change position. Shoulders should touch the board, and the spine should not be arched.
- Hold down the child's legs with one hand and move the footboard with the other. Apply gentle pressure to the knees to straighten the legs as far as they can go without causing injury. (*Note: it is not possible to straighten the knees of newborns to the same degree as older children. Their knees are fragile and could be injured easily, so apply minimum pressure.)*

  If a child is extremely agitated or failing to be calmed down, and both legs cannot be held in position, measure with one leg in position.
- While holding the knees, pull the footboard against the child's feet. The soles of the feet should be flat against the footboard, toes pointing upwards. If the child bends the toes and prevents the footboard from touching the soles, scratch the soles slightly and slide in the footboard quickly when the child straightens the toes.
- The length should be measured to the nearest 0.1 cm for research purpose, but accuracy to the nearest 0.5cm is adequate for general use.[6]
- Plot length measurement on a standardized growth chart.

Other issues to note

- Ideally, the measurement should be performed three times to improve accuracy and use the average.[7]
- If the child whose length is measured at 2 years old or more, subtract 0.7 cm from the length and record the result as height in the clinical notes.

1.4.2 Standing Height[4,5,8]

Procedures

- Remove the child's shoes, bulky clothing, and hair ornaments, and unbraid hair that interferes with the measurement.
- Take the height measurement on flooring that is not carpeted and against a flat surface such as a wall with no molding.
- Have the child stand with feet flat, together, and against the wall. Make sure legs are straight, arms are at sides, and shoulders are level.
- The back of the head, shoulder blades, buttocks, calves, and heels should all touch the vertical board of the stadiometer/the wall (diagram 1). Depending on the overall body shape of the child, all points may not touch the vertical board/the wall. This alignment may be impossible for an obese child, in which

case, help the child to stand on the floor with one or more contact points touching the board. The trunk should be balanced over the waist, i.e. not leaning back or forward.

- Position the child's head so that he looks straight forward with the lower borders of the eye sockets in the same horizontal plane as the external auditory meati (i.e. Frankfurt plane) (diagram 2).
- If necessary, push gently on the tummy to help the child stand to full height.
- Align the horizontal measuring bar perpendicular to the wall and parallel to the floor. The measuring bar is lowered to rest firmly on top of the child's head and compress the hair to obtain the measurement (diagram 1). Breath-holding should be avoided.
- Make sure the measurer's eyes are at the same level as the measuring bar.
- Record height to the nearest 0.1 cm
- Plot height measurement on a standardized growth chart.

<u>Other issues to note</u>

- Ideally, the measurement should be performed three times to improve accuracy and use the average.[7]
- If the child whose height is measured at less than 2 years old, add 0.7 cm to the height and record the result as length in the clinical notes.

Diagram 1: Position of the child for height measurement viewed from the side

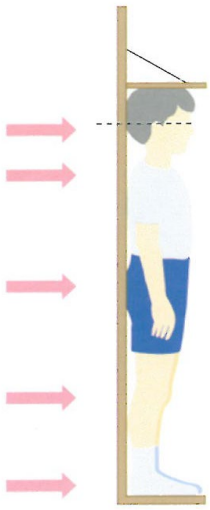

Diagram 2: Frankfurt plane

1.4.3 Weighing

Procedures

- Weight measurements should be obtained on a scale that has been calibrated properly.
- The balance reading should be set at 0.00 before measurement.
- Ensure the infant or child is at the centre of the scale and make sure he/she is not touching anything during measurement.
- The infant should be weighed without diapers and to the nearest 0.01 kg.[9]
- The older child should be measured without shoes, in little or no outer clothing, and to the nearest 0.1 kg.
- If it is too cold to undress a child, or if the child resists being undressed and becomes agitated, the clothed child can be weighed, but note in the record that the child was clothed.[4]
- Plot the weight measurement on a standardized growth chart.

Other issues to note

- Tared weighing can be done if the child is less than 2 years old or is unable to stand[4], or if the infant or child fails to cooperate. The procedure is as follows:
  1. Have the caretaker stand on the scale and reset the scale to zero.
  2. The caretaker then holds the infant/child.
  3. Read the scale when it stabilizes.
  4. Record the weight to 1 decimal place.
- If a taring scale is not available, the caretaker can be weighed alone; then the caretaker and child can be weighed together and the caretaker's weight is subtracted to determine the child's weight.

1.4.4 Head Circumference

Head circumference accurately reflects brain size and growth during gestation and the first years of life, which is the period of the majority of brain growth, except in unusual situations e.g. hydrocephalus, significant scalp oedema, rickets-thickened skull etc.

Procedures

- Use a narrow, flexible, non-stretchable measuring tape or disposable paper tape.
- Pull the tape gently to compress the hair, with rest of fingers keeping the tape in position.
- Measure the occipital frontal circumference (OFC), which is over the most prominent part on the back of the head (occiput) and just above the eyebrows (supraorbital ridges).
- Measure to the nearest 0.1cm.
- Plot the head circumference measurement on a standardized growth chart.

Other issues to note

- Centers for Disease Control and Prevention (CDC) suggests to take the measurement three times and select the largest reading as the recorded value.[10]
- Measurement of head circumference in the newborn may be unreliable until the third or fourth day of life because it may be affected by caput succedaneum, cephalohaematoma, or molding.[11] The presence of these findings should be recorded.

1.5 Plotting and interpretation of growth charts

1.5.1 Plotting of growth charts

It is essential to select the appropriate growth charts for the age and sex of the child or adolescent. The growth charts that are commonly used locally including those established from Hong Kong Growth Survey 1993[12], and those of WHO[13,14] and Centers for Disease Control and Prevention (CDC)[15]. The growth charts for use in Hong Kong are under review by expert group when this document is being published. Hence, information about the use of growth charts will be updated in due course as necessary.

Adjustment should be made for preterm babies (delivered before 37 completed weeks of gestation) with reference to the estimated date of confinement (EDC).

Measurements taken before EDC are plotted on the preterm chart. Measurements taken after EDC are plotted on the usual growth charts according to the corrected age which is calculated by [chronological age – (40 weeks – gestational age at birth)]. Correction for prematurity is performed up to 12 months after EDC regardless of the prematurity.

On plotting, the intersecting point of the axis values is located and the percentile recorded. Check to see if they are consistent with those from previous visits (i.e., the child is on roughly the same percentile lines as before). If not, check the measurements, graphing, or both.[5] If there is drifting across the percentile position after checking the accuracy of plotting, further assessment for the child is necessary.

1.5.2 General principles for interpreting growth charts

- It is important to consider the whole set of a child's growth charts (instead of any single chart in isolation) which cover the various growth parameters, particularly if only one of the charts shows a problem.
- Observation of the child's appearance is also crucial when interpreting the growth charts. For example, a child with high weight-for-height may be fine if he appears muscular instead of having noticeable fat.
- The growth trend should be observed and monitored. For example, if there is a downward drifting in the percentile position, it may indicate a problem.
- In addition, the child's general well-being and nutrition should also be considered when interpreting trends on growth charts in order to determine whether the condition is pathologic or not. For example, if a child has been ill and lost weight, a rapid gain that follows is a good sign of recovery and indicates "catch-up growth". Similarly, for an overweight child a slightly declining or static weight growth trend towards the median may indicate desirable "catch-down".[4]

1.5.3 Interpretation of length/height-for-age growth chart

Length/height-for-age reflects attained growth in height. **Short stature** is defined as a height more than two standard deviations below the mean for age, or less than the 3rd percentile.[16] It is expected that 3% of the normal population would be below the third centile and they can be normal because height is normally distributed. However, it is more likely that pathologic cause may be present if the child's height is too much below the 3rd percentile. It is important to observe for the trend also. There is a greater chance that the child may suffer from an illness if there is a downward drifting in the percentile position. However, there are exceptions where crossing downward centile can be physiological. For example, there could be a period of

slower growth compared to the others before a child goes into the growth spurt if he/she has physiological delay in puberty or constitutional delay in maturation. Also, physiological shifting can occur at the first year of life when the growth determining factor is switching from maternal size and maternal nutritional status during intrauterine life to a child's own inherited genetic growth potential.[12] **Tall stature** is defined as height above 97th percentile for age and sex or more than 2 standard deviations above the mean for a defined population.[16,17] Most of the children who grow beyond the percentile are part of a continuum of a normal distribution curve, and only a minority will have a defined abnormality.[18] Nonetheless, it is warranted to have further assessment by detailed history taking, physical examination, and lab tests if indicated to rule out underlying pathologic cause.

It is advisable to obtain parents' height to predict the growth potential of the child. Most children will have a projected adult height within 10 cm, or two standard deviations, of their mid-parental height. A possible pathologic condition is suggested if a projected height differs from the mid-parental height by more than 10 cm. Mid-parental height formulas are as follows:[16]

- Boys: [Paternal height (cm) + 13 cm + maternal height (cm)] ÷ 2
- Girls: [Paternal height (cm) – 13 cm + maternal height (cm)] ÷ 2

1.5.4 Interpretation of weight-for-age and weight-for-height growth chart

Weight-for-age reflects body mass relative to chronological age. It is affected by both the height of the child (height-for-age) and his or her weight (weight-for-height). Weight-for-length/height is a reliable growth indicator even for unknown age. The ratio of weight to height can be used to predict adiposity. **Underweight** is defined as having a weight below 80% median weight for height, **overweight** is having a body weight above 120% median weight for height.[19] For boys taller than 175 cm and girls taller than 165 cm, their weight status should be assessed by the BMI, which is applicable to individuals aged 18 or above. BMI ≥23 is defined as overweight, whereas BMI ≥25 indicates obesity.[20]

1.5.5 Interpretation of head circumference-for-age growth chart

Head circumference measures skull size and it also reflects overall brain volume.[21,22] Measurements may be affected by abnormal head shape. Brain size outside of normal values is an important risk factor for cognitive and motor delay.[23,24] Deviations from normal head growth may indicate an underlying congenital, genetic, or acquired problem. **Microcephaly** is commonly defined as head circumference more than 2 standard deviations below the mean, or less than the 3rd percentile,

compared to age- and gender-matched population-based samples.[25,26] **Macrocephaly** is defined as a head circumference greater than two standard deviations above the mean, or ≥97th percentile, for a given age and gender.[27] Parents' head circumferences should be measured if possible to assess familial variation in head size.[28] The weight and length percentiles should be compared with the head circumference percentile. Increases in head size disproportionate to the child's height and weight may be familial or pathologic. It is often pathologic if the head size decreases disproportionately to the child's height and weight.[29]

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Chapter 2. Normal growth in children

2.1 Normal growth

Physical growth depends on the interaction between genetic, hormonal, nutritional and psychosocial variables. A newborn's size is determined by the intrauterine environment, which is affected by maternal size, nutrition, general health and social habits. After birth, the growth rate becomes more dependent on the infant's genetic background. Growth hormone, which does not play a major role in the growth of foetus, becomes the predominant factor when the child reaches two years old.[1] Growth rates are similar between genders until puberty. Sex hormones emerge as the main factor of growth during adolescence.[1] The pubertal spurt is later and of higher velocity in males.[2]

Girls begin puberty with breast buds, followed by development of pubic hair and menarche. In boys, testicular enlargement occurs initially, followed by enlargement of penis and appearance of pubic hair.[3] According to 1993 Hong Kong Growth Survey, the normal age range for the onset of breast development in girls is 7.1 to 12.3 years while that for the onset of testicular development in boys is 8.4 to 14.4 years.[4] For practical purpose, puberty onset at age 7-13 years in girls and 9-14 years in boys is generally considered normal in our locality taking into consideration the finding of the above survey, local clinical experience and the age references commonly adopted in the literature. (Please refer to Chapter 3.4 for further information and elaboration of this issue.)

2.2 Normal variations and genetic factor of growth

Children's height potential is closely related to parental height, most children also follow their parents' pubertal tempos. Some genetic disorders can lead to short or tall stature.[1] During assessment of growth problem, it is important to determine whether it is a normal variant of growth or due to an underlying pathologic condition. Normal variants of growth would be discussed in relevant chapters of growth problems in Chapter 3.

Catch-up or catch-down growth

Between 6 and 18 months of age, the growth rate percentile may shift linearly until the child reaches his or her genetically determined growth channel. Some children move up on the growth charts since they have tall parents, while others move down because they have short parents. By 2 years of age, most children's lengths have shifted to their genetically determined percentiles and grow along the same percentile until the onset of puberty.[1]

2.3 Nutrition and physical activities

A balanced diet and healthy eating habit is essential for normal growth. Inadequate caloric intake is a potential cause of failure to thrive. Food diaries can help evaluate quality and quantity of diet, as well as identify dysfunctional feeding behaviours.[5] On the other hand, excessive energy intake leads to obesity. Skipping breakfast is associated with higher body mass index (BMI) and larger percentage of body fat.[6]

Lack of physical activity contributes to obesity.[6] Excessive use of Internet and electronic screen products is another risk factor of obesity.[7] On the contrary, extensive physical training may result in delayed puberty in elite athletes.[3] Sleep is also a determinant of healthy weight. A study found that shorter sleep duration resulted in higher BMI.[6]

It is important to promote healthy eating and physical activity in order to attain normal growth. Please refer to Chapter 5.3 and Chapter 5.4 of the Core Document of the Hong Kong Reference Framework for Preventive Care for Children in Primary Care Settings for recommendations of nutrition and physical activity.[8]

2.4 Psychosocial factors

The reason for failure to thrive and weight faltering is usually multifactorial. Although dietary and feeding problem is the most common cause, weight faltering may be associated with neglect or maternal mental health problems.[9] Eating disorders could induce weight problems or delayed puberty.[3] Barriers to healthy lifestyle, such as inaccessibility to healthy food choices in schools and lack of facilities for physical activity, are contributing factors of overweight and obesity.[6]

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Chapter 3. Assessment and management of growth problems

3.1 Height problems

3.1.1 Introduction

Short or tall stature is commonly found in variants of a normal growth pattern. However, some cases may have serious underlying pathologies. Primary care physicians have important role in identification of abnormal growth, appropriate referral, counselling and co-ordination of services.

3.1.2 Definition

Short stature

Short stature is defined as height that is two standard deviations (SD) below the mean height for age and sex (i.e. less than the third percentile on growth chart).[1,2] (Please refer to Appendix 1 for the means and SDs of weight and height.)[3]

Idiopathic short stature (ISS)[4]

ISS is defined as short stature with normal birth weight, sufficient growth hormone, and without evidence of systemic, endocrine, nutritional, skeletal or chromosomal abnormalities. Among children with ISS, two normal variants are commonly found namely constitutional delay in growth and familial short stature.

Constitutional delay of growth and puberty

There is a transient deceleration of growth at approximately 3 years and again at 11-12 years of age. This condition is more prevalent in boys than girls. Family history usually reveals one of the parents, siblings or relatives who had history of growth or pubertal delay. Bone age is delayed but corresponds to height age. Although pubertal development occurs later during adolescence but normal adult height could be achieved finally.[5,6]

Familial short stature

Children with family history of short stature may present with early deceleration in linear growth, depending on their birth parameters. They subsequently grow in normal velocity, with normal bone age and pubertal development. The final adult height is short, but appropriate for mid-parental height.[1]

Tall stature

Tall stature is defined as height which is two standard deviations higher than the mean for age of a defined population (more than the 97th percentile on growth chart).[1,7]

Familial tall stature is the most common cause of tall stature. The child's height is consistent with the mid-parental height. The parents are tall and may have history of early puberty.[1,7]

3.1.3 Assessment of short stature

3.1.3.1 History

A comprehensive history starting from the prenatal period should be obtained in order to identify possible causes and risk factors of short stature. The most common causes of short stature are familial short stature, constitutional delay and small gestational age (SGA) with no catch up growth.

Growth pattern

Review birth weight and all available growth chart and growth information.

Family history

A child's adult potential height is usually genetically determined and can be predicted by mid-parental height. Growth pattern of parents, for example, age of menarche or accelerated growth is important, especially for those who are possibly constitutionally small.[1,5] Certain genetic disorders can also lead to short stature.

Birth history

SGA with no catch up growth is another common cause of short stature. Intrauterine infection, smoking and alcohol intake during pregnancy, as well as adverse effects of medications can lead to intrauterine growth retardation (IUGR).[2] IUGR may also be associated with chromosomal disorder like Russell-Silver Syndrome.[5,6] For child who was born prematurely, height and weight should be adjusted for gestational age up to 12 months after estimated date of confinement.

Systematic review for chronic illness and chromosomal disorder

Symptoms of different organ systems could indicate the underlying pathologic cause of short stature. Table 1 illustrates features of different medical conditions which would lead to short stature. Majority of these conditions are uncommon and do not present with short stature alone.

Table 1. Conditions associated with short stature [1,5,6,8,9]

Secondary causes of short stature	Symptoms and signs
Endocrine	
• Hypothyroidism	• Weight gain, lethargy, constipation, bradycardia
• Growth hormone deficiency	• Immature face with frontal bossing, underdeveloped nasal bridge, micropenis, delayed dentition
• Cushing syndrome	• Obesity, moon face, striae
• Pseudo-hypoparathyroidism	• Short metacarpals, obesity, moon face, hypothyroidism
Chronic illness	
• Malabsorption	• Diarrhoea, flatulence
• Chronic renal failure, haematological disorders, complex congenital heart disease, intracranial neoplasm	• Features of underlying disorder
Musculoskeletal	
• Achondroplasia	• Short upper arms and thighs, normal trunk length , large head, depressed nose bridge and small nose
• Rickets	• Craniotabes, bulbous wrists, bowing of extremities
• SHOX deficiency	• Mesomelia, cubitus valgus, wrist deformity, short metacarpals/ metatarsals, high-arched palate, abnormal auricular development, micrognathia, short neck
Chromosomal	
• Turner syndrome	• Webbed neck, shield-shaped chest, low posterior hairline
• Russell-Silver syndrome	• SGA, triangular facies, frontal bossing, body asymmetry
• Prader-Willi syndrome	• Obesity, hypogonadism
• Noonan syndrome	• Ptosis, low-set and posterior rotated ears, pulmonary stenosis

Drug history

Prolonged use of glucocorticosteroids could induce Cushingnoid features. Certain medications such as stimulants used for attention-deficit/hyperactivity disorder, anticonvulsants and antidepressant may affect growth.[1,5]

Psychosocial history

Poor nutrition could result in short stature which is preceded by weight loss.[1] Psychological condition like anorexia nervosa, as well as extreme physical activity (such as gymnastics, ballet) may lead to poor growth.[10]

3.1.3.2 Physical examination

Accurate and serial measurement of height, weight, body proportions and growth velocity is vital in evaluation of growth problem. Growth chart and mid-parental height should be obtained.

(Please refer to Chapter 1 for techniques of measurement of height and weight.)

Mid-parental height and projected height[1]

A child's adult height potential can be predicted on the ground of parental height. Parental height can be recorded and interpreted as follows:

- Measure parents' height if possible. Reported height is less reliable since parents usually over-estimate their heights.
- Formulas for calculating mid-parental height:
  - Girls: (father's height in cm + mother's height in cm-13)/2
  - Boys: (father's height in cm + mother's height in cm+13)/2
- Most children will reach a projected height within 10cm of their mid-parental height.
- Suspect possible pathologic condition if projected height deviates from the mid parental height by more than 10cm.

Body weight

Body weight provides vital clues toward analysis of short stature. Loss of weight commonly precedes slow growth, therefore raising the possibility of chronic illness, nutritional or psychosocial causes.[1,5] On the other hand, short stature with overweight or obesity can be found in Prader-Willi syndrome, as well as endocrine disorder like hypothyroidism and Cushing syndrome.[5]

Body proportions

Most patients with disproportionate short stature have skeletal dysplasias.

Assessment of body proportions helps discriminate skeletal dysplasia resulting in disproportionate limb shortening from conditions that primarily affect the spine. Different body segments and proportions can be measured as follows: [11]

- **Arm span:** Measure between middle finger tips with both arms abducted to 90 degrees.
- **Lower segment:** Measure from the symphysis pubis to the floor at the inside of the heel.
- **Upper segment:** Subtract the lower segment from the total height.

Arm span should be close to total height. Upper/ lower segment (U/L) ratio is about 1.7 at birth; 1.4 at age 4-5 years; 1.0 by around age 10 years and 0.95 as an adult.[5,11]

Children with SHOX gene mutation would present with reduce arm span.[4] Spine problem such as scoliosis can lead to shortened vertebral growth and lower U/L ratio. Higher U/L ratio can be found in rickets.

Growth velocity

Growth velocity is a measurement of growth rate and helps differentiate abnormal growth patterns from normal variants. Gain in height is usually less dramatic and follow-up duration of more than 6 months is necessary to determine the growth velocity.

