

Training Course on Child Growth Assessment

WHO Child Growth Standards

C

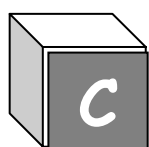
Interpreting Growth Indicators



World Health
Organization

Training Course on Child Growth Assessment

WHO Child Growth Standards



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**World Health
Organization**

**Department of Nutrition for
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C: Interpreting Growth Indicators

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C: Interpreting Growth Indicators

Introduction

Growth indicators are used to assess growth considering a child's age and measurements together. This module describes how to interpret the following growth indicators for a child:

- length/height-for-age
- weight-for-age
- weight-for-length/height
- BMI (body mass index)-for-age

The specific charts used will depend on the child's age, which determines whether the child will stand for measurement of height or lie down for measurement of length. The measurements will be plotted on growth charts in the *Boy's Growth Record* or the *Girl's Growth Record* so that trends can be observed over time and any growth problems identified. It is important to use the *Growth Record* for the correct sex since boys and girls grow to different sizes.

The growth charts used in this course were derived from the WHO Multicentre Growth Reference Study.¹ In this module, you will learn to use the growth charts to identify normal growth for a given child, as well as growth problems or trends that suggest that a child is at risk of a problem.

Module objectives

Participants will learn how to:

Refer to section:

- | | |
|--|-----|
| • Plot points for the following growth indicators on line graphs: | 1.0 |
| – length/height-for-age | 1.1 |
| – weight-for-age | 1.2 |
| – weight-for-length/height | 1.3 |
| – BMI-for-age | 1.4 |
| • Interpret plotted points for growth indicators, and identify normal growth and growth problems. | 2.0 |
| • Interpret trends on growth charts, and determine whether a child is growing normally, has a growth problem, or is at risk of a growth problem. | 3.0 |

¹ More information on this study is provided in Module A: *Introduction* and in the following reference:

de Onis M, Garza C, Victora CG, Bhan MK, Norum KR, editors. WHO Multicentre Growth Reference Study (MGRS): Rationale, Planning and Implementation. Food Nutr Bull 2004;25 (Suppl 1):S1–89.

1.0 Plot points for growth indicators

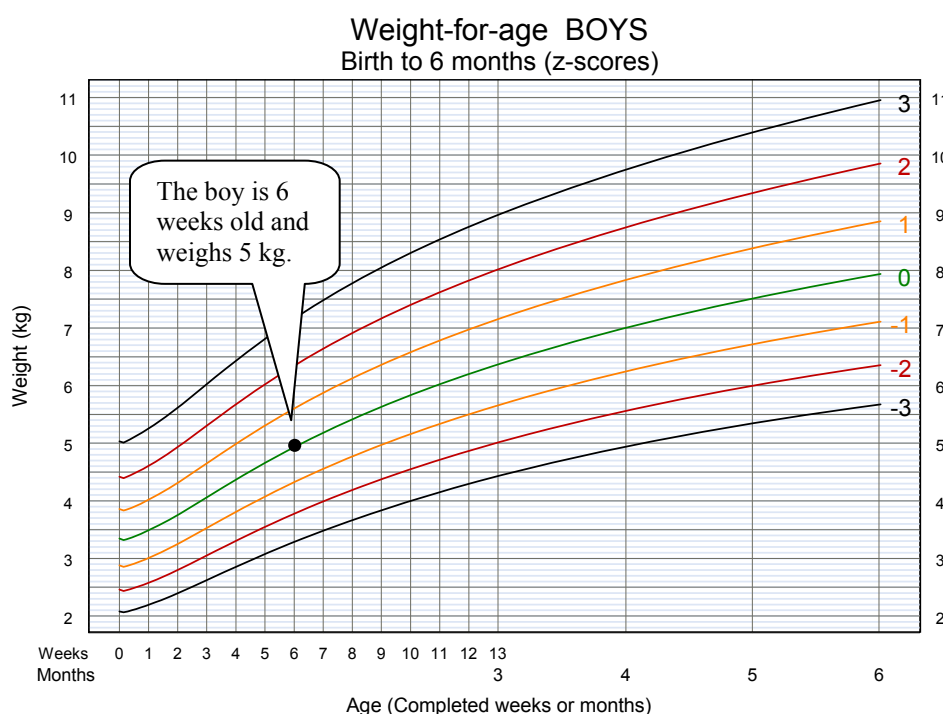
Growth charts are provided on pages 27–40 of the both the boy's and the girl's *Growth Records*. Select the appropriate *Growth Record* based on the child's sex. Then select the four charts to use based on the child's age at a given visit. Refer to the table of contents at the beginning of the *Growth Record* to make the selection. Growth measurements will be plotted on the selected charts (also called line graphs).

In order to plot points, one needs to understand certain terms related to graphs and the plotting convention that applies in this course:

- **x-axis** – the horizontal reference line at the bottom of the graph. In the *Growth Record* graphs, some x-axes show age and some show length/height. Plot points on vertical lines corresponding to completed age (in weeks, months, or years and months), or to length or height rounded to the nearest whole centimetre.
- **y-axis** – the vertical reference line at the far left of the graph. In the *Growth Record* graphs, the y-axes show length/height, weight, or BMI. Plot points on or between horizontal lines corresponding to length/height, weight or BMI as precisely as possible.
- **plotted point** – the point on a graph where a line extended from a measurement on the x-axis (e.g. age) intersects with a line extended from a measurement on the y-axis (e.g. weight)

Example

On the graph below, age (in weeks or months) is on the x axis; weight in kilograms is on the y axis. The horizontal lines represent 0.1 kg (100 g) increments. A point has been plotted for an infant boy who is 6 weeks old and weighs 5 kg. The curved lines on the graph are reference lines that will help you interpret the plotted points and trends; you will learn more about them in later sections of this module.



1.1 Plot length/height-for-age

Length/height-for-age reflects attained growth in length or height at the child's age at a given visit. This indicator can help identify children who are stunted (short) due to prolonged undernutrition or repeated illness. Children who are tall for their age can also be identified, but tallness is rarely a problem unless it is excessive and may reflect uncommon endocrine disorders.

Charts for **length**-for-age for younger age groups (birth to 6 months, and 6 months to 2 years) are given on pages 29 and 33 of the *Growth Record*. A chart for **height**-for-age (for children 2 years and older) is given on page 37. In each of these charts, the x-axis shows age, and the y-axis shows length or height in centimetres. Age is plotted in completed weeks from birth until age 3 months; in completed months from 3 to 12 months; and then in completed years and months.

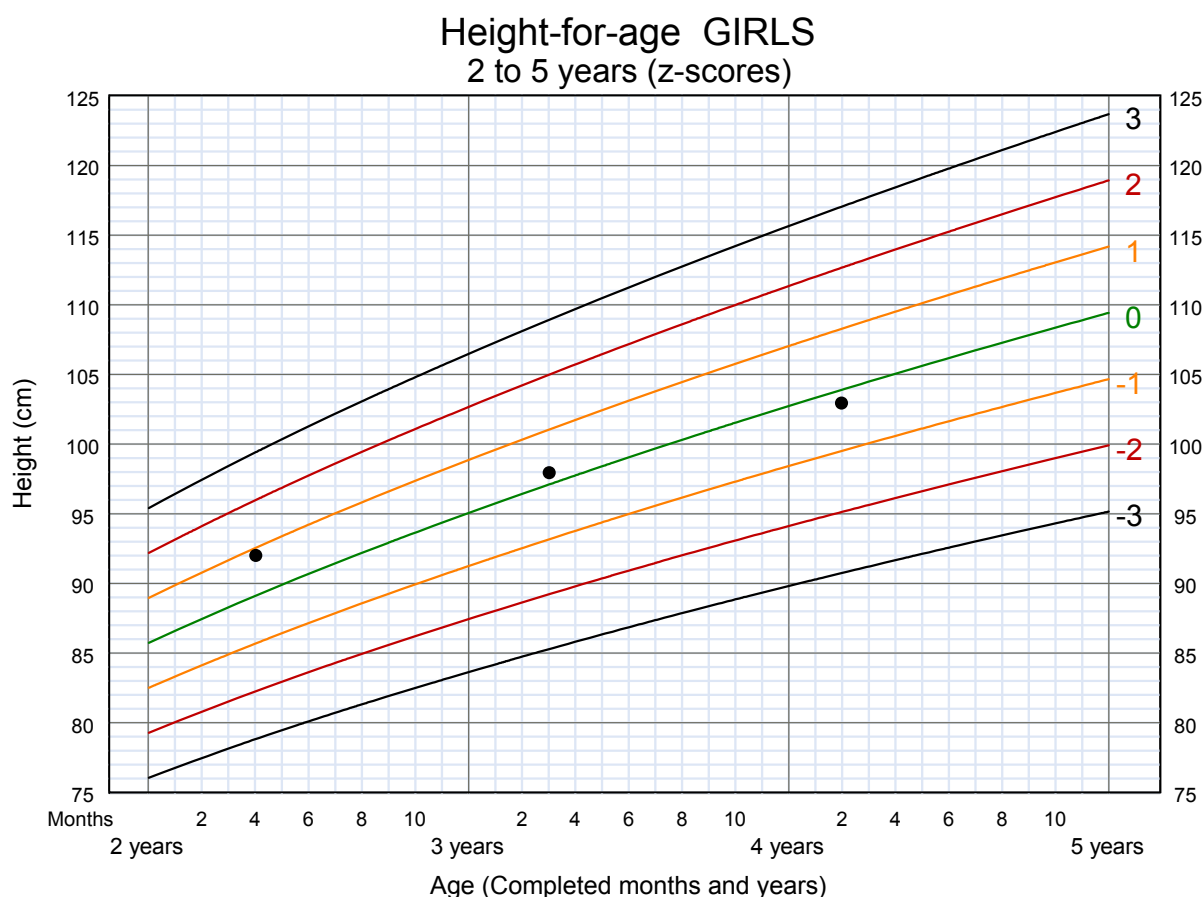
To plot length/height-for-age:

- Plot completed weeks, months, or years and months on a vertical line (not between vertical lines). For example, if a child is 5 ½ months old, the point will be plotted on the line for 5 months (not between the lines for 5 and 6 months).
- Plot length or height on or between the horizontal lines as precisely as possible. For example, if the measurement is 60.5 cm, plot the point in the middle of the space between horizontal lines.
- When points are plotted for two or more visits, connect adjacent points with a straight line to better observe the trend.

Judge whether a plotted point seems sensible, and if necessary, re-measure the child. For example, a baby's length should not be shorter than at the previous visit. If it is, one of the measurements was wrong.

Example – Anna

The following graph shows Anna's height-for-age at three visits. The horizontal lines represent 1 cm increments. At the first visit, Anna was 2 years and 4 months of age and was 92 cm in height.



SHORT ANSWER EXERCISE

1. Connect the plotted points on the growth chart for Anna above.
2. Fill in the blanks in the sentences below to describe the meaning of the points plotted.
 - a) At her second visit, Anna was _____ in height at age _____ years and _____ months.
 - b) At her third visit, Anna was _____ in height at age _____ years and _____ months.

When you have finished this exercise, compare your answers to those given on page 43 at the end of this module. If you have questions, talk with a facilitator.

1.2 Plot weight-for-age

Weight-for-age reflects body weight relative to the child's age on a given day. This indicator is used to assess whether a child is underweight or severely underweight, **but it is not used to classify a child as overweight or obese**. Because weight is relatively easily measured, this indicator is commonly used, but it cannot be relied upon in situations where the child's age cannot be accurately determined, such as refugee situations. It is important to note also that a child may be underweight either because of short length/height (stunting) or thinness or both (see section 1.3).

Note: If a child has **oedema of both feet**, fluid retention increases the child's weight, masking what may actually be very low weight. Plot this child's weight-for-age and weight-for-length/height, but mark clearly on the growth charts (close to the plotted point) that the child has oedema. This child is automatically considered severely undernourished and should be referred for specialized care.

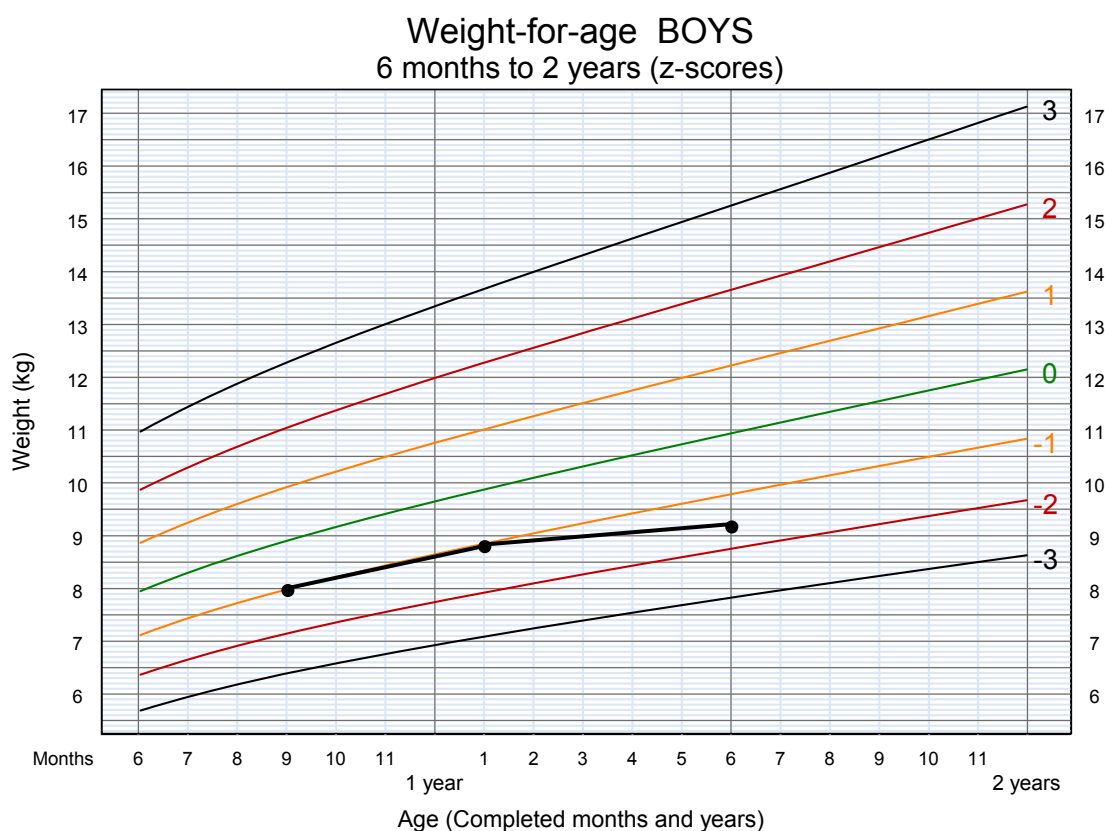
Weight-for-age charts for three age groups are given on pages 30, 34, and 38 of the *Growth Record*. On each of these charts, the x-axis shows age, and the y-axis shows weight in kilograms. Age is plotted in completed weeks from birth until age 3 months; in completed months from 3 to 12 months; and then in completed years and months.

To plot weight-for-age:

- Plot completed weeks, months, or years and months on a vertical line (not between vertical lines).
- Plot weight on a horizontal line or in the space between lines to show weight measurement to 0.1 kg, e.g. 7.8 kg.
- When points are plotted for two or more visits, connect adjacent points with a straight line to better observe trends.

Example – Amahl

The following graph shows weight-for-age at three visits of a boy named Amahl. The horizontal lines represent 0.1 kg (100 g) increments.



SHORT ANSWER EXERCISE

Refer to Amahl's weight-for-age chart above to answer the following questions:

1. How much did Amahl weigh at age 9 months?
2. How old was Amahl at the visit when he weighed a little less than 9 kg?
3. What was Amahl's age and weight at the last visit shown?
4. Plot a point for Amahl's next visit, when he is age 1 year and 11 months and weighs 11.2 kg. Draw a line to connect this visit to the previous one.

When you have finished this exercise, compare your answers to those given on page 43 at the end of this module. If you have questions, talk with a facilitator.

1.3 Plot weight-for-length/height

Weight-for-length/height reflects body weight in proportion to attained growth in length or height. This indicator is especially useful in situations where children's ages are unknown (e.g. refugee situations). Weight-for-length/height charts help identify children with low weight-for-height who may be wasted or severely wasted. Wasting is usually caused by a recent illness or food shortage that causes acute and severe weight loss, although chronic undernutrition or illness can also cause this condition. These charts also help identify children with high weight-for-length/height who may be at risk of becoming overweight or obese.

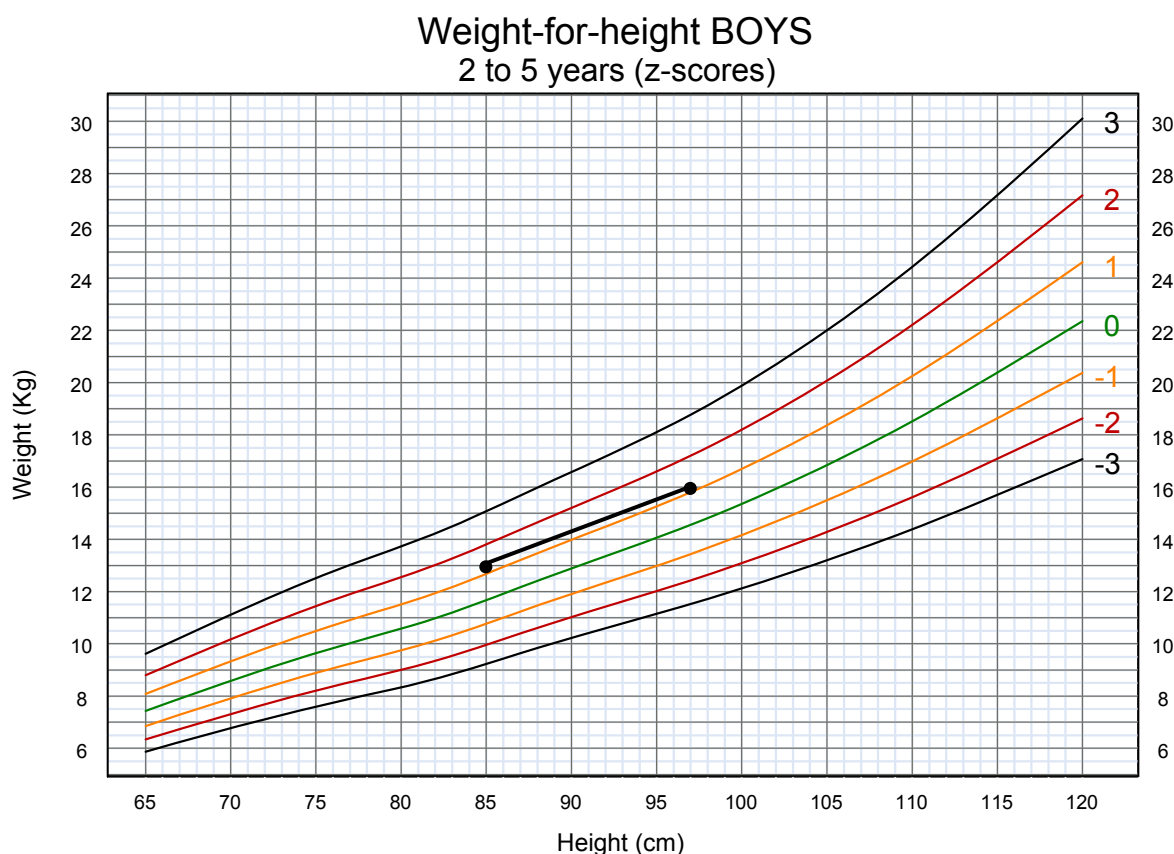
Charts for weight-for-length are given on pages 31 and 35 of the *Growth Record*. The chart for infants from birth to 6 months (page 31) is an enlargement of part of the chart for children from birth to 2 years (page 35); the enlargement is provided to allow more room for plotting and detecting small changes in the growth of infants. A chart for weight-for-height (for children age 2 to 5 years) is given on page 39. In these charts, the x-axis shows length or height in centimetres, and the y-axis shows weight in kilograms.

