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Growth curves for preterm infants

Shripada C. Rao [a,b,*], **Jeffrey Tompkins** [a,1]

[a] *King Edward Memorial Hospital for Women, Perth, Western Australia, 6008, Australia*
[b] *Princess Margaret Hospital for Children, Perth, Western Australia, 6008 Australia*

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Abstract

The commonly used growth curves for preterm infants are four decades old and may not be suitable for the current population. Uncertainty exists regarding the most suitable curves for monitoring the growth of preterm infants. While intrauterine growth rate appears to be the ideal growth that needs to be attained by the preterm infants, it may not be feasible given the limitations set by the morbidities of prematurity. Babson and Benda's chart has been updated using recent data from large samples of preterm infants making it useful for monitoring growth of infants in the preterm period. Once a corrected age of 40 weeks is reached, the recently released WHO growth curves can be used to monitor their ongoing growth. While aiming for achieving intrauterine growth velocities in postnatal life, one should not lose sight of the potential short term adverse effects of aggressive nutrition and long term adverse effects of excessive catch up growth.

Contents

* Corresponding author. Department of Neonatology, Princess Margaret Hospital for Children and King Edward Memorial hospital for women, Perth, Western Australia, 6008, Australia. Tel.: +61 8 93408672; fax: +61 8 93408037.
E-mail addresses: Shripada.Rao@health.wa.gov.au (S.C. Rao), Jeffrey.Tompkins@health.wa.gov.au (J. Tompkins).
[1] Tel.: +61 8 93401260; fax: +61 8 93401266.

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1. Growth curves for preterm infants

Growth assessment using growth curves is a useful tool for defining health and nutritional status in children [1]. Growth monitoring helps to improve nutrition, educate the care givers and enables early detection of growth disorders. Proper growth monitoring consists of serial assessments of various physical parameters like weight, length/height, head circumference etc over time [2].

Growth monitoring is especially important in preterm infants because several studies have shown that postnatal growth restriction in very preterm infants is associated with long term adverse neuro-developmental sequelae [3,4]. Diligent growth monitoring using appropriate growth charts and early intervention has the potential to prevent this long term morbidity.

There are two types of growth curves: "growth reference" and "growth standard" [5].

A 'reference' chart simply describes its sample without making any claims about the health of its sample, whereas a 'standard' represents the ideal healthy growth of a population and hence is of prescriptive nature [6]. Growth charts currently in use in infants and children describe existing growth patterns and are therefore references, not prescriptive standards [7]. Both approaches have been tried in the development of growth charts for preterm infants.

Various currently-existing growth charts for monitoring preterm infants are listed below.

1.1. 'Standard' growth charts

1.1.1. 'Intrauterine growth curves' derived from anthropometric data measured at birth on preterm infants delivered at various gestations

Theoretically intrauterine growth appear to be the 'ideal growth' of preterm infants. The American Academy of Pediatrics [8] and Canadian Pediatric society [9] recommend that preterm infants should ideally be growing at intrauterine growth rates till they reach term gestation.

There are at least 25 studies reporting on 'intrauterine growth' by gestational age. These growth curves are based on the measured parameters at birth of preterm infants born at different gestations. These have been best summarized by Karna et al. [10].

Currently most units use the charts developed by Babson and Benda, Lubchenko or Usher [11].These charts were developed in 1960s and hence may not be appropriate in the current situation. Studies have shown conflicting secular trends in birth weights of preterm infants [10,12,13]. A number of studies have reported on the 'intrauterine' growth charts of preterm infants delivered after the year 1990 [10,14–18] and it may be more appropriate to use these.