Normal variants of short stature usually have normal growth velocity. Children may exhibit catch-up or catch-down growth between 6 and 18 months of age. However, pathologic causes of short stature should be considered if a child's growth curve is crossing the centiles after two years of age.[1]

Local growth velocity chart is not available. A growth velocity of less than 5cm/ year would be regarded as abnormal in prepubertal children between the ages 3 and 10 years. However, a lower growth velocity value could be allowed one to two years before onset of puberty.[2] Growth velocity in puberty increases to around 6-10 cm and 7-12cm per year for girls and boys respectively.[10]

Others

Pubertal status, stigmata of chronic illness and dysmorphic features of genetic syndromes (Table1) should also be identified in physical examination.

3.1.3.3 Diagnosis

Try to arrive at a working diagnosis according to the information from history and physical examination and ask these clinical questions:

- Does the child present with features suspicious of endocrine, musculoskeletal or syndromal disorder or chronic illness as stated in Table 1?
- Is there any shift in height across 2 centiles after 2 years of age?
- Is the child too short for his/ her parents?
- Is the child born SGA with no catch up growth?
- Does the child present with features suggestive of a normal variant of short stature?

3.1.4 Management of short stature

Management of short stature is largely dependent on the underlying cause. Children with suspected pathologic causes should be referred to specialists for further investigation and management. Follow-up can be considered for children with ISS whose height is just below 3rd centile or crosses one to two centile width.

Advice and counselling

Irrespective of the diagnosis of short stature, balanced diet and adequate exercise should be recommended. Family physicians should also explore issues around school, sports and family in order to encourage these patients to feel comfortable with their height outcome. Using examples of short people who have achieved in any aspect of life and promoting positive thinking could help to boost the self-esteem for this potentially vulnerable group.[5]

Follow-up

Follow-up can be considered for children with good health who are just below the third centile in height.[2] Growth parameters are measured every 6 to 12 months. One to 2 follow-ups are usually sufficient to determine whether the growth velocity is normal.

Children with familial short stature grow at a normal velocity within the limits for their parents' height. For familial short stature, explanation and reassurance are crucial for both parents and children to feel supported.[5,6]

Growth delay of up to two years is not uncommon for children with constitutional delay of growth. They can be reassured that puberty occurs eventually and their genetically predicted height can be achieved.[6]

Children of SGA typically show catch-up growth by age 2, which is most prominent in the first 6 to 12 months after birth. Measurements of length, weight and head circumference should be taken every 3 months in the first year of life and every 6 months afterwards.[12]

Referral

Consider referral to paediatricians if the child presents with the following features:[1,5]

- Too short (<3 SDs)
- Abnormally short for his/her parents
- Height crosses down 2 centile width
- Abnormal growth velocity
- Suspected disorders and medical illness (Table 1)

Children with ISS whose height is more than 2.25 SDs below the mean for age and sex and wish for treatment should be referred to specialist for further management. Growth hormone had been approved for treatment of this condition.[4]

If children with constitutional delay of puberty are not satisfied with reassurance alone, they could be referred to specialists for treatment. For boys who only concern height, anabolic steroid could induce earlier onset of growth spurt without compromising adult height.[6] If they are concerned about the lack of pubertal development, testosterone can be considered. In girls with extreme constitutional delay, low dose oestrogen can be used, but this may cause premature epiphyseal fusion.[5,6]

A child of SGA without spontaneous catch-up growth by age 3, or age 4 in preterm infants, is unlikely to experience it later without therapeutic intervention, early referral to paediatricians for growth hormone therapy is necessary.[12]

Referral to psychiatrist would be helpful for children with mood or eating disorder.

3.1.5 Assessment of tall stature

3.1.5.1 History

As with short stature, a comprehensive history starting from the prenatal period should be obtained to identify possible causes of tall stature.

Family history

The vast majority of children with tall stature have tall parents, which is referred to as familial tall stature. Family history of early puberty may suggest constitutional advancement of growth.[1] Some uncommon syndromes such as Marfan syndrome may also run in family.[5,6]

Growth pattern

Review birth weight and all available growth chart and growth information.

Review for endocrine and chromosomal disorder

Secondary causes of tall stature (Table 2) can be classified into endocrine and chromosomal disorder. Endocrine disorders of tall stature rarely present at preschool age.

Table 2. Conditions associated with tall stature [1,5,6,7]

Secondary causes of tall stature	Symptoms and signs
Endocrine	
• Precocious puberty	• (Please refer to Chapter 3.4)
• Growth hormone excess	• Coarse facial features, mandibular prominence, enlargement of hands and feet
Chromosomal	
• Marfan syndrome	• Hyperextensibility, long thin fingers, kyphoscoliosis, high arched palate
• Klinefelter syndrome	• Poor musculature, sparse body/ facial hair, small testes, gynaecomastia, aggressive impulsive personality
• Sotos syndrome	• Large head, hands and feet

3.1.5.2 Physical examination

Similar to the evaluation of short stature, it is important to obtain all growth parameters for child presenting with tall stature.

Mid-parental height

A child's height is consistent with the mid-parental height in familial tall stature.[1] On the other hand, the child's projected height greatly exceeds the mid-parental height in condition like growth hormone excess.

Body weight

Obesity is a common cause of tall stature in children.[1]

Body proportions

Children with Klinefelter syndrome have eunuchoid proportions (i.e. disproportionately long limbs with decreased U/L ratio.)[5] Marfan syndrome is characterized by increased arm span and kyphoscoliosis.[1]

Others

Signs of precocious puberty or other endocrine disorders, as well as dysmorphic features as described in Table 2 should also be looked for during physical examination.

3.1.5.3 Diagnosis

Try to arrive at a working diagnosis according to the information from history and physical examination and ask these clinical questions:

- Does the child present with features suspicious of endocrine or chromosomal disorder as stated in Table 2?
- Are there signs of puberty?
- Is there any upward shift in height across 2 centiles between 2 years of age and the onset of puberty?
- Is the child too tall for his/ her parents?
- Is the child obese?
- Does the child present with features suggestive of a normal variant of tall stature?

3.1.6 Management of tall stature

Intervention is usually not necessary in children with tall stature. Follow-up visits can be arranged for those with familial tall stature or obesity for continual growth monitoring.

Advice and counselling

Tall stature usually causes less concern than short stature. However, some tall children may be labelled as clumsy or aggressive, which may lead to psychological stress. Counselling with advice on predicted height according to mid-parental height usually reassures most cases of tall stature.[5,6]

Referral

Consider referral to paediatricians for further assessment if precocious puberty, endocrine or chromosomal disorder is suspected. Again, if the child's height is crossing up centiles, or abnormally exceeds his/her genetic potential, referral for investigations of pathologic causes is suggested. If extreme tall stature is associated with psychological or behavioural difficulties, referral to specialists for medical or surgical treatment can be arranged.[5,6,7]

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Chapter 3 -- Appendix 1

Mean height (cm) and standard deviation (SD) of Hong Kong children and adolescents aged 6 to 18 years by gender in 1963, 1993 and 2005/6, with age groups defined as > 5.5–6.5 = 6 years

Age	1963			1993			2005/6		
Boys	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
6	283	110.7	5.1	223	116.0	5.4	138	117.9	4.5
7	742	115.5	5.3	643	120.6	5.6	483	122.9	5.8
8	1030	120.5	5.5	724	126.1	5.4	564	127.9	5.9
9	1076	125.2	5.7	634	131.0	5.8	640	133.1	5.7
10	1144	130.0	6.1	694	136.3	5.9	602	138.5	6.5
11	1121	134.8	6.6	597	141.6	6.5	636	143.5	7.2
12	1033	140.0	7.3	638	147.8	8.0	739	151.0	8.1
13	1052	147.0	8.2	642	155.3	8.6	647	158.2	8.5
14	1288	155.6	7.8	550	162.3	7.9	672	164.2	7.6
15	1622	161.5	6.6	479	166.9	6.2	588	167.9	6.0
16	1711	164.9	5.8	430	169.5	6.5	562	170.6	5.5
17	1370	166.8	5.3	442	169.8	5.8	572	171.4	5.9
18	874	167.0	5.1	311	170.7	5.9	468	171.7	5.5
Girls	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
6	282	110.0	4.7	211	115.4	5.5	128	117.3	5.0
7	742	114.7	5.1	553	119.8	5.1	488	120.8	5.3
8	970	120.0	5.6	647	125.2	5.6	471	127.2	5.5
9	1022	125.1	6.2	617	131.1	6.3	601	132.7	6.3
10	1178	130.5	6.7	633	137.1	6.9	554	138.4	6.8
11	1312	136.6	7.2	584	143.7	7.2	584	145.4	7.0
12	1340	144.0	7.5	579	149.6	6.7	734	151.5	6.4
13	1159	150.0	6.9	633	153.2	5.9	640	155.2	6.0
14	1152	154.0	6.1	617	156.3	5.4	667	157.0	5.3
15	1275	155.4	5.4	552	157.0	5.3	637	157.9	5.2
16	1267	155.6	5.0	520	157.3	5.1	590	158.4	5.4
17	984	155.6	4.9	536	157.8	5.3	642	158.7	5.4
18	614	155.6	4.7	334	158.3	5.3	453	158.7	5.7

Source: So HK, Nelson EA, Li AM, et al. Secular changes in height, weight and body mass index in Hong Kong Children. BMC Public Health. 2008 Sep 21;8:320

Mean weight (kg) and standard deviation (SD) of Hong Kong children and adolescents aged 6 to 18 years by gender in 1963, 1993 and 2006, with age groups defined as > 5.5–6.5 = 6 years

Age	1963			1993			2005/6		
Boys	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
6	283	17.5	1.5	223	21.3	4.5	138	22.4	3.3
7	742	19.0	2.2	643	22.9	4.5	483	24.9	5.7
8	1030	20.6	2.6	724	25.7	5.2	564	27.7	6.4
9	1076	22.4	3.1	634	28.8	6.5	640	30.5	6.7
10	1144	24.6	3.9	694	32.4	8.0	602	35.5	9.2
11	1121	27.1	4.8	597	36.3	8.9	636	38.8	9.8
12	1033	30.0	5.9	638	39.9	10.0	739	44.4	10.8
13	1052	34.5	7.0	642	44.9	10.8	647	49.4	12.3
14	1288	40.0	6.8	550	50.5	10.5	672	53.3	11.0
15	1622	45.6	6.4	479	53.8	10.4	588	57.3	11.5
16	1711	49.0	6.0	430	57.5	9.8	562	59.5	11.2
17	1370	51.3	5.9	442	59.1	9.1	572	61.3	11.6
18	874	52.3	5.9	311	60.3	9.4	468	62.0	10.5
Girls	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
6	282	16.9	1.7	211	20.2	3.5	128	21.3	4.0
7	742	18.3	2.3	553	22.1	4.3	488	23.0	4.7
8	970	20.2	2.9	647	24.9	5.1	471	26.1	5.1
9	1022	22.4	3.5	617	27.9	6.2	601	29.5	6.4
10	1178	25.0	4.2	633	31.4	7.1	554	33.2	7.8
11	1312	28.0	5.4	584	35.9	8.5	584	37.2	8.3
12	1340	32.7	6.8	579	40.3	8.7	734	42.6	9.6
13	1159	37.3	6.9	633	44.3	9.7	640	46.5	8.8
14	1152	41.4	6.3	617	47.6	8.4	667	48.4	8.5
15	1275	43.6	5.7	552	48.7	7.0	637	49.5	8.9
16	1267	44.5	5.3	520	49.5	7.4	590	51.1	9.1
17	984	45.1	5.1	536	50.5	7.2	642	51.1	9.5
18	614	45.5	5.1	334	51.0	6.9	453	51.3	8.3

Source: So HK, Nelson EA, Li AM, et al. Secular changes in height, weight and body mass index in Hong Kong Children. BMC Public Health. 2008 Sep 21;8:320

3.2 Obesity

3.2.1 Introduction

Childhood obesity is an emerging epidemic problem globally and locally. According to the Student Health Service, the detection rate of overweight and obesity among primary school students decreased from 22.2% in 2008/09 to 17.6% in 2017/18, whereas the corresponding detection rate for secondary school students increased from 17.7% in 2008/09 to 19.9% in 2017/18.[1] Although genetics account for about 40% of body mass index, environment is the main causative factor for the epidemic of obesity.[2] Primary care providers should measure weight and length/ height for children aged below 5 years to determine weight-for-length/height and to classify nutritional status.[3] Screening for obesity in children and adolescents age 6 years and older in the primary care setting is recommended.[4] Children found to have obesity should be offered or referred to intensive programmes that help them manage their weight and improve overall health.[3,4]

3.2.2 Definition of obesity

Defining obesity in children is difficult since growth rates in weight and height vary during different developmental stages. There is no universally agreed method to measure obesity in children; each method carries its strength and limitation.[5]

Weight-for-height

Weight-for-height chart was developed according to the data obtained from the Hong Kong Growth Survey 1993. The chart provides local reference to assess if the weight of a child is proportional to the height. It is used locally by Maternal and Child Health Centre and Student Health Service to monitor growth of children.

Overweight is defined as follow: body weight > median weight-for-height x 120%.[5]
(Please refer to Appendix 2 for weight-for-height chart)[6]

Body mass index (BMI)

BMI is a useful means to measure fatness in children. BMI in children varies with age and requires age-related reference curve for assessment. Local BMI-for-age curves were constructed with reference to the data from the Hong Kong Growth Survey 1993.[7]

BMI is used for male students with height >175cm and female students with height >165cm by the Student Health Service to measure fatness. BMI ≥23 is defined as overweight, whereas BMI ≥25 indicates obesity.[8]

3.2.3 Assessment of obesity

3.2.3.1 History

Although nutritional obesity is the most common cause of obesity, comprehensive history helps to identify risk factors, rule out secondary causes and look for physical and psychological comorbidities of obesity.

Growth pattern

Children with simple obesity would have normal height or tall stature. On the other hand, those with endocrine disorders usually have short stature.[9] Genetic disorder, such as Prader-Willi syndrome, is characterized by early onset of obesity and short stature.

Systematic review

Secondary causes of obesity (Table 3) are rare, but should be considered if dysmorphic features, growth failure and developmental delay are present.

Table 3. Secondary causes of obesity[9]

Genetic
· Prader-Willi syndrome
Neurologic
· Brain injury · Brain tumour · History of cranial irradiation · Hypothalamic obesity
Endocrine
· Hypothyroidism · Cushing syndrome · Growth hormone deficiency · Pseudohypoparathyroidism
Psychological
· Depression · Eating disorders

Comorbidities of obesity

Children with obesity should be evaluated for symptoms of comorbidities such as hypertension, hyperlipidaemia, diabetes mellitus, fatty liver, sleep apnoea, oligomenorrhoea, orthopaedic complications and psychological sequelae.[9-13]

Drug history

Sulfonylureas, glucocorticoids, oral contraceptives, tricyclic antidepressants, antipsychotics and anticonvulsants could induce obesity.[9] Furthermore, use of laxatives and weight losing pills should be explored.

Birth history

Large pregnancy weight gain and gestational diabetes mellitus are risk factors for obesity.[10] Intrauterine growth restriction is associated with increased risk of developing metabolic syndrome and cardiovascular disease, systolic hypertension, obesity, insulin resistance, and diabetes type II in adulthood.[14]

Family history

Family history of obesity is an important risk factor of overweight or obesity.[2] Children with family history of type 2 diabetes mellitus or other obesity-related disease are susceptible to comorbidities.[11]

Dietary history/ Lifestyle

Evaluation of dietary habits, physical activities and sedentary behaviours is recommended.[2, 10, 11, 13] Details of eating habits including frequency, types of food, portion size and location of meals and snacks should be enquired. Assessment of physical activity should consist of time spent in organized sports, active transportation, unstructured active play as well as screen time.[9,15,16]

Inadequate sleep is also an important risk factor for childhood obesity. Sleep deprivation affects production and action of appetite regulation hormones, leading to increase in hunger and intake of unhealthy food. In addition, sleepiness can reduce motivation for physical activity and results in weight gain.[17]

3.2.3.2 Physical examination

Accurate measurement of body weight and height should be obtained to calculate BMI or determine weight-for-height.

Dysmorphic features and signs of neurological or endocrine disorders should be looked for to rule out secondary causes of obesity.

Blood pressure, as well as signs of comorbidities including hepatomegaly from fatty liver disease and acanthosis nigricans associated with insulin resistance should be assessed.[10, 11]

3.2.4 Management of obesity

Advice and counselling

At primary health-care settings, health workers should provide counselling on nutrition and physical activity to caregivers of overweight children.[3] Family has a significant role in control of childhood obesity.[18] Parents' eating habits and activity pattern affect children's behaviour. Lack of parent involvement is an important obstacle to long-term effectiveness of weight control.[2] Parents should be encouraged to act as positive role models, and build a supportive environment that would enable children achieving a healthy weight. Table 4 illustrates the initial interventions recommended for family and children with obesity.[5, 9-13,15,16,18-20]

Table 4. Diet and exercise advice for family and children with obesity

Diet	
DO	
✓	Encourage family meals at home.
✓	Offer three regular meals every day.
✓	Offer healthy food that is low in fat, salt and sugar but high in dietary fibre.
✓	Serve food in the portion size appropriate for age and development.
✓	Consume at least five servings of fruits and vegetables each day.
✓	Offer water as main drinks. Low-fat plain milk, low-sugar soy drinks are other healthy drink options.
✓	Serve healthy snacks such as fresh fruits, boiled eggs or green sandwiches.
AVOID	
×	Use food as reward.
×	Skip breakfast.
×	Feed until the plate is empty. (Accept the child's ability to regulate energy intake)
×	Consume sugar-sweetened beverages.
×	Calorie-dense food such as prawn crackers, potato chips, cookies and cakes.
Physical activity	
DO	
✓	Increase movement in daily routine like using stairs and walking to schools.
✓	Incorporate physical activity in family's regular activities, such as designated time for active games or after-dinner walks together.
✓	Encourage unstructured free play and outdoor activities, such as playing with them in playgrounds or visiting outlying islands.
✓	Offer rewards gifts that promote physical activities, such as balls or bicycles.
✓	Help children select school-based or community physical activity programmes that meet their interests and developmental needs.

✓ Support children in sports that may interest them, and accumulate at least: ■ 3 hours daily in a variety of physical activities at any intensity, including moderate- to vigorous-intensity physical activity, spread throughout the day and more is better, for toddlers and preschoolers aged 1-4 years. For children aged 3-4 years, at least 1 hour of the physical activities per day are suggested to be in moderate to vigorous intensity.[20] ■ 1 hour of moderate to vigorous intensity physical activity per day for children 5-17 years of age.
AVOID
× Screen time: ■ Toddlers aged under 2 years: avoid screen time other than interactive video-chat under parents' guidance ■ Children aged 2-5 years: limit the total daily screen time to within one hour of high-quality programmes under parents' guidance ■ Students aged 6-12 years: limit recreational screen time to no more than 2 hours per day ■ Adolescents aged 12-18 years: avoid prolonged screen time

In view of the increasing evidence for an association between sleep deprivation and overweight, good sleep habits and adequate amount of sleep should be promoted. Table 5 shows the recommended sleep time duration for different age groups of children.[20,21]

Table 5: Sleep time duration recommendation

Age	Recommended (hours of sleep)	May be appropriate (hours of sleep)
Newborn 0-3 months	14-17	11-13; 18-19
Infant 4-11 months	12-16	10-11; 16-18
Toddler 1-2 years	11-14	9-10; 15-16
Preschool 3-5 years	10-13	8-9; 14
School Age 6-13 years	9-11	7-8; 12
Teen 14-17 years	8-10	7; 11

(Please refer to Appendix 3 for patient education materials on weight management.)

Follow-up

The child should be followed monthly. Healthy weight goal is to maintain weight that results in decreasing weight-for-height as age and height increase. If weight further increases after three to six months, referral for a more structured weight management should be considered.