To plot weight-for-length/height:

- Plot length or height on a vertical line (e.g. 75 cm, 78 cm). It will be necessary to round the measurement to the nearest whole centimetre (i.e. round down 0.1 to 0.4 and round up 0.5 to 0.9), and follow the line up from the x-axis to wherever it intersects with the weight measurement.
- Plot weight as precisely as possible given the spacing of lines on the chart.
- When points are plotted for two or more visits, connect adjacent points with a straight line to better observe the trend.

Example – Tran

This chart shows Tran's weight-for-height at two visits. The horizontal lines represent 0.5 kg (500 g) increments while the vertical lines represent 1 cm increments. At the first visit, Tran is 2 years and 2 months old. He is 85 cm in height and weighs 13 kg.



SHORT ANSWER EXERCISE

Refer to Tran's weight-for-height chart to answer the following questions:

1. How tall is Tran at the second visit shown on the graph?
2. How much does Tran weigh at the second visit?
3. Plot the point for Tran's next visit, when he is 112 cm tall and weighs 19 kg. Connect the plotted point to the point for previous visit.

When you have finished this exercise, compare your answers to those given on page 44 at the end of this module. If you have questions, talk with a facilitator.

1.4 Plot BMI-for-age

Module B described how to determine BMI from a child's weight and length/height by using a reference table or a calculator. BMI-for-age is an indicator that is especially useful for screening for overweight and obesity. The BMI-for-age chart and weight-for-length/height chart tend to show very similar results.

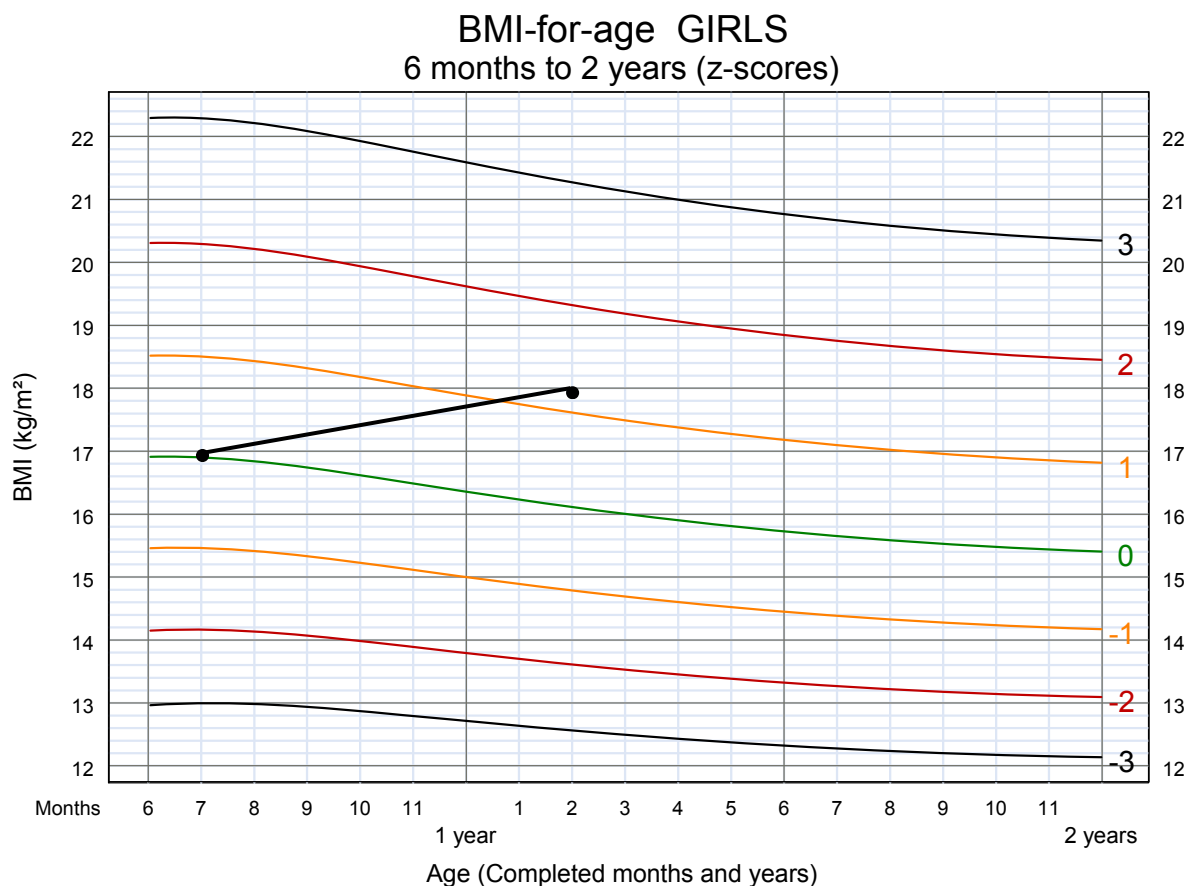
Graphs for BMI-for-age are given in the *Growth Record* on page 32 (for children from birth to 6 months), page 36 (for age 6 months up to 2 years) and page 40 (for age 2 to 5 years). In these graphs, the x-axis shows age in completed weeks, months, or years and months. The y-axis shows the child's BMI.

To plot BMI-for-age:

- Plot the age in completed weeks, months, or years and months on a vertical line (not between vertical lines).
- Plot BMI on a horizontal line (e.g. 14, 14.2), or in the space between lines (e.g. 14.5). If a calculator was used to determine BMI, it may be recorded and plotted to one decimal place.
- When points are plotted for two or more visits, connect adjacent points with a straight line to better observe trends.

Example – Rosita

The following chart shows Rosita's BMI-for-age at two visits. The horizontal lines represent 0.2 BMI units. At the first visit, she has completed 7 months since birth and has a BMI of 17.

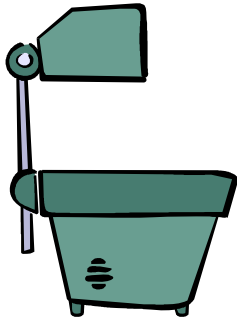


SHORT ANSWER EXERCISE

Refer to Rosita's BMI-for-age chart to answer the following questions:

1. How old is Rosita at the second visit?
2. What is her BMI at the second visit?
3. Plot the point for Rosita's next visit, when she is 1 year and 10 months old and has a BMI of 17.5. Connect the points.

When you have finished this exercise, compare your answers to those given on page 44–45 at the end of this module. If you have questions, talk with a facilitator.



Oral Drill

Reading Plotted Points on Graphs

When everyone is ready, your facilitators will lead an oral drill that will allow you to practise reading points on graphs. Please stop here until the drill is announced.



Exercise A

Continuing Case Studies – Nalah and Toman

In module *B: Measuring a Child's Growth* you began a *Girl's Growth Record* for Nalah and a *Boy's Growth Record* for Toman. Get out these *Growth Records* now. In this exercise you will plot these children's measurements on the appropriate growth charts in each booklet.

Nalah

1. On the Personal Data page of Nalah's *Girl's Growth Record*, you have recorded her birth weight as 2.9 kg and her length as 49 cm. Look at the Visit Notes in Nalah's *Girl's Growth Record*. You have recorded information from 5 visits there, including age, weight, length, and BMI at each visit.
2. Find the four growth charts suitable for Nalah's age group in the *Girl's Growth Record*.
3. Use the information from Nalah's Personal Data page and Visit Notes to plot points on each growth chart. Plot and connect points for all five visits on each growth chart.

Hint: You will need to calculate Nalah's BMI at birth before plotting her BMI-for-age at birth.

► If you have difficulties, talk with a facilitator at any time.

Toman

1. Look at the Visit Notes page of Toman's *Boy's Growth Record*. You have recorded information from 4 visits there, including age, weight, length, and BMI at each visit.
2. Find the four growth charts suitable for Toman's age group in the *Boy's Growth Record*.
3. Use the information from Toman's Visit Notes to plot points on each growth chart. Plot and connect points for all four visits on each growth chart.

**When you have finished this exercise,
review your answers with a facilitator.**

2.0 Interpret plotted points for growth indicators

The curved lines printed on the growth charts will help you interpret the plotted points that represent a child's growth status. The line labeled 0 on each chart represents the **median**, which is, generally speaking, the average. The other curved lines are **z-score lines**,¹ which indicate distance from the average. The median and the z-score lines on each growth chart were derived from measurements of children in the WHO Multicentre Growth Reference Study who were fed and raised in environments that favoured optimal growth.

Z-score lines on the growth charts are numbered positively (1, 2, 3) or negatively (–1, –2, –3). In general, a plotted point that is far from the median in either direction (for example, close to the 3 or –3 z-score line) may represent a growth problem, although other factors must be considered, such as the growth trend, the health condition of the child and the height of the parents.

2.1 Identify growth problems from plotted points

Next to each growth chart in the *Growth Record*, there is a list of the growth problems represented by plotted points that are above or below certain z-score lines. Read points as follows:

- A point between the z-score lines –2 and –3 is “below –2.”
- A point between the z-score lines 2 and 3 is “above 2.”

Refer to pages 27–40 of the *Growth Record*. Read the definitions of growth problems in the shaded boxes next to each growth chart. These include definitions, in terms of z-scores, of the following:

- stunted, severely stunted
- underweight, severely underweight
- wasted, severely wasted
- possible risk of overweight, overweight, obese

The table on the next page provides a summary of definitions of growth problems in terms of z-scores. Notice that an indicator is included in a certain definition by being plotted **above** or **below** a particular z-score line. If it is plotted exactly on the z-score line, it is considered in the less severe category. For example, weight-for age on the –3 line is considered “underweight” as opposed to “severely underweight.”

¹ Z-scores may also be called standard deviation (SD) scores. See the annex of this module for a more complete explanation of z-scores or SD scores.

Growth Problems

Compare the points plotted on the child's growth charts with the z-score lines to determine whether they indicate a growth problem. Measurements in the shaded boxes are in the normal range.

Z-score	Growth indicators			
	Length/height-for-age	Weight-for-age	Weight-for-length/height	BMI-for-age
Above 3	See note 1	See note 2	Obese	Obese
Above 2			Overweight	Overweight
Above 1			Possible risk of overweight (See note 3)	Possible risk of overweight (See note 3)
0 (median)				
Below -1				
Below -2	Stunted (See note 4)	Underweight	Wasted	Wasted
Below -3	Severely stunted (See note 4)	Severely underweight (See note 5)	Severely wasted	Severely wasted

Notes:

1. A child in this range is very tall. Tallness is rarely a problem, unless it is so excessive that it may indicate an endocrine disorder such as a growth-hormone-producing tumor. Refer a child in this range for assessment if you suspect an endocrine disorder (e.g. if parents of normal height have a child who is excessively tall for his or her age).
2. A child whose weight-for-age falls in this range may have a growth problem, but this is better assessed from weight-for-length/height or BMI-for-age.
3. A plotted point above 1 shows possible risk. A trend towards the 2 z-score line shows definite risk.
4. It is possible for a stunted or severely stunted child to become overweight.
5. This is referred to as very low weight in IMCI training modules. (Integrated Management of Childhood Illness, In-service training. WHO, Geneva, 1997).

Following are examples of some of the growth problems described above. The examples are illustrated by selected growth charts and photos. Refer to the photos in *E: Photo Booklet* as directed.

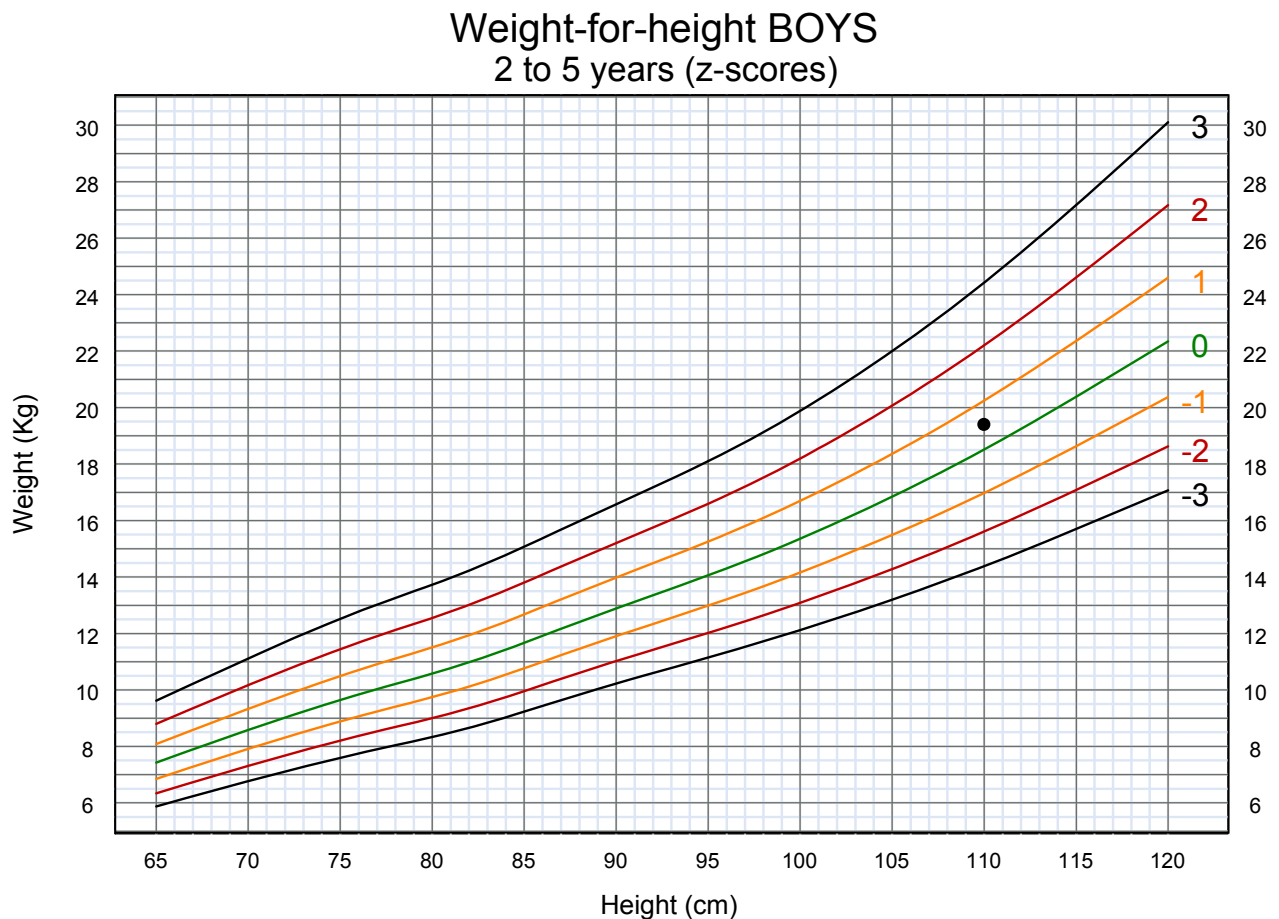
Example – Underweight boy, photo 9

The following weight-for-age chart is for a boy who is 1 year and 1 month old. He weighs 7.5 kg and is 70.3 cm in length. Notice that his weight-for-age is below the -2 z-score line, so he is considered underweight. This boy is pictured in photo 9 in *E: Photo Booklet*. Look at his photo now.



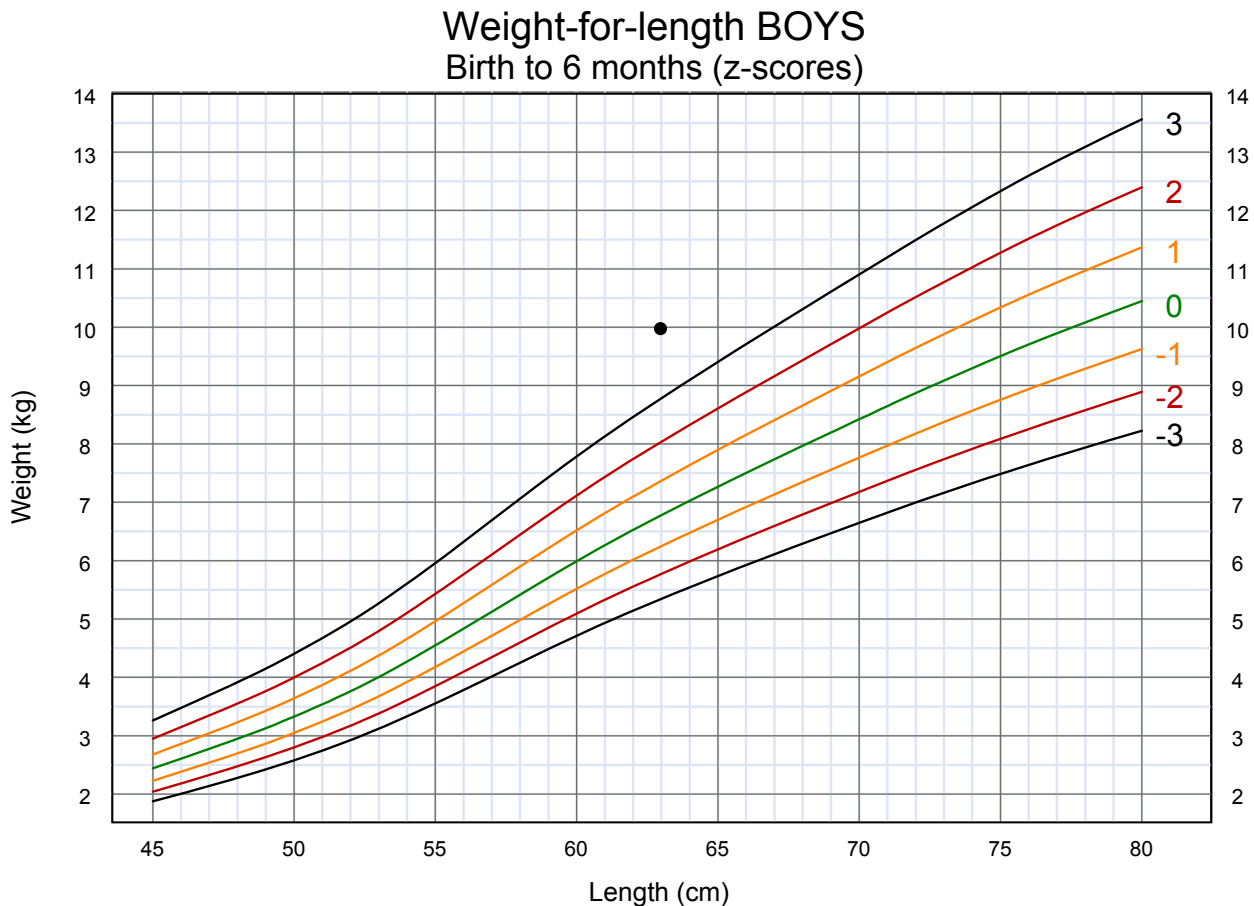
Example – Normal weight boy, photo 10

Look at photo 10 of a boy aged 3 years and 11 months. He weighs 19.5 kg and is 109.6 cm tall. His weight-for-age is above the 1 z-score line, and his height-for-age is above the 1 z-score line. His weight-for-height, shown on the chart below, is in the normal range.