Fenton [11] conducted a systematic review and meta-analysis to improvise on the data from Babson and Benda. They searched the existing literature on intrauterine and post term growth from three large databases (Pub Med, the Cochrane library, and EMBASE) from 1980 to 2002. Using preset criteria, three recent large population based surveys of birth weight for gestational age were identified. These studies utilised statistical methods to delete implausible birth weight–gestational age combinations. The Canadian study by Kramer et al. [16] with a sample size of 676,605 infants delivered between 22 to 43 weeks was used for updating the intrauterine weight section. Two large population based studies from Sweden [19] and Australia [20] were used to update the intrauterine head circumference and length section. The data were averaged together using a weighted average based on total sample size to derive the 3rd, 10th, 50th, 95th and 97th percentiles and create one growth chart. CDC 2000 growth charts were used to generate the growth curves from corrected gestation of 40 weeks onwards. To produce a working chart, the disjunctions between the pre and post term sections were merged and smoothed. In spite of various limitations of such a meta-analysis as admitted by the authors themselves, this chart appears to be useful in monitoring the growth of preterm infants during their NICU stay till they reach corrected gestation of 40 weeks (Fig. 1) .

1.1.2. 'Fetal growth curves' based on ultrasonographic measurement of fetal anthropometry at various gestations

The so called 'intrauterine' growth charts mentioned above in reality are based on measurement of growth parameters at birth from infants who are born prematurely at various gestations. Infants born prematurely are usually smaller than the fetuses of corresponding gestational age that later deliver at term [21–23]. Hence, more ideal 'intrauterine growth charts' would be derived from serial and longitudinal assessment of physical parameters of weight, length and head circumference using fetal ultrasound technique [24]. The drawback of this method is that fetal ultrasound is not very reliable and accurate in predicting the fetal weight. Ben-Haroush et al. [25] evaluated the accuracy of sonographically estimated fetal weight (EFW) in 840 women with different pregnancy complications prior to induction of labour. They concluded that sonographic EFW is correlated with birth weight, but the accuracy decreased with lower gestational age, higher birth weight, anterior placenta, higher gravidity, and younger maternal age.

Chauhan et al. [26] found that for a given EFW, for example, 800 g, the 90% ranges of actual weight based on