The child can be referred to dietitian to formulate a low-energy-dense, balanced diet plan. In addition, supervised physical activity of at least 60 minutes and limitation of screen time to one hour or less per day is suggested.[11]

Referral

Conditions that indicate referral to specialists for further assessment or management:[9-11]

- Failure to achieve healthier weight through measures suggested in management above
- Secondary causes of obesity like genetic and endocrine disorders
- Complications of obesity such as sleep disorder, metabolic syndrome, orthopaedics and psychiatric problems

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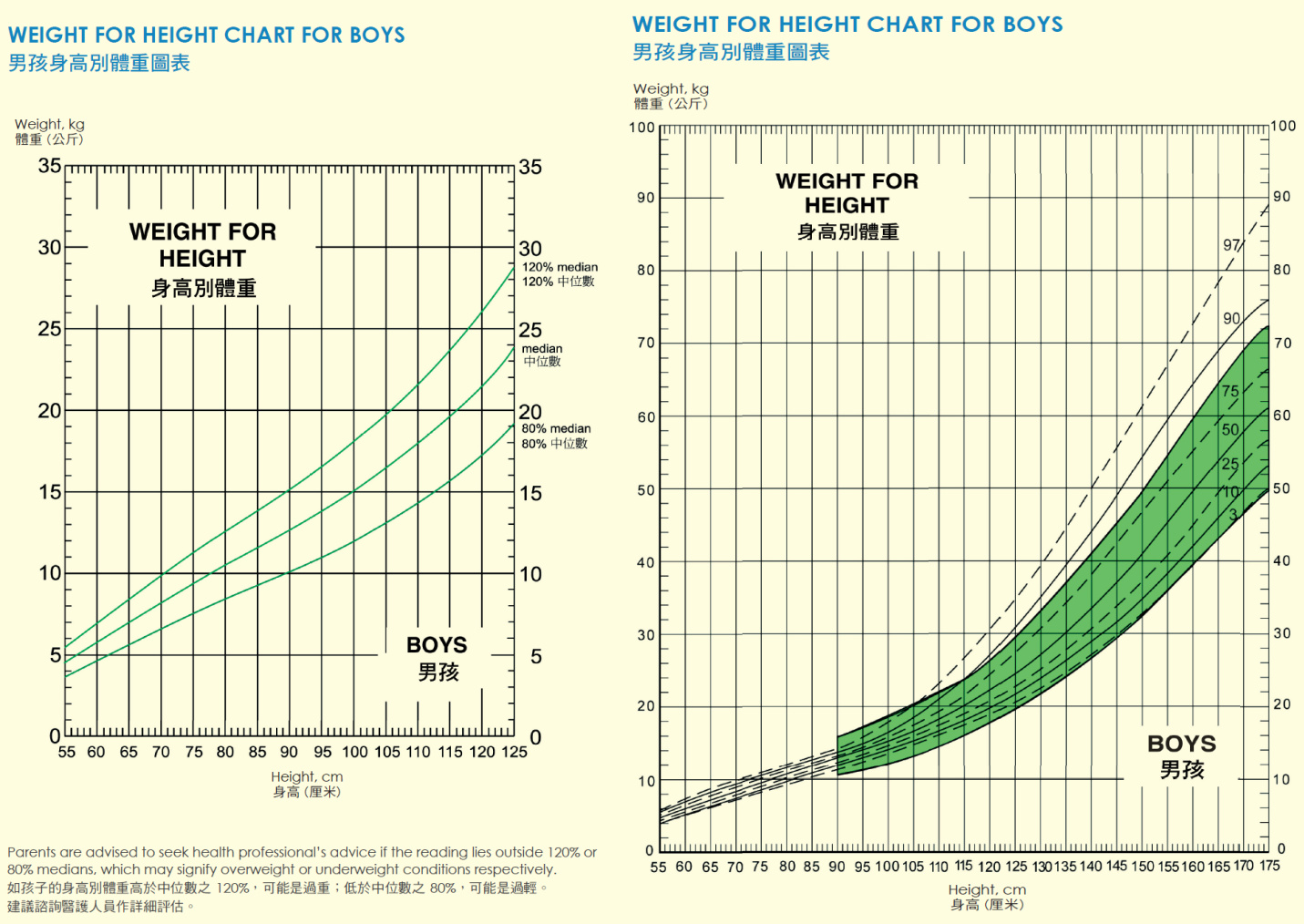
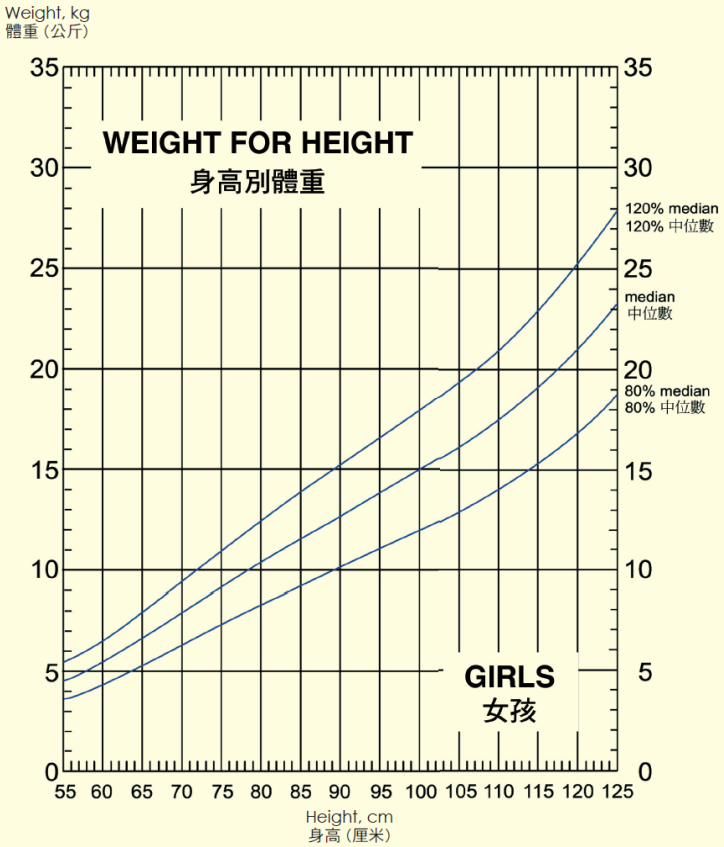
Chapter 3 -- Appendix 2
Weight-for-height reference chart for boys and girls



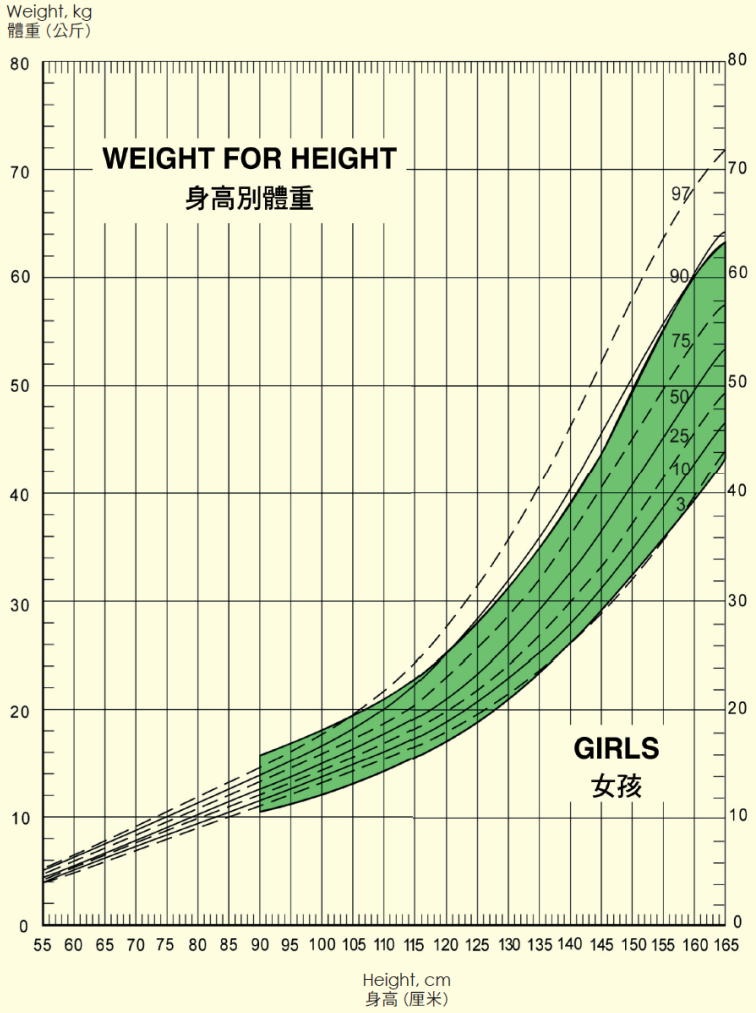
Source: HK Growth Survey 1993, the Chinese University of Hong Kong and the Department of Health

WEIGHT FOR HEIGHT CHART FOR GIRLS
女孩身高別體重圖表



Parents are advised to seek health professional's advice if the reading lies outside 120% or 80% medians, which may signify overweight or underweight conditions respectively.
如孩子的身高別體重高於中位數之 120%，可能是過重；低於中位數之 80%，可能是過輕。
建議諮詢醫護人員作詳細評估。

WEIGHT FOR HEIGHT CHART FOR GIRLS
女孩身高別體重圖表



Source: HK Growth Survey 1993, the Chinese University of Hong Kong and the Department of Health

Chapter 3 -- Appendix 3

Resources on obesity for parents and carers

Organisation	Resource	Website
Leisure and Cultural Services Department	Fitness Programmes for Children	http://www.lcsd.gov.hk/en/healthy/fitness/over.html [Internet]
Leisure and Cultural Services Department and Department of Health	Body Weight Management of Children	http://www.lcsd.gov.hk/en/healthy/common/download/child.pdf [Pamphlet]
Student Health Service Department of Health	Obesity and Health	http://www.studenthealth.gov.hk/english/health/health_dn/health_dn_oah.html
Strategy and Action Plan to Prevent and Control NCD in Hong Kong Department of Health	Physical Activity Guidelines for Children	https://www.change4health.gov.hk/en/physical_activity/guidelines/youth/index.html [Aged 5-17 years]
'EatSmart@school.hk' Campaign Department of Health	Guidelines	https://school.eatsmart.gov.hk/files/pdf/snack_guidelines_bi.pdf [Nutritional Guidelines on Snacks for Students] https://school.eatsmart.gov.hk/files/pdf/lunch_guidelines_bi.pdf [Nutritional Guidelines on Lunch for Students]
Centre for Health Protection Department of Health	Mobile application	https://www.chp.gov.hk/en/static/40563.html [Snack Check]
'StartSmart@school.hk' Campaign Department of Health	Guidelines	https://www.startsmart.gov.hk/files/pdf/nutritional_guide_en.pdf [Nutrition Guidelines for Children Aged 2 to 6]

		https://www.startsmart.gov.hk/files/pdf/physical_guide_en.pdf [Physical Activity Guide For Children Aged 2 to 6] https://www.startsmart.gov.hk/files/pdf/parent_guide_full_en.pdf [Start Smart Parent Guide]

3.3 Failure to thrive/ Faltering growth

3.3.1 Introduction

Failure to thrive (FTT), which is also known as faltering growth, is not a diagnosis itself but a sign of undernutrition,[1,2] to which biologic, psychosocial, and environmental factors processes can contribute. Undernutrition can lead to significant developmental delays in children, especially for rapid brain growth takes place at the first 2 years of life when neurodevelopmental outcomes can be influenced significantly. Motor, fine motor, speech, language, and cognitive delays have been documented. The resultant poor cognitive ability can lead to emotional and behavioural problems as well.

It is usually identified during the first 3 years of life. A careful history and physical examination can identify most causes of FTT, avoiding sophisticated or costly evaluations.[2] It should be borne in mind that while weight monitoring is usually practised as routine clinical care, a practicable screening system for FTT has yet to be operationalized.[3]

3.3.2 Definition of FTT/ faltering growth

Although there is no consensus about the definition of FTT, there are some commonly adopted definitions, which are based on serial measurements: [2,4,5]

- Height or weight below the third or fifth percentiles for age on more than one occasion.
- Height or weight measurements decrease across two major percentiles on the growth chart over multiple visits.

National Institute for Health and Care Excellence (NICE) guideline on faltering growth suggests considering to use the following as thresholds for concern about faltering growth in infants and children (a centile space being the space between adjacent centile lines on the UK WHO growth charts):[6]

- a fall across 1 or more weight centile spaces, if birth weight was below the 9th centile
- a fall across 2 or more weight centile spaces, if birth weight was between the 9th and 91st centiles
- a fall across 3 or more weight centile spaces, if birth weight was above the 91st centile

- when current weight is below the 2nd centile for age, whatever the birth weight.

3.3.3 Aetiology of FTT/ faltering growth

FTT is multifactorial.[2] Most cases are due to undernutrition but they can also be a result of organic disease, abuse or neglect.[7] When children exhibit persistent FTT that does not respond to increased energy intake through diet, primary care physicians should look for organic causes.[2,4]

Potential causes of FTT/faltering growth[8-11]

- Inadequate caloric intake
  - Breastfeeding difficulties
  - Inappropriate nutrition intake, e.g.
    - incorrect formula preparation
    - inadequate quantity of food
    - inappropriate food for age, early (before 4 months) or delayed introduction of solids
    - Restricted diet (e.g. low fat, vegan, factitious food allergy)
    - Picky eater
  - Poor feeding habits or technique
  - Mechanical feeding difficulties (e.g. cleft lip or palate)
  - Sucking or swallowing dysfunction (central nervous system, neuromuscular, oesophageal motility problems) or chewing difficulty
  - Gastro-oesophageal reflux
  - Anorexia of chronic disease or anaemia
  - Toxin-induced gastrointestinal upset (e.g. elevated lead levels leading to anorexia, constipation, or abdominal pain)
  - Psychosocial problems
    - Parental mood disorders
    - Substance abuse of one or both parents
    - Disability of chronic illness of one or both parents
    - Poor caregiver understanding
    - Attachment difficulties
    - Poverty
    - Poor social support
    - Behavioural disorders
    - Exposure to traumatic incident/family violence
    - Neglect or abuse

- Inadequate nutrient absorption or increased losses
  - Biliary atresia
  - Coeliac disease
  - Chronic gastrointestinal conditions (e.g. irritable bowel syndrome, inflammatory bowel disease, short bowel syndrome)
  - Infections (e.g. parasites)
  - Chronic liver disease
  - Cystic fibrosis
  - Lactose intolerance
  - Food allergy
  - Pancreatic cholestatic conditions
  - Persistent vomiting (related to infectious gastroenteritis, increased intracranial pressure, adrenal insufficiency, or drugs, etc.)
  - Intestinal tract obstruction (pyloric stenosis, hernia, malrotation, intussusception)

- Increased metabolism or ineffective metabolic utilisation
  - Chronic or recurrent systemic infection (e.g. human immunodeficiency virus infection, AIDS, tuberculosis, urinary tract infection, toxoplasmosis)
  - Inflammatory conditions (e.g. inflammatory bowel disease, juvenile idiopathic arthritis)
  - Chronic respiratory disease
  - Congenital or acquired heart disease
  - Renal failure
  - Malignancy
  - Hyperthyroidism
  - Chronic metabolic problems (e.g. hypercalcaemia, storage diseases, inborn errors of metabolism, diabetes mellitus, adrenal insufficiency)
  - Chromosomal or genetic abnormality

3.3.4 Assessment of FTT/ faltering growth

Some weight loss in the first days after birth is normal and usually relates to body fluid adjustments. This weight loss usually stops after about 3 or 4 days of life. Most infants have returned to their birth weight by 3 weeks of age.[6] Indications for holistic assessment to find out the underlying causes of poor weight gain include:

- Infants lose more than 10% of their birth weight in the early days of life,

- Infants fail to regain their birth weight by 3 weeks of age
- Faltering growth after the early days of life

3.3.4.1 History

Pre- and perinatal history

The following are the predisposing factors of FTT:[8,9,12,13]

- Intrauterine growth restriction
- Prenatal exposure to toxic agents (e.g. alcohol, drugs)
- Perinatal stress
- Prematurity (<37 weeks' gestation)
- Low birth weight (< 2,500 g)

History of present illness

- Age of onset of growth problem
- Developmental history
- Associated symptoms, e.g. diarrhoea or vomiting with or without food triggers, spitting up, abdominal pain, constipation, gagging, decreased appetite, polyuria, polydipsia, recurrent infections, respiratory symptoms, chewing or swallowing problem, urinary symptoms, dark yellow or brown urine, clay-coloured stools, etc.
- Travel history, which may signify the chance of having certain parasite or infection
- Medication intake including herbs and supplement

Diet and feeding history

- The most important part of the evaluation of FTT in primary care setting is obtaining an accurate account of a child's caloric intake, eating habits and parent-child interactions.[2,4]
- For breastfed infants:
  - Feeding patterns and environment
  - Observe breastfeeding to ensure proper technique, latch-on, and swallow.[2]
- For formula-fed infants:
  - Milk volume and changes to formula[11]
  - Caregivers' mixing technique[2,13]
- Timing of the introduction of solids and the types of food offered are evaluated for infants.[11]
- For toddlers:
  - The type and the amount of food consumed

- Feeding routines, difficulties, time required to feed, behaviour during feedings, sleep patterns[5]
- Food refusal[11]
- Milk volume intake by the child over 24 hours[11]
- Parental attitude towards food and mess[11]

- For older children and adolescents:[2]
  - A food journal for three days can help the primary care physician measure caloric intake.
  - The eating habits including inside and outside of the home (e.g. nursery, school)
  - The eating habits of parents or siblings when they were at the same age as the patient
- Food restrictions related to perceived food allergies or dietary beliefs and practices (e.g. vegetarianism, fear of cardiovascular disease, religious or cultural practices)[8,9]
- Assess caregiver's knowledge about dietary needs[12]

Past medical history

- Chromosomal or genetic disorder
- Significant illness preceding onset of growth problem[13]
- Recurrent infections, vomiting, diarrhoea or respiratory symptoms[10]
- History of food allergy
- History of frequent injuries which may signify child abuse or neglect

Family history[2,5,12,13]

- Genetic conditions
- Growth histories of parents and siblings
- Family history of medical illness, such as endocrine, respiratory, gastrointestinal, cardiovascular disorders
- Family history of milk protein intolerance or sensitivity
- Caregivers' knowledge of normal growth and development; their nutritional beliefs and social skills
- Family function, eating patterns, types of food available at home
- Parental or caregiver's psychosocial history including personal history of abuse, eating disorders, alcohol use, drug use, domestic violence, stress, anxiety and depression

Psychosocial history[5,8,11]

- The child's caregivers and family composition
- Employment status of caregivers
- Financial state
- Degree of family and social support
- Family stress
- Assess whether they have similar or different views of the growing and eating problem if there are multiple caregivers
- Explore how the child's FTT affects the parent and family (e.g. parental guilt, stress, family conflict)
- Risk factors of child abuse like domestic violence, drug abuse should be considered if abuse or neglect is suspected
- Community services history (e.g. elicit whether there is history of failure to engage with Maternal and Child Health services)
- Explore whether there is any previous history of child protection involvement

3.3.4.2 Physical examination

In the physical examination of FTT, accurate measurement of the growth parameters should be obtained and plotted on a correct growth chart over time.[2]

Eating or feeding observation by a person with appropriate training and expertise can be performed.[6] Feeding behaviour, the child's oral interest or aversion, and parent-child interactions before, during, and after feeding should be observed and recorded.[2,5]

Most children with FTT will have normal examination, but signs of undernutrition, genetic disorders or medical conditions contributing to FTT, and child abuse or neglect should be sought.[8,9]

General examination

- Vital signs: Blood pressure, pulse rate, respiratory rate
- Check for pallor/jaundice/central cyanosis
- Lymphadenopathy
- Oedema (Renal disease; liver disease; heart failure; protein deficiency)
- Clubbing (Chronic hypoxia due to cardiac or pulmonary disorders)
- Hydration status
- Nutritional status:
    - Fat deposits
    - Muscle wasting (Cerebral palsy; malignancy; significant malnutrition)

- Hair growth (Sparse hair or alopecia in significant malnutrition; hair colour/texture change in zinc deficiency)
- Skin (Scaling skin in zinc deficiency; cheilosis in vitamin deficiency: B2, B3, or B6)
- Nails (Spoon-shaped nails in iron deficiency)
- Bony deformities including craniotabes, beading of the ribs, scoliosis, bowing of the legs or distal radius and ulna and enlargement of the wrist (Rickets)

- Dysmorphic features (Clinical or genetic syndrome associated with poor weight gain)
- Rash (Food allergy; candidiasis in immune deficiency)

Head and neck examination

- Microcephaly (Neurologic disorder)
- Delayed closure of fontanelle (Vitamin D deficiency, hypothyroidism)
- Thyroid enlargement, signs of thyroid disease
- Oropharyngeal lesions, e.g. dental caries, tongue enlargement, mandibular hypoplasia, tonsillar hypertrophy, defects in soft or hard palate
- Aphthous stomatitis (Crohn's disease)

Cardiac examination

- Cardiac murmur (Congenital or acquired heart disease)

Chest examination

- Wheezing, crackles, prolonged expiratory phase, hyperexpansion (Lung disease; asthma)

Abdominal/rectal examination

- Abdominal distension, hyperactive bowel sounds (Malabsorption)
- Hepatosplenomegaly (Liver disease, glycogen storage disease, malignancy, infection)
- Rectal fistulae, large perianal skin tags (Crohn's disease)

Neurologic examination

- Developmental delay
- Abnormal deep tendon reflexes (Cerebral palsy)
- Hypotonia, weakness, spasticity (May be associated with oral motor dysfunction)
- Neuropathy (Vitamin deficiencies: B12, B3 , B6, E)

Signs of child abuse/neglect

- Chronic diaper rash
- Bruises in characteristic patterns, scar
- Poor parent-child interaction

Red flag signs and symptoms suggesting of medical causes of FTT:[2]

- Cardiac findings suggesting congenital heart disease or heart failure (e.g. murmur, oedema, jugular venous distention)
- Developmental delay
- Dysmorphic features
- Failure to gain weight despite adequate caloric intake
- Organomegaly
- Lymphadenopathy
- Recurrent or severe respiratory, mucocutaneous, or urinary infection
- Recurrent vomiting, diarrhoea or dehydration

3.3.4.3 Investigation

Routine laboratory testing identifies a cause of FTT in less than 1 percent of children and is not generally recommended.[2] Treatment can usually be initiated after a thorough history and physical examination without investigation. There is no standard set of laboratory tests recommended for FTT.[9] The choice of investigation depends on history, physical examination findings, and response to dietary interventions. If there are red flag symptoms or signs, initial laboratory tests including complete blood count, serum electrolyte levels, blood glucose, blood urea nitrogen measurement, creatinine levels, erythrocyte sedimentation rate, thyroid function test, liver function test, urinalysis, and urine culture can be performed.[2,4] Additional laboratory tests or imaging studies are considered as indicated by history, physical examination, or initial laboratory testing results.[2,8]

3.3.5 Management of FTT/ faltering growth

Management of children with poor weight gain is individualized according to severity and chronicity of undernutrition, underlying medical disorders, and the needs of the child and family.[14] A clear underlying medical condition cannot be identified in most of the cases. Appropriate guidance for catch-up growth should be made. Age-appropriate nutritional counselling should be provided to parents.[2] Different

expertise (e.g. primary care physician, paediatrician, paediatric dietitian, clinical psychologist) may be required to provide support to the child and parents/ carers. A multidisciplinary approach, including nutritional counselling, social service,[5] and home visits, has been shown to improve weight gain, parent-child relationship, and cognitive development.[2]

Management of weight loss in the early days of life[6]

- Provide feeding support if there is concern about weight loss in infants in the early days of life, for example if they have lost more than 10% of their birth weight.
- Information on breastfeeding is available in the Family Health Service, Department of Health, HKSAR: http://www.fhs.gov.hk/english/breastfeeding/
- Be aware that supplementary feeding with infant formula in a breastfed infant may help with weight gain, but often results in cessation of breastfeeding.
- If supplementation is needed for a breastfed infant, support the mother to continue breastfeeding and advise expressing breast milk to promote milk supply. Supplement the infant with available breast milk before giving any infant formula.
- Measure the infant's weight again at appropriate intervals depending on the level of concern, but not more frequent than daily.
- Recognise the emotional impact on parents and carers.
- Provide understandable information to parents or carers that is specific to them and their child, and clearly explain to them in spoken and written form.
- Discuss with the parents or carers about the reasons for the concern of the poor growth, the interpretation of the growth measurements, their worries, the possible causes of growth problem, and the management plan.