Example – Obese boy, photo 11

Look at photo 11 of a boy who is 3½ months old. He weighs 10 kg and is 63 cm long. On the length-for-age chart he is above the median. His weight-for-length chart, shown below, indicates that he is obese. Notice that his weight-for-length is above the 3 z-score line.



2.2 Consider all growth charts and observations

The preceding examples showed problems that were identifiable by looking at one point on one growth chart. However, it is important to consider all of a child's growth charts together, particularly if only one of the charts shows a problem. For example, if a child is underweight according to the weight-for-age chart, you must also consider the child's length-for-age and weight-for-length. Focus more on the weight-for-length/height and the length/height-for-age charts:

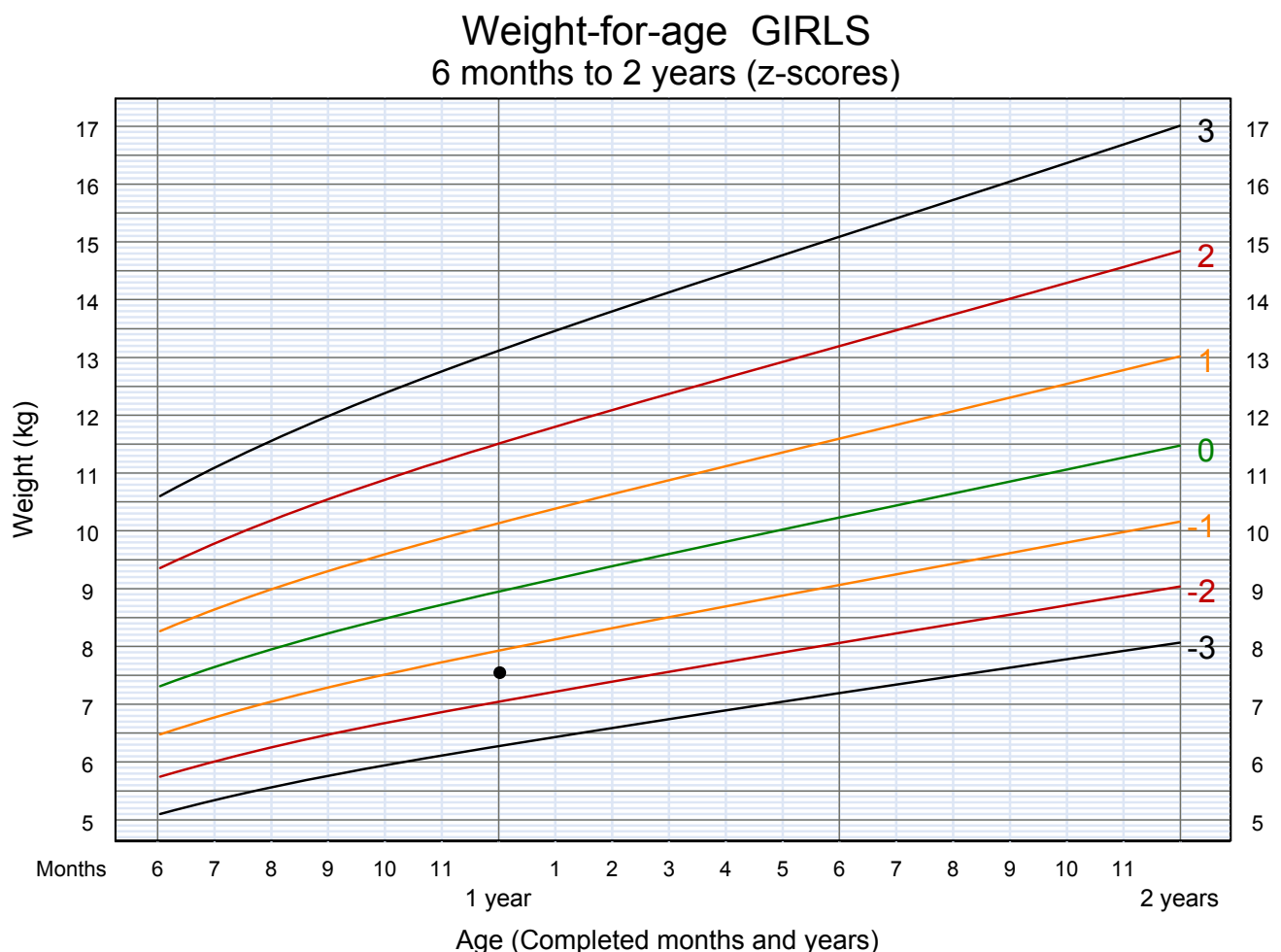
- Length/height-for-age reflects attained growth in height. Stunting (length/height-for-age below -2) implies that for a long period the child received inadequate nutrients to support normal growth and/or that the child has suffered from repeated infections. A stunted child may have a normal weight-for-height, but have low weight-for-age due to shortness.
- Weight-for-length/height is a reliable growth indicator even when age is not known. Wasting (weight-for-length/height below -2) usually results from a recent severe event,

such as drastically reduced food intake and/or illness that caused severe weight loss. BMI-for-age classifies children in a similar manner to weight-for-length/height. Both indicators also help to identify whether the child has excess weight relative to length/height.

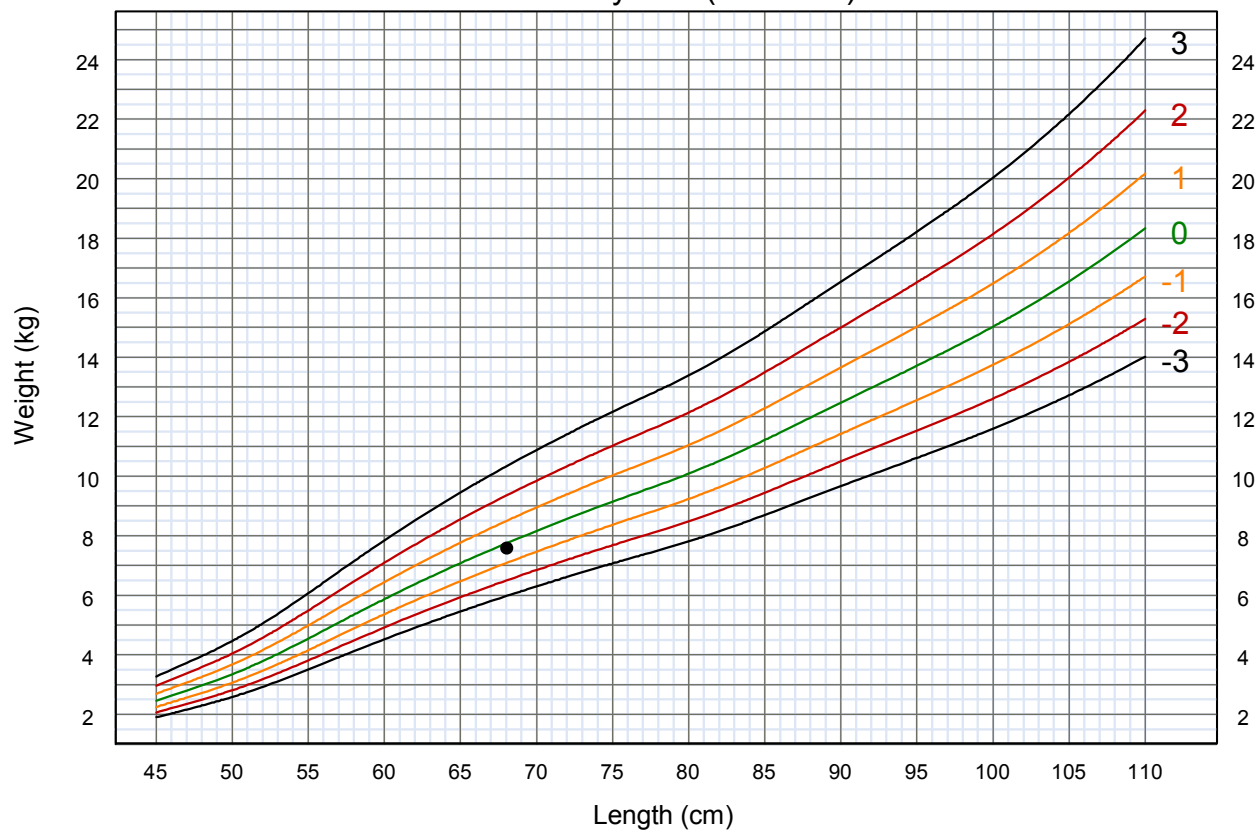
Looking at the growth charts all together will help you to determine the nature of growth problems. It will also be important to consider trends observed over time, as described in section 3.0 of this module.

Example – stunting, photo 12

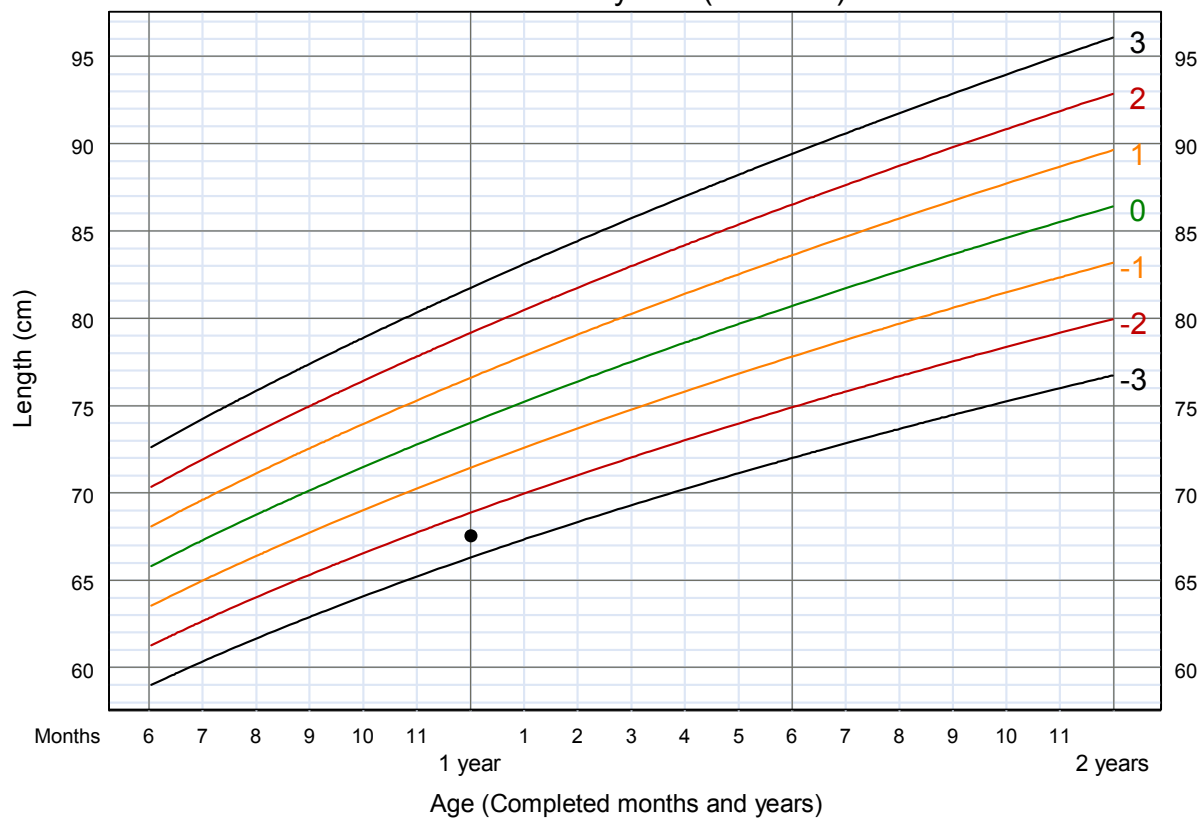
The girl in photo 12 is aged 1 year 0 months, is 67.8 cm long, and weighs 7.6 kg. Her weight-for-age chart is shown below, and her length-for-age and weight-for-length charts are on the next page. Notice that her weight-for-age is low, but still in the normal range. Her weight-for-length is on the median, so she has a completely normal appearance. Her length-for-age is below the -2 z-score line, however, showing that she is stunted.



Weight-for-length GIRLS Birth to 2 years (z-scores)



Length-for-age GIRLS 6 months to 2 years (z-scores)



When interpreting the growth charts, remember to consider your observation of the child's appearance. A child who is below -1 in weight-for-length may be fine if he appears lean (fleshed out) rather than wasted (too thin). A child who is above 1 in weight-for-length may be fine if he appears heavy (sturdy, mostly muscular) as opposed to having noticeable fat.

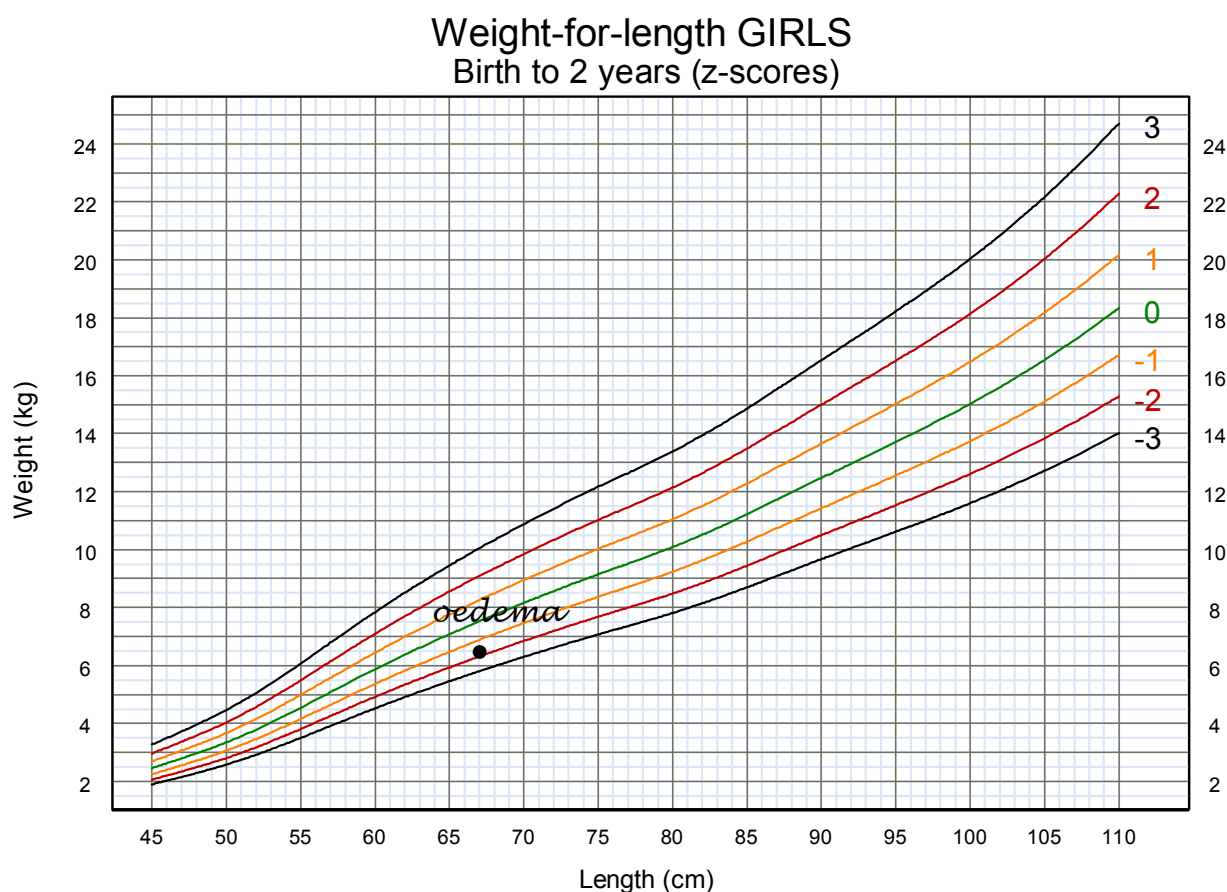
Clinical signs of marasmus and kwashiorkor require special attention. (These syndromes are described in module B, section 2.0.) The wasting associated with marasmus will be apparent in the child's graphs for weight-for-age and weight-for-length/height. However, the oedema (fluid retention) associated with kwashiorkor can hide the fact that a child has very low weight. When you plot the weight of a child who has oedema of both feet, it is important to note on the growth chart that the child has oedema. A child with oedema of both feet is assumed to have a z-score below -3 and should be referred for specialized care.

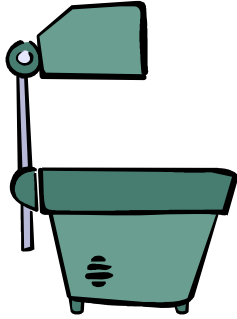
Example – marasmus, photos 1 and 2

Look at photos 1 and 2, which show a child with marasmus. It is clear that the child needs immediate referral.

Example – oedema of both feet, photo 8

Look at photo 8, which shows a girl with oedema of both feet. She is aged 1 year and 8 months, weighs 6.5 kg and is 67 cm long. Since she has oedema of both feet, she should be referred. Her weight-for-length is graphed below; it appears to be above the -2 z-score line because her fluid retention masks her low weight.





Group Discussion **Interpreting Plotted Points on Graphs**

When everyone is ready, your facilitators will lead a group discussion. Please stop here until the discussion is announced. Using measurements and BMIs obtained on several real children in the last module, a facilitator and some participants will plot points on the appropriate graphs for these children. The group will then discuss whether each child has a growth problem.