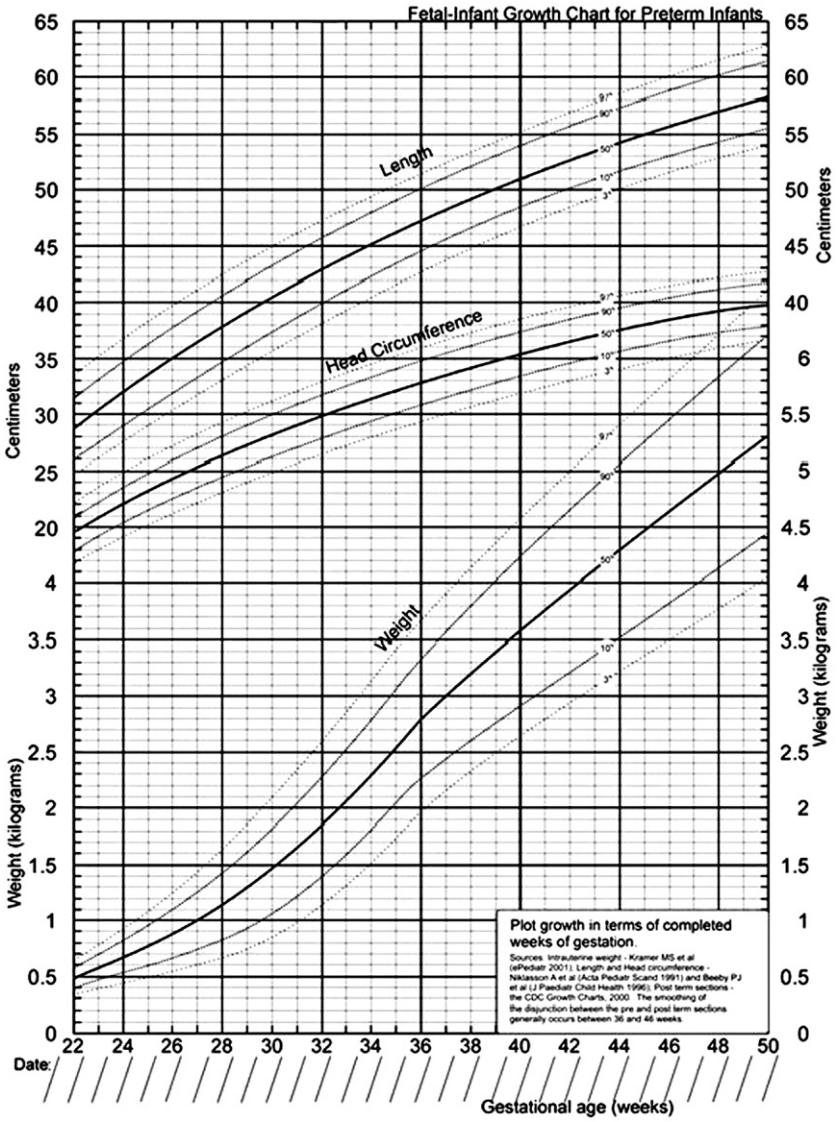

Figure 1 Suggested graph for monitoring growth of preterm infants till they reach corrected gestation of 40 weeks (reproduced with permission from Fenton 2003: http://www.biomedcentral.com/1471-2431/3/13/figure/F2).

sonographic EFW was 469–1667 g and concluded that both clinical and ultrasound methods have limited value in the estimation of actual birth weight.

Colman et al. [27] reported that, for one in four women, the fetal weight estimation using ultrasound was more than 10% different from the actual birth weight of the infant.

In view of these limitations, obstetricians often rely on additional parameters like Doppler flow in umbilical artery, in assessing the growth and wellbeing of the fetuses.

Hence fetal weight curves derived from currently available ultrasound technology may not be appropriate for use as ideal postnatal growth of preterm infants.

1.1.3. Customised intrauterine growth curves

Currently available intrauterine/fetal growth curves do not address the issue of variations in intrauterine growth because of ethnicity. Studies have suggested that the intrauterine growth of the fetuses differ depending on the ethnicity of mother and hence recommend the use of customised growth charts for different ethnicities [28–30].

One major development in this field has been the use software derived customised intrauterine growth charts [31–33].

Freely downloadable software "GROW" is available on the website www.gestation.net. Once maternal details like weight, height, parity, and major ethnicity are entered, it produces an 'ideal fetal growth curve' for that fetus. These have been evaluated and found useful in some centres in UK and New Zealand [34,35] and have been implemented in nearly 50 maternity units in the UK [36]. This method is recommended by the Royal College of Obstetricians in UK for the diagnosis of the small for gestational age fetus [37].

But ethnic variations may be related to factors like maternal nutrition, health and adequacy of perinatal health care. Further research is needed to confirm if true differences exist because of ethnicity. If such a difference exists,

then these customised intrauterine growth charts should be used as ideal growth for postnatal period in preterm infants.

1.1.4. A note of caution regarding the use of intrauterine growth charts as ideal growth in postnatal life

The intrauterine growth charts appear idealistic goals to achieve. But one needs to decide if it is really feasible and safe to attain those parameters. Any attempts to promote physical growth by aggressive enteral and parenteral nutrition may potentially harm the sick preterm infant. Rapid increases in enteral feeding are known risk factor for necrotizing enterocolitis [38]. In ELBW infants, higher fluid intake and less weight loss during the first 10 days of life are associated with an increased risk of BPD [39]. In addition there are concerns about the long term effects of excessive catch up growth in early neonatal period for preterm infants less than 32 weeks gestation as well as full term small for gestational age infants. Finken et al. [40] and Euser et al. [41] studied the effects of lower birth weight and infancy weight gain on insulin resistance at 19-year of age in preterm infants born before 32 weeks of gestation. This was a prospective follow-up study in 346 subjects from the Project on Preterm and Small-for-gestational-age infants' cohort, in whom fasting glucose, insulin and C-peptide levels were measured at 19 years. They concluded that in subjects born very preterm, rapid infancy weight gain until 3 months predicted higher insulin levels at 19 years, but the association was weak. They also concluded that rapid weight gain in both infancy and early childhood is a risk factor for adult adiposity and obesity. Similar concerns of relative over nutrition and excessive catch up growth on long term adverse cardiovascular effects and increased insulin resistance and obesity have been raised by other investigators in the field [42,43].

