Dietitians of Canada
Les diététistes du Canada

PROMOTING OPTIMAL MONITORING OF CHILD GROWTH IN CANADA

Using the New WHO Growth Charts

COLLABORATIVE PUBLIC POLICY STATEMENT

ABSTRACT

Growth monitoring and promotion of optimal growth are essential components of primary health care for infants and children. Serial measurements of weight, height/length for all children, and head circumference for infants and toddlers, compared with the growth of a large sample population of children depicted on a selected growth chart help to confirm a child's healthy growth and development. It also allows early identification of potential nutritional or health problems and enables prompt action before a child's health is seriously compromised. To date, growth charts have described the growth of their sample population regardless of whether that growth is ideal or not. The release of new, improved growth charts from the World Health Organization (WHO) has prompted a re-examination of existing recommendations for assessing the growth of Canadian children. The optimal growth displayed in the WHO Growth Standards for infants and preschool children represents the prescribed gold standard for children's growth. The newly constructed growth charts for older children have also been updated and improved to reflect optimal growth. The 2006 WHO Child Growth Standards for children (birth to five years) and the WHO Growth Reference 2007 (for children and adolescents (5 -19 years) are now recommended for the assessment of growth of Canadian children based on this review by Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada and Community Health Nurses of Canada. This statement presents recommendations and the rationale for implementation of both sets of the WHO growth charts for monitoring the growth of individual children. It is intended for use as a practice guideline to assist medical practitioners and allied health professionals to provide evidence-informed, consistent care.

RÉSUMÉ

La surveillance de la croissance et la promotion d'une croissance optimale constituent des éléments essentiels des soins de santé primaires pour les nourrissons et les enfants. La comparaison des mesures sérielles de poids et de taille/longueur chez tous les enfants et du perimeter de la tête chez tous les nourrissons et tout-petits à une courbe de croissance choisie qui illustre la croissance d'un important groupe échantillon composé d'enfants peut aider à confirmer la croissance et le développement sains d'un enfant. Une telle comparaison permet également de dépister de manière précoce des problèmes de santé ou des problèmes nutritionnels potentiels et de réagir rapidement, avant que la santé d'un enfant ne soit gravement compromise. Jusqu'à présent, les courbes de croissance décrivaient la croissance de leur groupe échantillon, peu importe s'il s'agissait d'un profil de croissance idéal ou non. Or, la publication de nouvelles courbes de croissance améliorées par l'Organisation mondiale de la Santé (OMS) a entraîné une révision des recommandations existantes pour l'évaluation de la croissance des enfants canadiens. En effet, la croissance optimale présentée dans les normes OMS de croissance pour les nourrissons et pour les enfants d'âge préscolaire constitue la norme or en matière de croissance des enfants. Par ailleurs, les courbes de croissance pour les enfants plus âgés, qui avaient été conçues récemment, ont également été mises à jour et améliorées afin de refléter la croissance optimale. Les diététistes du Canada, la Société canadienne de pédiatrie, le Collège des médecins de famille du Canada et les Infirmières et infirmiers en santé communautaire du Canada ont procédé à une revue de la littérature, et les normes OMS de croissance de l'enfant 2006 pour les enfants (de la naissance et à 5 ans) et les références OMS de croissance 2007 (pour les enfants et adolescents de 5 à 19 ans) sont maintenant recommandées pour évaluer la croissance des enfants canadiens. La présente déclaration décrit les recommandations et l'argumentaire relatifs à l'implantation des deux types de courbes de croissance OMS pour surveiller la croissance des enfants sur une base individuelle. Cette déclaration devrait être utilisée à titre de ligne directrice de pratique dans le but d'aider les médecins praticiens et le personnel paramédical à fournir des soins cohérents et fondés sur des données probantes.

ISSUES STATEMENT

Growth monitoring is the single most useful tool for defining health and nutritional status in children at both the individual and population level. This is because disturbances in health and nutrition, regardless of their aetiology, almost always affect growth.[1] When disturbances in growth are caught early, small changes in behaviour that are within the means of many families, are likely to be effective in reversing the trend. However, abnormal patterns of weight gain and growth often go unrecognized and undiagnosed for several reasons, namely:

- Some infants and children are not routinely weighed and measured at their regular health care visits, while others see a health professional only for acute care and may not be measured at all.
- Measurements taken incorrectly, plotted on a growth chart inaccurately, or not plotted at all, may lead to erroneous interpretation of growth patterns and missed or unnecessary referrals.
- More recent growth charts have reflected the increasing prevalence of unhealthy weights, raising the growth curves, leading to under-identification of overweight individuals and over-identification of individuals with failure-to-thrive.
- Furthermore, regular assessment of growth is not effective in improving child health unless what is revealed by the growth monitoring is discussed with the family, and information about adequate or inadequate changes in growth is used to reinforce or motivate positive nutritional and healthy lifestyle practices.[2]

Canada does not have a national paediatric surveillance system for collecting anthropometric and nutritional data; therefore, national growth charts do not exist for Canadian children. Growth references have been developed from small populations of Canadian children that were not nationally representative.[3-7] Over the last three decades there has been substantial discussion on which reference population to use in assessing adequacy of childhood growth. In 2004, Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada and Community Health Nurses of Canada published recommendations[8] for use of the 2000 American growth charts from the Centers for Disease Control and Prevention.[9] At the time, there was evidence that growth patterns of well-fed healthy preschool children from diverse ethnic backgrounds were comparable[10,11,12] thus supporting the use of a single international growth reference based on healthy, well-nourished children from different geographic and genetic origins who had fully met their growth potential.[1,13] However, until recently, no such international growth charts existed.

In 2006, the World Health Organization (WHO), in conjunction with the United Nations Children's Fund and others, released new international growth charts depicting the growth of children from birth to age five years, who had been raised in six different countries (Brazil, Ghana, India, Norway, Oman, USA) according to recommended nutritional and health practices, including exclusive breastfeeding for the first four to six months of life.[a] In 2007, the WHO also released charts for monitoring the growth of older children and adolescents that had been updated and improved to take into account the growing epidemic of childhood obesity. Availability of these new charts from the WHO has again raised the question of which are the most desirable growth charts to use for Canadian children. This statement focuses on growth monitoring and the use of growth charts for individual assessment of growth.

[a] The WHO Growth Study was initiated in 1997, before WHO's policy on the optimal duration of exclusive breastfeeding was changed in 2001 from "4 to 6" months to 6 months.

DEFINITIONS

Corrected age: for preterm infants (<37 weeks gestation), the age of the infant from birth minus the number of weeks premature.

Growth monitoring: the serial weighing and measuring of the length/height (and head circumference if ≤ 2 years old) of a child and graphing both measurements on a growth chart.[2]

Growth reference: simply describes the growth pattern of a defined population, without making any claims about health status. In simple terms, a reference describes "what is".

Growth standard: defines a recommended pattern of growth that has been associated empirically with specified health outcomes and minimization of long-term risks of disease. It represents 'healthy' growth of a population and suggests a model or target pattern of growth for all children to achieve. In simple terms, a standard describes "what should be".

Growth velocity: the average change in a specific anthropometric measure over a specific time period, ideally 1 year and no shorter than six months (e.g. increase in cm of height per month over the previous year). Growth velocity charts are created from incremental data acquired from longitudinal measurements. They are more sensitive indicators of small changes in growth status than regular (size-attained) charts, and more helpful when assessing changes in growth rates that are important in selected growth disorders and therapies.[14]

Malnutrition: deficiencies, excesses or imbalances in intake of energy, protein and/or other nutrients. Contrary to common usage, the term *malnutrition* correctly includes both undernutrition and overnutrition.