Management of faltering growth after the early days of life[6]

- Together with parents and carers, establish a management plan with specific goals for every infant or child. This plan could include assessments or investigations, interventions, clinical and growth monitoring, and the time for reassessment to review progress and achievement of growth goals.
- Provide feeding support if necessary.
- Be aware that while supplementary feeding with infant formula may increase weight gain in a breastfed infant if there is concern about faltering growth, it often results in cessation of breastfeeding.
- If supplementation is needed for a breastfed infant, support the mother to continue breastfeeding and advise expressing breast milk to promote milk

supply. Supplement the infant with available breast milk before giving any infant formula.

- Discuss the following, as individually appropriate, with the infant's or child's parents or carers:
  - encouraging relaxed and enjoyable feeding and mealtimes
  - eating together as a family or with other children
  - encouraging young children to feed themselves
  - allowing young children to be 'messy' with their food
  - making sure feeds and mealtimes are not too brief or too long
  - setting reasonable boundaries for mealtime behaviour while avoiding punitive approaches
  - avoiding coercive feeding
  - establishing regular eating schedules (for example 3 meals and 2 snacks in a day) for children aged over 9 months[15]
- If necessary, based on the assessment, advise on food choices for infants and children that:
  - are appropriate to the child's developmental stage in terms of quantity, type and food texture
  - optimise energy and nutrient density.
- In infants or children who need a further increase in the nutrient density of their diet beyond that achieved through advice on food choices, consider:
  - short-term dietary fortification using energy-dense food
  - referral to a paediatric dietitian.
- Advise the parents or carers that drinking too many energy-dense drinks, including milk, can reduce a child's appetite for other food.
- Regularly reassess infants and children receiving an oral nutritional supplement for faltering growth to decide if it should be continued. Take into account:
  - weight change
  - linear growth
  - intake of other food
  - tolerance
  - adherence
  - the views of parents or carers.
- Measure the weight at appropriate intervals taking account of factors such as age and the level of concern, but usually no more often than:
  - daily if less than 1 month old
  - weekly between 1–6 months old
  - fortnightly between 6–12 months
  - monthly from 1 year of age.

- Monitor length or height at intervals, but no more often than every 3 months.
- Recognise the emotional impact on parents and carers.
- Provide understandable information to parents or carers that is specific to them and their child, and clearly explain to them in spoken and written form.
- Discuss with the parents or carers about the reasons for the concern of the poor growth, the interpretation of the growth measurements, their worries, the possible causes of growth problem, and the management plan.

Referral

- Referral to an appropriate paediatric specialist care service if:[6]
  - Symptoms or signs that may indicate an underlying disorder
  - A failure to respond to interventions delivered in a primary care setting
  - Slow linear growth or unexplained short stature
- Referral to hospital for immediate care if:
  - Rapid weight loss or severe undernutrition
  - Features that cause safeguarding concerns in case of child abuse and neglect

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3.4 Puberty problems (premature/ delayed)

3.4.1 Introduction

Puberty is the process of physical changes through which progressive maturation of sexual characteristics ultimately leading to attainment of full reproductive capacity. Puberty results when pulsatile secretion of gonadotropin-releasing hormone (GnRH) is initiated and the hypothalamic-pituitary-gonadal (HPG) axis is activated.[1]

In Hong Kong, the median ages of onset of puberty, onset of pubic hair development, and menarche for girls were 9.78 years, 11.64 years and 12.38 years respectively in 1993, while those in 1961-1962 were 10.73 years, 12.44 years, and 12.85 years respectively.[2] The median ages of onset of puberty and pubic hair development for boys were 11.4 years and 12.7 years respectively in 1993, while those in 1961-1962 were 13.19 years and 13.31 years respectively.[3,4] The average age of puberty has been observed to decrease in many developed countries. Genetic factors, environmental aetiology, obesity, changes in foetal nutrition, childhood dietary habits, physical activity and exposure to endocrine disrupting chemicals are possible causes of influence to the endogenous endocrine system, and therefore potentially affecting the maturation of reproductive system.[5]

3.4.2 Definition

Precocious puberty is defined as the onset of secondary sexual characteristics at an age that is 2 to 2.5 standard deviations earlier than the population mean. According to the definitions commonly adopted overseas, precocious puberty is diagnosed when secondary sexual characteristics are identified in girls younger than 8 years and boys younger than 9 years.[6,7] However, sexual maturation may vary in different racial or ethnic populations. In Hong Kong, with reference to the 1993 Hong Kong Growth Survey, onset of puberty before 7 years in girls and before 8 years in boys is considered premature.[8] Yet, for practical purposes, primary care doctors may consider initiation of clinical evaluation if onset of puberty appears before 7 years for girls and before 9 years for boys. This relatively more cautious approach for boys is taken because boys are more likely to have a pathologic cause if precocious puberty is suspected at any age.[7,9] In contrast, while it is more common to encounter girls suspected of precocious puberty, the cause is commonly idiopathic for those presenting older than 6 years.[9]

Delayed puberty is defined as the absence of physical signs of puberty 2 to 2.5

standard deviations older than the population mean.[10] It is commonly adopted as lack of breast development by 13 years of age in girls or lack of testicular enlargement (less than 4 mL in testicular volume or less than 2.5cm in testicular length) by 14 years of age in boys.[7,10] Pubertal delay should be suspected if there is halting or regression of pubertal development. In girls with initial pubertal changes, absence of menarche by 15 years of age is also concerning.[7]

The above age should be viewed as references and not a definitive cutoff for normality/abnormality. Some of the children falling into the one end of the normal distribution curve may not necessarily have pathologic issues.[8] On the other hand, a "normal" timing of onset of pubertal development does not rule out a pathologic condition.[1] The age references should be used with caution and the overall clinical condition of the child should also be considered.

3.4.3 Presentation

With reference to the information provided in Chapter 3.4.2, the clinical features related to normal, precocious and delayed puberty are listed in Table 6 below.

Table 6. Clinical features related to normal, precocious and delayed puberty

	Development of secondary sexual characteristics in normal puberty	**Features that may indicate precocious puberty**	**Features that may indicate delayed puberty**
Girls	■ Typical sequence in girls:[11] • onset of breast development (thelarche) • onset of pubic hair development (pubarche) usually occurs 1-1.5 years after thelarche, but can also precede or occur simultaneously with thelarche • onset of menses (menarche) usually occurs about 2-2.5 years after thelarche	■ Onset of secondary sexual characteristics before the age of 7 years	■ Lack of breast development by the age of 13 years ■ Halting or regression of pubertal development ■ Absence of menarche by the age of 15 years in girls with initial pubertal changes
Boys	■ Typical sequence in boys:[11]	■ Onset of	■ Lack of testicular

	• testicular enlargement (>4 mL in volume or >2.5cm in length) • onset of pubic hair development (pubarche) and penile growth • start of sperm production (spermarche) • voice change and appearance of facial hair	secondary sexual characteristics before the age of 9 years	enlargement by the age of 14 years ■ Halting or regression of pubertal development

N.B.: The above age should be viewed as references and not a definitive cutoff for normality/abnormality. The child's overall clinical condition should be taken into consideration.

3.4.4 Differential Diagnosis of Premature and Atypical Puberty

The aetiology of early pubertal maturation may range from a variant of normal development (e.g. isolated premature thelarche, isolated premature adrenarche) to pathologic conditions with significant risk of morbidity and mortality. Precocious puberty can be classified into central precocious puberty, peripheral precocious puberty, and benign or non-progressive pubertal variants according to the underlying pathophysiology. It is important to distinguish between the common variants and true precocious puberty. Findings that suggest pathology include a rapid tempo of progression; advanced development; rapid linear growth; advanced skeletal maturation; and in girls, the presence of both breasts and pubic hair.[12] Apart from precocious puberty, lipomastia and gynaecomastia in children and adolescents may also raise the concern of parents and children as puberty problem.

3.4.4.1 Central and Peripheral Precocious Puberty

The causes of abnormally early pubertal maturation can be separated into GnRH-dependent and GnRH–independent processes. GnRH-dependent precocious puberty, also known as central precocious puberty, results from activation of the HPG axis by a variety of central nervous system (CNS) abnormalities (Table 7). The aetiologies of central precocious puberty are similar in boys and girls with idiopathic central precocious puberty more common in girls, comprising about 90% of cases.[12] Boys with precocious puberty are much more likely to have identifiable pathology. Organic forms of central precocious puberty usually occur at an earlier age than the idiopathic form, and the progression of secondary sexual maturation is often more rapid.[6]

GnRH-independent precocious puberty, also known as peripheral precocious puberty, is caused by exogenous sex hormone exposure or excess secretion of endogenous sex hormones from the adrenal glands or gonads.[6] In contrast to central precocious puberty, the aetiologies of peripheral precocious puberty are different among boys and girls (Table 7).[12]

It is crucial to determine whether the cause of precocious puberty is GnRH-dependent or -independent. Boys with central precocious puberty typically have symmetrically enlarged testicular volumes, whereas those with most forms of peripheral precocious puberty have testes that are either prepubertal or disproportionately small compared with the degree of virilisation. In girls, pelvic ultrasonography to assess ovarian volume is not sufficiently sensitive to distinguish the form of precocious puberty, but it may be helpful as an adjunct to other studies. Serum sex hormone study in specialist care is usually needed.[12] The different characteristics of central precocious puberty and peripheral precocious puberty can be referred to Table 8.

Table 7. Causes of Central and Peripheral Precocious Puberty[6,12]

Central Precocious Puberty (GnRH-Dependent): Females and Males	Peripheral Precocious Puberty (GnRH-Independent): Females	Peripheral Precocious Puberty (GnRH-Independent): Males
■ Idiopathic ■ Central nervous system (CNS) insults • Brain tumour - Astrocytoma - pineal tumour - optic pathway glioma (neurofibromatosis type 1) - craniopharyngioma (rare) - hypothalamic hamartoma • Cerebral palsy • Hydrocephalus • CNS irradiation • CNS trauma • CNS infection • CNS granulomatous disease • Subarachnoid cyst ■ Tuberous sclerosis ■ Sturge-Weber syndrome ■ Withdrawal of chronic sex hormone exposure ■ Septo-optic dysplasia (rare) ■ Gain of function mutation of kisspeptin/kisspeptin receptor	<u>Isosexual:</u> ■ McCune-Albright syndrome ■ Oestrogen-secreting ovarian tumour ■ Ovarian cyst ■ Oestrogen-secreting adrenal tumour ■ Exogenous oestrogen exposure ■ Peutz-Jeghers syndrome ■ Primary hypothyroidism ■ Aromatase excess <u>Contrasexual:</u> ■ Virilising congenital adrenal hyperplasia ■ Androgen-secreting adrenal tumour ■ Androgen-secreting ovarian tumour ■ Aromatase deficiency ■ Iatrogenic (i.e. exposure to androgens)	<u>Isosexual:</u> ■ Familial male-limited precocious puberty (testotoxicosis) ■ Leydig cell tumour ■ Human chorionic gonadotropin-secreting tumour ■ Androgen-secreting adrenal tumour ■ Exogenous testosterone exposure ■ Congenital adrenal hyperplasia ■ Primary hypothyroidism (testicular enlargement only) ■ Familial glucocorticoid resistance ■ McCune-Albright syndrome (rare) <u>Contrasexual:</u> ■ Oestrogen-secreting adrenal tumour ■ Oestrogen-secreting testicular tumour ■ Aromatase excess syndrome ■ Iatrogenic (i.e. exposure to oestrogens)

Table 8. Characteristics of Central and Peripheral Precocious Puberty[1,6,7,12]

Central Precocious Puberty (CPP)	Peripheral Precocious Puberty (PPP)
- Result from premature activation of the hypothalamic-pituitary-gonadal axis	- Caused by exogenous sex hormone exposure or excess secretion of endogenous sex hormones from the adrenal glands or gonads
- More common than PPP - About 10-fold more common in girls than in boys	- Less common
- The range of aetiologies is similar in boys and girls, but idiopathic CPP is much more common in girls (about 90% of cases). - Pathologic causes are more common in boys.	- The aetiologies are different among boys and girls.
- Early but normal development, symmetric progression of secondary sexual characteristics, and increasing growth velocity, e.g. boys with CPP typically have symmetrically enlarged testicular volumes	- Varied pubertal symptoms depending on nature of sex steroid produced. More likely to have deviations from the normal sequence and/or pace of puberty, e.g. the onset of menses before later Tanner stages of breast development in girls, testes are either prepubertal or disproportionately small compared with the degree of virilisation in boys.
- Always be isosexual (consistent with patient's known gender)	- Either be isosexual or contrasexual (not consistent with patient's known gender)
- Basal luteinizing hormone (LH) level is at post-pubertal levels (> 0.3 IU/L) - Peak LH level above the pubertal cutoff after stimulation with GnRH or GnRH agonist (>5 to 8 IU/L)	- Follicle-stimulating hormone (FSH) and luteinizing hormone (LH) levels are suppressed (in the prepubertal range) and do not increase substantially with GnRH stimulation. - Very high concentrations of oestradiol or testosterone, with associated suppression of gonadotropins, are generally indicative of peripheral precocity. - May have change in other hormones, e.g. elevated thyroid stimulating hormone in primary hypothyroidism, elevated human chorionic gonadotropin (hCG) in boys may suggest hCG-secreting tumour, significantly elevated serum adrenal androgens may suggest adrenal tumour.
- Can be treated with a GnRH agonist	- Treatment depends on the cause. - GnRH agonist therapy is ineffective

3.4.4.2 Benign or non-progressive pubertal variants

- Benign premature adrenarche
- Benign premature thelarche
- Benign prepubertal vaginal bleeding
- Genital hair appearing in infancy
- Non-progressive precocious puberty

Benign Premature Adrenarche

Premature adrenarche (PA) is a variant of normal development. It is driven by adrenal androgens leading to slowly progressive appearance of pubic and axillary hair, body odour, sweating, and/or mild acne without change in linear growth velocity or enlargement of the testes, penis, breasts, ovaries, or clitoris. Dehydroepiandrosterone sulfate (DHEAS) may be at a pubertal level (i.e., slightly elevated for the patient's chronologic age), whereas oestradiol, testosterone, luteinizing hormone (LH), and follicle-stimulating hormone (FSH) remain at prepubertal levels.[7] Bone and height ages may be slightly advanced. It is more common in girls and is typically found in children older than 6 years of age. The presenting signs and symptoms of PA may overlap with non-classical congenital adrenal hyperplasia, and adrenocorticotropic hormone (ACTH) stimulation testing may be required to differentiate the two.[6] In some populations, PA has been associated with increased cardiometabolic risk factors and an increased risk for polycystic ovary syndrome (PCOS) in later life.[12] The extent of radiologic and laboratory testing required for typical cases of PA is somewhat controversial. Laboratory or bone age assessment may be deferred initially for children presenting with typical PA without rapid growth or red flags.[7] No treatment other than reassurance is required. Children with PA are followed up at approximately 6-month intervals with careful assessment of growth velocity, weight gain, and progression of signs of androgen excess. More frequent follow-up may be needed depending on the clinical condition. Families should be counselled regarding the increased risk of early puberty and should be given instructions to return promptly if marked growth acceleration or progressive virilisation occurs. Cardiometabolic risk factors (e.g. type 2 diabetes and hyperlipidaemia) should be watched out for, particularly if there has been significant weight gain.[13] Referral to paediatric endocrinologist should be considered for atypical or worrisome cases of early onset of pubic hair in order to have further evaluation and testing.[14]

Benign Premature Thelarche[15]

Premature thelarche is a benign, self-limited condition. It is characterized by isolated breast development without other sins of secondary sexual development at an age younger than the accepted lower limits for age of onset of puberty. It occurs most commonly during the first 2 years of life. It is usually bilateral but sometimes is unilateral. The breast enlargement is not excessive and there are no significant changes of nipples or areolae. It typically does not progress beyond Tanner stage 3; in unilateral cases it does not progress beyond Tanner stage 2. The breast enlargement may be transient but in most cases it persists for several months or years. The pathophysiology of isolated breast development is still not well known. Postulated mechanisms include increased breast tissue sensitivity to normal circulating oestrogen in prepubertal girls, transient oestrogen secretion by follicular cysts of the ovary, increased production of oestrogens from precursors of adrenal origin, increased dietary oestrogen as a result of exogenous contamination of food, and transient partial activation of the HPG axis with excessive secretion of FSH. Exposure to certain environmental agents such as lavender oils and tea tree oils has also been implicated in some cases of premature breast thelarche. The children with premature thelarche have a normal growth pattern with puberty onset occurs at the usual age and their sexual maturation pattern is completely normal. It does not require treatment. Clinical follow-up every 3 to 6 months is recommended to monitor the pubertal progression and growth in order to help differentiate it from central precocious puberty. Referral to paediatric endocrinologist and further assessment with laboratory and radiologic testing are indicated for patients with clinical signs of potential puberty progression including progressive breast development, appearance of other secondary sexual characteristics, and growth acceleration.

Benign Prepubertal Vaginal Bleeding[16]

It is defined as isolated or recurrent vaginal bleeding in a prepubertal female in the absence of appropriate secondary sexual characters or a known pathologic cause. It is also known as premature menarche. It usually presents with isolated or repeated periodic episodes of menses and is diagnosed by exclusion after ruling out possible underlying organic disorders. In the absence of other appropriate secondary sexual characteristics, it is a benign entity. The underlying cause is unknown but potential mechanisms include increased sensitization of endometrial lining to oestrogens or transient stimulation of the HPG axis. Although most of these patients tend to have a few episodes of menses that stop spontaneously, some may continue to have periods into adulthood. In contrast to true puberty, there is no advanced skeletal maturation in these patients, and the final adult height is normal. Fertility also appears to be

normal. The differential diagnosis of unexpected vaginal bleeding includes ovarian cysts, infections or tumours of the genital tract, foreign bodies, trauma, sexual abuse, McCune-Albright syndrome or central precocious puberty. Specialist referral should be considered to rule out organic pathologies. Once having confirmed benign prepubertal vaginal bleeding, these girls should be monitored periodically until vaginal bleeding resolves, and the families should be reassured.

