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Growth (including short stature and tall stature)

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Introduction

Introduction

Failure to grow normally may be:

- due to a 1° growth disorder
- 2° to chronic illness.

Normal growth

Fig. 1.1 shows the earliest known growth chart, that of the son of the Comte Philibert de Montbeillard (1759–1777). Growth data can be shown in terms of either height achieved (Fig. 1.1a) or increase in height over a period of time—the height velocity (Fig. 1.1b).

Physiology

Growth consists of three phases superimposed upon each other, each of which is under different controls, nutritional and hormonal (Fig. 1.2):

Infantile phase

This is predominantly under nutritional control, as children with congenital hormone deficiencies usually have relatively normal birthweights/lengths.

It is both a rapid and rapidly decelerating growth curve, lasting from birth until around 3 years of age, and is a continuation of the intrauterine growth curve. During the first year of life, an infant grows more rapidly than at any other period of their (extrauterine) life, at up to 2.5 cm a month. By 2 years of age, a child is roughly half its adult height, indicating that ~50% of growth has already occurred.

Childhood phase

This is under hormonal control, predominantly growth hormone (GH) and thyroid hormone, although nutritional factors also play a role.

It is a steady and slowly decelerating growth curve which starts at around 2–3 years of age and continues until puberty. By their 8th birthday most children will have achieved around three-quarters of their final height.

Puberty phase

This is under the control of GH and sex hormones acting synergistically.

It lasts from adolescence onwards, and has different timing and strength in the two sexes. It is this phase of growth which accounts for the sex differences in final height of around 14 cm between males and females. While girls enter their growth spurt earlier, the peak height velocity is not as great as that in boys (Fig. 1.3 and ➔ Fig. 1.4, p. 6).