Nutrition negotiation: the process of decision-making between a health professional and a parent(s) or other care provider, regarding the actions the parent/care provider will take to correct their child's abnormal pattern of growth.[2]

Growth surveillance: monitoring the growth status of a population. Usually measurements of height and weight are taken periodically on a representative sample of children to monitor trends in their growth status over time.[2]

Nutritional status: the condition or state of the body in relation to the matters influenced by the diet; the levels of nutrients in the body and the ability of those levels to maintain normal metabolic integrity, including growth in children.

Overnutrition: a chronic condition where intake of food is in excess of dietary energy requirements, resulting in overweight or obesity.

Promotion of optimal growth: the process of weighing and measuring the length/weight (and head circumference if ≤ 2 years old), assessing growth, and providing counselling and motivation for actions to improve abnormal patterns of growth.[2]

Undernutrition: The result of food intake that is continuously insufficient to meet dietary energy requirements, poor absorption and/or poor biological use of nutrients consumed.

z-scores: Also known as standard deviation (SD) scores, z-scores are a dimensionless quantity used to describe how far a measurement is from the mean (average) or median. Percentiles are commonly used in the clinical or community setting because they indicate simply and clearly a child's position within the context of the reference population. Use of z-scores is almost universal for population-based applications and research reporting. For comparison purposes, the 50th percentile is equal to a z-score of 0, the 15th and 85th percentiles *approximate* z-scores of -1 and +1 respectively, the 3rd and 97th percentiles *approximate* z-scores of -2 and +2 respectively, and the 1st and 99th percentiles *approximate* z-scores of -3 and +3, respectively.

z-score	*Exact Percentile*	*Rounded Percentile*		*z-score*	*Exact Percentile*	*Rounded Percentile*
0	50th	50th				
-1	15.9	15th		+1	84.1	85th
-2	2.3	3rd		+2	97.7	97th
-3	0.1	1st		+3	99.9	99th

INTRODUCTION

Optimal growth depends on genetic constitution, normal endocrine function, adequate nutrition, a nurturing environment, and an absence of chronic disease. Fetal, infant, maternal, and environmental factors can interact to impair intrauterine and postnatal growth.[15] Genetic differences in birth-weight among various populations are small and, although there are some racial/ethnic differences in growth, these differences are now known to be relatively minor, compared to worldwide variations in growth which are due to health and environmental influences (e.g. poor nutrition, infectious disease, socio-economic status).[10,11,12]

Growth Monitoring

The main objectives of growth monitoring and promotion of optimal growth are to[16,17]:

- provide a tool for nutrition and health evaluation of individual children
- initiate effective action in response to abnormal patterns of growth
- teach parents how nutrition, physical activity, genetics and illness can affect growth and, in doing so, motivate and facilitate individual initiative and improved child-care practices
- provide regular contact with primary health care services and facilitate their utilization.

There are five main activities linked to growth monitoring and promotion at the individual level:[16]

1. accurately measuring weight, length or height, and head circumference
2. precisely plotting measurements on the appropriate, validated growth chart
3. correctly interpreting the child's pattern of growth
4. discussing the child's growth pattern with the parent(s)/caregiver and agreeing on subsequent action when required
5. on-going monitoring and follow-up, when required, to evaluate the response to the recommended action to improve the child's growth.

Importance of Accurate Measurements and Plotting

Accurate, reliable measurements are fundamental to growth monitoring and to making sound clinical judgments on the appropriateness of a child's pattern of growth. A number of studies have illustrated a disturbing frequency of inaccurate growth measurements in a variety of health care settings.[18,19,20,21] Accurate measurements have three components:

- a standardized measurement technique
- quality equipment which is regularly calibrated and accurate and
- trained measurers who are reliable and precise in their technique.[22,23]

Reliable growth data does not require expensive equipment, just careful technique and accurate charting. Information on the appropriate equipment and techniques for accurate weighing and measuring is readily available.[24,25] A child's measurements should be consistently and accurately recorded in an age and gender-appropriate growth record, carefully plotted and then analyzed to identify any disturbances in the pattern of growth. Failure to plot measurements and/or document growth abnormalities also contribute to missed opportunities to identify and address nutrition or illness-related growth problems.[18,26]

Growth Charts

Growth charts are graphic presentations of body measurements of a population that aid in the assessment of body size and shape, as well as the observation of patterns in growth performance. They are used in the assessment and monitoring of individual children and in screening whole populations.[27] They serve as one component in a holistic approach to growth assessment and management. They are not a diagnostic tool and they should always be used in conjunction with other information when evaluating a child's general health. The ideal growth chart would be based on data collected longitudinally and should be representative of

children whose feeding and care comply reasonably with recommended health practices so that the growth illustrated represents the best standard possible for all children.

Because no geographically diverse growth chart existed, in 1978 the World Health Organization (WHO) adopted for international use[28] the growth charts from the American National Centre for Health Statistics (NCHS).[29] These charts had been developed from data of American children (ages 2 to 18 years) collected in five nationally representative surveys between 1963-1974. Charts for infants and toddlers (birth to 36 months) were based on data collected in a single regional study of predominantly white infants from middle to upper socioeconomic class, who were primarily formula-fed. In May 2000, these NCHS charts were replaced with 16 more current and improved American growth charts from the Centers for Disease Control and Prevention (CDC).[30] The CDC revised growth charts included more current and nationally representative data for infants. They also incorporated secular changes in growth, utilized improved statistical methods for smoothing growth curves, and added BMI-for-age curves for children older than two years to evaluate weight as a function of height. This latter feature was not included on previous growth charts for older children and adolescents.

In 2004, the CDC growth charts[30] were recommended nationally for use in monitoring the growth of Canadian children.[8] At that time, limitations of the charts were noted and an acknowledgement was made of the need to reassess growth chart recommendations as more appropriate data became available.[8]

LITERATURE REVIEW AND DISCUSSION

International Growth Charts from the World Health Organization (WHO)

WHO Child Growth Standards: Birth to five years

In April 2006, new by the WHO.[31,32] They were the product of the Multicentre Growth Reference Study (MGRS - subsequently to be referred to as the WHO Growth Study), initiated by the WHO to generate new growth curves for assessing the growth and development of infants and young children around the world.[33] The community-based, multi-country project ran from 1997-2003 and involved 8,440 affluent children from widely different ethnic backgrounds and cultural settings (i.e. single cities in Brazil, Ghana, India, Norway, Oman, and the USA). Study sites were chosen to ensure children lived in socioeconomic and environmental conditions favourable to growth, were geographically stable and had ≥20% of mothers practising breastfeeding (Table 1).

An important finding from the WHO Growth Study was that, in spite of differences in racial and ethnic background, there were minimal differences in the rates of linear growth observed among the six countries. After adjusting for age and sex, the variability in the measured length of participants from birth to 24 months was overwhelmingly due to differences among individuals (70% of the total variance) and only minimally to differences among countries (3% of the total variance).[36] This strengthens the evidence that children of all ethnic backgrounds have similar potential for growth when raised in environmental conditions favourable to growth, particularly smoke-free households, and have access to good nutrition.

Table 1: Study design and individual eligibility and exclusion criteria for the sample population in the WHO Growth Study used to construct the WHO Child Growth Standards[32,34]

	Birth to24 Months	*18 to 71 Months*
Study Design	longitudinal; 21 measurements: at birth; weeks 1,2,4,6; monthly from 2-12 months; bimonthly in 2nd year of life	cross-sectional; except in Brazil and USA where a mixed-longitudinal design was used in which some children were measured 2-3 times at 3-month intervals in the 2nd year of life
Sample Size	882[b]	6,669[b]
Eligibility	▪ gestational age ≥ 37 wk and < 42 wk ▪ singleton birth ▪ absence of significant morbidity in the newborn ▪ optimal health care including immunizations and good routine paediatric care ▪ non-smoking mother ▪ exclusive or predominant breastfeeding for at least four months[c] and partial breastfeeding continued to at least 12 months for infants in the longitudinal (birth to 24 month) group ▪ minimum duration of three months of any breastfeeding for children in the cross-sectional (18-71 month) group ▪ introduction of complementary foods between 4 and 6 months[c]	
Exclusion	▪ preterm infants ▪ very low birth-weight infants (<1,500 g)	

An important finding from the WHO Growth Study was that, in spite of differences in racial and ethnic background, there were minimal differences in the rates of linear growth observed among the six countries. After adjusting for age and sex, the variability in the measured length of participants from birth to 24 months was overwhelmingly due to differences among individuals (70% of the total variance) and only minimally to differences among countries (3% of the total variance).[36] This strengthens the evidence that children of all ethnic backgrounds have similar potential for growth when raised in environmental conditions favourable to growth, particularly smoke-free households, and have access to health care and good nutrition.