Genital Hair Appearing in Infancy

It is usually a benign condition and the infants present with isolated genital hair which is typically fine and straight and located more along the labia or over the scrotum, in contrast to older children with PA, in whom the hair is thicker, curlier, and located more over the pubic symphysis.[14] The condition is transient and the hair typically disappears within 6 months to 2 years.[17] The concentrations of testosterone and 17-hydroxyprogesterone are normal for age, but some have a modest elevation of DHEAS, suggesting an adrenal source of androgens. Laboratory tests are not needed if there is no genital enlargement and no crossing of growth percentiles.[14]

Non-progressive precocious puberty

Some cases of precocious pubertal development will have stabilization or regression of pubertal signs. The underlying mechanism is unknown, but the gonadotropic axis is not activated. The growth velocity is usually normal for age. The bone age is normal and the uterus on ultrasound examination is at prepubertal stage. The LH peak after GnRH or GnRH agonist is in the prepubertal range. In children with non-progressive precocious puberty, no treatment is necessary because their adult height is within target height range.[1] It is important to differentiate it from true central precocious puberty by monitoring for evidence of pubertal progression. It is suggested to have surveillance every 3 to 6 months to evaluate for progression of pubertal development.[7]

3.4.4.3 Lipomastia[14]

Breast enlargement may be caused by adipose tissue in overweight or obese prepubertal children. It is more apparent in the sitting than in the supine position. When examined supine, careful palpation under the areolae fails to detect firm glandular tissue. In addition, the nipples and areola will show no oestrogenic stimulation. If the breast examination is inconclusive, the child may be observed over a period of 4 to 6 months for signs of pubertal progression.

3.4.4.4 Physiologic Gynaecomastia in Children and Adolescents

Gynaecomastia is defined as benign proliferation of glandular breast tissue in males. Physiologic gynaecomastia in children and adolescents can appear bilaterally or unilaterally with incidence peaking in the neonatal period and early to mid-puberty.

An estimated 60%-90% of neonates have transient gynaecomastia, which can occur due to placental transfer of oestrogens from mother to child. It usually resolves spontaneously within four weeks of age.[18] Children with symptoms that persist after 1 year old should be examined further and they may be at risk of persistent pubertal gynaecomastia.[19]

Physiological pubertal gynaecomastia results from the imbalance between oestrogens and androgens within the breast tissue and occurs in as many as 70% of adolescent boys.[18] The onset is typically at 13 to 14 years of age, or Tanner stage 3 or 4, with spontaneous resolution within 6 months to 2 years.[19] The breast tissue is usually asymmetric and often tender. If the history, sexual development, and physical examination, including palpation of the testes, are unremarkable, reassurance and periodic reevaluation are the mainstay of management with no further diagnostic work-up is necessary.[20,21] However, further evaluation is indicated and specialist referral should be advocated if there is evidence of an underlying pathology, for example, macrogynaecomastia (>4 cm) with rapid progression (indicative of the magnitude of hormonal imbalance); galactorrhoea (hyperprolactinaemia); small testicles and lack of or reduced secondary male sexual characteristics (hypogonadism); an abdominal or testicular mass (tumour); eunuchoidal body habitus, behavioural problems, and firm testicles (Klinefelter syndrome); accelerated linear growth (aromatase excess); goitre (hyperthyroidism); systemic symptoms suggestive of chronic disease; use of prescription, recreational, or performance-enhancing drugs; symptoms persist after two years or past 17 years of age; and so on.[7,19,21]

3.4.4.5 Prepubertal gynaecomastia

Gynaecomastia in a prepubertal boy is rare and pathologic cause should be ruled out. Endogenous or exogenous source of oestrogen should be searched for and an urgent referral to paediatric endocrinologist is warranted. Conditions to consider include androgen-producing and oestrogen-producing tumours, inherited disorders of steroid synthesis, aromatase excess, medications, and unintentional environmental exposures.[21]

3.4.5 Differential diagnosis of Delayed Puberty

The causes of delayed puberty are broad (Table 9). Constitutional delay of growth and puberty is the most common cause of delayed puberty in boys (60%) and girls (30%). It is a non-pathologic condition where puberty occurs at extreme end of normal spectrum and is a diagnosis of exclusion. Family history may reveal parental pubertal delay in more than 75% of patients with constitutional delay of growth and puberty.[7] Yet, the differentiation between constitutional delay of puberty and isolated (or congenital/idiopathic) hypogonadotropic hypogonadism remains difficult and it is usually resolved by serial observation.[22,23] Isolated hypogonadotropic hypogonadism is diagnosed if endogenous puberty has not begun by the age of 18 years.[23]

Other aetiologies of delayed puberty are categorized based on gonadotropin levels. Hypergonadotropic hypogonadism is due to gonadal failure or the inability to synthesize or respond to sex steroids despite an appropriate activation of the hypothalamic-pituitary component. It is characterized by elevated levels of FSH and LH.[22] Hypogonadotropic hypogonadism is secondary to delay or failure of the hypothalamic/pituitary portion of the HPG axis.[10] It is characterized by low levels of FSH and LH and can be further classified by the pathology. Functional hypogonadotropic hypogonadism is caused by chronic disease, stress, or inadequate nutrition and the condition may be transient or reversed. Persistent hypogonadotropic hypogonadism is caused by a congenital abnormality in the HPG axis or an acquired aetiology such as a CNS tumour, trauma, surgery, or radiation.[7]

Table 9. Aetiologies of delayed puberty[7,10,22-24]

■ Constitutional delay of growth and puberty

■ Hypogonadotropic hypogonadism (low levels of FSH and LH)

<u>Functional hypogonadotropic hypogonadism</u>

- Systemic Illness/Conditions
  - Cystic Fibrosis
  - Asthma
  - Inflammatory Bowel Disease
  - Coeliac Disease
  - Juvenile Rheumatoid Arthritis
  - Anorexia Nervosa/Bulimia
  - Sickle Cell Disease
  - Hemosiderosis
  - Thalassemia
  - Chronic Renal Disease
  - AIDS
- Endocrinopathies
  - Diabetes Mellitus
  - Hypothyroidism
  - Hyperthyroidism (rare)
  - Hyperprolactinaemia
  - Growth Hormone Deficiency
  - Cushing Syndrome
- Excessive Exercise
- Malnutrition
  - E.g. poverty, starvation, or anorexia nervosa

<u>Persistent hypogonadotropic hypogonadism</u>

- CNS Tumours/Infiltrative Diseases
  - Astrocytoma
  - Germinoma
  - Glioma
  - Craniopharyngioma
  - Prolactinoma
  - Langerhans Cell Histiocytosis
- Rathke Pouch Cyst
- Genetic Defects
  - Kallmann syndrome
  - Isolated (or congenital/idiopathic) hypogonadotropic hypogonadism
  - Hypothalamic-pituitary-gonadal Axis Development
  - Obesity and hypogonadotropic hypogonadism
- Syndromes
  - Prader-Willi
  - Laurence-Moon-Bardet-Biedl
  - CHARGE
- Gaucher Disease
- Post Central Nervous System Infection
- Midline Defects
  - Septo-Optic Dysplasia
  - Congenital Hypopituitarism
- Chemotherapy/Radiation Therapy
- CNS trauma/surgery

■ Hypergonadotropic Hypogonadism (elevated FSH and LH)

- Genetic Syndromes
  - Turner Syndrome
  - Noonan Syndrome and related disorders
  - Klinefelter Syndrome (boys)
- Fragile X premutation
- Cryptorchidism
- Gonadal Dysgenesis
- Vanishing Testes Syndrome
- Trauma/Testicular Torsion
- Chemotherapy/Radiation Therapy
- Gonadal Infection
  - Mumps, Coxsackie
- Galactosaemia
- Autoimmune Oophiritis
- Autoimmune Orchitis
- Defects in Steroidogenesis
  - 5-alpha reductase deficiency
  - 17, 20 lyase deficiency
  - Congenital Lipoid Adrenal Hyperplasia
- Androgen Insensitivity
- Sertoli Cell only Syndrome (Del Castillo Syndrome)

■ Unclassified

3.4.6 Assessment of puberty problem

In the assessment of abnormal puberty, primary care physicians should bear in mind the possible benign constitutional causes and pathologic causes. The assessment should include a focused medical history, a directed physical examination, assessment using a complete growth chart, and appropriate investigations.

3.4.6.1 History[7,14,20,22,23]

History of present illness

- Growth and development history, with previous growth charts as reference
- The onset and progression of body odour, acne, breast or testicular development, and pubic and axillary hair
- Nutrition and exercise patterns
- Associated symptoms: (Table 10 and Table 11)

Table 10. Early Pubertal Development: Associated Symptoms and Possible Underlying Aetiology

Early Pubertal Development	
Symptoms	**Possible underlying aetiology**
Abdominal pain	Gonadal malignancy
Asymmetric testes	Gonadal tumour
Enlarged thyroid, temperature intolerance, weight change, gastrointestinal symptoms, tremor, palpitations	Thyroid disease
Head trauma	Central precocious puberty
Hirsutism, acne, body odour	Hyperandrogenism: premature adrenarche, peripheral precocious puberty
Headache, visual changes, dyskinesia, and seizures	Intracranial pathology
Vaginal bleeding (isolated)	Benign variant, genital trauma or abuse, foreign body, infection, McCune-Albright syndrome
Virilisation in girls	Androgen-secreting tumour, congenital adrenal hyperplasia

Table 11. Delayed Puberty: Associated Symptoms and Possible Underlying Aetiology

Delayed Puberty	
Symptoms	**Possible underlying aetiology**
Abdominal pain, constipation, diarrhoea, per rectal bleeding	Inflammatory bowel disease, coeliac disease
Abnormal sense of smell	Kallmann syndrome
Asymmetric testes	Orchitis
Bilateral cryptorchidism, micropenis	Congenital (idiopathic) hypogonadotropic hypogonadism
Enlarged thyroid, weight gain, cold intolerance, fatigue	Hypothyroidism
Galactorrhoea	Hyperprolactinaemia
Joint pain	Inflammatory disorder
Headache, visual changes, dyskinesia, and seizures	Intracranial pathology
Visual disturbance, intellectual disability, seizures, congenital midline defects	Congenital syndrome (e.g. septo-optic dysplasia)
Weight loss	Malignancy, chronic illness, eating disorder
Vasomotor symptoms in girls	Ovarian insufficiency

Past medical history

- Past medical illness
- History of head trauma or testicular trauma
- History of medical or surgical treatment, including chemotherapy or radiation therapy

Drug history

- Possible exogenous sources of sex steroids, e.g. sex hormone treatment, ingestion of oral contraceptive pills, exposure to transdermal oestrogen creams or testosterone gels.

Family history

- Childhood growth patterns and age at pubertal onset of the parents and siblings
- Family history of chronic disease (e.g. coeliac disease, thyroid disease, and anorexia) or genetic disease

Psychosocial history

- Psychosocial functioning
- Stress
- Mood disorder symptoms
- Behaviour change
- Sexual activity
- Ethnicity
- Exposure to environmental chemicals with oestrogen-like activity such as phthalates, polychlorinated biphenyls, lavender, or tea tree oil

3.4.6.2 Physical examination[7,14,20,22,23]

General/ head and neck examination

- Height, weight, and body mass index with growth charts plotting
- Arm span: eunuchoid habitus (arm span exceeds height by more than 5 cm) signifies delayed epiphyseal closure caused by hypogonadism.
- Document height velocity. Determine whether and when a growth spurt has occurred (an abrupt increase in the annual growth rate).
- Calculate target height (mid-parental height): [maternal height (cm) + paternal height (cm) + 13cm in boys or - 13cm in girls]÷2
  A pathologic condition may be suggested if a target height differing from the projected height, as established by extending the growth curve to adulthood or bone age radiography, by approximately more than 10cm.
- Look for midline defects (e.g. cleft lip and/or palate in septo-optic dysplasia), dysmorphic features (e.g. webbed neck, short stature, low hairline, cubitus valgus, hypertelorism in Turner syndrome), and café au lait spots in McCune-Albright syndrome and neurofibromatosis. Presence of port-wine stain on the forehead and upper eyelid (primarily in the distribution of the first or second division of the trigeminal nerve) on one side of the face may suggest Sturge-Weber syndrome.
- Look for goitre and signs of hyperthyroidism (e.g. exophthalmos, sweaty skin, tremor, hypertension, tachycardia) or hypothyroidism (e.g. dry skin, dry hair, bradycardia).

Genital examination and pubertal staging

- Examination of the genitalia and determination of the status of the pubertal milestones is essential [please refer to Annex II] and should be documented for future reference. In boys, determining the location, consistency, and size of the testes can evaluate for cryptorchidism, orchidopexy, malignancy, or Klinefelter

syndrome (small, firm testes). In girls, dull pink vaginal mucosa suggests oestrogen exposure, whereas red or thin vaginal mucosa suggests lack of oestrogen exposure (hypogonadism); virilisation (e.g. clitoromegaly) should be excluded.

Examination of other systems

- Perform abdominal and neurologic systems examination to exclude gastrointestinal disease and intracranial pathology respectively.
- Cardiovascular examination may reveal congenital heart disease which may be associated with genetic syndrome.
- Examine the optic fundi and estimate the visual fields. Abnormality may suggest pituitary tumours.
- Evaluate the sense of smell which may be impaired in Kallmann syndrome.

3.4.6.3 Investigation

A radiograph of the left wrist and hand is used to estimate physiologic age for comparison with the child's chronologic age.[20] Additional testing will be determined by the initial clinical assessment and suspected aetiology.

For precocious puberty:

- The initial workup includes measurement of serum FSH, LH, and testosterone in boys or oestradiol in girls; and thyroid function testing.[7]
- If a central pathologic cause is suspected after obtaining hormone measurements or uncertain diagnosis based on the basal gonadotropin levels, a GnRH analogue stimulation test may be warranted.[7]
- Measure hCG in boys if peripheral precocious puberty is suspected to evaluate for the possibility of an hCG-secreting tumour.[6]
- In cases of hyperandrogenic findings, serum DHEAS and 17-hydroxyprogesterone are measured.[7]
- Girls younger than six years, all boys with precocious puberty, and children with neurologic symptoms should be screened with CNS magnetic resonance imaging.[7]
- If a peripheral cause is suspected from the initial clinical assessment or by the pattern of hormone levels, high-resolution ultrasonographic images of the ovaries or computed tomographic images of the adrenal glands are indicated, depending on the clinical impression.[20]
- In cases of uncertain diagnosis, pelvic ultrasonography can also be used to evaluate for increased uterine and ovarian volume expected for age, which may

signify central precocious puberty or a tumour.[7]

- Consider testicular ultrasound for asymmetric testes or suspected testicular tumour, e.g. Leydig-cell tumour, in boys with peripheral precocious puberty.

For delayed puberty:

- Baseline blood tests include complete blood picture, liver function test, renal function test, and thyroid function test.[25] The initial hormonal workup includes serum FSH, LH, testosterone in boys or oestradiol in girls. If growth velocity is abnormal, measure prolactin and insulin-like growth factor 1. If chronic disease is suspected, perform directed testing.[7]
- Perform karyotype if chromosomal abnormalities are suspected, such as Klinefelter syndrome in boys and Turner syndrome in girls.[20,22,23]
- Pelvic ultrasonography is useful in girls to examine pelvic anatomy and maturity, and signs of ovarian follicles identify gonadotrophin stimulation.[24]
- Perform testicular ultrasound when physical examination detects a testicular mass.
- If CNS lesion is suspected, MRI scanning of the brain and pituitary gland is indicated.[7,20,22-24]

3.4.7 Management of puberty problem

Many cases of puberty problem are non-pathologic, in which reassurance and regular follow-up for monitoring the puberty development are warranted. Advice on appropriate diet and exercise should be given for those with dietary and sports related pubertal problems.

Parental and patient anxiety is common when sexual development is abnormal. A supportive doctor patient relationship can help in the management. Children with puberty disorder may have psychosocial difficulties.[20,23,26] Counselling and psychotherapy may be required.

When a pathologic cause is suspected or the diagnosis is not certain, paediatric endocrinologist referral should be advocated. Treatment is directed at the underlying cause.

The increased growth, accelerated bone maturation and premature fusion of the growth plates in precocious puberty may result in adult short stature.[27] Height loss due to precocious puberty is inversely correlated with the age at the onset of puberty.[1] The mainstay of treatment for central precocious puberty is GnRH analogues

with the aims at preserving the adult height potential, especially in those with puberty onset before 6 years of age, and relieving the psychosocial difficulties with early puberty and menarche.[12] For peripheral precocious puberty, treatment varies with the underlying pathology.

Medical treatment is unnecessary in most children with constitutional delay of growth and puberty. However, those with the condition suffering from significant psychosocial stress and disadvantage should be identified and informed of the availability of different treatment options. Referral to a paediatric endocrinologist for a detailed assessment is recommended before the commencement of medical intervention including sex hormone treatment.[25] For other aetiologies of delayed puberty, the underlying pathology is treated accordingly.

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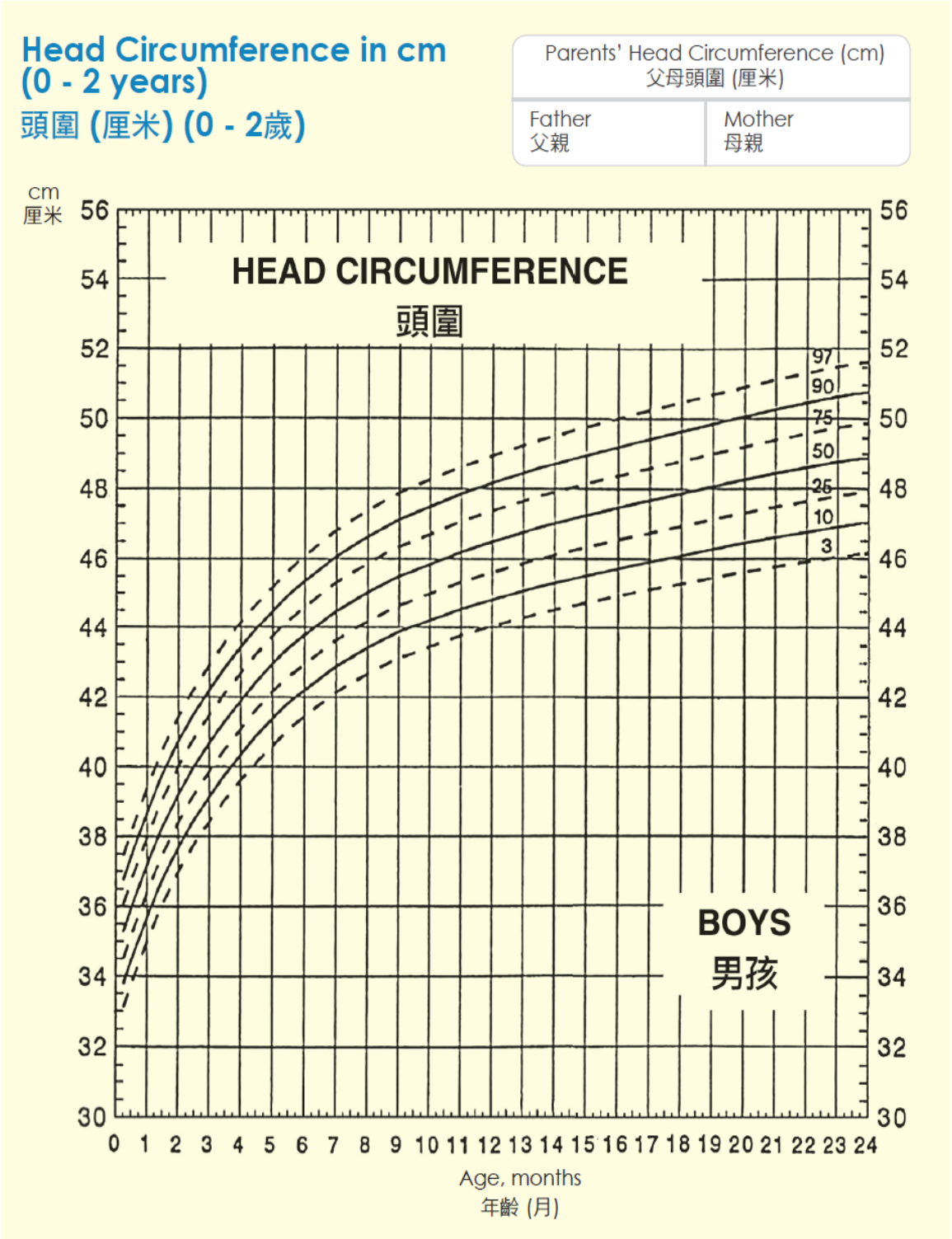
Annex I. Growth Charts