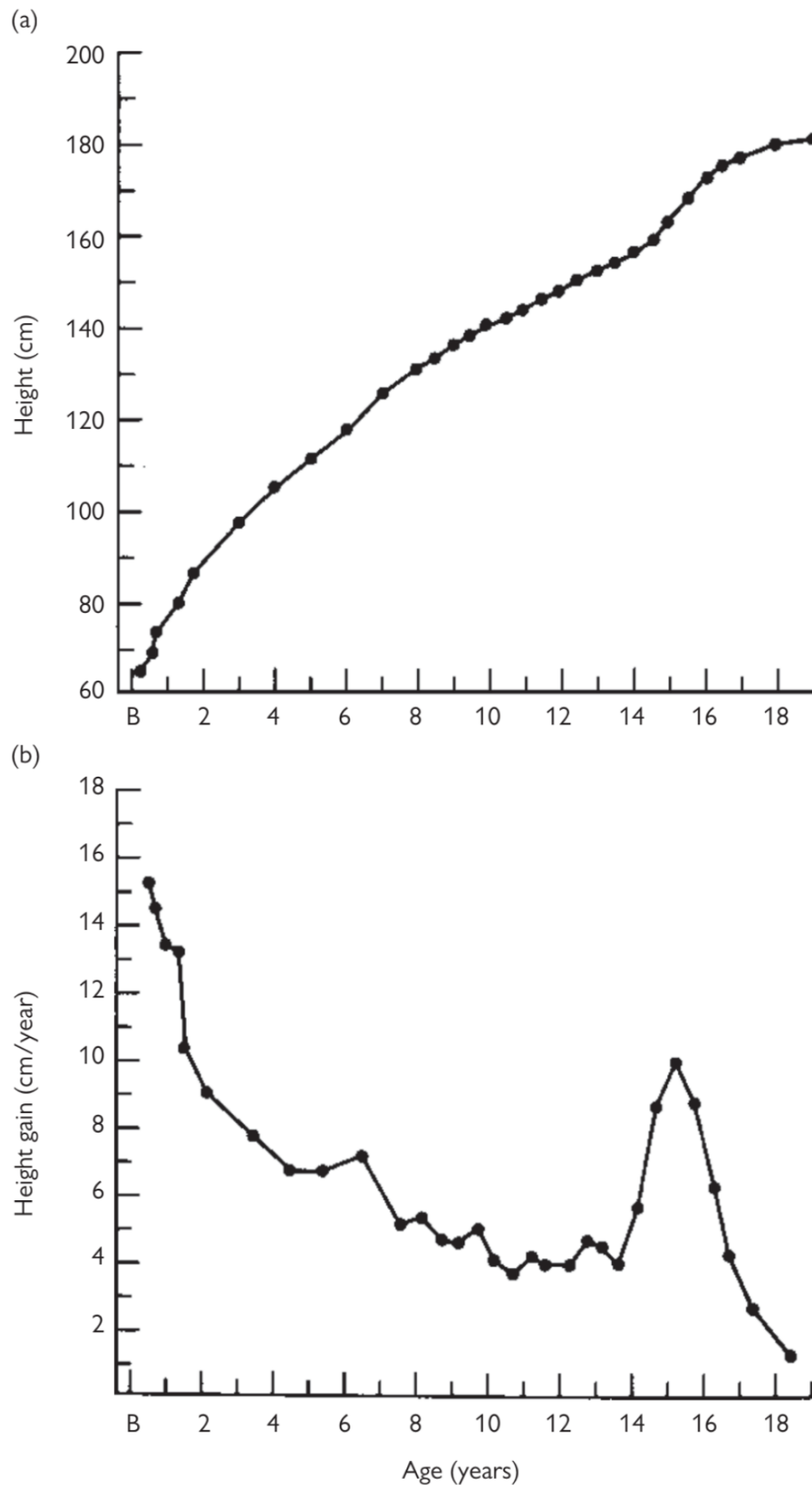


Fig. 1.1 (a) The growth chart for height of a single boy from birth to maturity. (b) The same data as in (a), but expressed as height gain or velocity.

Reproduced with permission from Wass JAH, Shalet SM (eds) (2002). *Oxford Textbook of Endocrinology and Diabetes*, Oxford University Press, Oxford. Copyright © 2002 OUP.

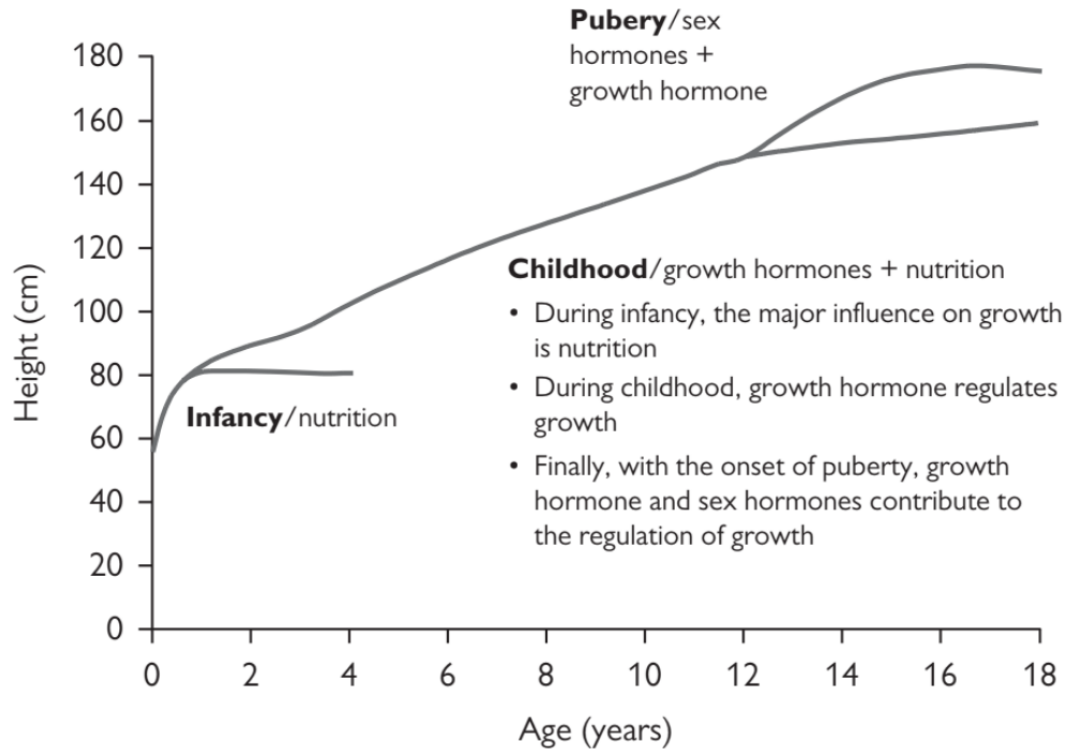


Fig. 1.2 The infancy–childhood–puberty (ICP) model of growth.