Exercise B

Interpreting plotted points for growth indicators

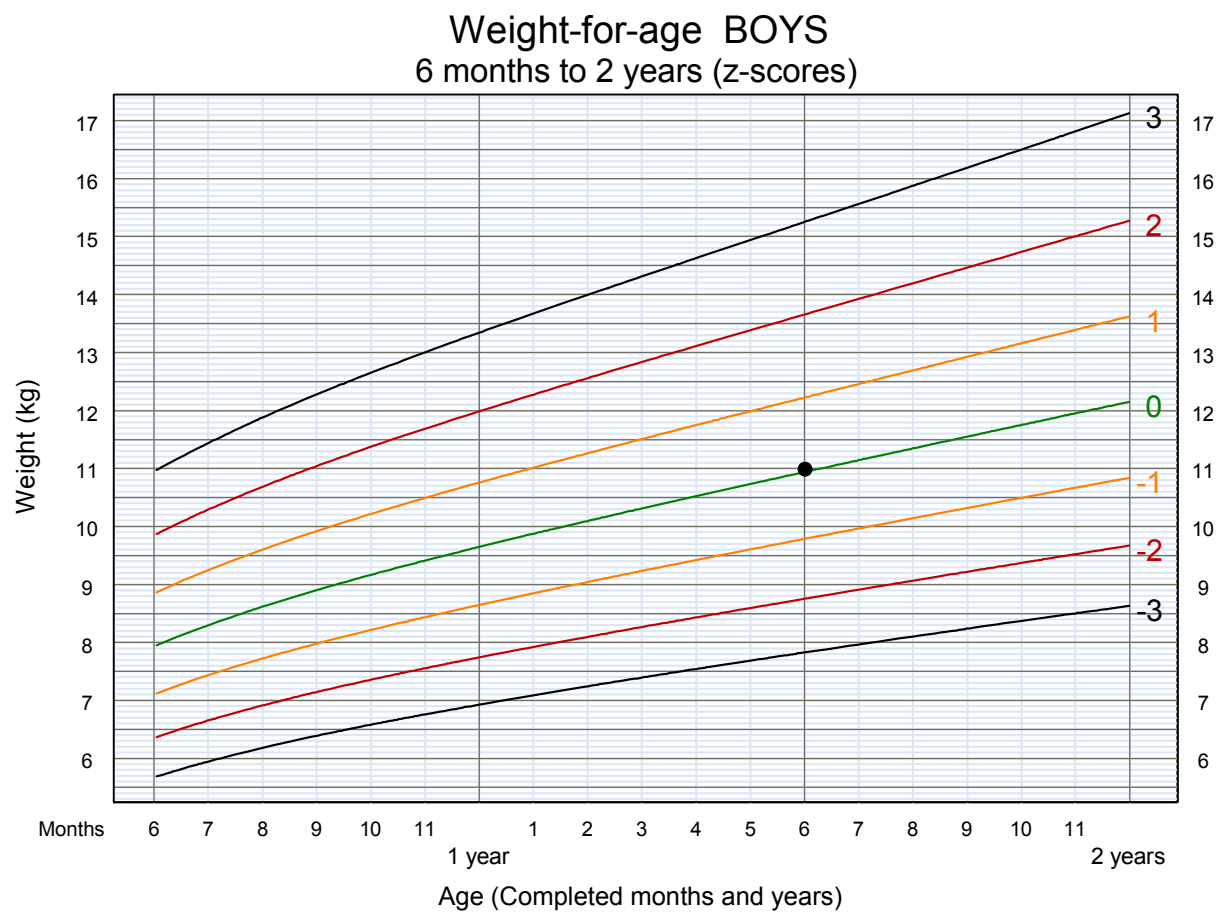
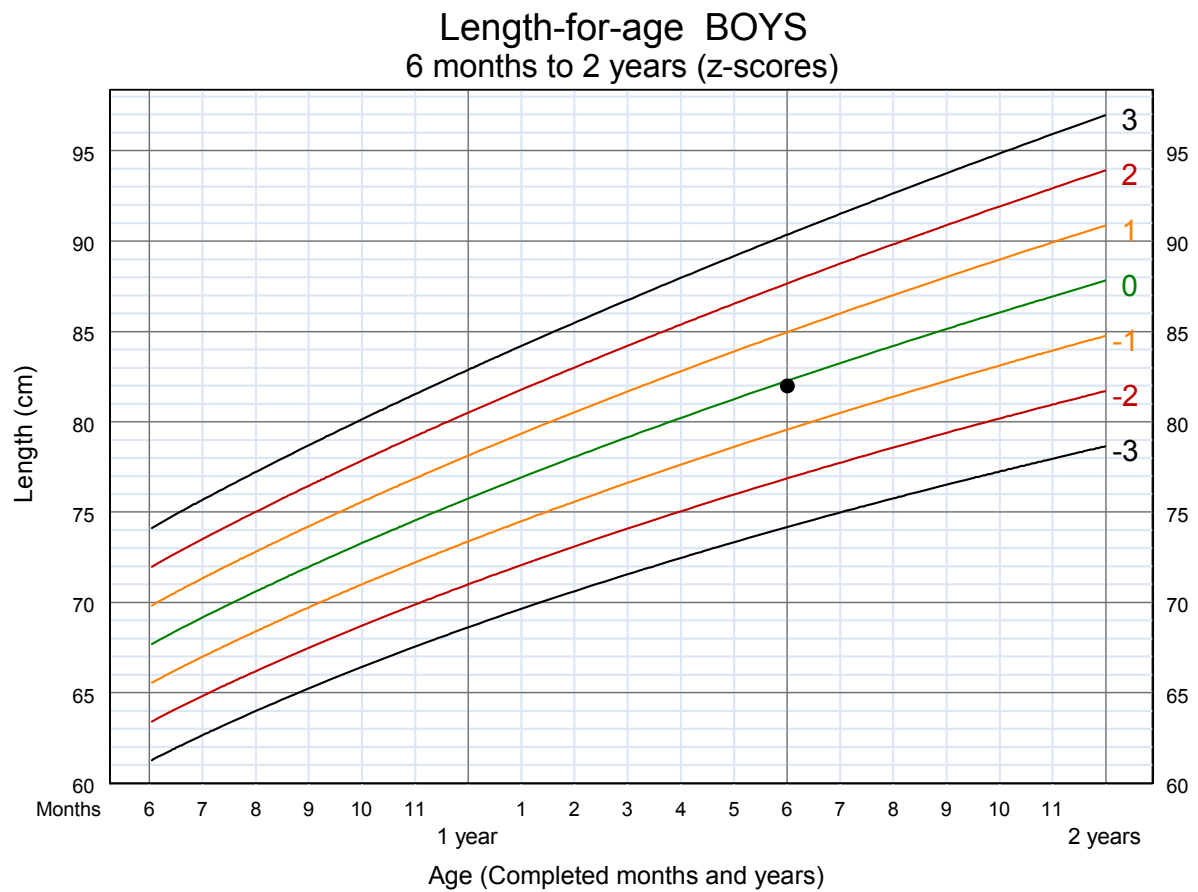
In this exercise you will view a set of four growth charts for each of three children. Each chart shows a plotted point for a single visit. You will answer questions about the growth charts and identify what growth problems, if any, are apparent.

Case 1 – Malek

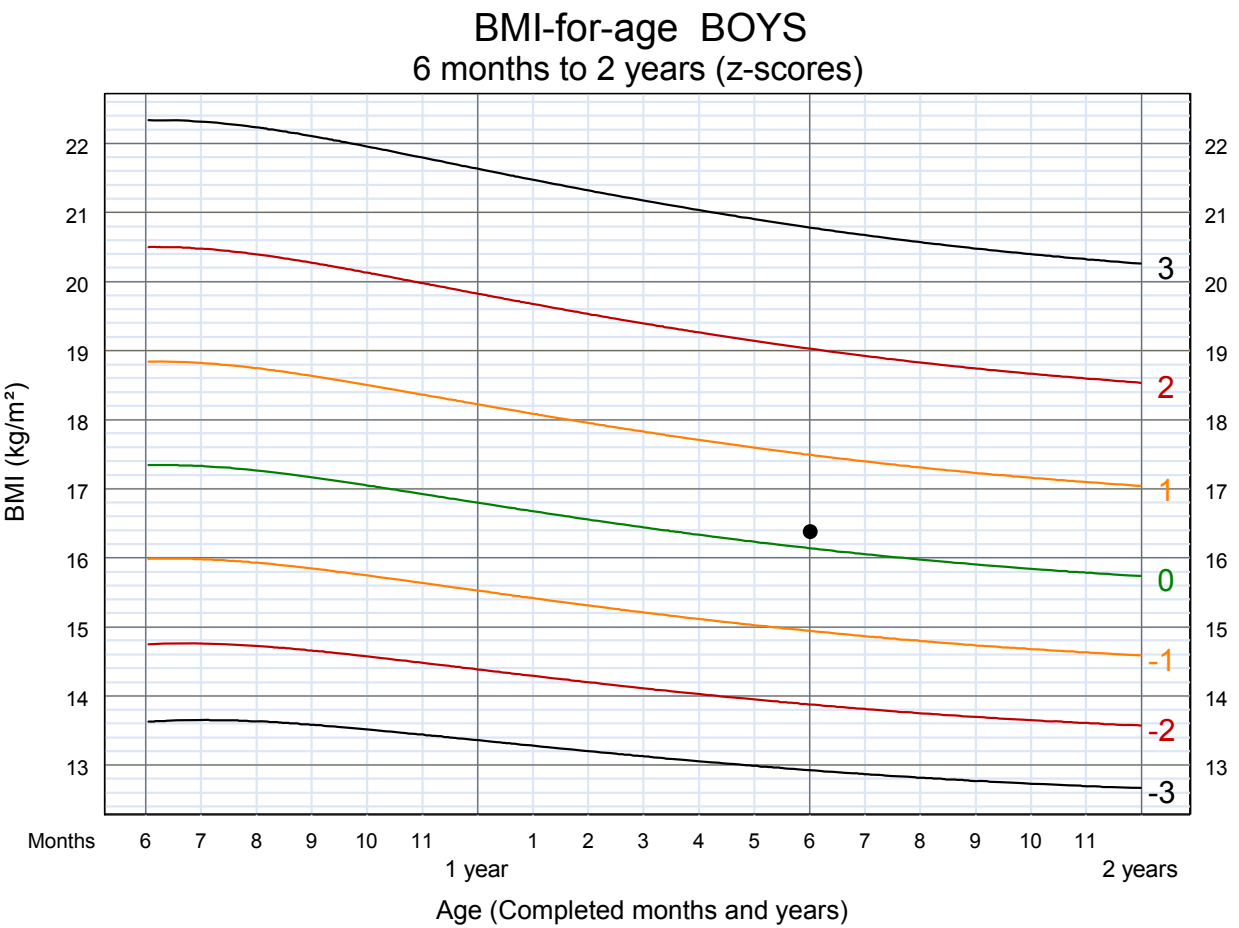
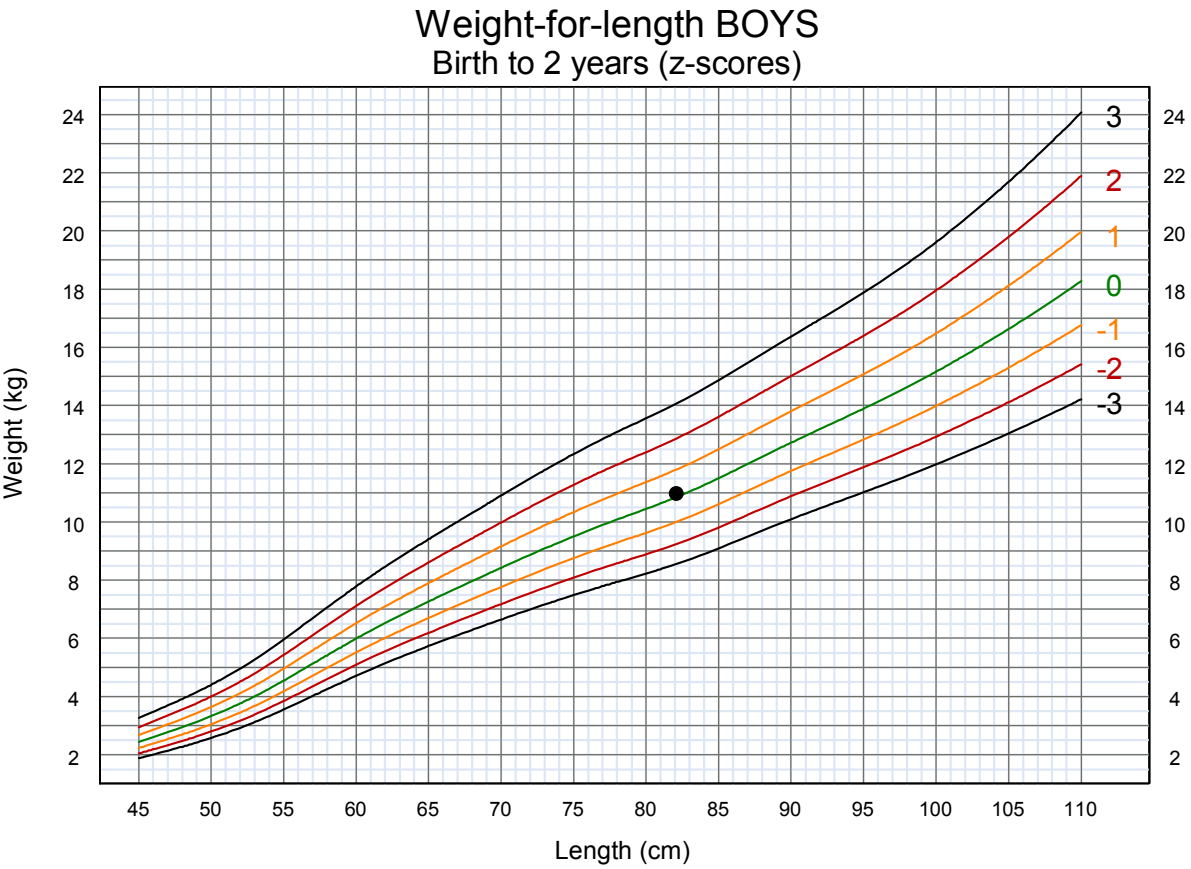
Malek is a boy who visits the health centre at age 1 year and 6 months (18 months). His length is 82 cm and his weight is 11 kg. His BMI is 16.4. Four growth charts from Malek's visit are shown on the next two pages. Study them and answer the questions below:

1. How does Malek's length-for-age compare to the median?
2. How does Malek's weight-for-age compare to the median?
3. How does Malek's weight-for-length compare to the median?
4. How does Malek's BMI compare to the median?
5. Judging from the plotted points from this one visit, does Malek seem to have any growth problem or risk of a growth problem? If so, what problem?

Charts for Malek



Charts for Malek



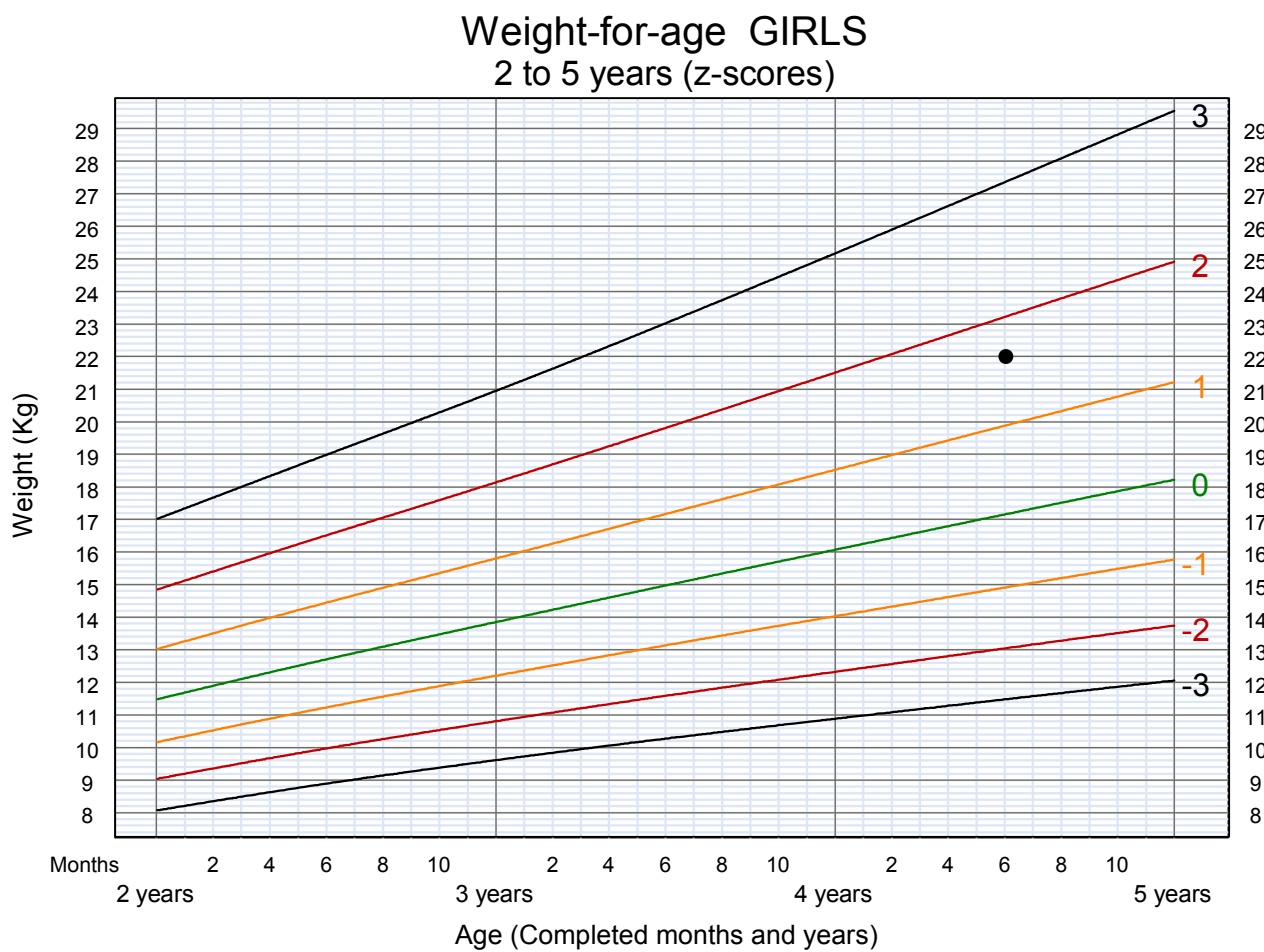
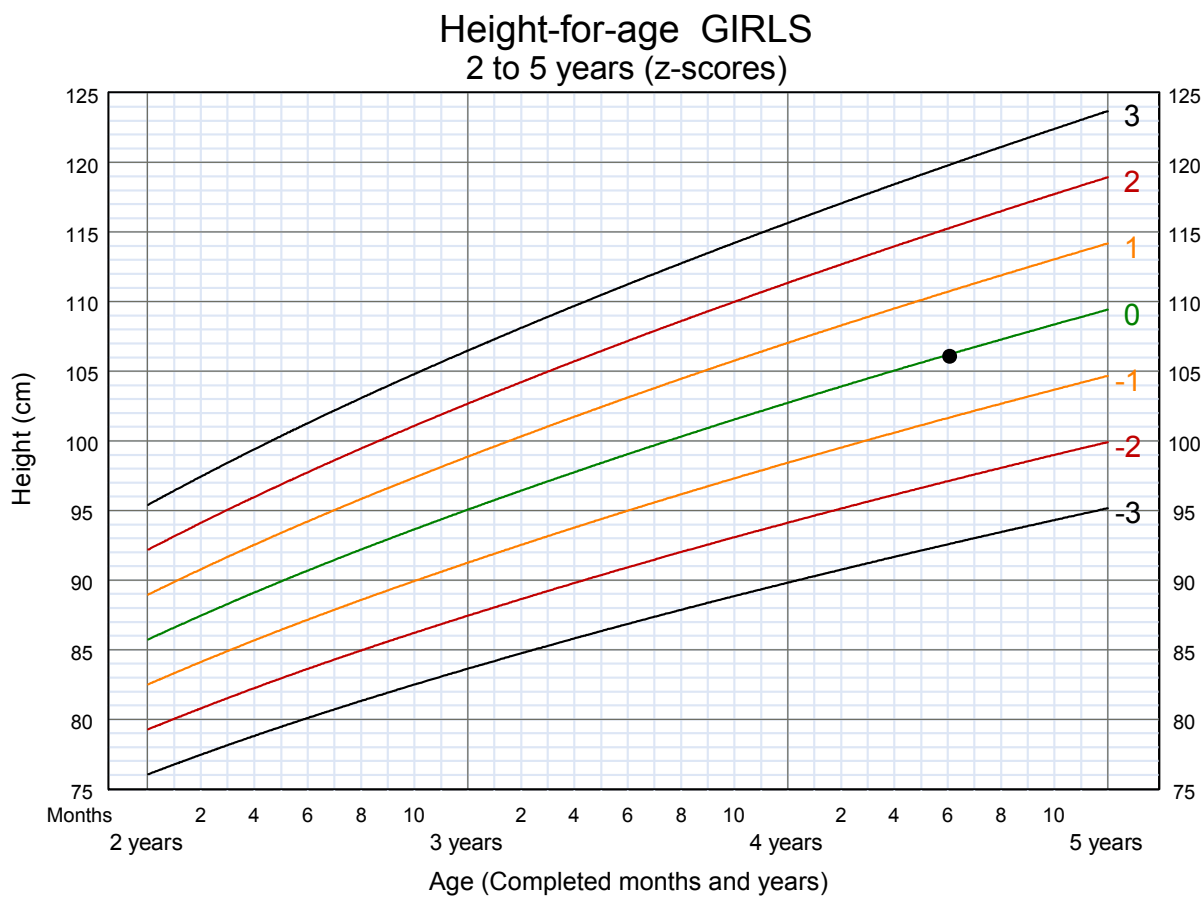
Case 2 – Nora

Nora comes to the health centre at age 4 years and 6 months for a check-up that is required before she enters the local preschool. Nora weighs 22 kg and is 106 cm in height. Her BMI is 19.6.