1.2. 'Reference' growth charts

1.2.1. Postnatal growth reference charts of preterm infants

Many reference charts that describe the actual longitudinal growth of preterm infants during the course of their stay in the NICU have been published [44–53]. If these reference charts are used to monitor the ongoing growth of preterm infants, then extrauterine growth retardation would be considered as normal. Hence they are not ideal for monitoring the growth of preterm infants. However, these charts do give an idea of what can be achieved with the available resources and limits set by the morbidities of prematurity. They can be used compare the growth of preterm infants between individual units. As with intrauterine charts, it is preferable to use the growth curves developed based on growth of preterm infants born after 1990.

1.3. Growth charts from corrected age of 40 weeks into early childhood

USA, Canada and some centres in Australia use growth charts released by Centre for Disease Control (CDC) in the year 2000 for monitoring the growth of term infants and children [54].

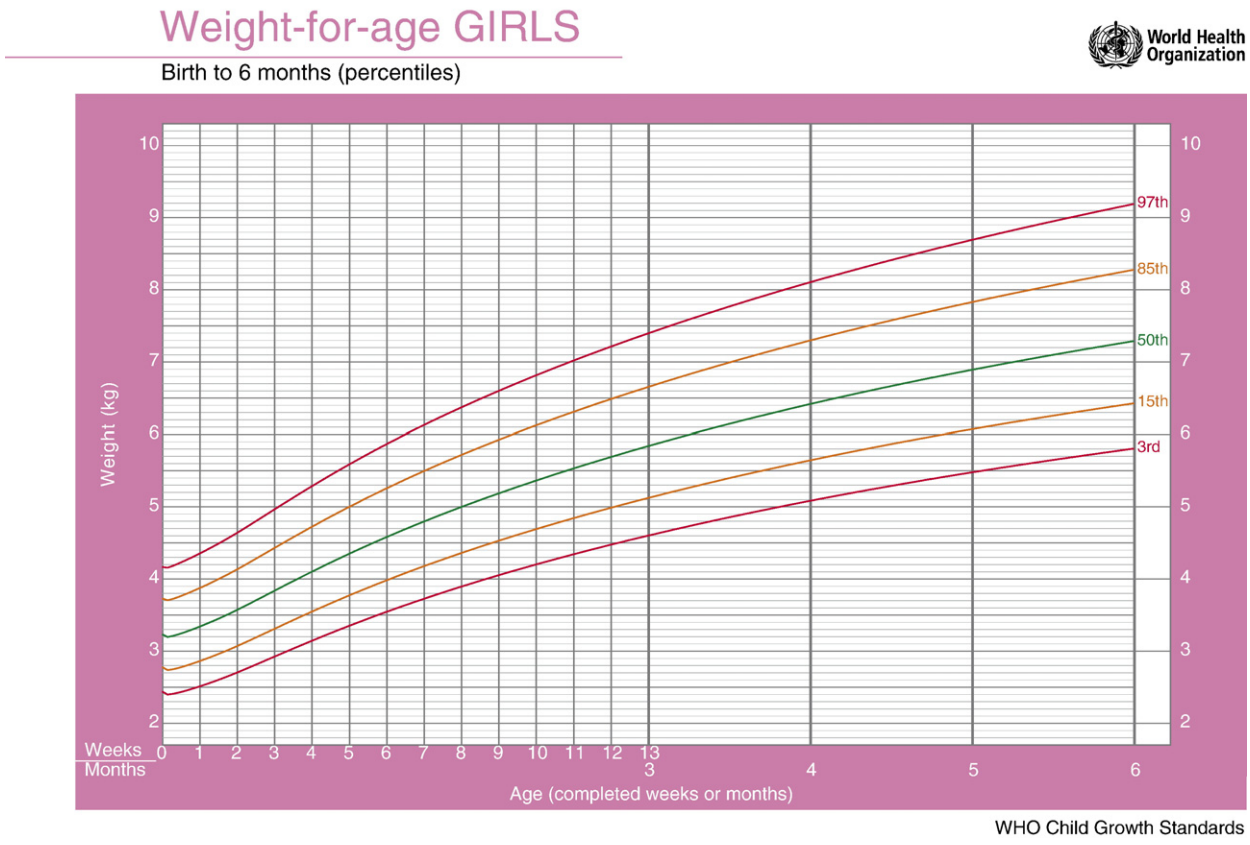

Figure 2 Suggested chart for monitoring weight in preterm female infants after reaching term postnatally (reproduced with permission from de Onis 2006, the WHO Multicentre Growth Reference Study).