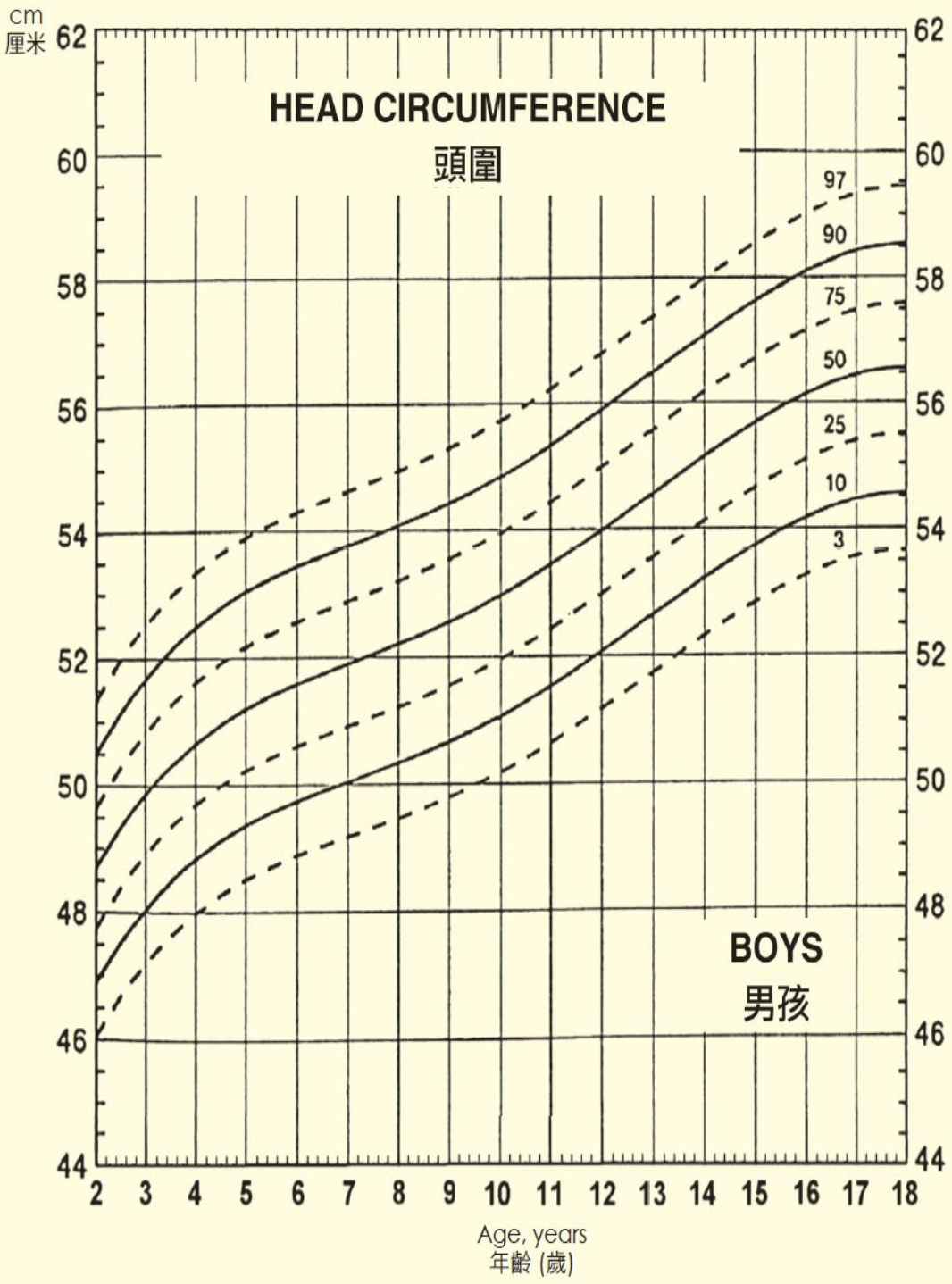
Growth Charts for Hong Kong Chinese

(Adopted from HK Growth Survey 1993, the Chinese University of Hong Kong and the Department of Health)

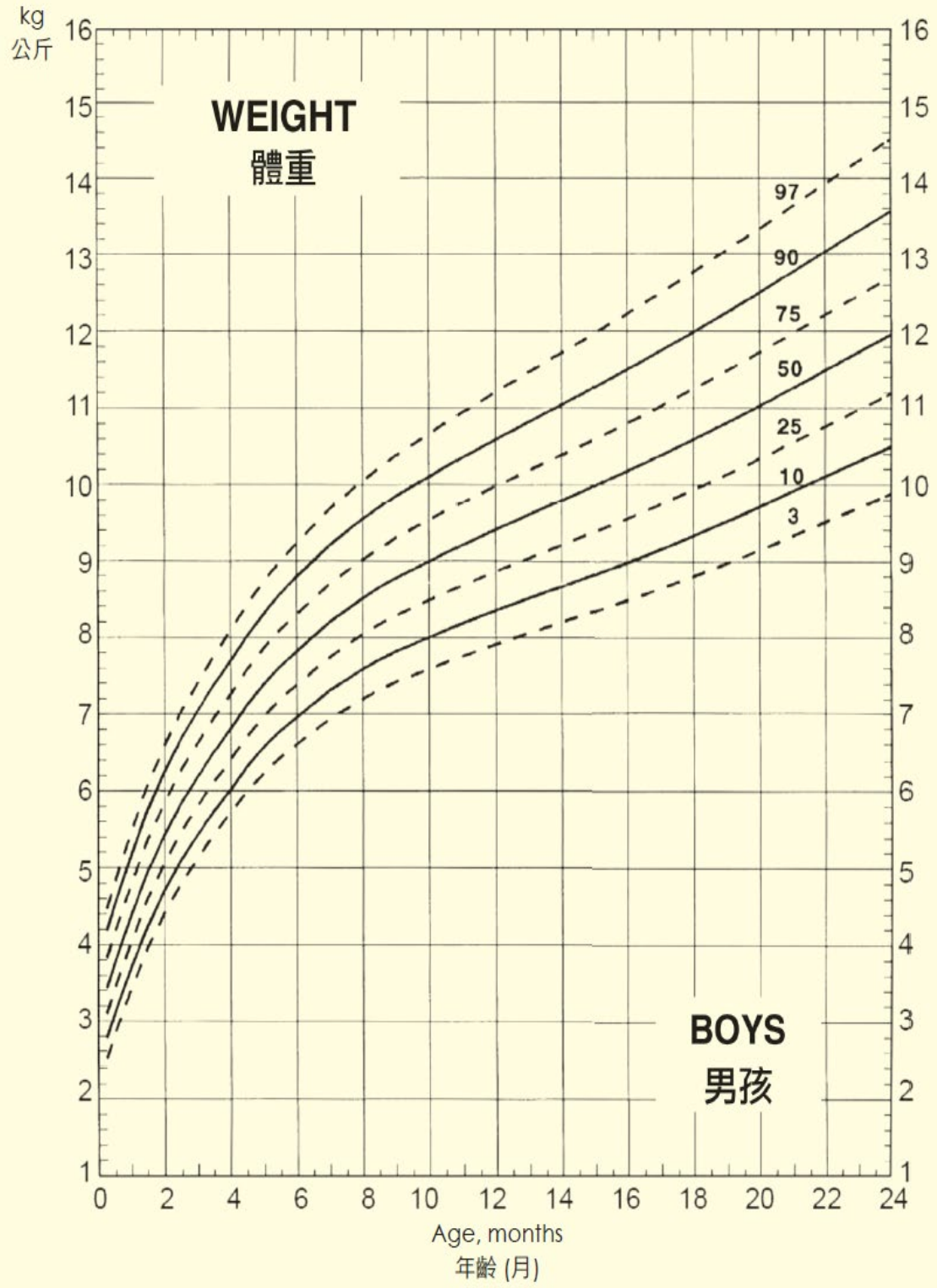
(N.B.: The growth charts for use in Hong Kong are being reviewed when this Module is first published. The charts will be updated when new information is available in due course)



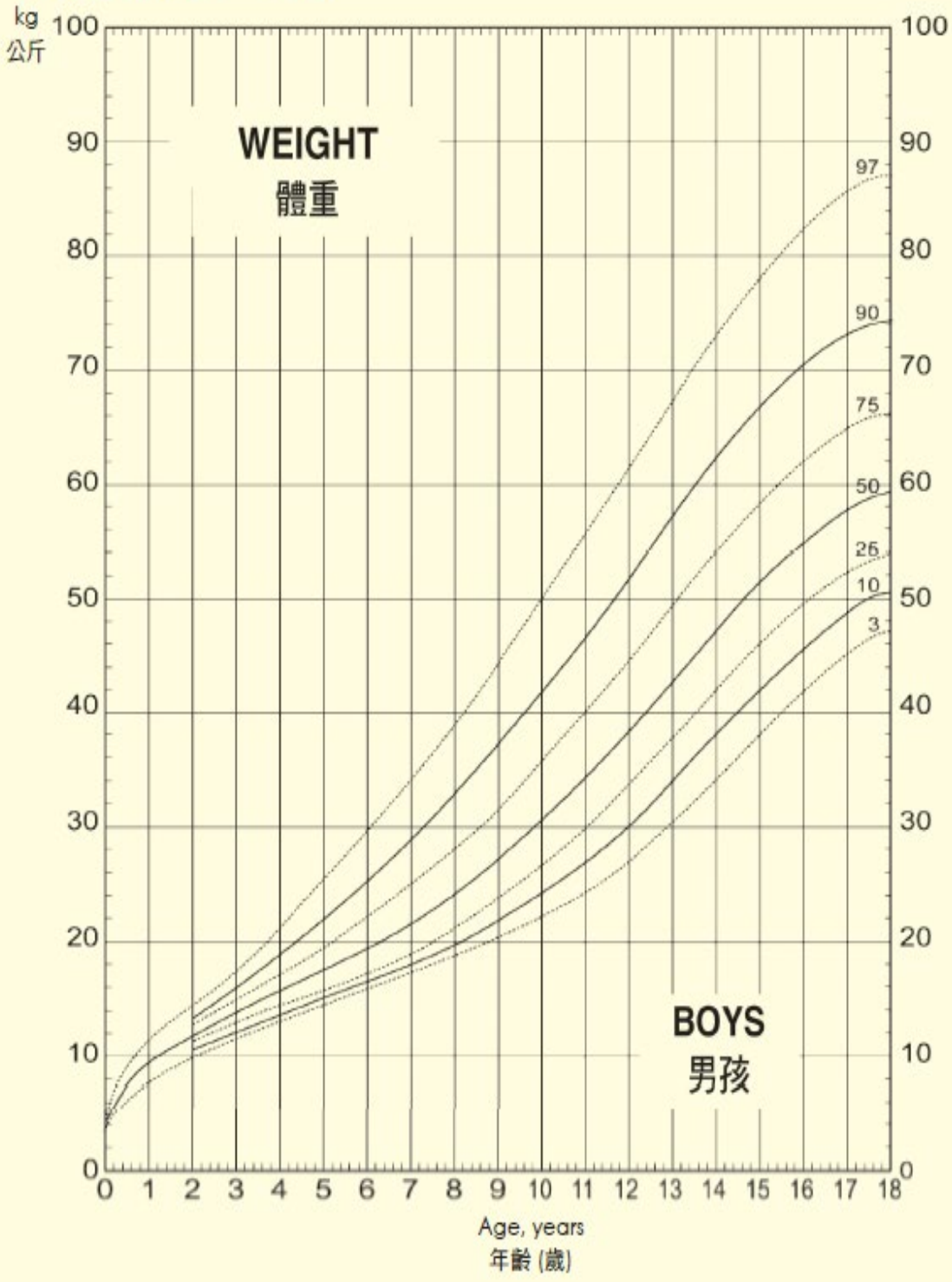
Head Circumference in cm (2 - 18 years)
頭圍 (厘米) (2 - 18歲)



Weight in kg (0 - 2 years)
體重 (公斤) (0 - 2歲)

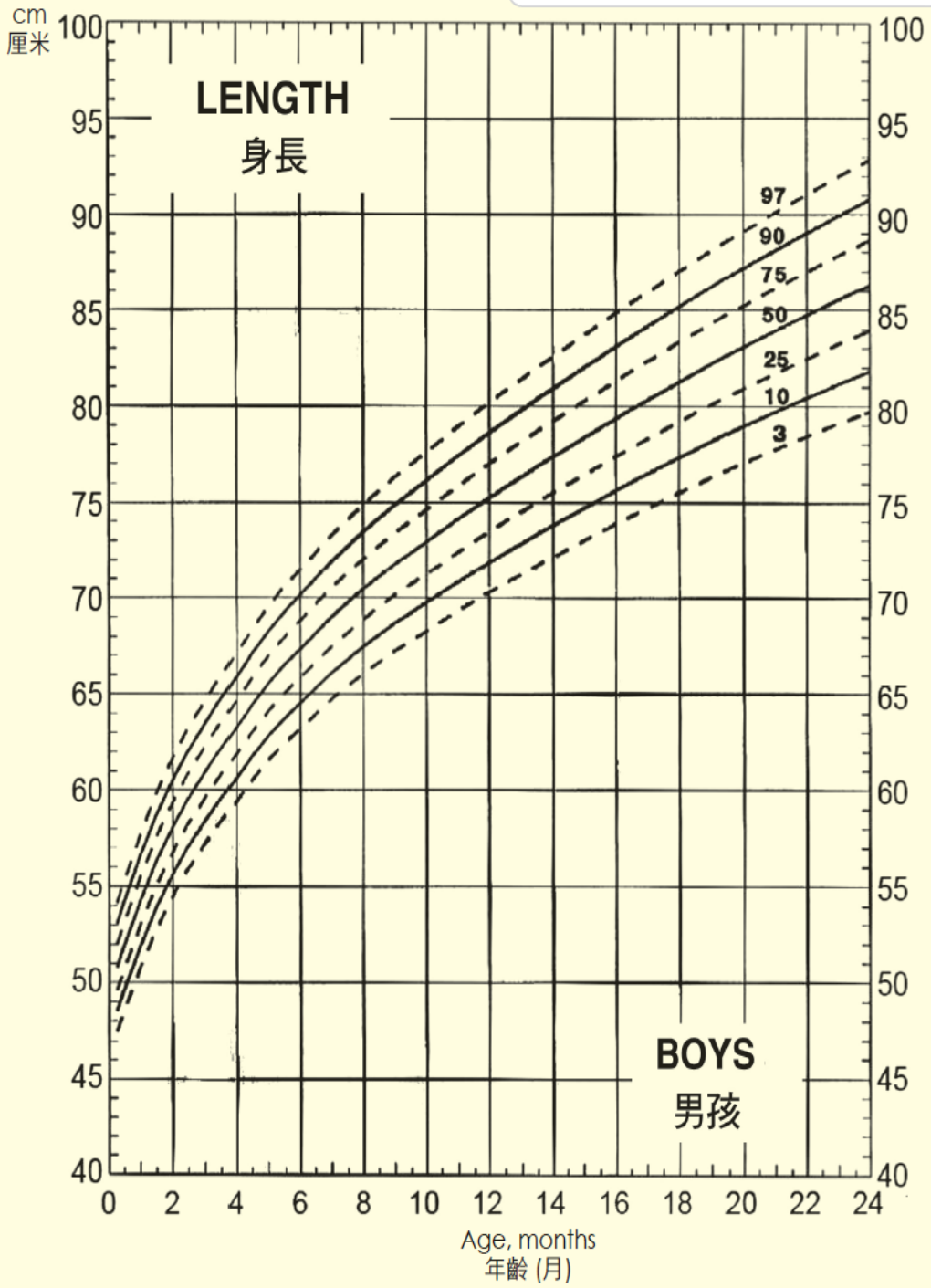


Weight in kg (2 - 18 years)
體重 (公斤) (2 - 18歲)

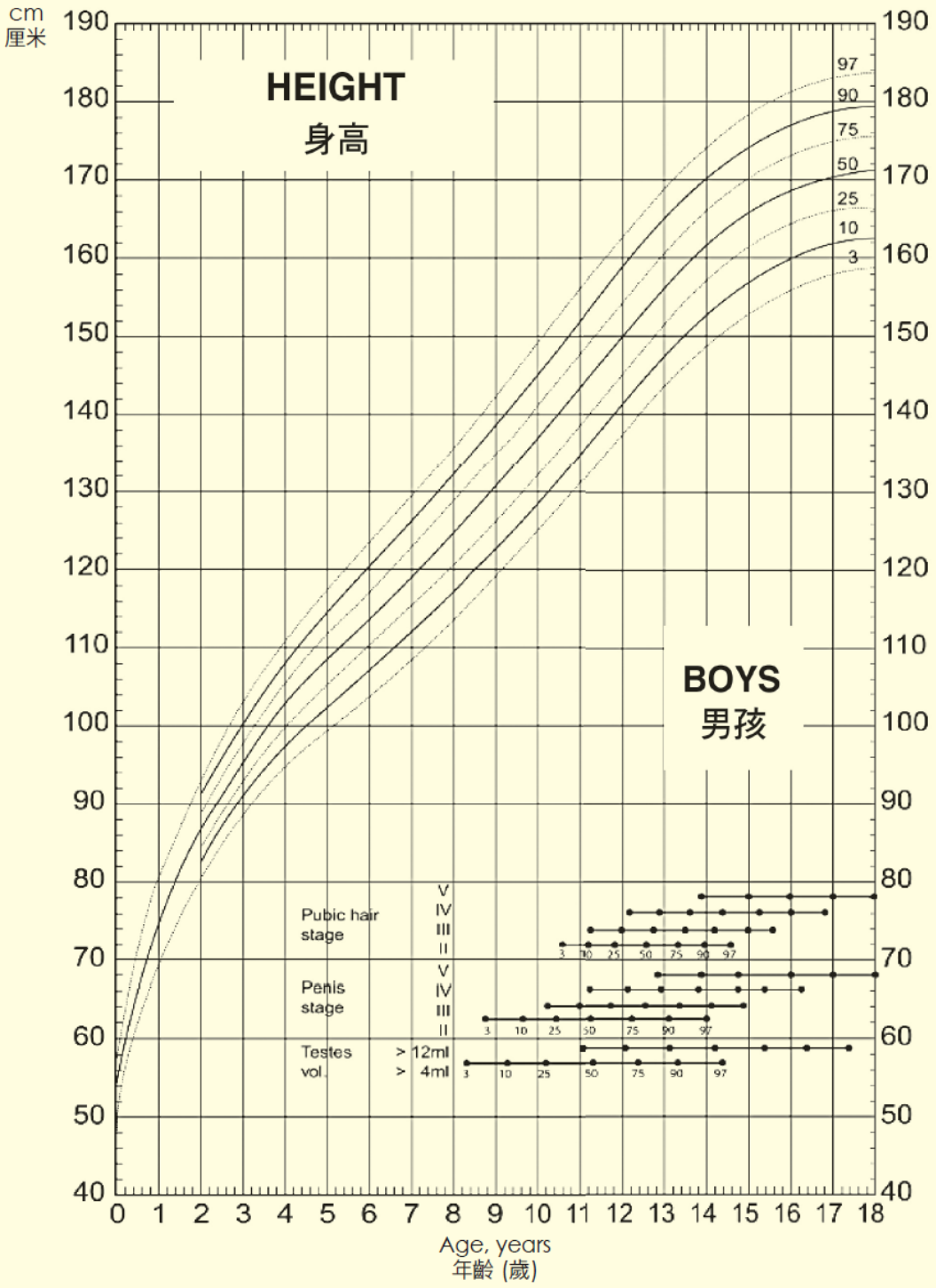


Length in cm (0 - 2 years)
身長 (厘米) (0 - 2歲)