Study Nora's growth charts from this visit (on the next two pages) and answer the questions below:

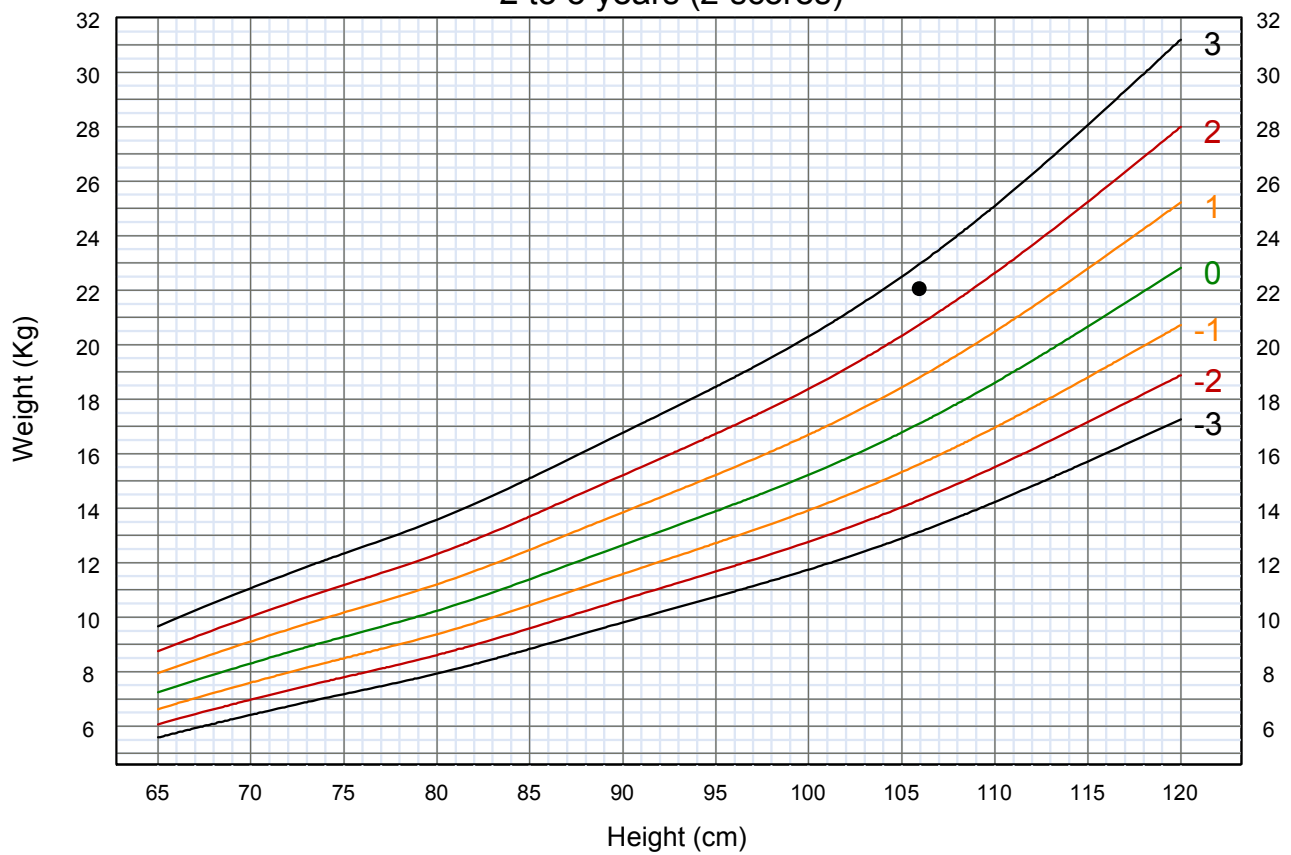
1. How does Nora's height compare to that of other girls her age?
2. Between which z-score lines is Nora's weight-for-age? Is Nora heavier or lighter than "average" for her age?
3. Describe Nora's weight-for-height in terms of z-scores.
4. Describe Nora's BMI-for-age in terms of z-scores.
5. Judging from the plotted points from this one visit, does Nora seem to have any growth problem or risk of a growth problem? If so, what problem?

Charts for Nora

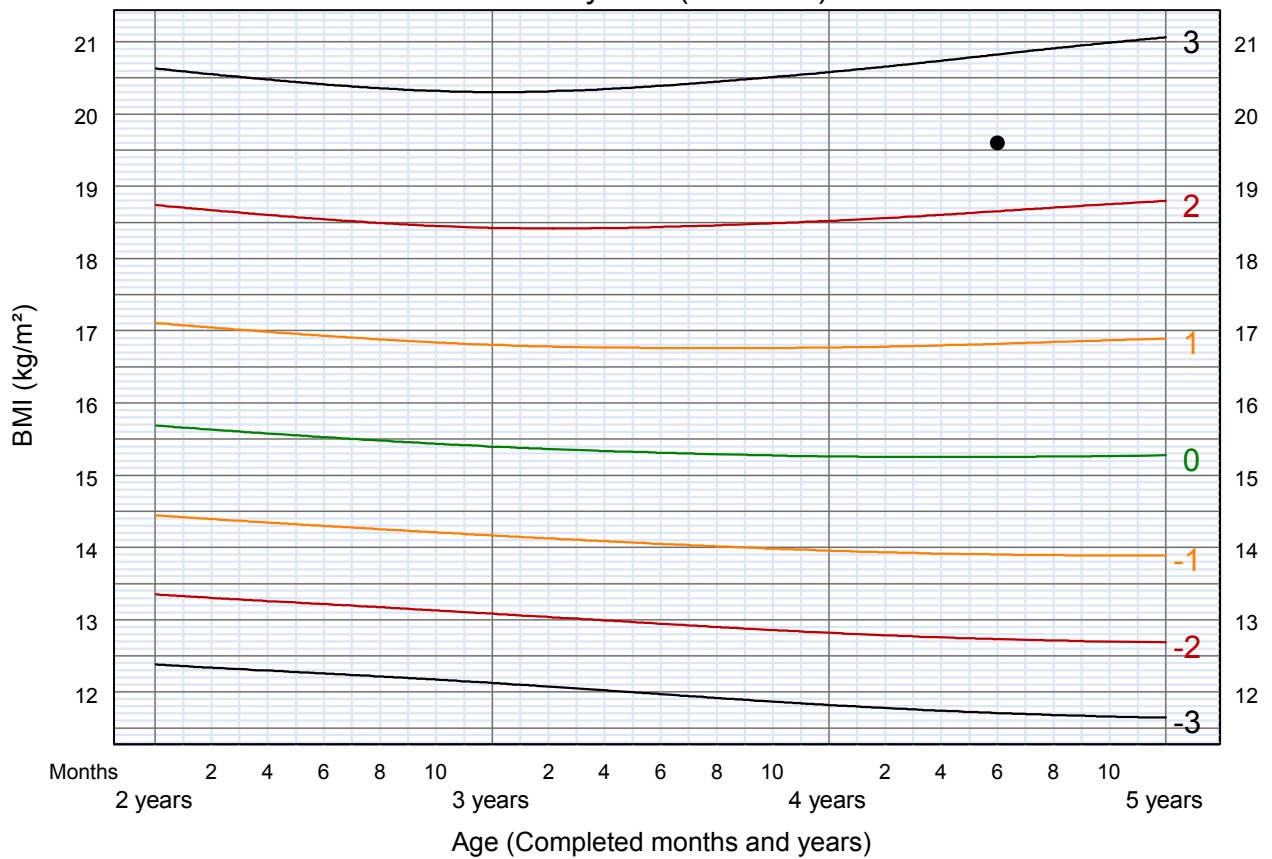


Charts for Nora

Weight-for-height GIRLS 2 to 5 years (z-scores)



BMI-for-age GIRLS 2 to 5 years (z-scores)



Case 3 – Delphie

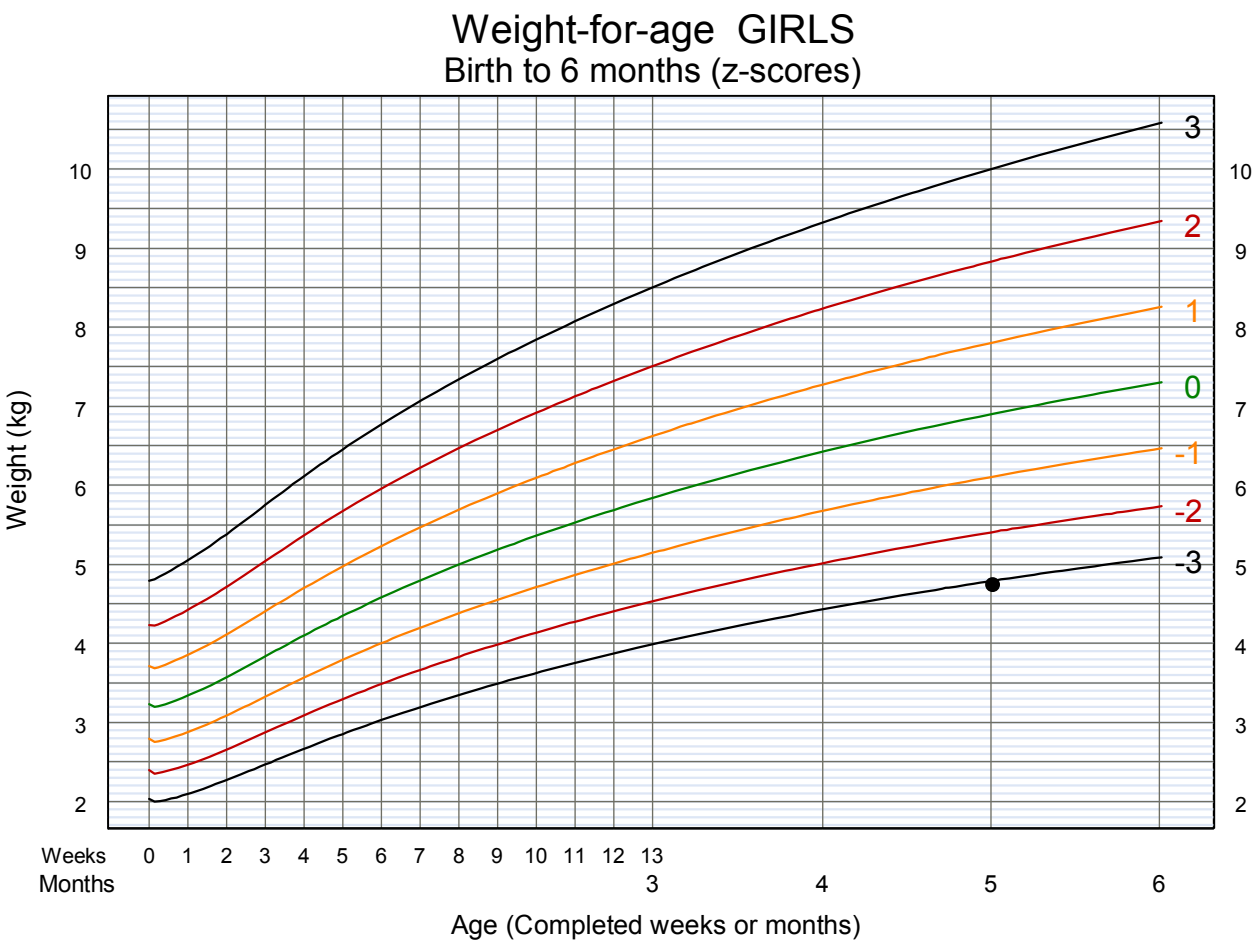
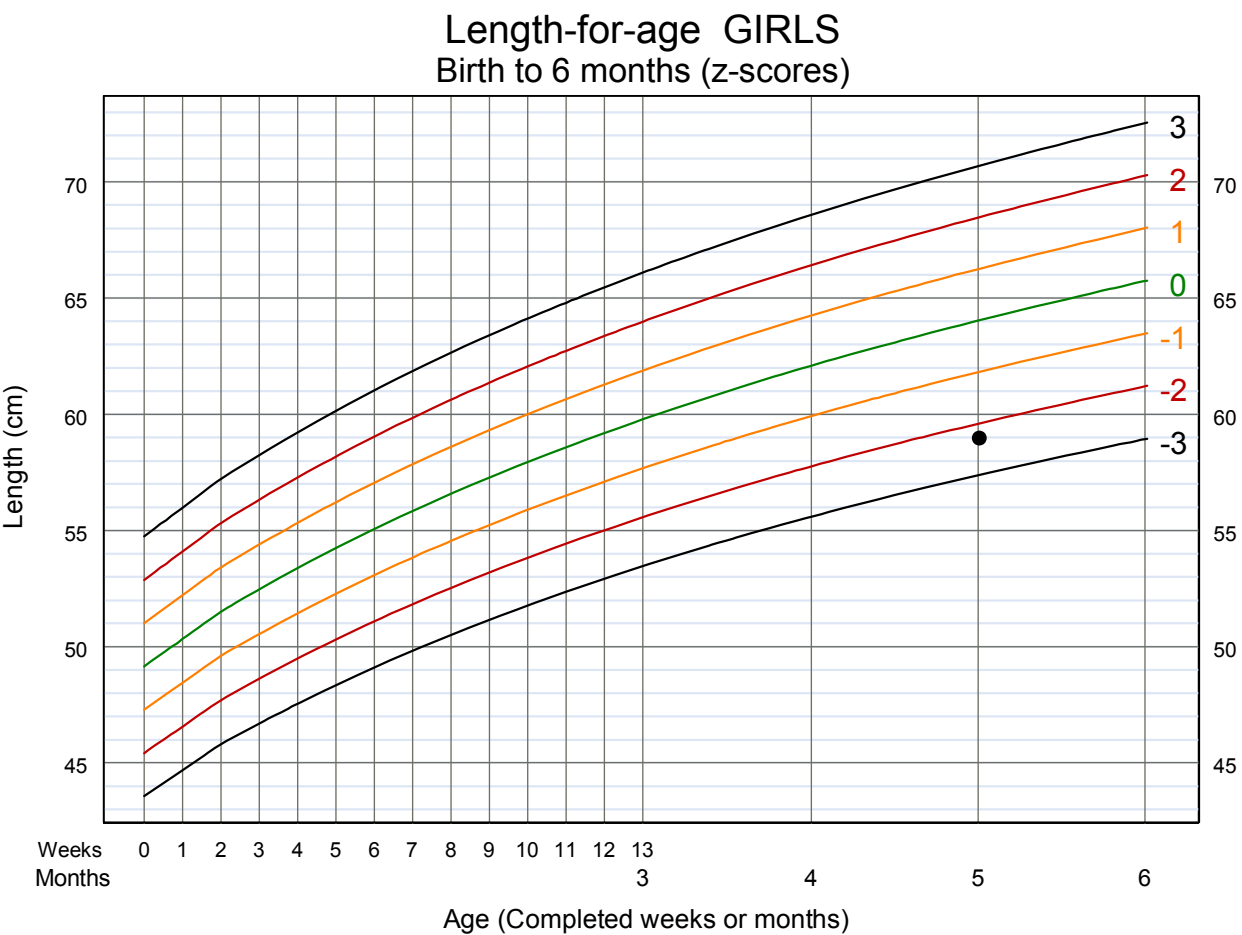
Delphie is 5 months old. She appears very thin, but not severely wasted, to the health care provider. She weighs 4.7 kg and is 59 cm in length. Her BMI is 13.5.