In UK the RCPCH has recommended the use of new UK90 charts for monitoring growth of term infants [7]. Likewise, most of the countries use their own population based growth charts to assess the growth of their infants and children. The same charts are usually used for ongoing growth monitoring of preterm infants after reaching a corrected gestational age of 40 weeks.

The inherent problem with all these charts is that they represent the actual existing growth patterns instead of recommended standards. Because of various environmental and lifestyle influences, the incidence of overweight in infants and children has increased markedly over the past 30 years. Hence any new reference charts describing this population of overweight children would accept these abnormally high weights for age as normal.

To resolve this problem inherent with 'reference' charts, WHO has recently released new 'Standard' growth charts for term infants and children [55,56]. Primary growth data and related information were gathered from 8440 healthy breastfed infants and young children from widely diverse ethnic backgrounds and cultural settings in different countries. The mothers of the study population involved were from socioeconomically affluent societies in all the countries. The infants were breastfed exclusively for four months. Subsequent nutrition was in accordance with WHO recommendations. The study population was also free of any major morbidity which could hinder growth. The mothers were also in optimal health and practiced healthy lifestyles. All these factors ensured the attainment of full growth potential by these children.

WHO has recommended these new charts to be used worldwide as standard "prescribed" charts for assessing the growth of full term infants. These charts are recommendations for how children should grow. Deviations from the pattern it describes would be considered as evidence of abnormal growth. Australia, Canada, USA and UK and Czekaslovakia [57] have already set up committees to look into the feasibility of using these charts. It is expected that they will be used all over the world.

These curves appear suitable to monitor the ongoing growth of preterm infants once they reach a corrected gestational age of 40 weeks Figs. 2–5.

2. Summary and conclusions

There is lot of uncertainty regarding the ideal growth curves for preterm infants. Due to improvements in management of sick preterm infants, the growth of these infants in 1990 and 2000s is different from those of previous years. Hence it is preferable to use the growth curves developed based on preterm infants born after 1990. Intrauterine growth curves represent ideal growth, but may not be feasible given the limitations imposed by the immature gut and other morbidities of prematurity. Postnatal growth curves represent the reference values rather than the ideal growth curves. The aim when caring for preterm infants is to at least match the