The set of charts from the WHO include charts for weight-for-age, length/height-for-age, weight-for-length/height, body mass index (BMI)-for-age, head circumference, mid-upper arm circumference, and triceps and subscapular skin-fold thicknesses. Growth velocity tables for weight, length and head circumference are available from birth to 24 months of age and, like the charts for skin-folds and arm circumference, are used primarily in specialized clinical practice (e.g. endocrinology) or research for more accurate portrayal of rate of growth or body composition. For all parameters, the WHO charts and tables are available for both percentiles and z-scores as well as a number of different age ranges (Table 2). Also available from WHO are downloadable software (WHO Anthro, Version 2)[37] for generating percentiles and z-scores for individual children, and macros for other statistical software packages (SPSS, SAS, S-Plus, STATA) to facilitate population data analysis.

[b] Data from some of the 8,440 children in the WHO Growth Study whose families did not adhere to all feeding aspects of the study or who had medical conditions affecting growth were not used to generate the growth charts.

[c] The WHO Growth Study was initiated in 1997, before WHO's policy on the optimal duration of exclusive breastfeeding was changed. In 2001, WHO changed its recommendation for exclusive breastfeeding from four to six months of age to exclusive breastfeeding until six months of age, with the introduction to nutrient rich solid foods at six months with continued breastfeeding for up to 2 years and beyond.[35]

Table 2: Sets of growth charts in the WHO Child Growth Standards

Parameters	*Age Ranges*[d]	*Percentiles*	*z-scores*
Weight-for-age length- or height-for-age	birth-6 mo; birth-2 yr; birth-5 yr; 6 mo-2 yr; 2-5 yr	0.1st, 3rd, 15th, 50th, 85th, 97th, 99.9th for all sets	
Weight-for-length	birth-2 yr	1st, 3rd, 5th, 15th, 25th, 50th, 75th, 85th, 95th, 97th, 99th for all sets	-3, -2, -1, 0, + 1, + 2, + 3 for all sets[e]
Weight-for-height	2-5 yr		
Body mass index (BMI)-for-age	birth-2 yr; birth-5 yr; 2-5 yr		
Head circumference	birth-13 wk; birth-5 yr		
Mid-upper arm circumference	3 mo-5 yr		
Triceps skinfold thickness			
Subscapular skinfold thickness			
Weight velocity tables	birth to 24 months[f]	1st, 3rd, 5th, 15th, 25th, 50th, 75th, 85th, 95th, 97th, 99th for all sets	-3, -2, -1, 0, + 1, + 2, + 3 for all sets
Length velocity tables	birth to 24 months[g]		
Head circumference velocity tables	birth to 24 months[h]		

Rationale for Recommending the WHO Child Growth Standards from birth to five years

i) Growth references versus growth standards

The CDC growth charts merely describe how their sample population of children grew, regardless of whether their rate of growth was optimal or not. Although very low birth-weight infants (<1500 g) were excluded, no other restrictions were made to limit the infants to those who were healthy and growing optimally. Therefore, the CDC growth curves potentially depict the growth of some infants who may have been fed inappropriately, raised in substandard environmental circumstances, or had infectious or chronic illness or disease. Because of their descriptive nature, the CDC growth charts are considered to be growth *references*.

On the other hand, because the children in the WHO Growth Study were raised under optimal health conditions, the WHO growth charts represent the best description of physiological growth for children from birth to five years of age. They embody optimal growth and, as such, depict the rate of growth that should serve as a goal or prescription for all healthy Canadian infants and children to achieve, regardless of ethnicity, socioeconomic status, and type of feeding. Because of their prescriptive nature, they are considered to be growth *standards*. Adoption of the WHO standards will promote evidence-informed practice for the benefit of Canadian families.

[d] For each age range cited, such as birth to 6 months or birth to 5 years, the range should be interpreted as up to, but not including the 6th month or up to, but not including 5 years etcetera.

[e] ± 1 z-scores for length/height-for-age are not displayed because they are seldom used for clinical purposes.

[f] Velocity standards for weight are presented as 1 month increments from birth-12 months, and as 2 to 6-month increments from birth-24 months. Weight increments by birth-weight category (particularly useful for lactation management purposes) are presented in 1-week and 2-week intervals from birth-60 days.

[g] Velocity standards for length are presented in 2 to 6-month increments.

[h] Velocity standards for head circumference are presented in 2 and 3-month increments from birth-12 months, and 4 to 6-month increments from birth-24 months. Weight increments by birth-weight category (particularly useful for lactation management purposes) are presented in 1-week and 2-week intervals from birth-60 days.

ii) Promotion of breastfeeding as the norm

Breastmilk is the optimal source of nutrition to support healthy growth and cognitive development of infants. Breastfeeding is also associated with better short-term outcomes such as lower morbidity from gastrointestinal infections. There is a smaller body of evidence, still somewhat conflicting, suggesting potential benefits of breastfeeding on long-term health outcomes, such as obesity, hypertension, diabetes, and cardiovascular disease.[38,39,40,41] For these reasons, current Canadian[42] and international[35] infant feeding guidelines recommend exclusive breastfeeding until six months of age, with the introduction to nutrient rich solid foods, with particular attention to iron, at six months with continued breastfeeding for up to two years and beyond. Recognizing that breastfed and formula fed infants grow differently,[43] growth charts more reflective of the growth of breastfed infants are preferable.

Although the CDC charts were based on a higher percentage of breastfed infants than the NCHS charts they replaced, they were created by pooling data from breastfed and formula-fed infants. Breastfeeding rates remained low, with only 50% of the infants having been breastfed at all and approximately 30% were breastfed for three months or longer. As a result, the CDC growth curves continue to reflect a different pattern of growth than typically observed in healthy breastfed infants.

The WHO Child Growth Standards were constructed based on the growth of healthy breastfed infants and clearly establish the breastfed infant as the normative model for growth and development. In the WHO Growth Study, an extensive breastfeeding support program for mothers was provided to achieve compliance with the feeding criteria.[44] As a result, 75% of the infants followed longitudinally were exclusively or predominantly breastfed for at least the first four months, 68% were partially breastfed to at least 12 months of age and 16% were still breastfeeding at 24 months. The median duration of any breastfeeding was 17.8 months. Therefore, the WHO Child Growth Standards were developed based on the growth of infants and children raised according to feeding recommendations that approach the most current Canadian[42] nutrition recommendations.

iii) Cross-sectional versus longitudinal growth monitoring

The CDC curves are based on compiled anthropometric measurements that were performed only once on the infants and toddlers who were sampled. National survey data were unavailable for the first two to three months of life, so supplementary data was incorporated[14]. Weight data were not available between birth and two months of age and sample sizes for the remainder of infancy were significantly below the 200 observations per sex and age group recommended for construction of growth curves with stable outer centiles.[45] Anthropometric measurements were only available at three- month age intervals after infancy. The cross-sectional nature of the CDC charts represents achieved size of infants; it does not describe rates of growth as accurately as growth represented in longitudinal growth charts.