Reproduced with permission from Karlberg JA (1989). Biologically-oriented mathematical model (ICP) for human growth. *Acta Paediatr Scand Suppl* (ACTA PAEDIATRICA: NURTURING THE CHILD) 350: 70–94. Copyright © 1989 John Wiley and Sons.

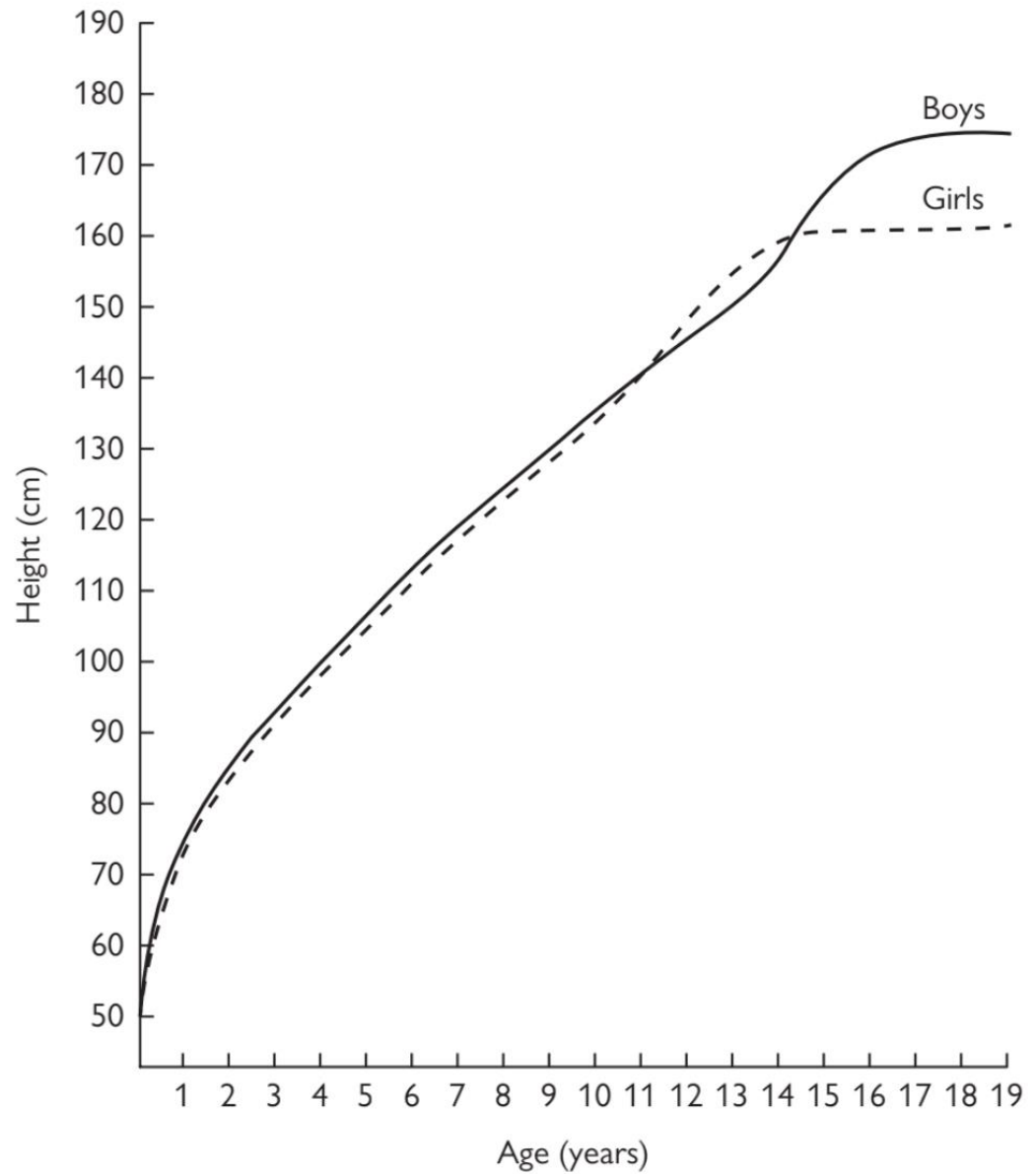


Fig. 1.3 Typical individual height-attained curves for boys and girls (supine length to the age of 2 years; integrated curves of Fig. 1.2).