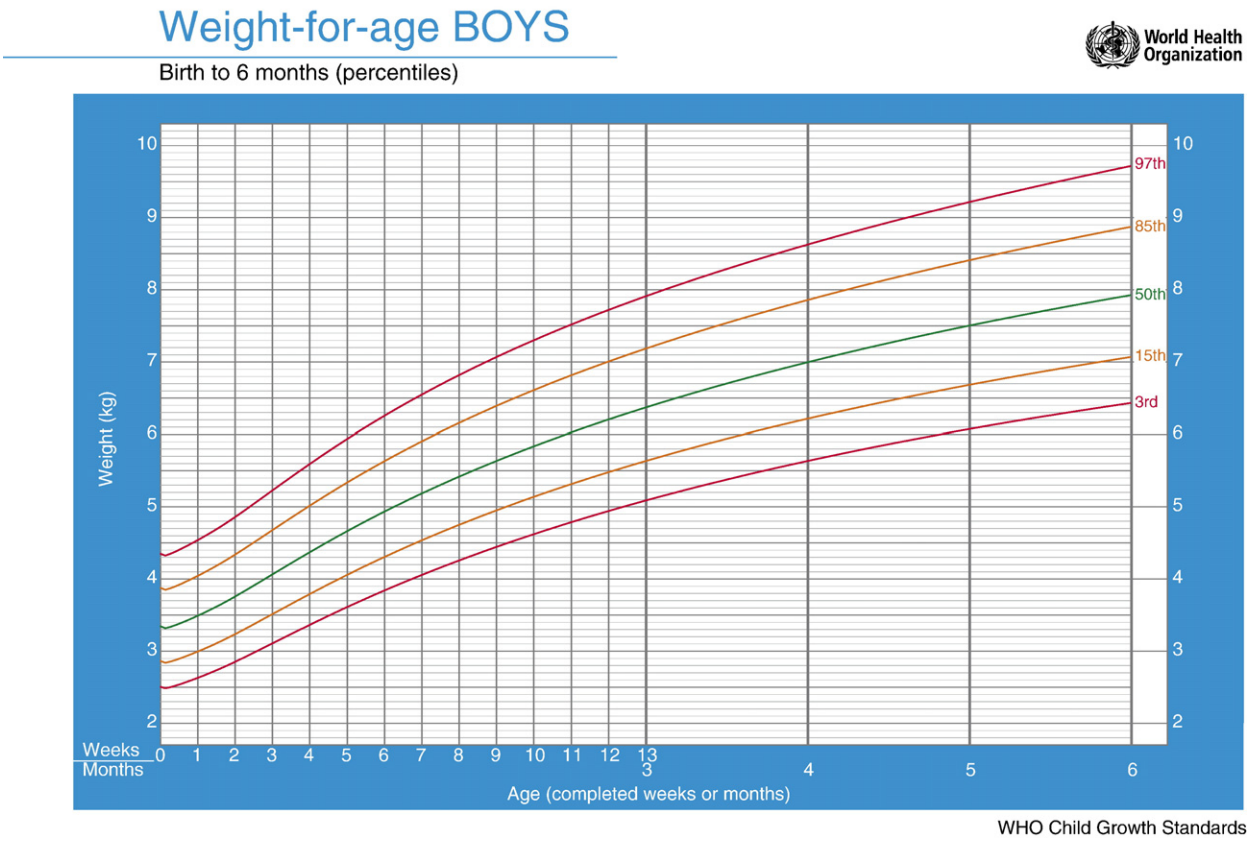

Figure 3 Suggested chart for monitoring weight in preterm male infants after reaching term postnatally (reproduced with permission from de Onis 2006, the WHO Multicentre Growth Reference Study).