The growth of infants in the WHO Growth Study, however, was followed incrementally, with each infant measured 21 times between birth and two years. The longitudinal nature and the shorter measurement intervals used in the WHO Growth Study result in a better tool for monitoring the rapid, changing rate of growth in early infancy, including the physiological weight loss that takes place in the first few days of life.[46]

iv) Addressing the obesity epidemic

While the CDC removed their most current national survey weight data for children ≥6 years old to help eliminate the influence of the obesity epidemic on the 2000 CDC growth curves, they did not exclude weight data for children <6 years. This meant that the weights of overweight and obese children <6 years old pulled or skewed the CDC weight-for-age, weight-for-length/height and BMI curves upwards, artificially suggesting that children at some of the higher curves were not necessarily overweight or obese.

To avoid the influence of unhealthy weights for length/height when constructing the Child Growth Standards, the WHO excluded observations for infants and toddlers followed longitudinally that were above +3 z-scores (›99.9th centile) and below -3 z-scores (‹0.1st centile) of the sample median.[32] For the two to five year old children in the cross-sectional sample, +2 z-scores (› 97.7th centile) was used as the cut-off instead of +3 SD, because the sample was very skewed to the right, indicating the need to identify and exclude high weights for height. This was considered to be a conservative cut-off, given that various definitions of overweight apply lower cut-offs than the definition used by the WHO.[32] There were 340 observations (1.2%) excluded for unhealthy weight-for-length/height, the majority of which were in the upper curves (i.e. overweight/obesity) of the older children.

v) International sample population

The varied cultural and ethnic backgrounds of the sample population used to develop the WHO Child Growth Standards, and the striking similarity in growth between sites, are relevant not only to growth monitoring in the global community, but also for the multicultural mix of Canada's children. Including data from multiple countries improves the estimate of variability of physiologic growth.[47] While not all races were sampled, the fact that only small differences in growth were associated with cultural/racial background would suggest that the trends in growth of children from non-sampled cultures should be similar. In addition, use of data from diverse sites avoids political controversies that arise from using a single country's growth patterns as the reference for optimal growth internationally.[9] One international standard for assessing the growth of all children exemplifies the compelling message that when nutritional, health, and key environmental needs are met, children around the world grow very similarly.[36]

vi) Validation with subjective assessments by health care professionals

To demonstrate clinical soundness of the WHO Child Growth Standards prior to their release, the growth curves were field-tested in 4 countries (Maldives, Pakistan, Argentina, Italy) by comparing children's length/height-for-age and weight-for-length/height z-scores with clinicians' assessments of the same children.[48] In all sites, children classified by clinicians as thin were also classified as wasted (weight-for-height ≤ -2 z-scores) and a positive linear association was also seen for the clinicians' classification of children's weight from thin to obese and weight-for-length/height z-scores.

The WHO Reference 2007: 5 to 19 years

Motivated by the global surge in childhood obesity, and development of the WHO Child Growth Standards for younger children, a work group convened in 2006 by the WHO, United Nations University, and Food and Agriculture Organization recommended development of a single international standard for the screening, surveillance, and monitoring of school-aged children and adolescents.[49,50] Experts agreed that the 1977 NCHS/WHO charts, the CDC 2000 charts, and the International Obesity Task Force centile curves and cut-offs all had shortcomings that necessitated a new, more appropriate standard for clinical and public health applications for older children. A study similar to the WHO Growth Study was deemed impossible because of challenges in controlling the environmental dynamics of older children in a large multicentre international study.[51] As an alternative, the WHO chose to construct a growth reference for pre-adolescents and adolescents using the best available historical data. After examining existing data sets from various countries, the WHO elected to reconstruct the 1977 NCHS/WHO growth reference by addressing its limitations and linking construction to the WHO Child Growth Standards curves for children under five years old. Data points for children and adolescents with measurements suggestive of high

adiposity were excluded. The total sample size used to generate the curves was 22,917 children.

State of the art statistical techniques were used to construct and smooth the new growth curves[51] and the same statistical methodology was used as in the construction of the WHO Child Growth Standards.[32,46]

The resulting curves[34] for BMI-for-age, height-for-age, and weight-for-age (up to ten years of age) (Table 3) are considered new charts. The reconstructed charts for school-aged children and adolescents have been named the WHO Reference 2007, and are being adopted by countries concerned about the growing problem of childhood obesity. Online application tools from the WHO include free software (WHO AnthroPlus, WHO 2009)[52] and macros in SAS, S-Plus, SPSS, and STATA to monitor growth of school-age children and adolescents.

Table 3: Sets of growth charts in the WHO Reference 2007

Parameters	*Age Ranges*	*Percentiles*	*z-score*
Weight-for-age	5-10 yr	0.1st, 3rd, 15th, 50th, 85th, 97th, 99.9th for all sets	-3, -2, -1, 0, + 1, + 2, + 3 for all sets
Height-for-age	5-19 yr		
Body mass index (BMI)-for-age	5-19 yr		

Rationale for Recommending the WHO Reference 2007 from 5 to 19 years

The rationale for adoption of the WHO Reference 2007 charts is less compelling than for the WHO Child Growth Standards. While the WHO Reference 2007 continues to be based on cross-sectional data collected from a single country, several features suggest they are superior to the American CDC growth charts.

i) Addressing the obesity epidemic

In developing the 2000 CDC growth charts, the CDC excluded the most recent national survey weight data (NHANES III; 1988-1994) for children ≥6 years to avoid an upward shift in weight-for-age and BMI-for-age curves.[14,30] Despite this, the 97th and the 99.9th percentile curves (+2 and +3 z-scores) are located very high on the CDC weight-for-age and BMI-for-age charts, meaning that fewer overweight and obese children and adolescents are identified as such, because the norms have been raised.[47] The lower centiles are also shifted upwards, leading to overestimation of undernutrition, and thus advice leading to overfeeding.

In choosing to revise the older NCHS charts rather than the newer CDC charts, the WHO reduced the influence of rising obesity rates over time because data for the 1977 NCHS charts were collected between 1963-1974, before the onset of the obesity epidemic. As well, data were cleaned to avoid the influence of unhealthy weights-for-length/height (i.e. › +2 SD or ‹ -2SD) by excluding 677 data points (3% of observations) meeting these criteria.[46] This prescriptive approach taken by the WHO to construct the charts based on healthy growth moves them a step closer to a standard than to a reference and is important in light of the increasing problem of childhood obesity.

ii) Transitioning from a chart for young children to a chart for older children

In revising the NCHS charts, the WHO merged data from the WHO birth to five year old Child Growth Standards with the NCHS final sample before fitting the new growth curves for 5 to 19 year olds. This resulted in an almost perfect match at five years-of-age between the WHO Child Growth Standards and the WHO 2007 References. In practice this facilitates transitioning a child from one chart to the other at age five years.[51] In addition, at 19 years of age, the WHO 2007 Reference values for BMI-for-age at the 85th centile (overweight) and 97th centile (obesity) match almost perfectly with adult cut-offs for BMI of 25 and 30 kg/m^2, respectively.

Given that development of growth charts for older children based on an international population and longitudinal study design is unlikely to occur, the WHO Reference 2007 charts appear to be the best charts available for monitoring the growth of Canadian children from 5 to 19 years old.

Differences Between the CDC and WHO Growth Charts

For children near the outer extremes of the growth curves, a switch to the WHO growth charts may result in a change in their previous classification of growth or nutritional status compared to when they were plotted on the CDC charts. An understanding by health-care professionals of the underlying differences between the CDC and WHO charts is required in order for them to help children and parents understand whether this change is significant or not.

a) Appearance and age ranges

Small visual differences exist between the charts, most noticeably the horizontal orientation and use of two fewer centile curves in the central curves of the WHO charts. The WHO charts provide a wider range of available charts by age for younger children and the transition to an older age growth chart occurs at five years-of-age, compared to at two years or 36 months for the CDC charts.

b) Increased emphasis on the use of BMI-for-age

While each of the existing measures that estimate body fatness (i.e. weight-for-height, percent ideal body weight, BMI-for-age) have limitations, current consensus is that BMI is probably the best choice for assessing body weight status in children, adolescents and adults. Therefore, BMI should be calculated and plotted during a paediatric health maintenance visit for all Canadian children 2 years and older,[53] not just those who look overweight or obese.