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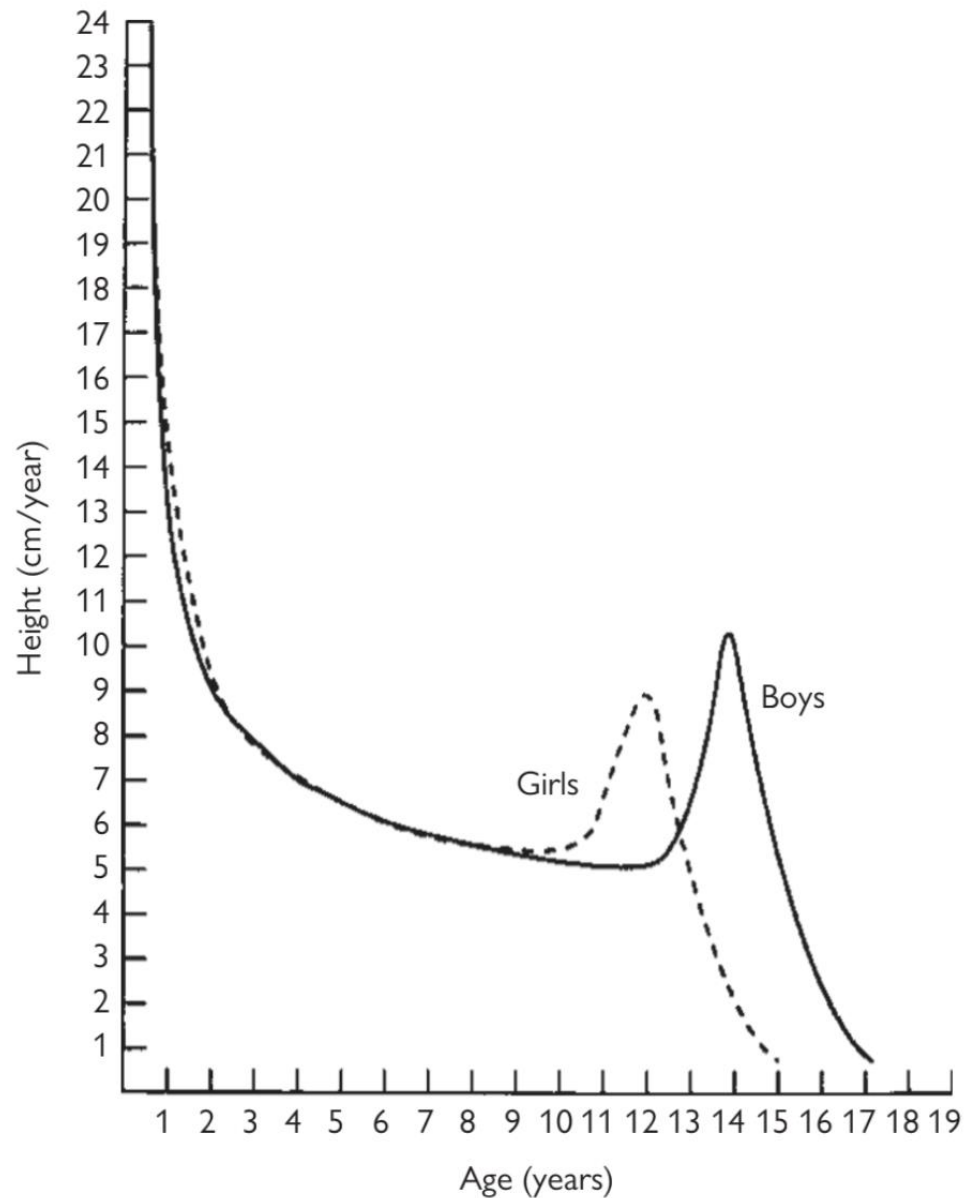


Fig. 1.4 Mean growth velocity curves of British girls and boys whose peak growth spurt is reached at an average age (12 years and 14 years respectively).