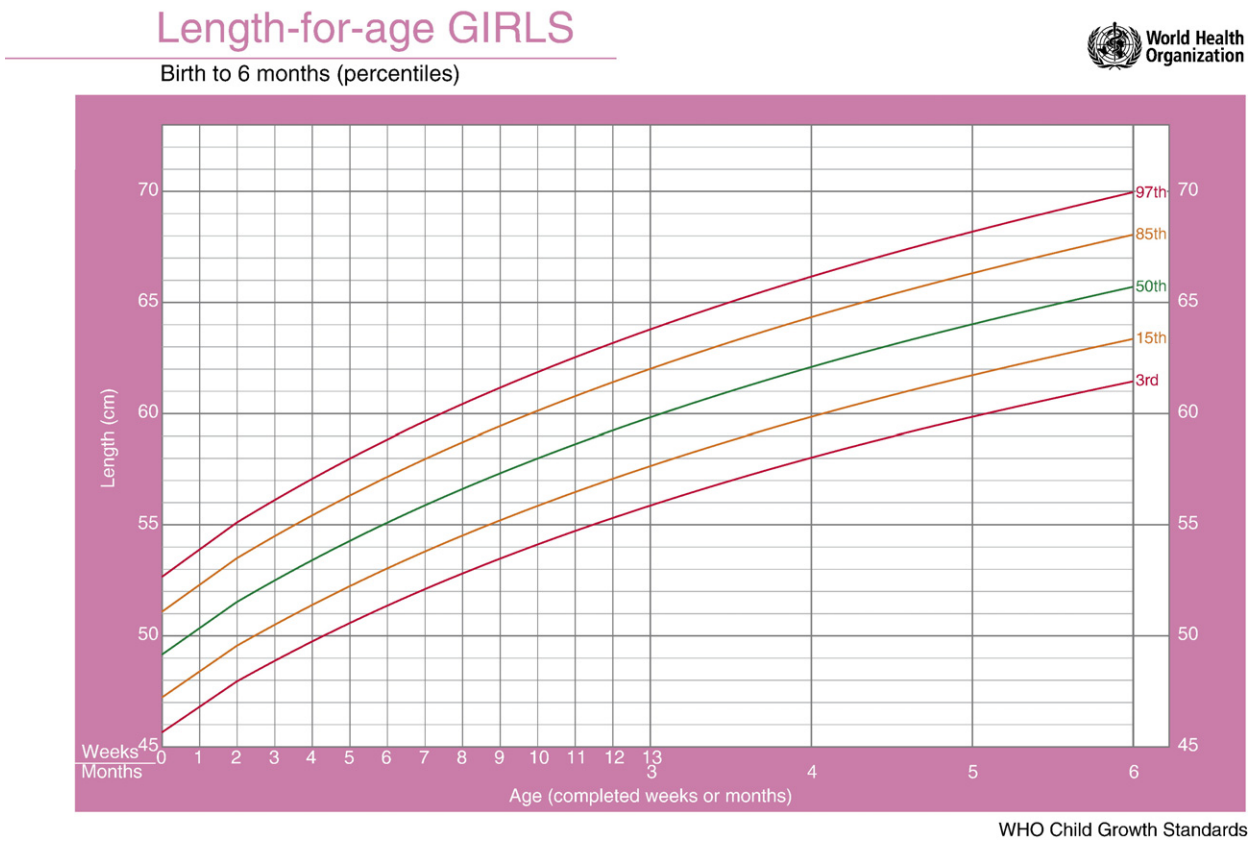

Figure 4 Suggested chart for monitoring length in preterm female infants after reaching term postnatally (reproduced with permission from de Onis 2006, the WHO Multicentre Growth Reference Study).

growth velocity of published best postnatal growth curves and strive towards reaching ideal growth velocities of intrauterine growth curves. Babson and Benda's chart which has been updated with data from very large sample size of preterm infants born in the last two decades appears to be reasonably suitable for monitoring growth of preterm infants. Once a corrected age of 40 weeks is reached, the recently released WHO growth curves can be used to monitor their ongoing growth. A promising area is the development of customised intrauterine growth charts which have the potential to be used as ideal prescriptive postnatal growth for preterm infants of different ethnicity. While aiming for achieving intrauterine growth velocities in postnatal life, one should not lose sight of the potential short term adverse effects of aggressive nutrition and long term adverse effects of excessive catch up growth.

3. Key guidelines

1. Updated Babson and Benda's charts have incorporated the growth parameters from three recent large population samples and appear suitable for monitoring growth of preterm infants until they reach term gestation.
2. Once the preterm infants reach term gestation, the recently released WHO growth curves appear appropriate to monitor their ongoing growth.
3. While aiming to achieve intrauterine growth rate in postnatal life, one should not lose sight of the adverse effects of overly aggressive nutrition and catch up growth.

4. Research directions

4.1. In the short term

1. A meta-analysis of all the published intrauterine growth curves from preterm infants born from the year 1990 onwards using appropriate statistical methods to provide a pooled estimate of the intrauterine growth and hence the ideal prescriptive postnatal growth.
2. Meta-analysis of all the published postnatal growth curves of preterm infants from 1990 onwards using appropriate statistical methods to arrive at the 'actually feasible' growth and the minimum standard required to be achieved.