Because the focus of BMI has traditionally been identification of overweight and obesity, there is a larger, more established body of research linking paediatric BMI to future obesity and adverse health/outcomes[54,55,56] than there is for BMI and identification of underweight. While correlation between BMI and measures of body fat has been shown, no correlation between BMI and lean body mass has been demonstrated. Use of BMI to study underweight or failure-to-thrive is relatively new,[57,58,59] but there is increasing reference to its use, primarily in children aged 2-20 years.[60] BMI-for-age, but not weight-for-height or percent ideal body weight, was shown to be associated with outcomes in children older than two years with cystic fibrosis.[60] Additionally, international cut-offs for BMI to define "thinness" in children older than two years have recently been developed based on adult cut-offs, but still need to be validated.[61]

The appropriate age at which to start using BMI is unclear. Whether for thinness or overweight, there has been little usage to date of BMI during infancy. The CDC added BMI-for-age growth charts starting at age two years, whereas the WHO Child Growth Standards include BMI-for-age charts starting at birth.

National BMI-for-age growth charts starting from birth have been used for one to two decades in the United Kingdom and a number of European countries; [62,63] however, there are no reports evaluating its association with outcomes in this age group.

Until more evidence is available, there are several concerns that suggest against the use of BMI for children under two years-of-age:

1. Dramatic changes in body composition. Median BMI increases sharply as an infant rapidly gains weight relative to length in the first 6 months of life. BMI rises from approximately 13.5 kg/m^2 at birth to a peak of 17.5 kg/m^2 at six months, before declining in later infancy and remaining relatively stable from age two to five years (median of 15.2 kg/m^2). Slight differences in the timing of the rise in BMI and subsequent fall can lead to marked centile crossing; therefore, BMI may be difficult to interpret in infancy, and infants on the outer or extreme centiles would need to be viewed conservatively.
2. Challenges in accurate measurement of length in infants. Despite use of standardized techniques and equipment,[64,65] infants resist full extension of their legs and rarely lie still during the measuring process. Because length/height is squared, and appears in the denominator of the BMI equation, inaccurate lengths can result in significant errors in BMI.

3. Responding to overnutrition identified by BMI. Should an infant or young toddler be identified as overweight or obese by BMI, current recommendations would not support dietary restriction because of the potential negative impact on linear and brain growth.

At this time, there is a lack of convincing evidence that BMI-for-age is better than weight-for-age or weight-for-length at assessing adequacy of feeding and over and underweight for infants and toddlers under two years-of-age. There is insufficient evidence to support its use before six months of life, and reason to be cautious about its use to screen for underweight or overweight/obesity before 24 months of age. BMI-for-age becomes more useful once children enter age periods when overweight begins to be a risk factor. In circumstances where underweight or overweight is of concern in individual infants or toddlers below the age of two years, BMI could be used cautiously as a supplemental component of nutritional and growth assessment, provided length is measured accurately.

c) Weight-for-age

The WHO chose to stop weight-for-age charts at age ten years on the basis that it does not distinguish between height and body mass in an age period where many children are experiencing their pubertal growth spurt. Pubertal children may appear as having excess weight by weight-for-age when in fact they are just tall. At the other extreme, overweight children that are short or stunted would appear to be normal when weight-for-age is used to screen for overnutrition. The WHO recommends that weight continue to be measured for children beyond ten years-of-age, but solely for the purpose of calculating, plotting and monitoring BMI-for-age.[51]

d) Cut-off points and Terminology

Cut-off points for anthropometric measurements are intended to provide guidance for the need for further assessment, referral, or intervention; they should not be used as diagnostic criteria. Longitudinal patterns of growth should always be considered when applying cut-offs. Ideally, cut-off points for identifying individuals at risk should be linked to short, intermediate and/or long-term health outcomes, such as evidence of increased risk of morbidity, impaired function, or mortality.[47] In reality, paediatric anthropometric cut-off points have been chosen primarily on the basis of statistical criteria. This is because assessing the relationship between cut-off points and health outcomes is more challenging in the paediatric population than for adults. More long-term longitudinal studies are needed.

Undernutrition

The third percentile is recommended by the WHO as the lower cut-off for identifying children in developed countries who are underweight, stunted, or wasted (Table 4) and referring them for further assessment and intervention. These cut-offs are consistent with those from the CDC, with the exception of BMI-for-age, for which the CDC recommends a cut-off of the 5th percentile. This cut-off for underweight was based on a recommendation from the WHO[22], prior to the release of the new WHO Child Growth Standards.

Preliminary scientific research and clinical experience regarding the use of BMI in underweight, and the choice of percentile as the cut-off suggest that BMI-for-age may be the preferred method for identifying wasting. However, until further evidence on BMI and undernutrition indicates otherwise, the alternative practice may continue of using either weight-for-length/stature ‹ 3rd centile, or weight ‹ 89% of ideal body weight (IBW) [66] as a surrogate measure of wasting. These parameters would particularly apply under the age of two years, with an awareness of their limitations.[67,68,69]

Table 4: Recommended cut-offs by the WHO for screening for undernutrition and overnutrition

Parameters	*WHO Child Growth Standards*	*WHO Reference 2007*
Age	birth to 5 years	5-19 years
Underweight weight-for-age	‹ 3rd centile	‹ 3rd centile
Stunted length-for-age/ height-for-age	‹ 3rd centile	‹ 3rd centile
Wasted weight-for-length/ BMI-for-age*	‹ 3rd centile	‹ 3rd centile
Risk of overweight weight-for-length/ BMI-for-age*	› 85th centile	not applicable
Overweight weight-for-length/ BMI-for-age*	› 97th centile	› 85th centile
Obese weight-for-length/ BMI-for-age*	› 99.9th centile	› 97th centile
Severe obesity BMI-for-age	not applicable	› 99.9th centile

* weight-for-length from birth-2 years; BMI-for-age ≥ 2 years

Overnutrition

The most recent Canadian and CDC recommendations for cut-off points and terminology for using BMI to classify abnormally high body-weights in children ≥2 years old[53,70] are:

Overweight: 85th centile ≤ BMI-for-age ‹ 95th centile

Obesity: BMI-for-age ≥ 95th centile

Using two cut-off points for BMI-for-age captures varying levels of high weight and minimizes over and under-diagnosis of body fatness. Body fat levels below the lower cut-off are likely to pose little risk. Above the higher cut-off, body fat levels are likely to be high. BMI-for-age values between the two cut-offs indicate variable health risks depending on body composition, BMI trajectory, family history, and other factors. The term obesity denotes excess body fat more accurately and reflects the associated serious health risks more clearly than does the term overweight, which is not recognized as a clinical term for high adiposity.[70] Overweight, or BMI-for-age values between the two cut-offs, includes children with excess body fat as well as children with high lean-body-mass and minimal health risks.[70] This terminology provides continuity with adult definitions.

The BMI-for-age cut-offs recommended by the new WHO charts for overweight and obesity differ slightly from the CDC, and are not the same in preschool children and older children (Table 4). For older children (5-19 years), the cut-off for overweight is the 85th centile, which at 19 years coincides with the adult cut-off for overweight of BMI ≥25 kg/m^2. The cut-off for obesity for older children is the 97th centile, which coincides with the adult cut-off for obesity of BMI ≥30 kg/m^2.[51] The 99.9th centile is considered severe obesity, and coincides with an adult cut-off of BMI › 35 kg/m^2. These centile cut-offs also correspond to z-score values at +1, +2, and +3 standard deviations, respectively.