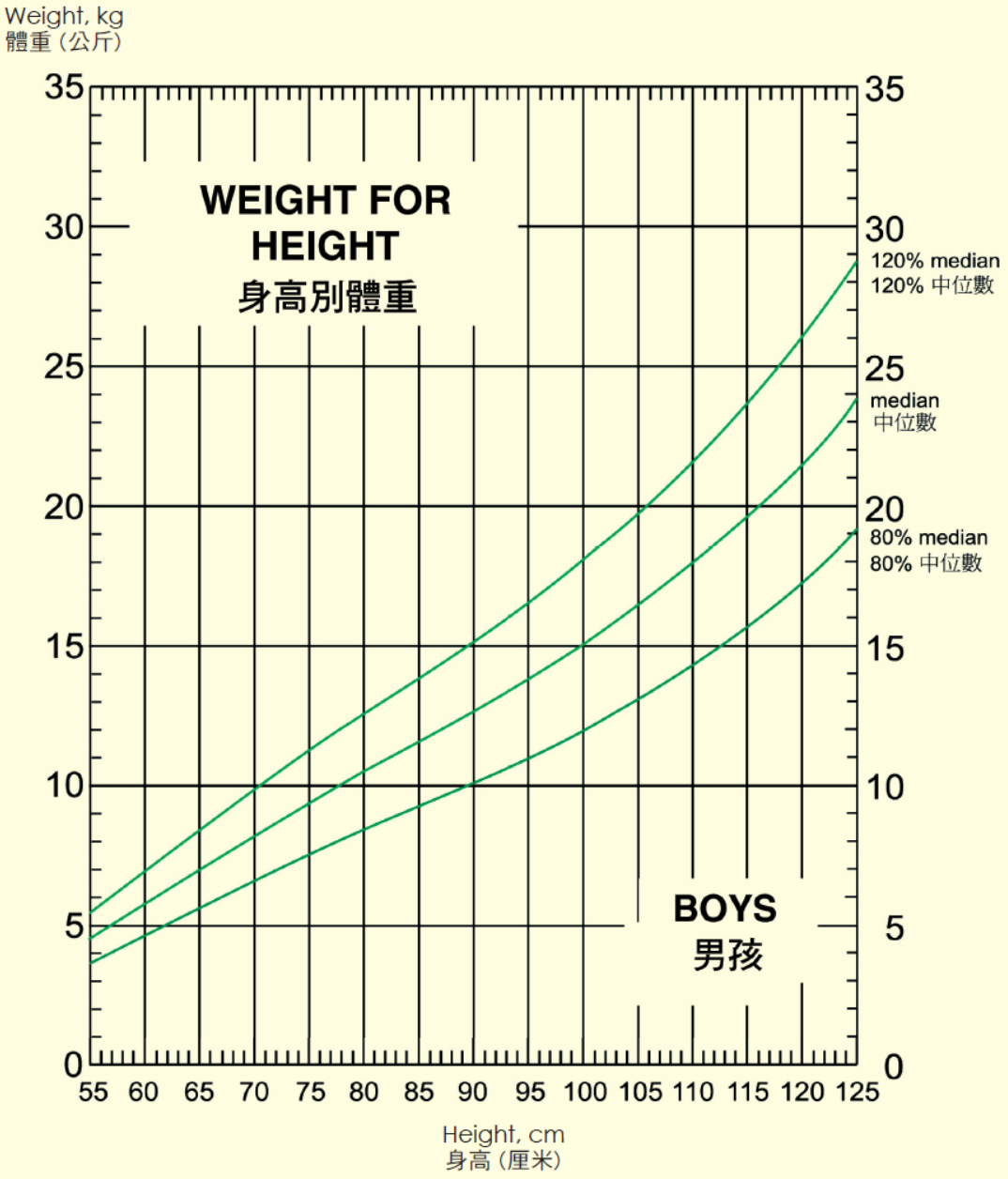
Parents' Height (cm) 父母身高 (厘米)	
Father 父親	Mother 母親
Mid-parental height 父母親中位身高	



Height in cm (2 - 18 years) and Pubertal Development
身高 (厘米) (2 - 18歲) 與青春期發育

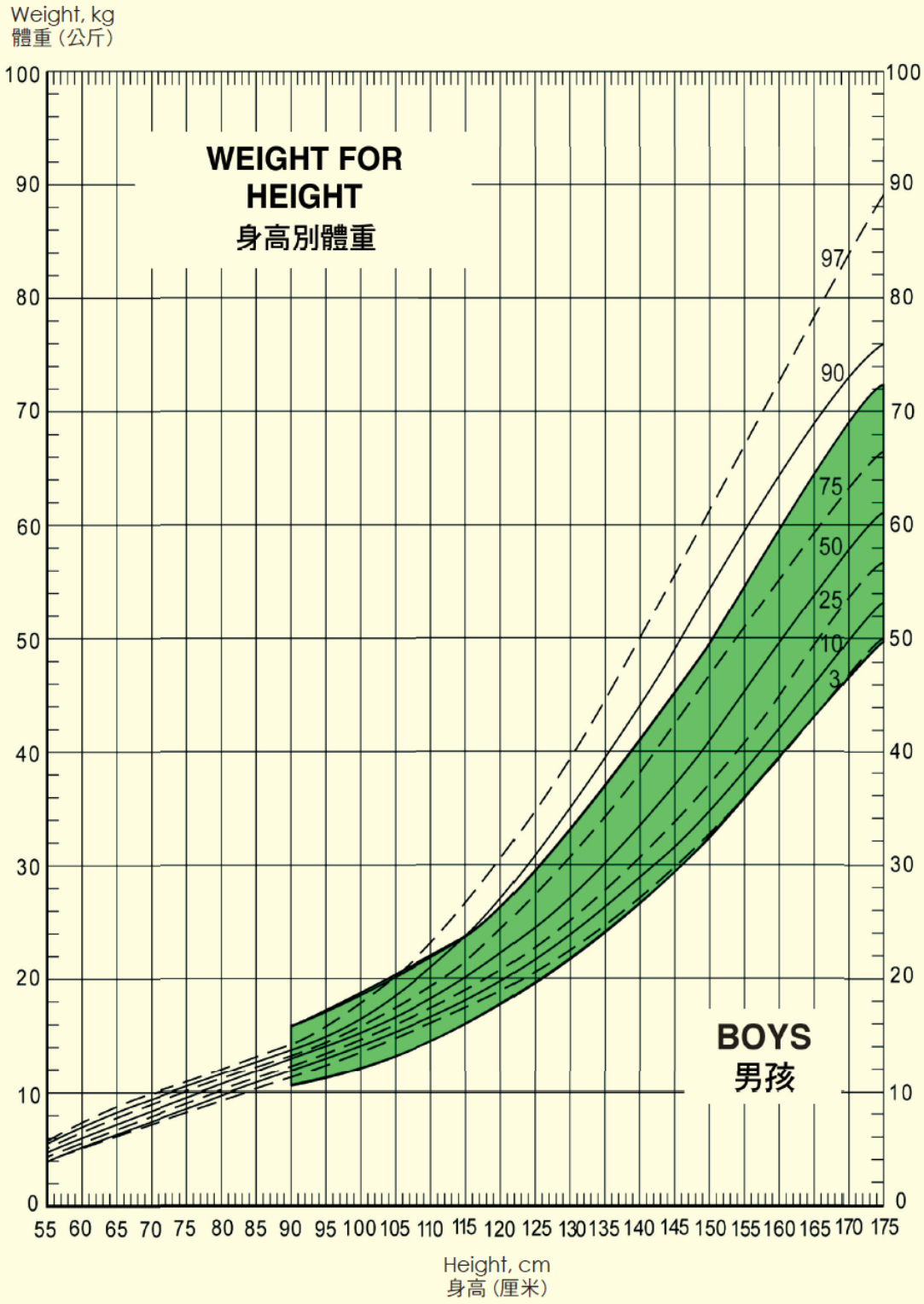


WEIGHT FOR HEIGHT CHART FOR BOYS
男孩身高別體重圖表



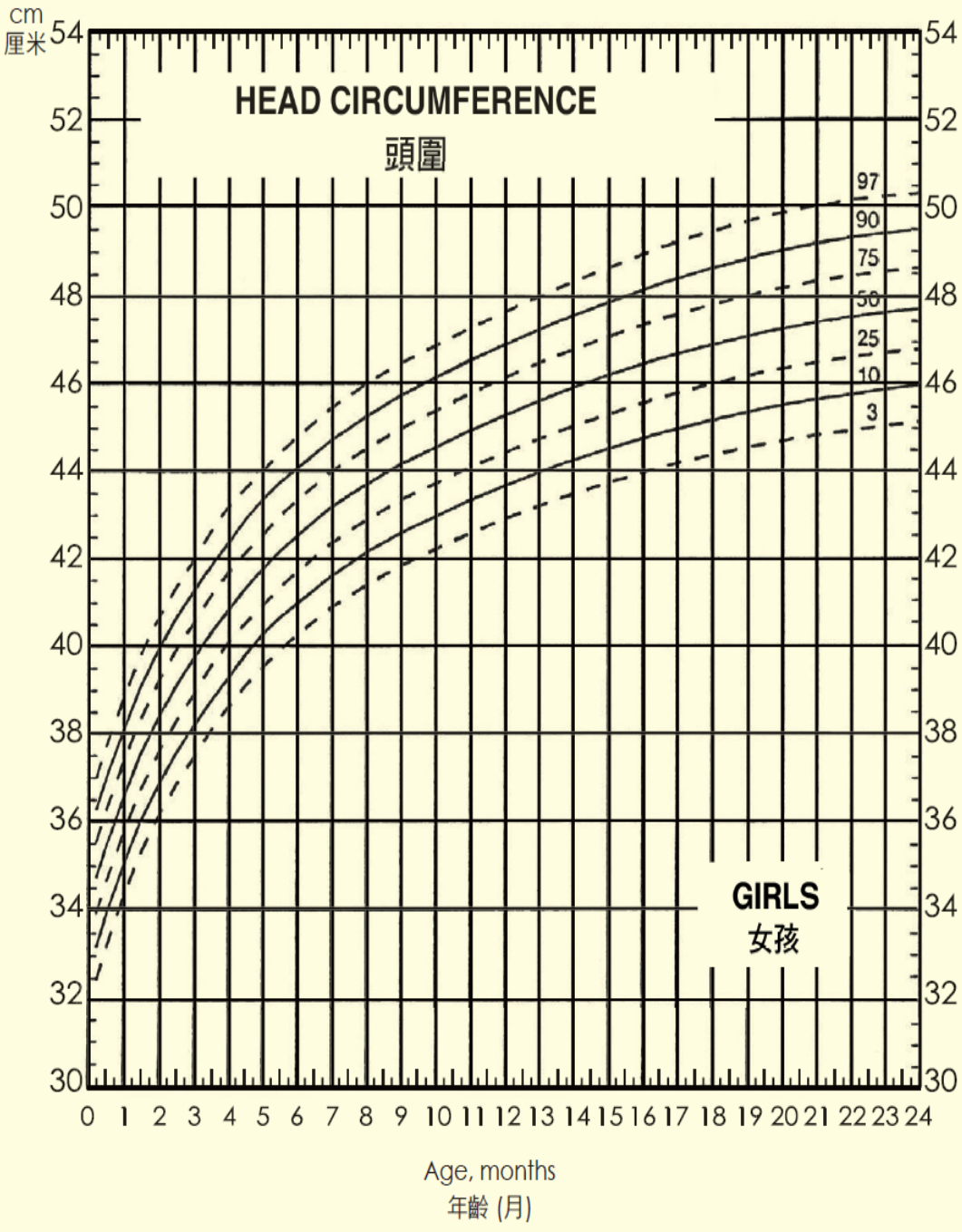
Parents are advised to seek health professional's advice if the reading lies outside 120% or 80% medians, which may signify overweight or underweight conditions respectively.
如孩子的身高別體重高於中位數之 120%，可能是過重；低於中位數之 80%，可能是過輕。建議諮詢醫護人員作詳細評估。

WEIGHT FOR HEIGHT CHART FOR BOYS
男孩身高別體重圖表

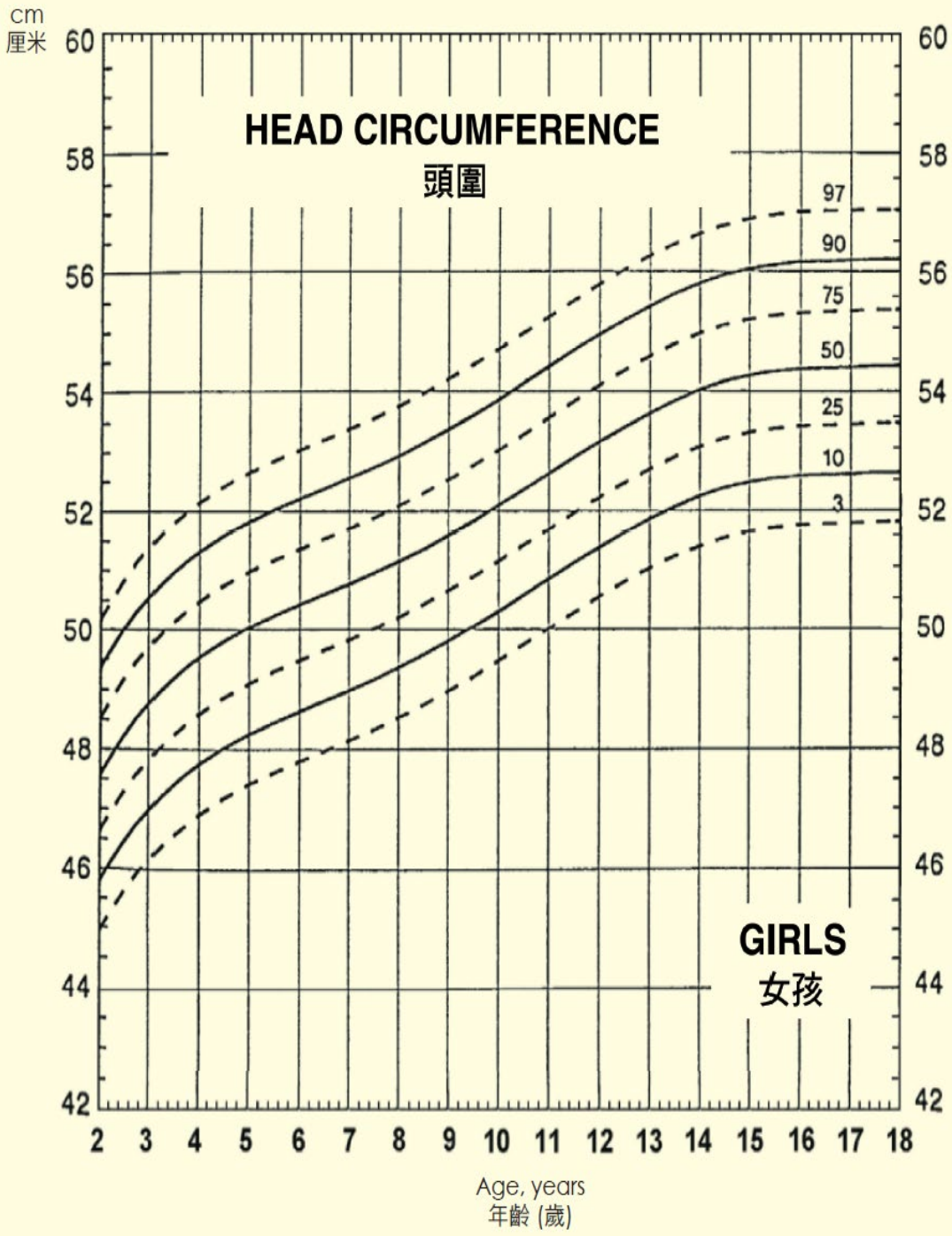


Head Circumference in cm (0 - 2 years)
頭圍 (厘米) (0 - 2歲)

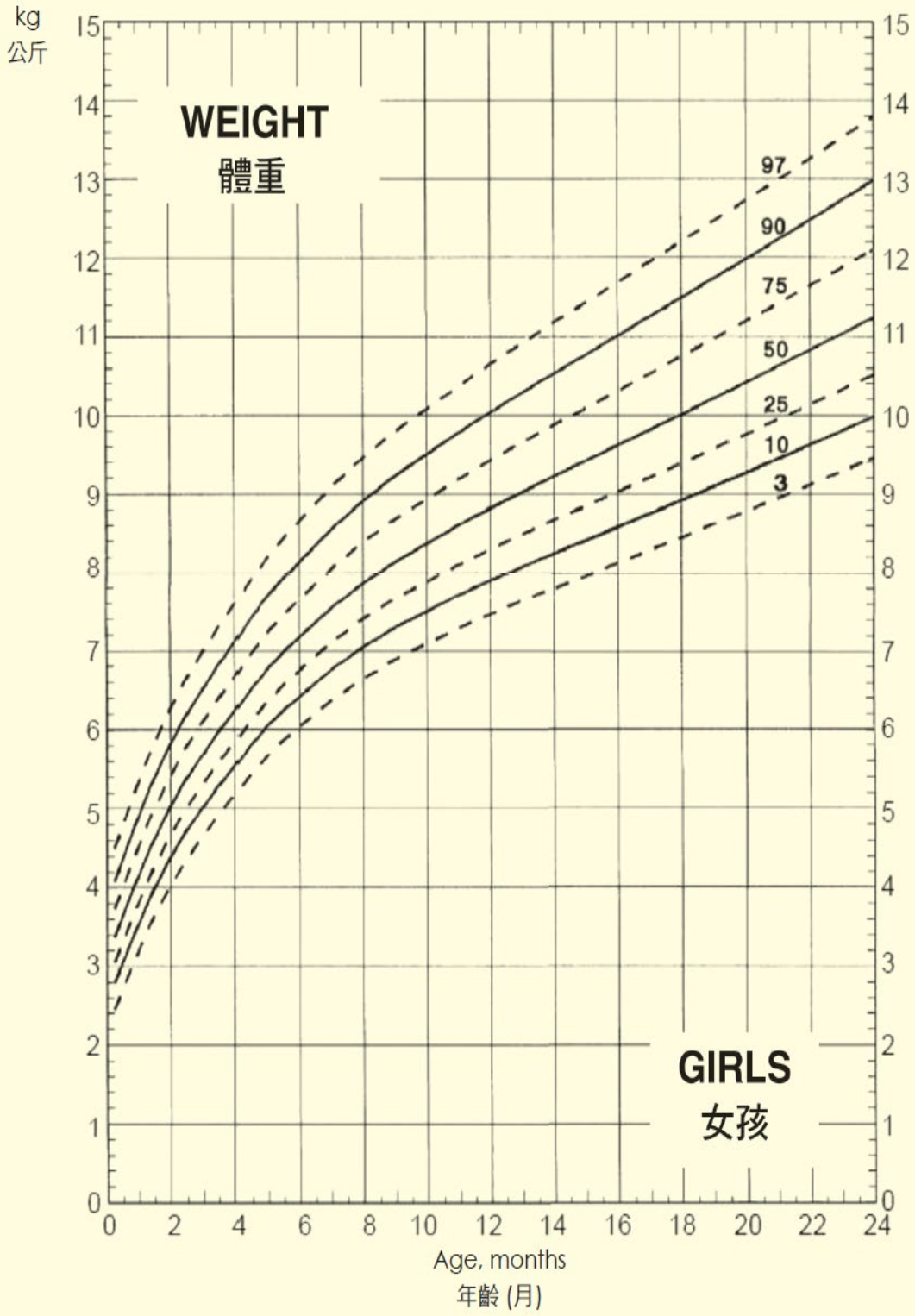
Parents' Head Circumference (cm) 父母頭圍 (厘米)	
Father 父親	Mother 母親



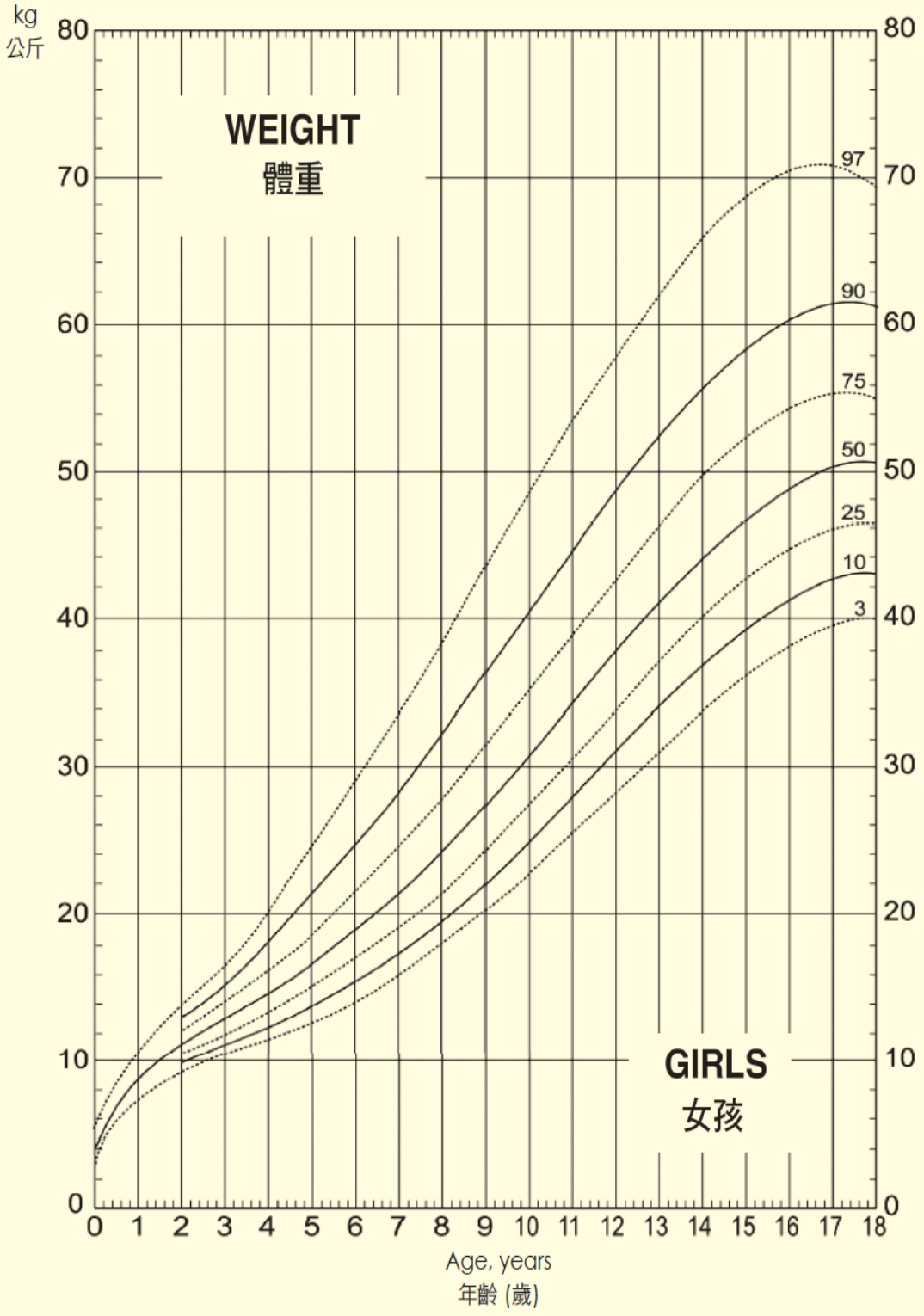
Head Circumference in cm (2 - 18 years)
頭圍 (厘米) (2 - 18歲)