Study Delphie's growth charts from the visit and answer the questions below:

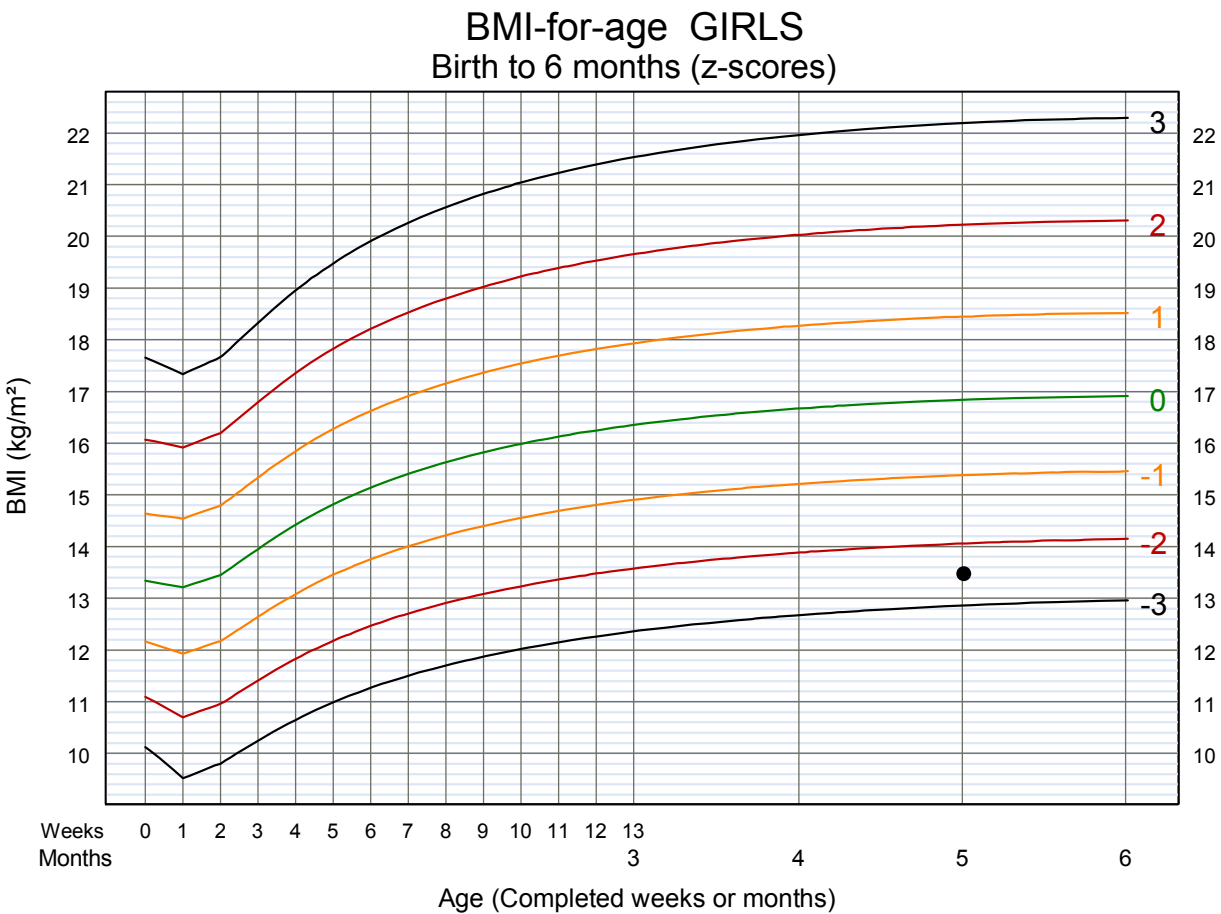
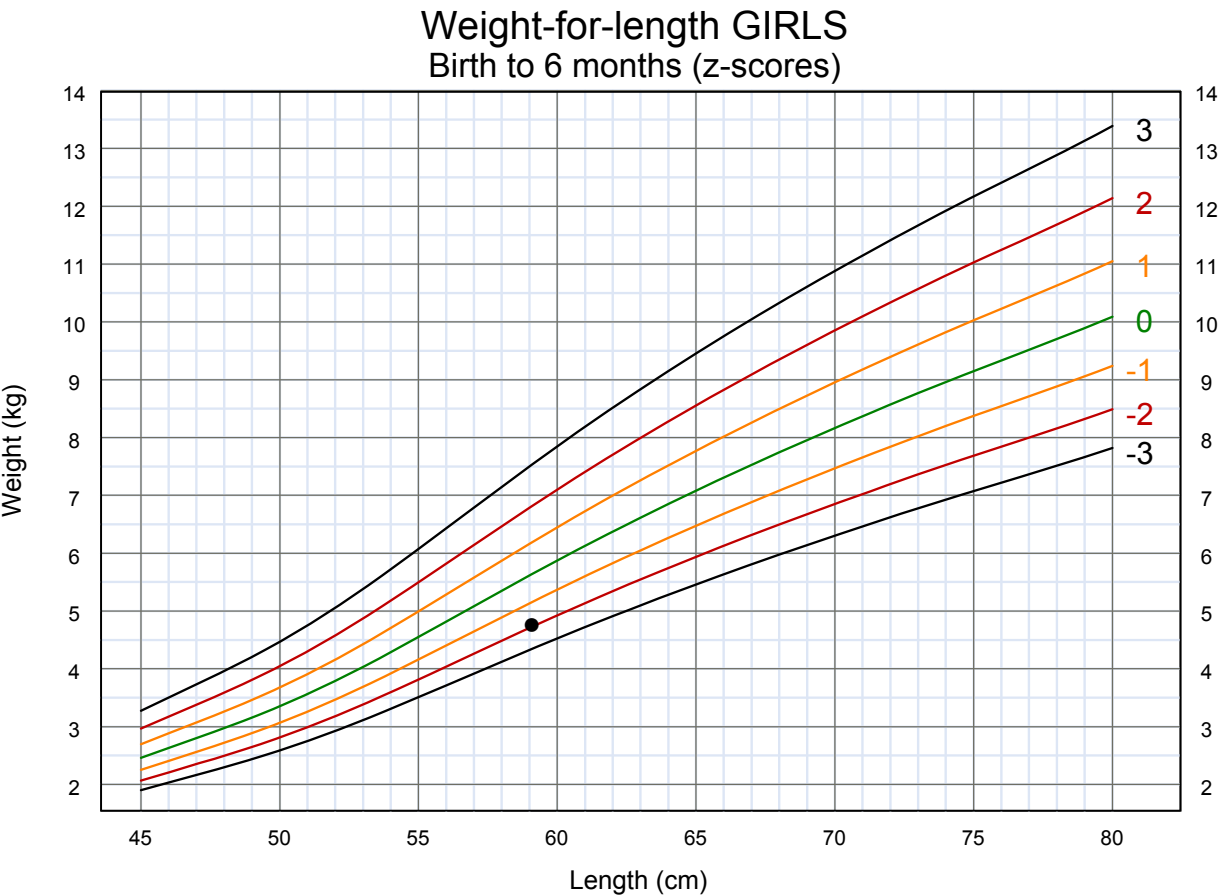
1. Describe Delphie's length-for-age in terms of z-scores.
2. Describe Delphie's weight-for-age in terms of z-scores.
3. Describe Delphie's weight-for-length in terms of z-scores.
4. Describe Delphie's BMI-for-age in terms of z-scores.
5. On the following list, tick the growth problems that Delphie has. Use the definitions beside the growth charts in the *Girl's Growth Record* and on page 14 of this module.
 - ☐ Stunted
 - ☐ Severely stunted
 - ☐ Underweight
 - ☐ Severely underweight
 - ☐ Obese
 - ☐ Overweight
 - ☐ Possible risk of overweight
 - ☐ Wasted
 - ☐ Severely wasted

**When you have finished this exercise,
review your answers with a facilitator.**

Charts for Delphie



Charts for Delphie



3.0 Interpret trends on growth charts

To identify trends in a child's growth, look at points for growth indicators plotted at a series of visits. Trends may indicate that a child is growing consistently and well, or they may show that a child has a growth problem, or that a child is "at risk" of a problem and should be reassessed soon.

"Normally" growing children follow trends that are, in general, parallel to the median and z-score lines. Most children will grow in a "track," that is, on or between z-score lines and roughly parallel to the median; the track may be below or above the median. When interpreting growth charts, be alert for the following situations, which may indicate a problem or suggest risk:

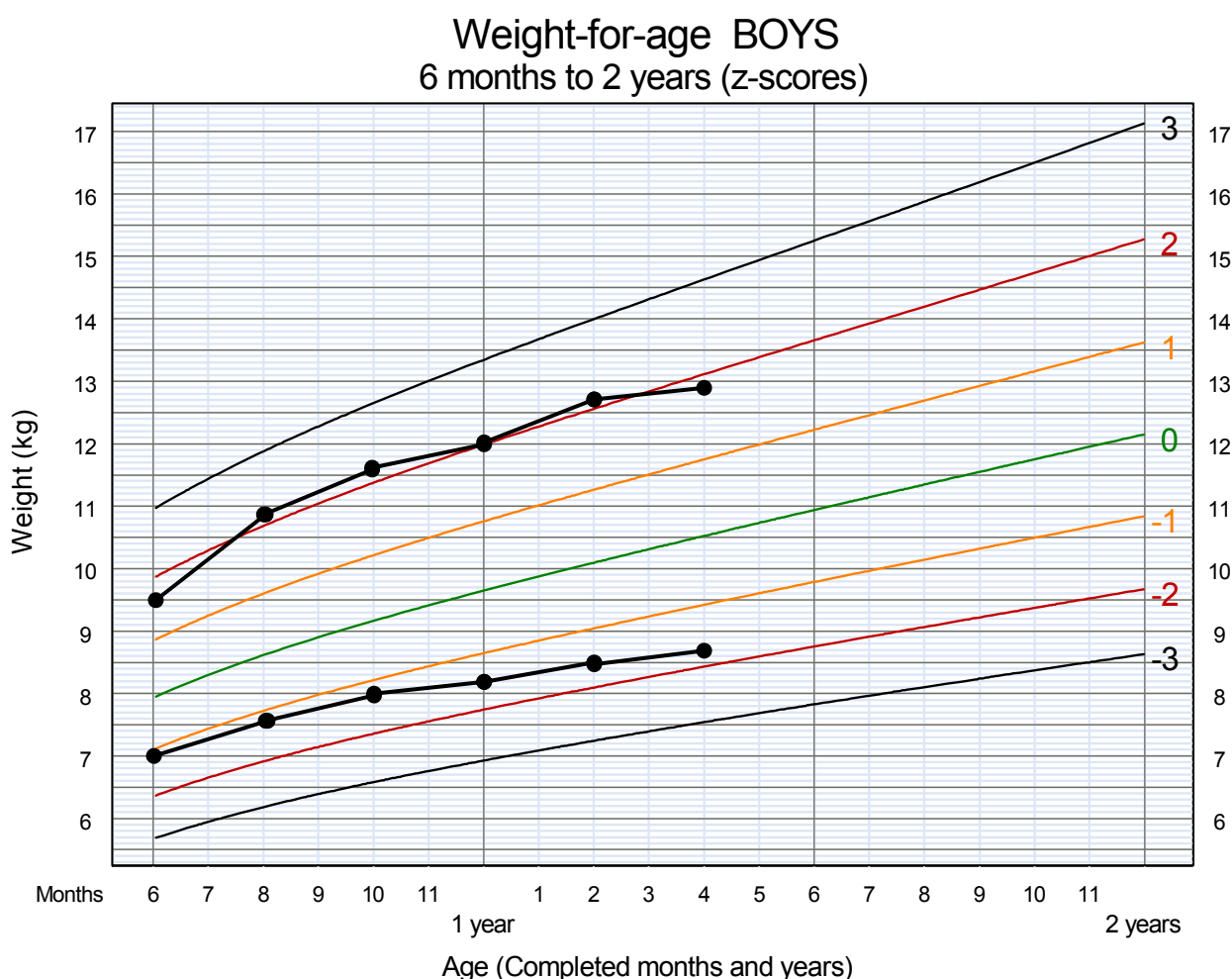
- A child's growth line crosses a z-score line.
- There is a sharp incline or decline in the child's growth line.
- The child's growth line remains flat (stagnant); i.e. there is no gain in weight or length/height.

Whether or not the above situations actually represent a problem or risk depends on where the change in the growth trend began and where it is headed. For example, if a child has been ill and lost weight, a rapid gain (shown by a sharp incline on the graph) can be good and indicate "catch-up growth." Similarly, for an overweight child a slightly declining or flat weight growth trend towards the median may indicate desirable "catch-down." It is very important to consider the child's whole situation when interpreting trends on growth charts.

3.1 Crossing z-score lines

Growth lines that cross z-score lines (not just those that are labelled on the chart) indicate possible risk. Children who are growing and developing normally will generally be on or between -2 and 2 z-scores of a given indicator. The growth of an individual child plotted over time is expected to track fairly close to the same z-score. The figure below presents two theoretical growth lines. In one of the lines growth generally tracks along 2 z-score crossing it from time to time in a pattern that indicates no risk. The other line shows a boy's weight falling away from his expected growth track. Although his growth line remains between -1 and -2 z-score, this child has in fact crossed z-scores following a systematic trend that indicates risk.

The interpretation of risk is based on where (relative to the median) the change in trend began and the child's health history. If the growth line tends towards the median, this is probably a good change. If it tends away from the median, this likely signals a problem or risk of a problem. If the growth line is inclining or declining so that it may cross a z-score line soon, consider whether the change may be problematic. In the example graph, if the trend in the lower growth line continues, it will soon cross the cut-off line (-2 z-score) that defines underweight. If a trend towards stunting, overweight or underweight is noticed in time, it may be possible to intervene in good time to prevent a problem.



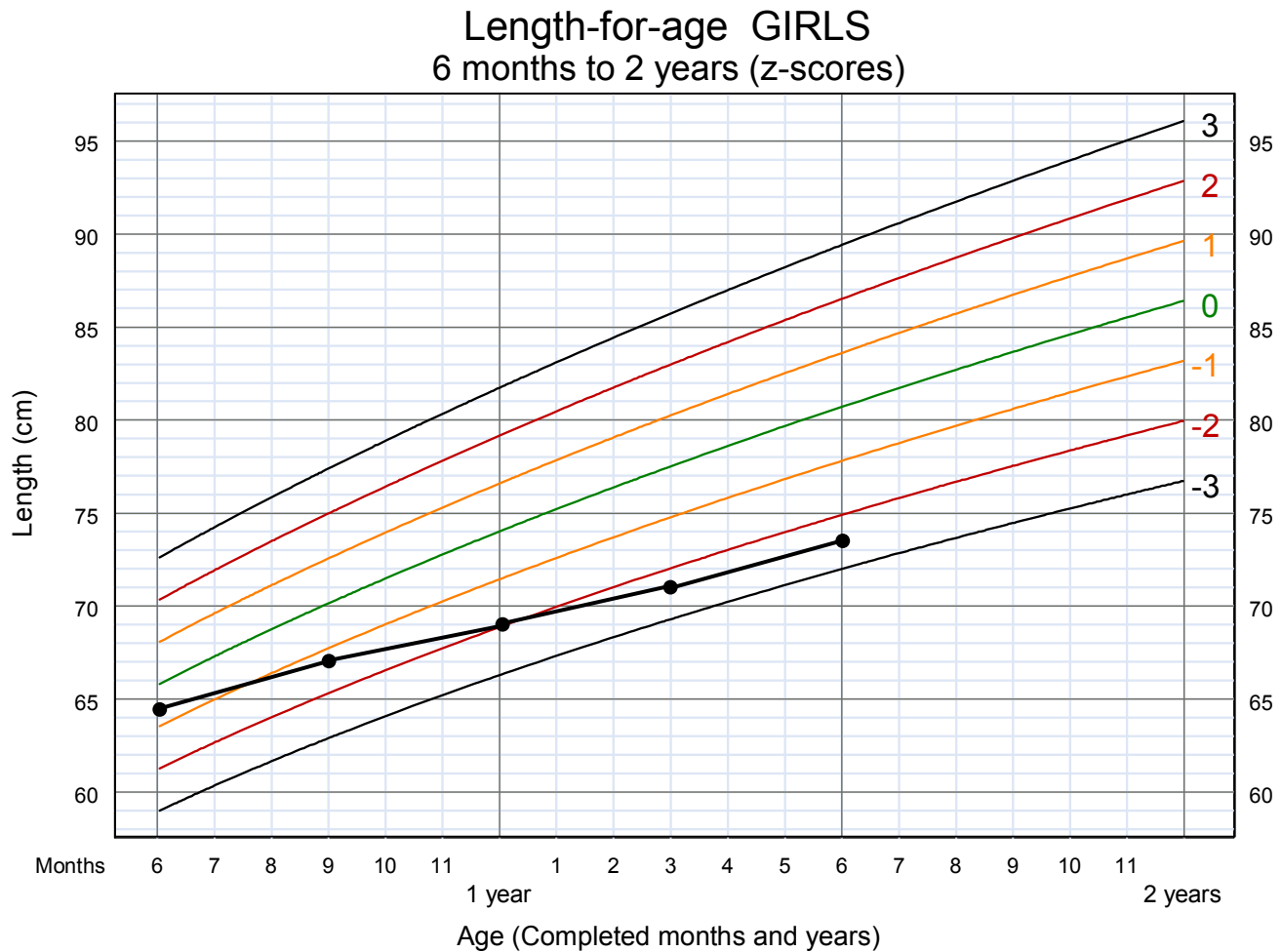
Example – Marco

Marco's weight-for-age chart below shows his weight at five visits from age 2 to 4 years old. Notice that Marco's weight-for-age has stayed on a track around the -2 z-score line for 2 years. This consistency suggests that he is gaining weight normally and is simply a "lean" child. However, it would be important to look at his height-for-age and weight-for-height charts as well. If Marco is a tall child, his weight-for-height chart could indicate a problem.



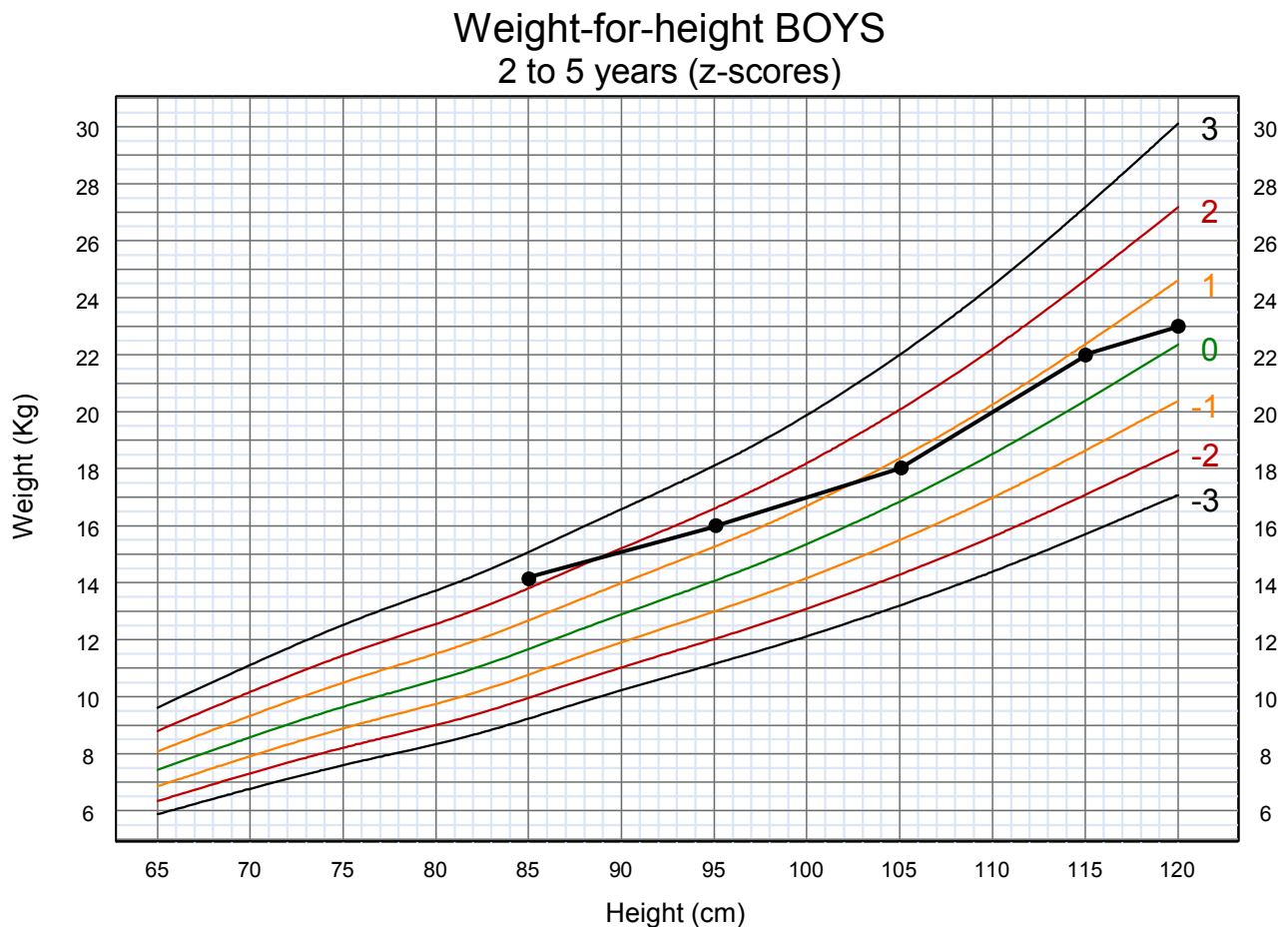
Example – Cecile

Cecile's length-for-age chart shows points plotted at five visits from the age of 6 months to 1 year and 6 months. Notice that Cecile's height-for-age dropped from above -1 to below -2 in a period of 9 months, crossing two z-score lines. Her growth in length seems to have slowed down at an age when rapid growth is expected. She is now stunted.