For the WHO Child Growth Standards for birth to five years, the WHO took a more cautious approach in their recommended cut-offs because children are growing and, to date there are no data on the functional significance of the cut-offs for the upper end of the distribution. An additional reason for the WHO's caution was to avoid the risk of health professionals or parents putting young children on diets. As a result, the WHO felt more comfortable identifying young children above the 85th centile as at risk of overweight, a term the CDC recently abandoned due to its vagueness and confusion for patients and health professionals.[70] The WHO consider younger children above the 97th centile to be overweight, and children above the 99.9th percentile to be obese.

e) Prevalence of undernutrition and overnutrition

Important differences between the WHO and CDC charts exist, and vary by age, growth indicator, and specific centile or z-score curve.[45] The biggest differences occur during the first 24 months, likely due to differences in study design and sample characteristics, such as type of feeding. Overall, the WHO charts reflect a lighter, and somewhat taller sample than the CDC charts.[45,71] When both are applied to the same population, the WHO Child Growth Standards will result in lower rates of underweight, wasting or thinness (except during the first six months of life), and higher rates of stunting, overweight and obesity. Prevalence rates appear more comparable when the 5th and 95th percentiles on the CDC charts are compared with the 2.3rd centile (-2 z-score) and 97.7th centile (+2 z-score) on the WHO charts rather than the 5th and 95th percentiles.[71]

Underweight

Generally, weight for-age percentiles are lower on the WHO curves compared to the CDC curves, except between the ages of one and six months where they are lower on the CDC curves. In the first 6 months, a slightly higher proportion of infants are below the 3rd centile using the WHO curves versus the CDC curves while the opposite is true after six months. The fact that more infants between birth and six months will be screened as being underweight using the WHO standards is likely reflective of the faster rate of weight gain by breastfed babies compared with formula-fed babies in the first few months of life and the resulting shift upwards in the WHO weight-for-age centiles during this time period.[45] Thereafter, the slower pattern of weight-gain on the WHO charts reflects a healthier rate of growth for breastfed infants. As they move towards using the WHO Child Growth Standards, health professionals will need training to understand that more infants are likely to be screened as underweight using the WHO Child Growth Standards, and that it is important to consider the pattern of weight and linear growth and weight relative to height before suggesting there is a problem with lactation.

Stunting

Length/height-for-age is very similar on both sets of charts. Because the growth of children in the WHO Growth Study was optimal, on average, children in the WHO Child Growth Standards are somewhat taller than those in the CDC reference. As a result, the WHO curves are shifted upwards relative to the CDC charts and for all age groups, stunting rates (i.e., height-for-age ‹- 3rd percentile) will be higher when based on the WHO Child Growth Standards.

Wasting

Using weight-for-length, weight-for-height, or BMI-for-age, the proportion of children classified as overweight or obese will be greater using the WHO Child Growth Standards and the prevalence of wasting will be lower.

Applicability of the WHO Child Growth Standards to Canadian Infants and Children

i) National Birth-weights

The mean birth-weight (genders combined) in the WHO Growth Study was 3.3 ± 0.5 kg, ranging from 3.1 kg in India to 3.6 kg in the United States and Norway. In a 2001 paper reporting national birth-weights of Canadian male and female singleton births between 1994 and 1996, the mean birth-weight for full-term infants (40 week) was 3.56 kg.[72]

ii) Canadian Regional Databases

The Collaborative Statement Advisory Group retrospectively applied the WHO Child Growth Standards and CDC references to a large sample of Canadian children ranging in age from birth to five years. [73] The sample was derived by merging four regional databases containing length or height and weight measurements of children from three different geographical regions in Canada (94,936 data points). None of the data sets contained information on whether the individual child had been breastfed or bottle-fed. Percentiles and z-scores for each complete set of weight and

length/height measurements were electronically generated using the respective CDC (NutStat, EpiInfo)[74] and WHO (WHO Anthro)[37] anthropometric computer programs.

Applying Canadian data, the following observations were made when applied to the WHO Child Growth Standards and compared to the CDC references:

- Underweight: More Canadian infants between birth to six months of age were classified as underweight (weight-for-age ‹3rd centile). After six months, the reverse was true.
- Stunting: At all ages, more Canadian infants were classified as stunted (length/height-for-age ‹3rd centile).
- Wasting: More Canadian infants between birth and two months of age were classified as wasted (weight-for-length ‹3rd centile). From four months of age onwards, the opposite was true. Using BMI-for-age ‹3rd centile between the ages of two and five years, fewer Canadian children were classified as wasted.
- Overweight: Differences in the classification of overweight using weight-for-length/height were small and varied by age. Using BMI-for-age between the ages of two and five years, more children were classified as overweight until four years old.
- Obesity: At all ages, more children were classified as obese using weight-for-length/height. Using BMI-for-age between the ages of two and five years, more children were classified as obese.

These observations are similar to those reported when comparing datasets from the WHO Child Growth Standards and the 2000 CDC growth references[45] and the WHO Child Growth Standards and available data from 2 population-based studies in the United Kingdom.[75,76]

iii. Cross-sectional regional study of Canadian infants

Differences in the rates of undernutrition and overnutrition were quantified when the WHO Child Growth Standards and 2000 CDC references were applied to a sample of 547 children younger than two years hospitalized in a paediatric tertiary care centre in Toronto, Ontario.[77] The WHO Child Growth Standards identified more infants and toddlers as overweight/obese (weight-for-length ›85th percentile) compared with the CDC reference (21% vs. 16.6%) and fewer infants and toddlers as wasted (weight-for-length ‹5th percentile; 18.6% vs. 23%). WHO BMI-for-age and weight-for-length centiles were strongly correlated but were not interchangeable, especially for children younger than six months. The proportion of all infants and toddlers considered stunted (length-for-age ‹3rd centile) was greater using the WHO Child Growth Standard (23.4%) compared to the CDC charts (17.7%).

iv. Longitudinal regional study of Canadian infants

van Dijk and Innis[78] compared the pattern of infant growth of 73 healthy babies in Vancouver, BC, followed longitudinally from birth to 18 months using the 2000 CDC growth references and 2006 WHO Child Growth Standards. Their results paralleled the findings of de Onis et al[45] that infants and young children in the US are heavier and somewhat shorter than those in the WHO Growth Study, and showed that infants fed according to Canadian recommendations for exclusive breastfeeding to six months and introduction of complementary foods at that time grew following the WHO weight-for-age growth standard.

v. Expert Review

An external five-person expert review panel, selected by the Public Health Agency of Canada, examined the methodological soundness of the WHO's process to create the 2006 Growth Standards and WHO Growth Reference 2007 in order to guide decision-making around adoption of these charts for growth assessment of Canadian children at the individual level.

There was general consensus amongst the experts that the methodology behind the Child Growth Standards was sound, and that the charts be adopted for use in Canada. Recognizing limitations of the Growth Reference 2007, the experts felt the methods used to generate these charts were acceptable, and felt comfortable recommending that these were the best growth charts available for older children and adolescents.

Can the WHO Growth Charts be Used for Special Populations?

Growth in low birth-weight (‹2,500 g) and very low birth-weight (VLBW: ‹ 1,500 g) preterm infants differs from term infants born at an appropriate weight, such that they appear not to catch up during early childhood.[79] The WHO growth charts lack data on preterm infants because they excluded infants born before 37 weeks gestation. Data on low birth-weight but not very low birth-weight infants were included. Alternate charts are available to assess the growth of preterm and low birth-weight infants in the neonatal intensive care unit or early post-discharge setting,[79,80] including the current and widely used growth chart for preterm babies from Fenton[81,82] and the Infant Health and Development Program (IDHP) charts[83]. After that time, growth of preterm infants should be monitored using the WHO Child Growth Standards and postnatal age corrected for prematurity (i.e. postnatal age in weeks – [40 weeks – gestational age at birth in weeks]) before plotting for at least 24 or 36 months.[84] Failing to correct for preterm can lead to inappropriate referrals for failure-to-thrive (FTT).