4.2. In the long term

Further research is needed to establish if true differences in intrauterine growth exist because of ethnicity. In order to establish this, ideal intrauterine growth curves need to be established from different ethnic population in different countries. They should be based on infants born prematurely at various gestations to well nourished mothers in stable

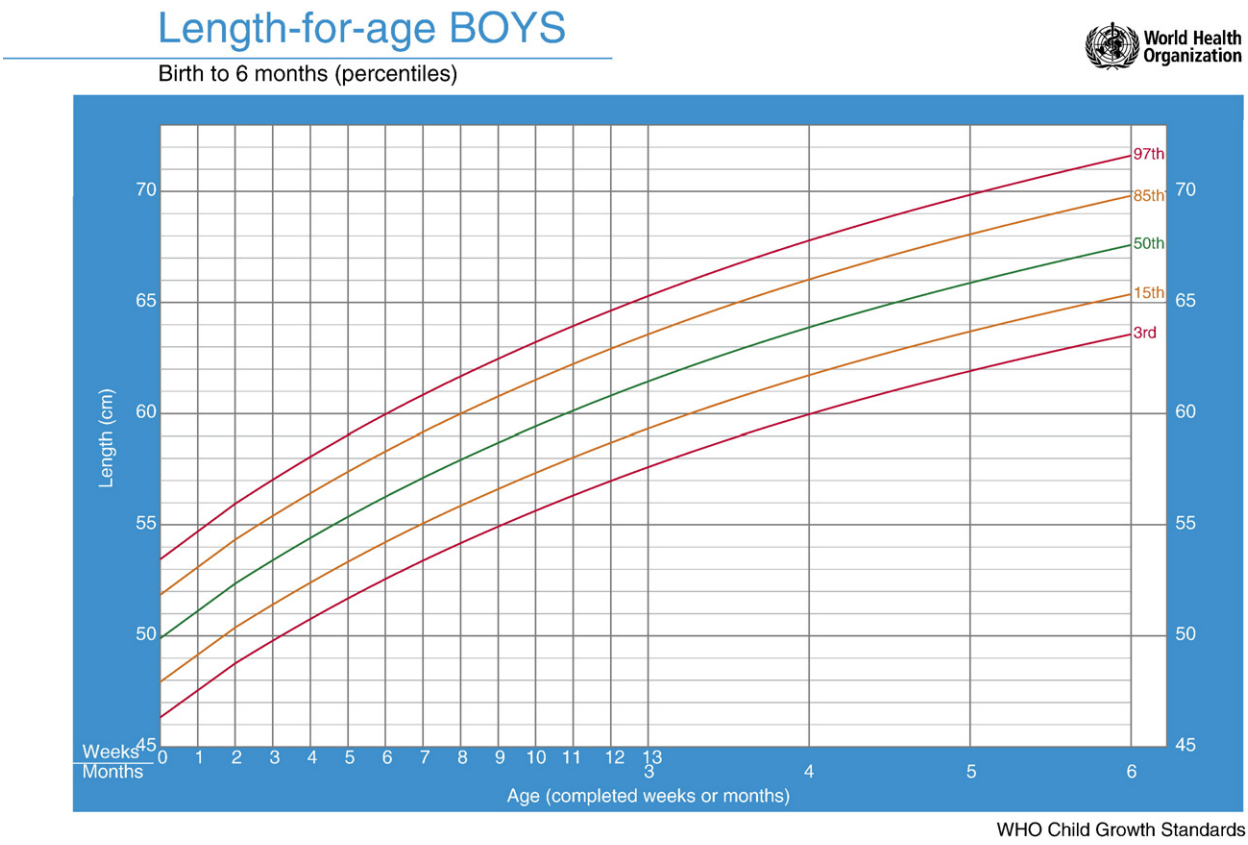

Figure 5 Suggested chart for monitoring length in preterm male infants after reaching term postnatally (reproduced with permission from de Onis 2006, the WHO Multicentre Growth Reference Study).

socioeconomic conditions and practising healthy lifestyles, with no antenatal risk factors and without preexisting illnesses. If no differences exist because of ethnicity, then a universal ideal intrauterine growth curve could be established. If differences are noted because of ethnicity, the data could be used to derive appropriate coefficients and incorporated into the 'GROW' or similar software to derive the ideal intrauterine growth curves for each ethnic group. Once derived, they could be used as standard and desirable growth of preterm infants in their postnatal life till they reach corrected age of 40 weeks.

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