Example – Raj

The chart below shows Raj's weight-for-height at five visits from age 2 to 5 years. At the first of these visits, Raj's weight-for-height was above the 2 z-score line, indicating that he was overweight. Raj's weight gain then slowed down in relation to his growth in height. By the fifth visit, Raj is approaching the median for weight-for-height. In Raj's case, the crossing of z-score lines towards the median and slowing of weight gain represent a good trend.



3.2 Sharp incline or decline in the growth line

Any sharp incline or decline in a child's growth line requires attention. If a child has been ill or severely undernourished, a sharp incline is expected during the refeeding period as the child experiences "catch-up" growth. Otherwise, a sharp incline is not good, as it may signal a change in feeding practices that will result in overweight.

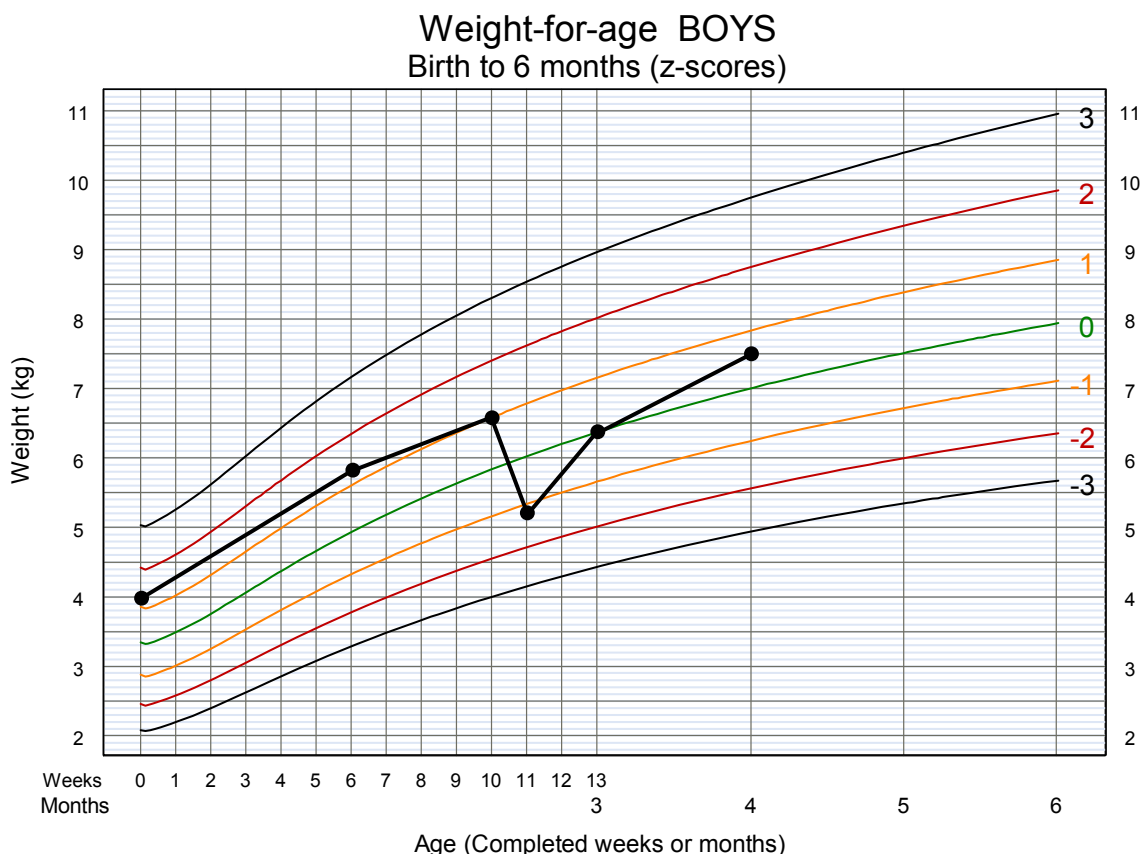
If a child has gained weight rapidly, look also at height. If the child grew in weight only, this is a problem. If the child grew in weight and height proportionately, this is probably catch-up growth from previous undernutrition, because of improvement in feeding or cure of previous infection. In this situation, the weight-for-age and height-for-age charts should show inclines, while the weight-for-height growth line tracks steadily along the z-score curves.

A sharp decline in the growth line of a normal or undernourished child indicates a growth problem to be investigated and remedied.

Even if a child is overweight, he or she should not have a sharp decline in the growth line, as losing too much weight rapidly is undesirable. The overweight child should instead maintain his weight while increasing in height; i.e. the child should "grow into his weight."

Example – Farhan

Farhan's weight-for-age chart (below) shows a sharp decline from age 10 to 11 weeks, when he had diarrhoea and lost 1.3 kg. The chart shows a sharp incline after the episode of diarrhoea, as Farhan gained back most of the lost weight.



3.3 Flat growth line (stagnation)

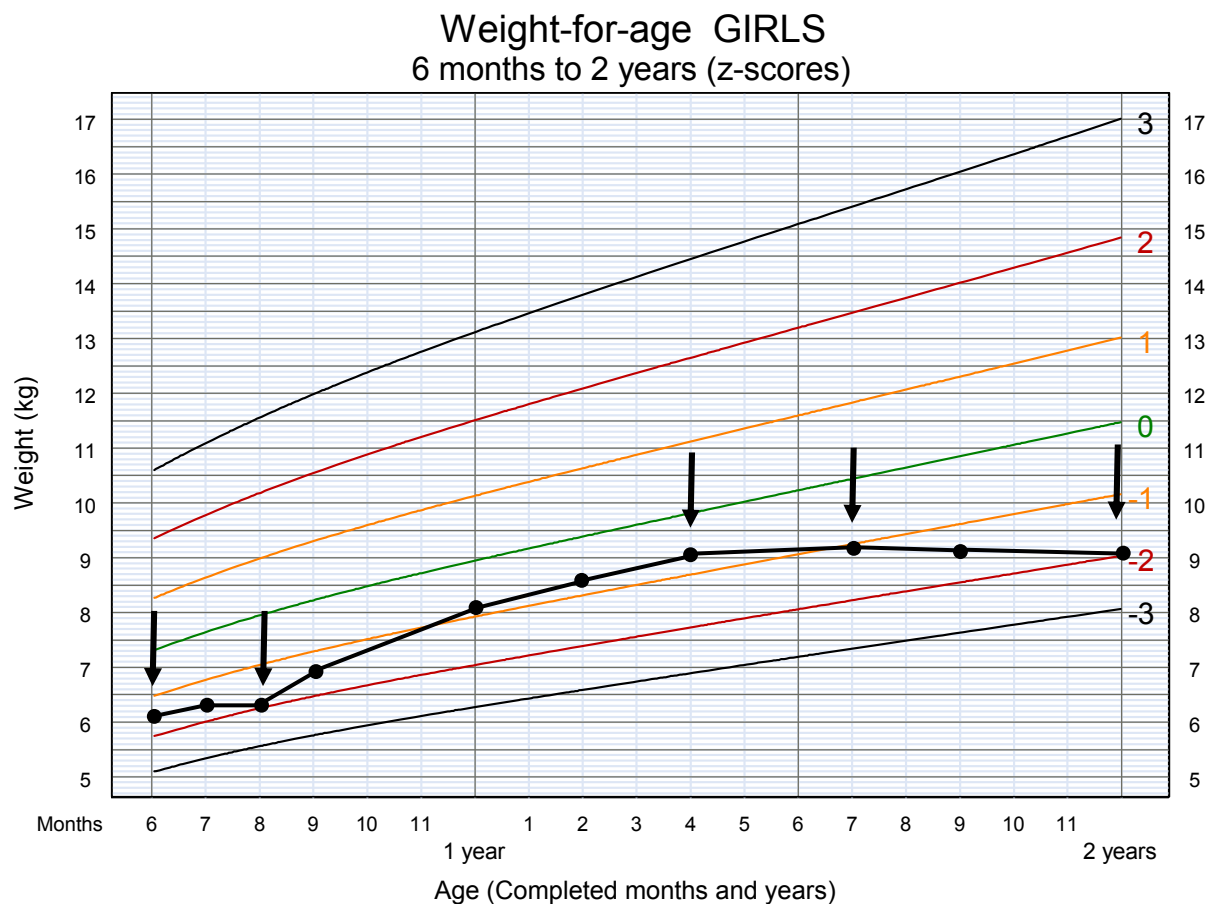
A flat growth line, also called stagnation, usually indicates a problem. If a child's weight stays the same over time as height or age increases, the child most likely has a problem. If height stays the same over time, the child is not growing. The exception is when an overweight or obese child is able to maintain the same weight over time, bringing the child to a healthier weight-for-height or BMI-for-age.

If an overweight child is losing weight over time, and the weight loss is reasonable, the child should continue to grow in height. However, if the child experiences no growth in height over time, there is a problem. This problem would be evident as a flat growth line on the height-for-age chart.

For children in age groups where the growth rate is fast, as shown by steep growth curves (e.g. during the first 6 months of life), even one month's stagnation in growth represents a possible problem.

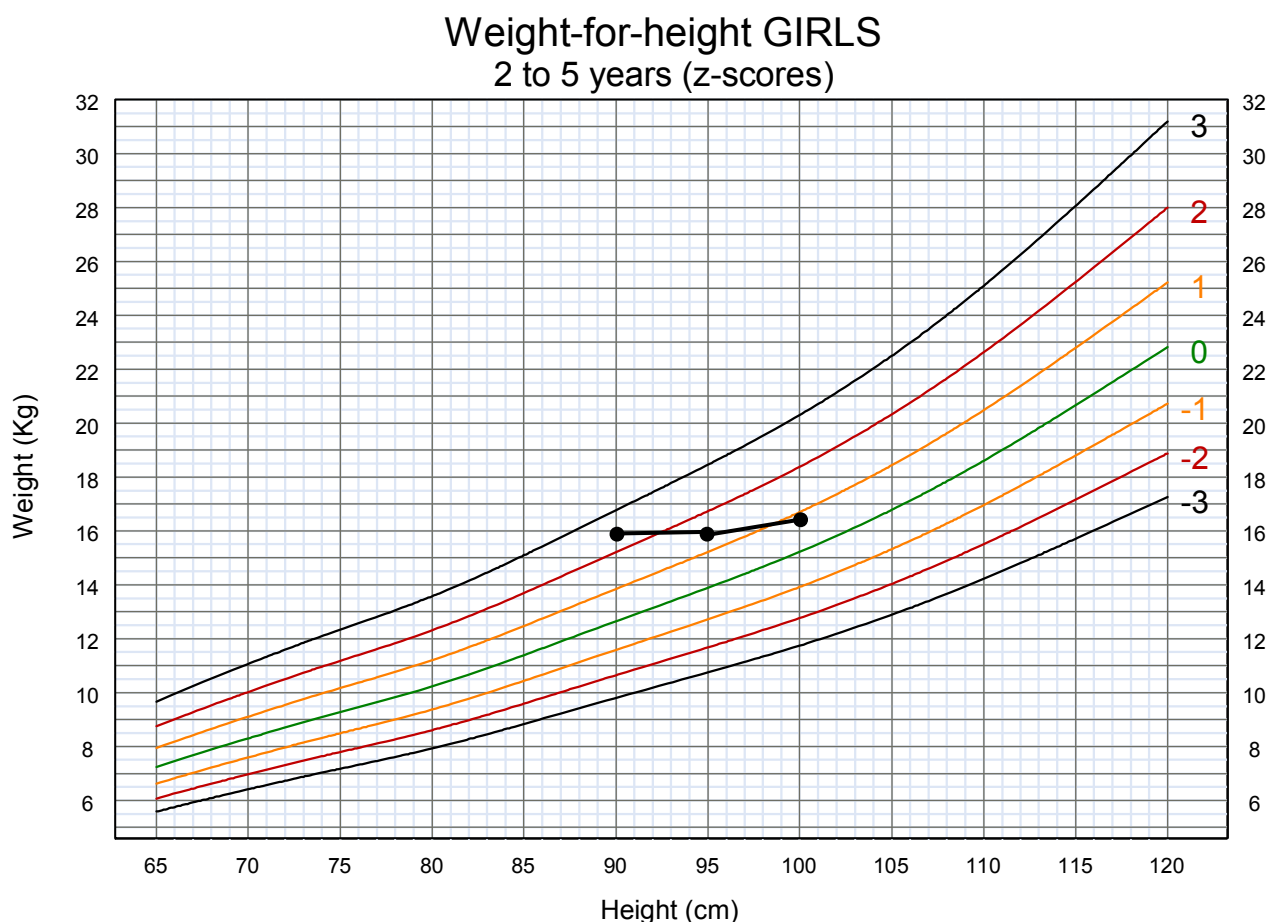
Example – Malini

Malini's weight-for-age chart shows a flat growth line (stagnation) from age 6 months to 8 months and again from about 1 year and 4 months to 2 years. These periods of stagnation correspond to times when Malini was having malaria episodes (indicated by arrows). From 8 months up to 1 year and 4 months, she grew. Due to periods of stagnation, Malini's weight-for-age is about to cross the -2 z-score line.



Example – Kadira

Unlike the flat line on Malini's chart, the flat line on Kadira's weight-for-height chart below shows a good trend. Kadira was overweight, but her weight remained about the same while she grew in height. She is no longer overweight.



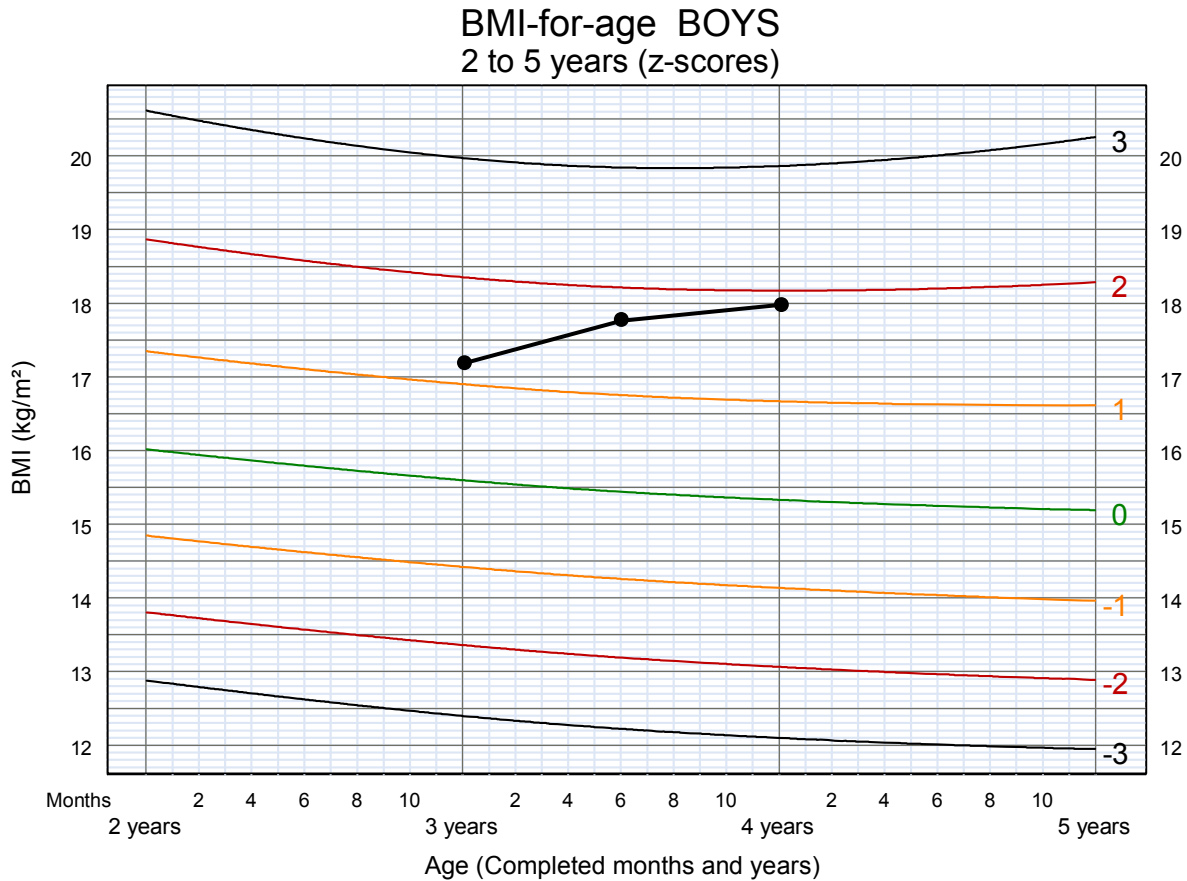
3.4 Trends in BMI-for-age

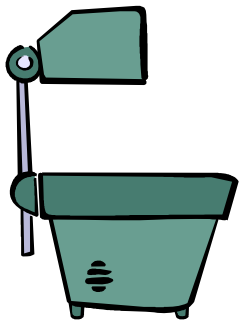
BMI does **not** normally increase with age as do weight and height individually. Looking at the BMI-for-age charts in the *Growth Record*, you will notice that an infant's BMI goes up sharply as the infant rapidly gains weight relative to length in the first 6 months of life. The BMI comes down in later infancy and remains relatively stable from age 2 to 5 years.

BMI-for-age is similar to weight-for-length/height and is useful for screening for overweight and obesity. When interpreting risk of overweight, it is helpful to consider the weight of the child's parents. If the child has an obese parent, this increases the child's risk of becoming overweight. A child with one obese parent has a 40% probability of being overweight; if both parents are obese, the probability goes up to 70%. It is important to know that overweight and obesity can co-exist with stunting.

Example – Adil

Adil's BMI-for-age chart below shows a trend towards overweight. If his growth line crosses the 2 z-score line, he will be considered overweight.





Group Discussion
Interpreting Trends on Graphs

When everyone is ready, your facilitators will lead a group discussion about growth trends shown on graphs for two children, Ben and Delia. Stop here until the group discussion is announced.



Exercise C

Continuing Case Studies – Nalah and Toman

In Exercise A of this module, you plotted points on the growth charts in Nalah's and Toman's *Growth Records*. In this exercise you will review the growth charts for Nalah and Toman to identify:

- each child's growth patterns
- any current growth problem(s)
- any growth trend(s) that may become a problem

To describe growth problems, use the definitions given on page 14 of this module, as well as next to the growth charts in the *Growth Record*. To describe growth patterns and trends, point out whether the growth line shows an incline or decline, whether it is tracking along or between certain z-score lines, whether it has crossed a z-score line, etc.

Nalah

Review the growth charts that you completed in Nalah's *Girl's Growth Record*. Then write short answers to the questions below:

1. a) Describe the growth trend shown on Nalah's length-for-age chart.

b) Does Nalah's length-for-age chart show a current growth problem or risk of a problem, and if so, what is it?
2. a) Describe the growth trend shown on Nalah's weight-for-age chart.

b) Does Nalah's weight-for-age chart show a current growth problem or risk of a problem, and if so, what is it?