Children with intellectual, developmental, genetic or other disorders often have growth patterns that are different from references. Specific growth curves have been created for some of these disorders;[85,86,87,88] however, they have been developed from very small samples and relatively old data that predate improved nutritional care. As a result, disorder-specific charts may not be accurate, may not reflect newer treatment protocols and may conceal an existing nutrition or growth problem. With consideration of the limitations of each chart, the specialized charts may provide additional useful information in the overall growth assessment, but they should only be used in conjunction with the WHO Child Growth Standards or WHO Reference 2007 charts. Alternative anthropometric measurements (e.g. sitting height, segment lengths such as upper arm or lower leg, skin-folds) may be required when muscular contractures, spasms, or scoliosis challenge the ability to obtain accurate measurement of weight or length/height in children with neuromuscular disabilities.[89]

Considerations in Interpreting Growth Charts

There are several key points to remember when interpreting patterns of growth on a growth chart:

- Measurements taken one time only describe a child's size. Serial measurements are needed to provide information on a child's growth.
- Assessing growth involves looking at the overall trajectory of weight-for-age, length/height-for-age, and weight-for-length (under two years) or BMI-for-age to determine whether a child is tracking along the growth curves or is crossing centiles downwards or upwards.
- In general, the centile positions of various anthropometric measures (i.e. length/height, weight, head circumference) will be similar in a normal child, with a gross difference in one indicating a potential problem.
- The more deviant an individual's anthropometric measure is, the more likely it is that a problem exists.[90]
- Despite many parents' perception, the 50th percentile is not the goal for each child.
- The direction of serial measurements on the curve is more important than the actual percentile.
- When a child's growth deviates from a given centile curve, an abnormality in growth may be suspected; however, some shifts in growth are normal.[91] In most children, height and weight measurements follow consistently along a 'channel' (i.e. on or between the same centile(s)). Normal children often shift one to two major centiles (i.e. 5th,10th,25th,

50th,75th,90th,95th) for both length and weight, especially in the first six months of life, with the majority settling into a channel towards the 50th centile (i.e. regression toward the mean) rather than away.[92]

- With the exception of the first two years of life when channel 'surfing' may be normal, and during puberty when the age at onset is variable, a sharp incline or decline in growth, or a growth-line that remains flat, are suggestive of a problem. Serial measurements showing unexpected movement downwards on the curves from a previously established rate of growth could be a sign of failure-to-thrive or growth failure.[23,57,58,93] Likewise, unexpected movement upwards on the curves may be a sign of development of overweight or obesity. Whether or not these situations actually represent a risk depend on where the change in growth pattern began and which direction the change is headed.[94] A shift toward the 50th centile is possibly a good change, whereas a shift away from the 50th centile likely signals a problem.[94]
- Historically, serial measurements showing unexpected crossing of two or more major centiles downwards or upwards from a previously established rate of growth have been considered reflective of failure-to-thrive,[23,93] or rapid growth, respectively. These criteria no longer apply to the WHO growth charts. While the WHO and CDC charts both have 7 major centiles, measurements on the inner curves of the WHO charts (3rd, 15th, 50th, 85th, 97th) are farther apart than on the middle curves in the CDC charts (10th, 25th, 50th, 75th, 90th). Waiting for a child to cross two major centiles on the WHO charts would result in a child experiencing a greater loss or gain of weight or length/height before being identified as a problem, than when the CDC charts were used.
- Breastfed infants born with low birth-weight will be expected to track along the lower centiles of the WHO Standards because exclusive breastfeeding does not change the fact that the infants were small for their age in the first place. By looking at a single point, an infant in this category would be considered low weight-for-age; however, before deciding that exclusive breastfeeding is inadequate for any infant, health professionals should consider the baby's birth-weight, growth trajectory, any problems with lactation, or acute or chronic illness that might explain apparent growth failure.[94]
- Formula-fed infants grow differently than breastfed infants during the first year of life.[43] In particular, formula-fed infants tend to be lighter in the first three to four months of life and become heavier after four to six months. These differences should be anticipated when assessing growth of a formula-fed infant in order to avoid unnecessary investigations or counselling to increase or limit formula or food intake.
- BMI-for-age is an effective screening tool for identifying children who have an unhealthy amount of body fat; however, it is not a diagnostic tool. It should be used as guidance for further assessment, referral, or intervention, rather than as diagnostic criterion for classifying children. BMI-for-age charts are less affected by differences in the timing of puberty than simple height and weight charts, but care must be taken not to confuse heavy musculature with obesity in a minority of children.[95] A decision about whether a child with a given BMI is truly over-"fat" or simply over-"weight" requires additional information such as their state of pubertal maturation, comorbidities, family history and ethnic background, level of physical activity, somatotype and frame size, and use of good clinical judgment.[53,96] As with other anthropometric measures, serial measurements of BMI are more revealing and the pattern of BMI-for-age on the growth chart is more informative than the actual BMI number.
- Children who are crossing BMI percentiles in an upwards direction may be at risk for becoming overweight or obese.[97] Unlike adults, age-related increases in BMI during growth are associated with increases in both fat mass and fat-free mass.[97] The extent to which each component contributes to the change in BMI depends on the age, sex and pubertal maturation of the child.[98]
- Ethnic differences in paediatric BMI have not been thoroughly investigated. An initial study demonstrated that white subjects had higher body fatness for a given BMI than black subjects.[99]

Internationally, universal use of BMI cut-off points for adults has been debated, because health-related risks for obesity are observed at different levels of BMI for different populations.[100] Variations in body fat distribution (intra-abdominal versus visceral) or the degree of muscularity may explain these differences.

SUMMARY/CONCLUSIONS

The objective of growth monitoring is timely identification of disturbances in normal weight gain and linear growth in order to instigate corrective interventions and achieve full growth potential. Growth monitoring also provides health professionals with an opportunity to discuss breastfeeding for infants and toddlers, and healthy eating and active living with children and/or their parents/caregivers. These discussions can promote positive changes when required and influence health outcomes. When a growth problem occurs, counselling on growth and feeding should be sensitive and positive, avoiding judgment or instilling feelings of guilt. A focus on health rather than on numbers or physical appearance is encouraged.[94,101] Optimal growth monitoring requires accurate anthropometric measurements using appropriate equipment and techniques and accurate plotting on a consistent growth chart appropriate for age and gender. Differences in growth between populations are affected primarily by environmental factors; the role of ethnic factors is smaller than previously thought. Therefore, use of a single international growth chart for Canadian children is appropriate. While local growth charts are unnecessary, this does not argue against the collection and use of local anthropometric survey data to facilitate monitoring of the overall nutritional and health status of Canadian infants and children and identification of trends within this population.[90]

Growth charts from the WHO Child Growth Standards (birth to five years)[31] and WHO Reference 2007 (5 to 19 years)[34] are now recommended for monitoring growth and BMI in Canadian children in the community, clinical, and research settings, for the following reasons:

WHO Child Growth Standards

- The standards were developed based on the growth of infants and children raised according to feeding recommendations that approach the most current Canadian and international nutrition recommendations, which include exclusive breastfeeding until six months of age, with the introduction to nutrient rich solid foods at six months with continued breastfeeding for up to two years and beyond.
- The ideal or optimal growth depicted in the WHO Child Growth Standards should serve as a goal or prescription for all healthy children to achieve.
- The international, multicultural nature of the WHO Child Growth Standards is universally appealing compared to growth charts based on the growth pattern of only one nation. One international standard for assessing the growth of all children exemplifies the compelling message that when nutrition, health, and key environmental needs are met, children of different cultures have similar growth potential.[36]
- Data points for unhealthy weights were excluded from the datasets of the WHO Child Growth Standards to avoid the influence of obesity.