Reproduced from Tanner JM, Whitehouse RH, Takaishi M (1966). Standards from birth to maturity for height, weight, height velocity, and weight velocity: British children, 1965. *J. Arch Dis Child* 41: 454–71. Copyright © 1966 BMJ Publishing Group Ltd.

Measurement techniques

- When measuring children ≤ 2 years, all clothes and nappies should be removed.
- In those > 2 years, only minimal clothing should be worn, and shoes must be removed.

Measurers should be appropriately trained, especially in height/length measurements. Measure height/length recorded to the last millimetre.

Standing height

This is performed from 2 years onwards, producing measurements ~ 1 cm less than supine length. Measurement should be performed without shoes and with only thin socks being worn.

Measurement should be made with the feet together, heels on the floor and against the backboard, with the head held in the Frankfurt plane (an imaginary line drawn from the centre of the auditory meatus to the lower border of the eye). Ideally, repeat height measurements should be carried out at the same time of day and by the same measurer.

Supine length

This is performed before 2 years of age or if unable to stand: appropriate equipment is a length board or mat. This measurement requires two people: one to hold the head vertically against the headboard in the Frankfurt plane, and the other to straighten the knees and hold the feet flat against the footboard.

Measuring equipment varies in cost but, if properly set up and maintained, all produce consistent and accurate measurements in trained hands. Height measurements should be accurate to the nearest 1 mm; significantly better than that seen in many biochemical investigations.

Weight

This is performed using class III electronic scales in metric setting, which do not require regular calibration. Children < 2 years of age are usually measured naked, and after that in light clothing only, with nappies and shoes removed. If minimal clothing is used, its estimated weight (about 100 g) should be subtracted before weight is recorded. Scales are usually graduated to 10 g.

Typically an infant doubles their birthweight in the first 4 months of life (gaining 150–190 g per week), and trebles it by 1 year. A child is approximately half the adult weight by 9–11 years.

Body mass index (BMI)

This is a way of assessing weight for height, and calculated by dividing the weight W (in kilograms) by the square of height H (in metres): W/H^2 . It is most easily calculated on a smartphone by entering weight (in kilograms) then dividing twice by height (in metres).

BMI varies throughout childhood:

- rises steeply in infancy
- falls during the preschool years
- rises progressively into adulthood.

An alternative, the ponderal index (cube root of weight/height), is often used in babies.

Head circumference

This is the measurement to the nearest millimetre (using a non-stretchable plastic or paper tape) of the maximum head circumference (from the mid-point of the forehead to the occipital prominence). It is routinely measured up to 2 years of age, but is usually only measured subsequently if there are any clinical concerns.

At birth, head circumference is ~75% of its adult size, and subsequent growth phases are:

1. the first years of life, when most postnatal growth occurs
2. a relative plateau period of growth in mid-childhood
3. a further increase from puberty onwards.

Other measurements

Sitting height

This is not routinely measured, although it is important to assess short stature with disproportion. For example:

- skeletal dysplasias, where limb length is usually reduced
- spinal irradiation in the treatment of malignant disease, where spinal growth is retarded.

Subtraction of sitting height from standing height produces subischial leg length, and these measurements are then plotted onto special charts to assess any discrepancy. Discrepancies between measurements of >2 standard deviations (SD) prepubertally and >2.5 SD during puberty indicate significant disproportion.

Alternatives are:

- standing height vs arm span
- upper and lower segment measurements (taken from the pubis).

Growth charts

NB: website links to various growth charts are listed in ➞ 'Further reading', p. 12.

The original UK growth charts, based on growth data from the 1950s to the 1960s,¹ were updated in the early 1990s and subsequently in 2013 because:

- there was a secular trend towards increased height and earlier maturation
- the data were not representative of the UK as a whole.

Compared with the earlier charts, the secular trend is 1.2 cm in total, with most of this being due to increased leg length.

The normal distribution of organic variables such as height and weight can be shown as either:

- centiles
- SD from the mean.