3. a) Describe the growth trend shown on Nalah's weight-for-length chart.

b) Does Nalah's weight-for-length chart show a current growth problem or risk of a problem, and if so, what is it?
4. a) Describe the growth trend shown on Nalah's BMI-for-age chart.

b) Does Nalah's BMI-for-age chart show a current growth problem or risk of a problem, and if so, what is it?
5. Summarize Nalah's growth pattern over the first 6 months of life below.

Toman

Review the growth charts that you completed in Toman's *Boy's Growth Record*. Then write short answers to the questions below:

1. a) Describe the growth trend shown on Toman's length-for-age chart.

b) Does Toman's length-for-age chart show a current growth problem or risk of a problem, and if so, what is it?
2. a) Describe the growth trend shown on Toman's weight-for-age chart.

- b) Does Toman's weight-for-age chart show a current growth problem or risk of a problem, and if so, what is it?
-
- 3. a) Describe the growth trend shown on Toman's weight-for-length chart.

 - b) Does Toman's weight-for-length chart show a current growth problem or risk of a problem, and if so, what is it?
-
- 4. a) Describe the growth trend shown on Toman's BMI-for-age chart.

 - b) Does Toman's BMI-for-age chart show a current growth problem or risk of a growth problem, and if so, what is it?
-
- 5. Briefly summarize Toman's growth pattern from age 1 year and 1 month to age 2 years.

**When you have finished this exercise,
review your answers with a facilitator.**

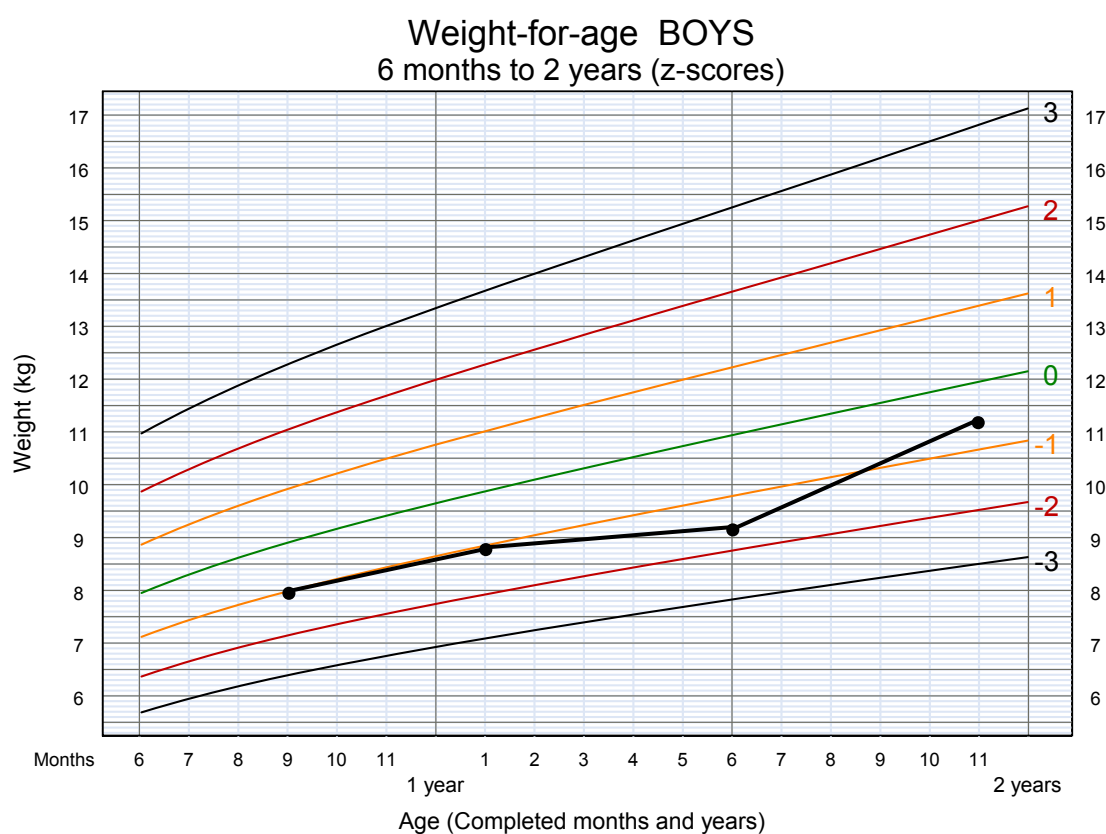
Answers to short answer exercises

Page 4 – Anna

1. The dots on the graph should be connected.
2. 98 cm at 3 years and 3 months
3. 103 cm at 4 years and 2 months

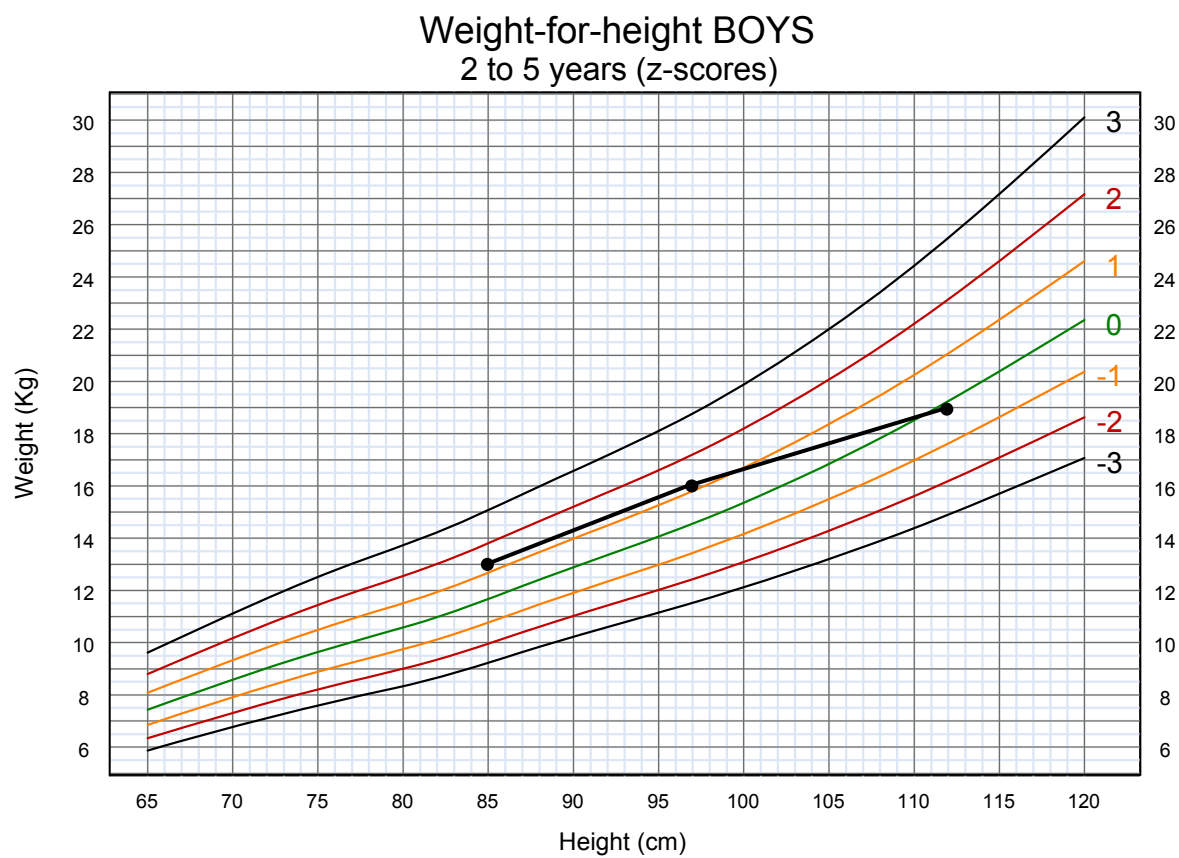
Page 6 – Amahl

1. 8 kg
2. 1 year and 1 month
3. 1 year and 6 months, 9.1 or 9.2 kg
4. Completed graph for Amahl:



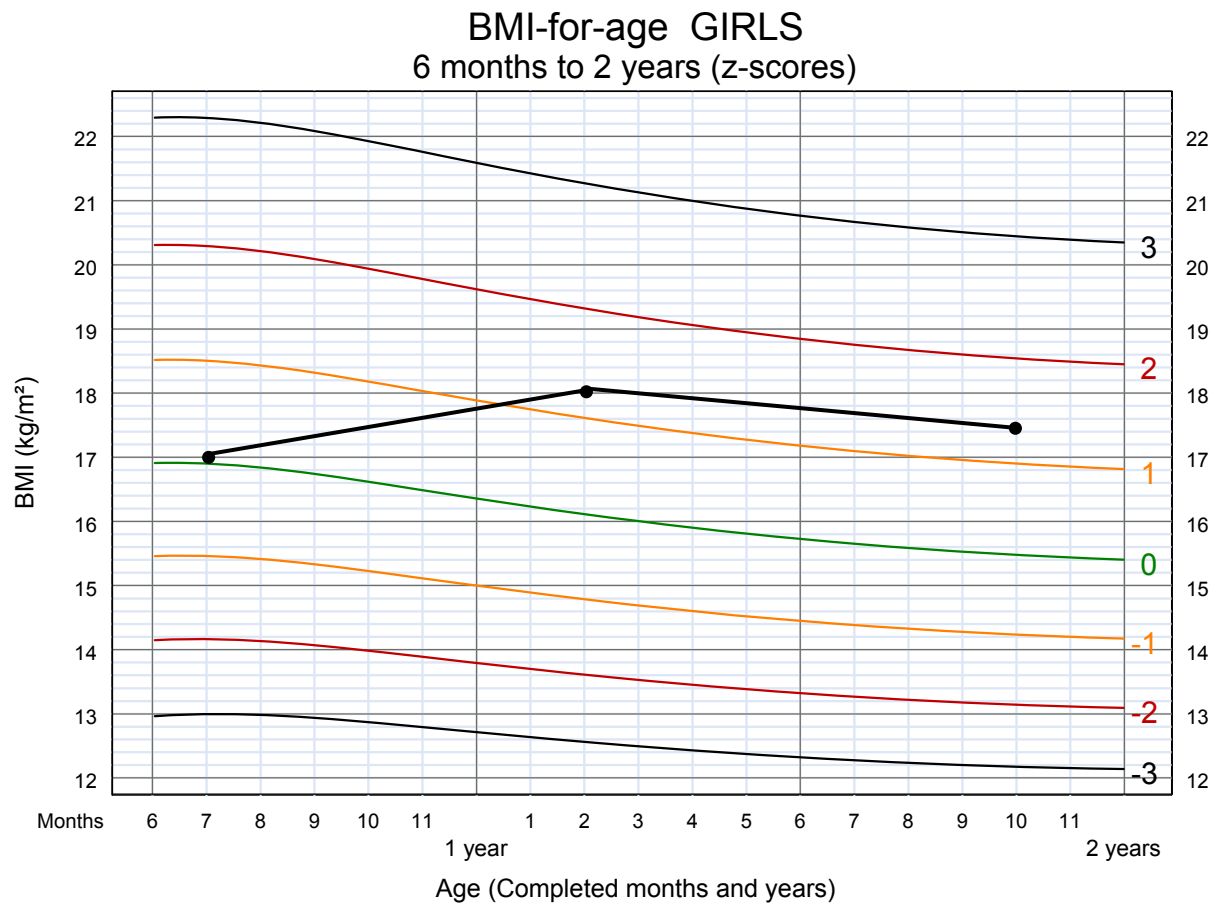
Page 8 – Tran

1. about 97 cm
2. 16 kg
3. Completed graph for Tran:



Page 10 – Rosita

1. 1 year and 2 months
2. BMI is 18
3. The completed graph for Rosita is on the next page.



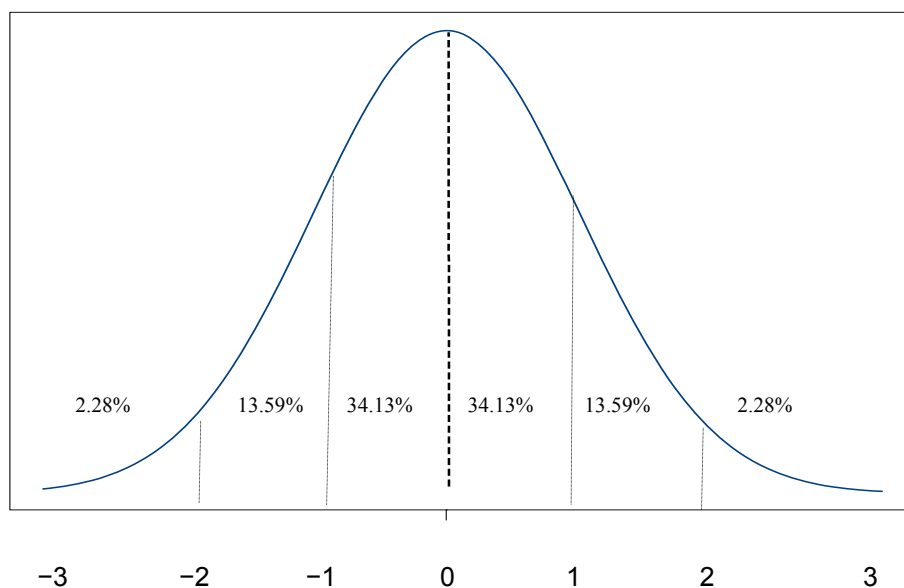
Annex: Explanation of z-score or standard deviation (SD) score

The reference lines on the growth charts are called z-score lines because they are based on z-scores, also known as standard deviation (SD) scores. Z-scores or SD scores are used to describe how far a measurement is from the median (average). These scores are calculated differently for measurements that are distributed normally and non-normally in the reference population.

Normally distributed measurements

The concept of a normal distribution is helpful for understanding what a z-score is. In a normal distribution, most values are grouped around the middle, and the distribution of measurements around the median forms a bell shape, as shown below. On a normal bell-shaped curve, a z-score gives an indication of how far a child is from the median.

A normal bell-shaped curve cut into z-score segments



The distribution of heights of all boys (or all girls) of a certain age forms a bell-shaped curve, or a normal (or almost normal) distribution.¹¹ When the heights of a large group of boys or girls of a certain age are graphed, the result resembles the normal distribution above. Notice that most of the heights are in the middle, with very few at the extreme ends. Each segment on the horizontal axis represents one standard deviation or z-score. In this normal distribution, the z-scores -1 and 1 are at equal distances in opposite directions from the median. The distance from the median to 1 is half of the distance to 2 .

¹¹ Note that 2.28% is what lies between -2 and minus infinity, and between $+2$ and plus infinity.

The z-score of an observed point in this distribution is calculated as follows:

$$\text{z-score} = \frac{(\text{observed value}) - (\text{median reference value})}{\text{z-score of the reference population}}$$

Example

This example applies the preceding formula to height-for-age in children. In this example, the child is a boy named Sam who is 96.1 cm tall and 2 years and 4 months old.

- The observed value is Sam's height (96.1 cm).
- The median reference value is the median height of all boys measured who are Sam's age (2 years and 4 months). The median height of boys of this age is 90.4 cm.
- The z-score of the reference population can be described in a simplified way as an average of differences from the median for each member of the reference population. In this example, the z-score of boys' heights at age 2 years and 4 months is 3.3.
- Inserting the above numbers in the formula, Sam's z-score is calculated as follows:

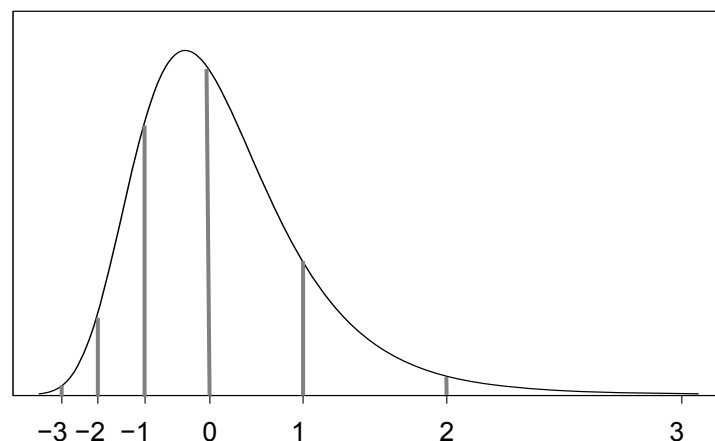
$$\frac{96.1 - 90.4}{3.3} = 1.73$$

- Sam's z-score for height-for-age is 1.73, or above 1.

Using the growth charts shown in the *Growth Records* in this course, we can easily plot Sam's height-for-age on the chart on page 37 of the *Growth Record* and see that Sam's z-score for height-for-age is above 1, almost 2.

Non-normally distributed measurements

Unlike the distribution of height, the distribution of some measurements, such as weight, has a shape when graphed that looks like a "deformed" bell whose right side is longer than the left and is described as right-skewed:



It is more difficult to calculate z-scores for measurements, such as weight, that are not normally distributed. Unlike in a normal distribution, distances between adjacent z-scores are not constant. For example, the distance between z-scores 3 and 2 is greater than between z-scores 2 and 1. Also, differences between the median and values at negative z-scores are smaller than the differences between the median and values at corresponding positive z-scores. Nevertheless, percentages between the various z-scores are the same as in the bell-shaped distribution, thus, 13.59% between -1 and -2, and 2.28% between +2 and plus infinity.

To calculate the z-score of an observed point involves a series of mathematical calculations that take into account the non-normal distribution of measurements in the reference population. The following formula is used:

$$\text{z-score} = \frac{(\text{observed value} \div M)^L - 1}{L \times S}$$

In this formula, M, L and S are values for the reference population. M is the reference median value which estimates the population mean. L is the power needed to transform the data in order to remove skewness (i.e. to normalize the data). S is the coefficient of variation (or equivalent).

This formula (sometimes called the LMS formula) is used to calculate z-scores for weight-for-age, weight-for-length/height, and BMI-for-age.

Example

Sam (the boy in the previous example) has a weight of 11.9 kg at the age of 2 years and 4 months. To calculate a z-score for his weight-for-age, we need to know the M, L and S reference values for boys' weight at age 2 years and 4 months. Those values are:

M = 12.94 (median weight for boys age 2 years and 4 months)

L = -0.06 (power to normalize the data)

S = 0.12 (coefficient of variation)

Applying the formula, Sam's z-score for weight-for-age is:

$$\frac{(11.9 \div 12.94)^{-0.06} - 1}{-0.06 \times 0.12} = -0.70$$

Sam's weight-for-age is below the median (0) but is not as low as -1.

Note: A modified version of the LMS formula given above must be used to calculate measurements that lie beyond -3 and +3 z-scores. This is because a restriction has been imposed in calculating z-scores that fall beyond the measurements observed in the sample used for the WHO child growth standards. The modified formula for z-scores beyond -3 and 3 has been integrated into the WHO Anthro software,¹ but it is considered to be too complex for hand calculation. For the application of the standards in public health, it will be sufficient to record that a given point lies beyond -3 and 3 z-scores. Exact estimates will have to be calculated by computer.

¹ WHO Anthro software can be downloaded from www.who.int/childgrowth/software/



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