Weight in kg (0 - 2 years)
體重 (公斤) (0 - 2歲)

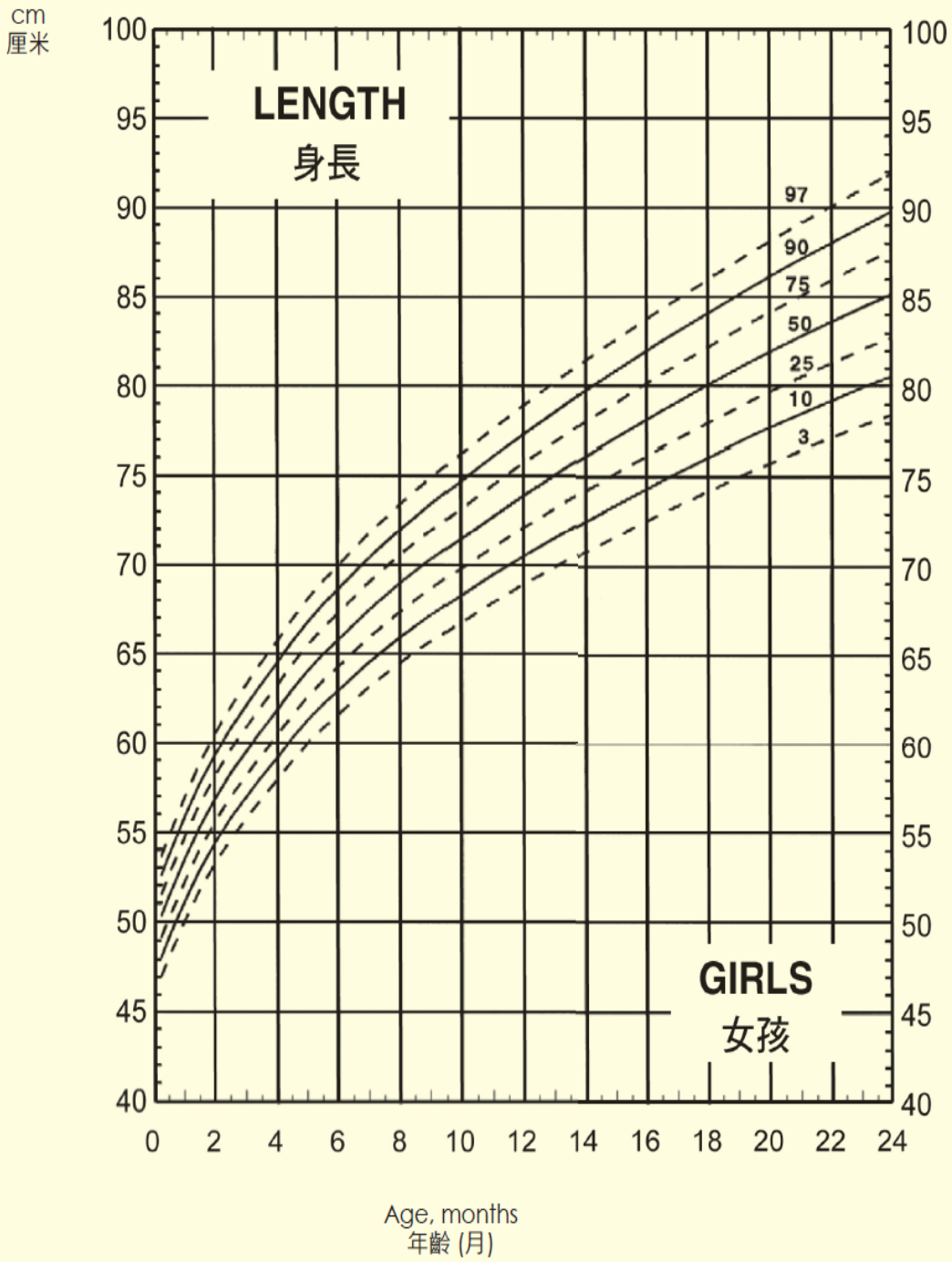


Weight in kg (2 - 18 years)
體重 (公斤) (2 - 18歲)

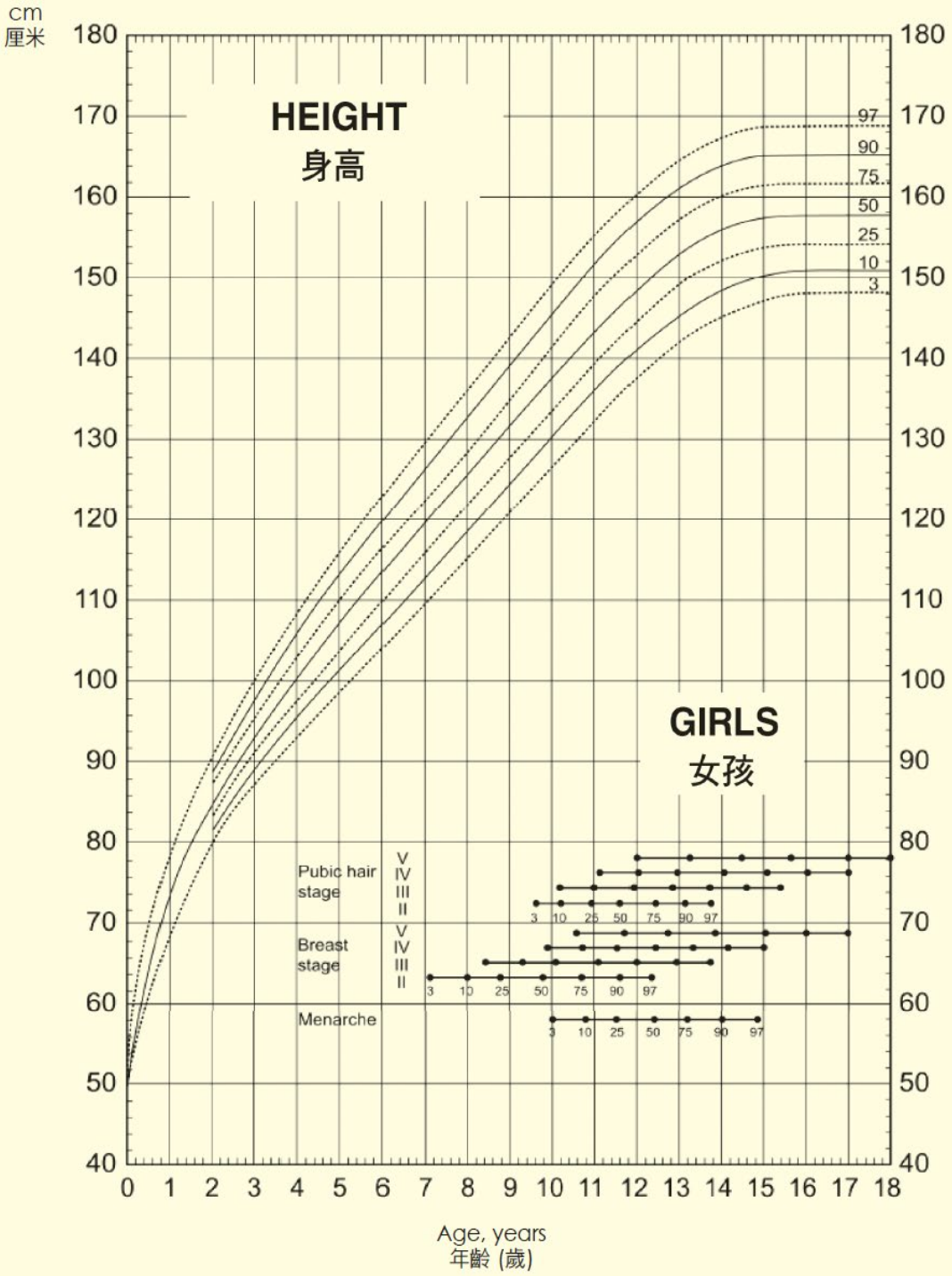


Length in cm (0 - 2 years)
身長 (厘米) (0 - 2歲)

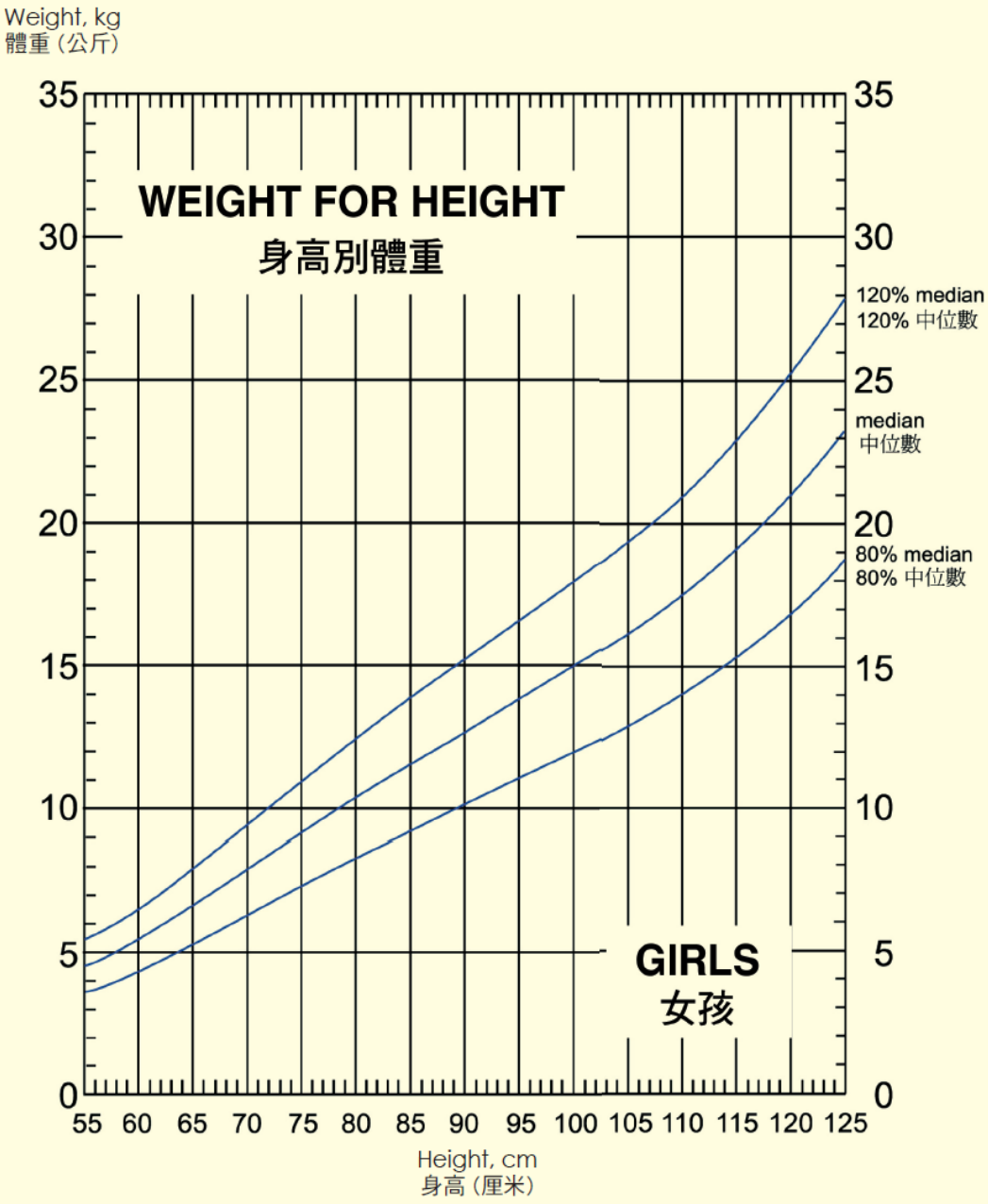
Parents' Height (cm) 父母身高 (厘米)	
Father 父親	Mother 母親
Mid-parental height 父母親中位身高	



Height in cm (2 - 18 years) and Pubertal Development
身高 (厘米) (2 - 18歲) 與青春期發育

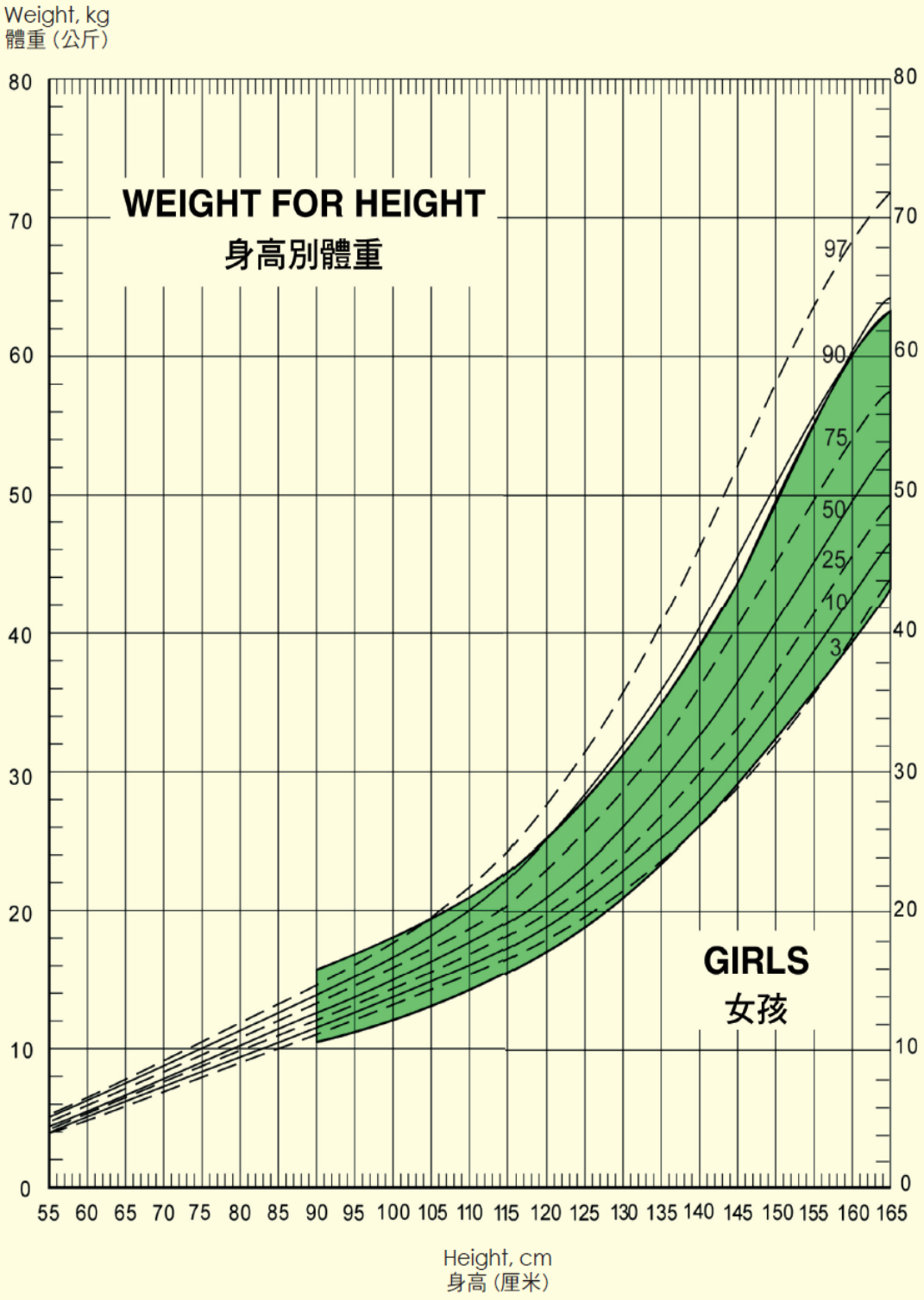


WEIGHT FOR HEIGHT CHART FOR GIRLS
女孩身高別體重圖表



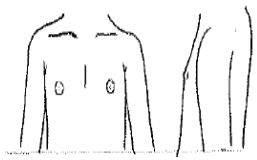
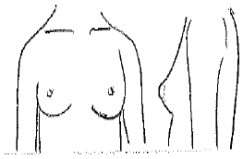
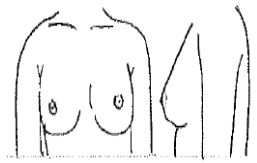
Parents are advised to seek health professional's advice if the reading lies outside 120% or 80% medians, which may signify overweight or underweight conditions respectively.
如孩子的身高別體重高於中位數之 120%，可能是過重；低於中位數之 80%，可能是過輕。
建議諮詢醫護人員作詳細評估。

WEIGHT FOR HEIGHT CHART FOR GIRLS
女孩身高別體重圖表



Annex II. Puberty and the Tanner stages

(I) Pubertal Milestones in Girls[1-3]

Tanner Stage	Breasts		Pubic hair		Growth	Remarks
	Description	Illustration	Description	Illustration		
Stage 1	Prepubertal		Prepubertal (the pubic area may have vellus hair)		~5-6cm/year	Adrenarche Ovarian growth
Stage 2	Breast bud stage with elevation of the breast and papilla; enlargement of the areola		Sparse growth of long, slightly pigmented hair, straight or slightly curled, along the labia		~7-8cm/year	Clitoral enlargement Labia pigmentation Uterus enlargement
Stage 3	Further enlargement of the breast and areola; no separation of their contours		Darker, coarser and more curled hair; spreading sparsely over the junction of the pubes		~8cm/year	Axillary hair (13.1 years) Acne (13.2 years)
Stage 4	Areola and papilla form a secondary mound above the level of the breast		Hair adult in type, but covering smaller area than in adult; no spread to the medial surface of the thighs		<7cm/year	Menarche (13.3 years) Regular menses (13.9 years)
Stage 5	Mature stage: projection of the papilla only, related to recession of the areola		Adult type and quantity; spreading to the medial thighs but not up the linea alba		No further height increase after ~16 years	Adult genitalia

(II) Pubertal milestones in Boys[2-4]

Tanner Stage	Genitalia		Pubic hair	Growth	Remarks
	Description	Illustration			
Stage 1	Prepubertal Testes: <2.5cm		Prepubertal (the pubic area may have vellus hair)	~5-6cm/year	Adrenarche
Stage 2	Enlargement of the scrotum and testes; testes: 2.5 to 3.2cm; scrotum skin reddens and changes in texture		Sparse growth of long, slightly pigmented hair, straight or slightly curled, at the base of the penis	~5-6cm/year	Decrease in total body fat
Stage 3	Enlargement of the penis (length at first); further growth of the scrotum and testes; testes: 3.3 to 4cm		Darker, coarser and more curled hair; spreading sparsely over the junction of the pubes	~7-8cm/year	Gynaecomastia (13.2 years) Voice break (13.5 years) Muscle mass increase
Stage 4	Increased size of the penis with growth in breadth and development of glans; testes and scrotum larger; testes: 4.1-4.5cm; scrotum skin darker		Hair adult in type, but covering smaller area than in adult; no spread to the medial surface of the thighs	~10cm/year	Axillary hair (14.0 years) Voice change (14.1 years) Acne (14.3 years)
Stage 5	Adult genitalia Testes: >4.5cm		Adult type and quantity; spreading to the medial thighs but not up the linea alba	No further height increase after ~17 years	Facial hair (14.9 years) Muscle mass continues to increase after Stage 5

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1. Marshall WA, Tanner JM. Variations in pattern of pubertal changes in girls. Arch Dis Child. 1969 Jun; 44(235):291–303.
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4. Marshall WA, Tanner JM. Variations in the pattern of pubertal changes in boys. Arch Dis Child. 1970 Feb; 45(239):13–23.