WHO Reference 2007

- Data points for unhealthy weights were excluded to avoid the influence of obesity.
- Improvements made in constructing the WHO Reference 2007 charts for age five up to age 19 years, particularly adjustments (smoothing) of the charts using results of the 2006 WHO Child Growth Standards, bring them closer to a prescriptive standard than a descriptive reference.
- There is an almost perfect match of the curves of the WHO Reference 2007 charts at five years-of-age with the curves of the WHO Child Growth Standards, supporting seamless transition of a five-year-old from one growth chart to the other.

The WHO Reference 2007 charts also match almost perfectly at 19 years-of-age with the adult BMI cut-offs for overweight (BMI=25 kg/m^2) and obesity (BMI=30 kg/m^2).

Use of the WHO growth charts will provide all who aim to improve the health of children with a powerful advocacy tool. With these standards, parents, dietitians, public health/community nutritionists, nurses, midwives, physicians, and advocates will have a yardstick for what represents healthy growth and development associated with good nutrition and health practices.

RECOMMENDATIONS

1. The growth of all full term infants, both breastfed and non breastfed, and preschoolers should be evaluated using growth charts from the World Health Organization Child Growth Standards (birth to five years). Growth of all school-aged children and adolescents should be evaluated using growth charts from the World Health Organization Growth Reference 2007 (5 to 19 years). These are recommended as the charts of choice for use by Canadian family physicians, paediatricians, dietitians, public health/community nutritionists, nurses, and other health professionals in the primary care, community, and hospital settings.
2. Growth monitoring should be a routine part of health care for all Canadian infants, children and adolescents. Serial measurements of recumbent length (birth to two to three years) or standing height (≥ 2 years), weight, and head circumference (birth to two years) should be part of scheduled well-baby and well-child or well-adolescent health visits. Measurements should also be performed at unwell visits for those who are not brought for recommended well-health visits. Health professionals are encouraged to work together across disciplines and sectors in performing growth monitoring and promotion of optimal growth to ensure Canada's most vulnerable populations do not fall through the cracks.
3. To yield accurate measurements, weights and measures should be obtained using calibrated, well-maintained quality equipment and standardized measurement techniques.[64,65] An individual child's measurements should be recorded in their personal chart or growth record, and then plotted on a consistent growth chart appropriate for age and gender to identify any disturbances in length/height or weight gain. Corrected age should be used at least until 24 to 36 months of age when plotting anthropometric measurements of premature infants.
4. The growth of preterm infants once discharged from the neonatal intensive care unit setting and children with special health care needs should also be monitored using the WHO Child Growth Standards and WHO Reference 2007.
5. BMI-for-age should be used to assess weight relative to height and to screen for thinness, wasting, overweight, and obesity for all children two years and older. Weight-for-length or percent ideal body weight can be used for children under two years-of-age.
6. Interpretation of plotted measurements should consider their centile rank, the relationship of weight, length/height, and BMI to each other, recommended cut-off values, parental heights (for stature measurements), and the trend relative to previous centile ranks to identify major shifts in growth patterns.
7. Table 5 outlines the cut-offs recommended as guidance for further assessment, referral, or intervention but not as diagnostic criteria for classifying children.
8. Health professionals are encouraged to take the time to teach children and their parents/caregivers how to interpret their individual pattern of growth on the growth chart and to involve them in decision-making about any potential actions they can take to correct abnormalities in the rate of weight gain and/or linear growth.

Table 5: Cut-off points

Birth to 2 years

Growth Status	*Indicator*	*Percentile*
Underweight	Weight-for-age	‹ 3rd
Severe underweight		‹0.1st
Stunting	Length-for-age	‹ 3rd
Severe stunting		‹0.1st
Wasting	Weight-for-length	‹ 3rd
Severe wasting		‹0.1st
Risk of overweight		›85th
Overweight		›97th
Obesity		› 99.9th

2 to 19 years

Growth Status	*Indicator*	*Percentile*	
		2-5 years	*5-19 years*
Underweight	Weight-for-age	‹ 3rd	‹ 3rd*
Severe underweight		‹0.1st	‹0.1st*
Stunting	Height-for-age	‹ 3rd	‹ 3rd
Severe stunting		‹0.1st	‹0.1st
Wasting	BMI-for-age	‹ 3rd	‹ 3rd
Severe wasting		‹0.1st	‹0.1st
Risk of overweight		›85th	not applicable
Overweight		›97th	›85th
Obesity		› 99.9th	›97th
Severe obesity		not applicable	› 99.9th

* weight-for-age not recommended after age 10 years; use BMI-for-age instead

9. To ensure knowledge translation and uptake by key organizations, training on the use and interpretation of the 2006 WHO Child Growth Standards and WHO Reference 2007 charts should be provided to all health professionals involved in measuring and assessing the growth of Canadian children. This includes an understanding of the differences a practitioner can expect to see when using the WHO vs CDC growth charts, and how to explain them to parents/caregivers.
10. While the recommendations in this collaborative statement pertain specifically to adoption of the WHO Child Growth Standards and Reference 2007 for individual children, it is suggested that these Standards and Reference charts should also be considered for the purposes of population health surveillance, so that children classified as underweight, overweight or obese at the individual level are captured in a consistent manner in population surveys. This data can then be used as evidence to inform community mobilization and social action to address underweight and overweight/obesity and for purposes of programme planning, implementation and evaluation.[22]
11. Development of a Canadian Paediatric Nutrition Surveillance System for organized and ongoing collection of anthropometric measurements is recommended to follow the growth and nutritional status of Canadian children and describe trends in key indicators of their nutritional status. Data could be used for program planning, targeting, development, and evaluation of health and nutrition interventions such as breastfeeding promotion programs, as well as monitoring progress toward health objectives for Canada. Collaboration with key stakeholders in the community health/population health sector is needed.
12. Research is required in the following areas:
    a) validation of using BMI-for-age to assess nutritional status in the first two years of life, looking for associations between BMI and subsequent health outcomes
    b) validation of using BMI-for-age to assess underweight in children of all ages
    c) evaluation in all age groups of the predictive power of proposed BMI cut-offs for overweight and obesity with respect to adverse short and long-term health outcomes.

IMPLICATIONS

The new WHO Child Growth Standards and WHO Reference 2007 provide an excellent opportunity for heightening health professionals' awareness about the importance of routine and accurate growth monitoring, and appropriate use and interpretation of growth charts. The process of replacing existing growth charts and providing training to dietitians, public health/community nutritionists, nurses, physicians and others in the use and interpretation of new charts is a good opportunity to revisit growth monitoring practices as-a-whole, and to disseminate knowledge about effective interventions to prevent or treat either excessive or inadequate growth at the individual level.[34]

A change to these new charts has a number of implications for health professionals, including:

1. the need for easily accessible training for busy practitioners on:
    a) performing accurate and reliable anthropometric measurements using precise equipment
    b) different features of the WHO charts compared to the CDC charts
    c) use and interpretation of the new WHO growth charts including differences between growth on these charts and the CDC charts, as well as the significance of the new WHO cut-off points
    d) effective nutrition-negotiation skills with parents and caregivers to effect positive changes in nutrition and health.

Examples of relevant training programs are the WHO training course and tools[94] and independent training modules on measuring growth on the CDC web site.[64,65,102] The WHO Training Course on Child Growth Assessment[94] is a comprehensive set of resources for training health professionals to apply the WHO Child Growth Standards. Resources are supportive of breastfeeding and sensitive in their approach to questioning and counselling of parents/caregivers. They provide clear and specific guidelines on what questions should be asked of parents/caregivers and what advice should be given in response to their specific replies. While a benefit of the WHO training resources is their multicultural focus, some aspects of the training course and tools are more appropriate for use in developing rather than developed countries so some adaptation to the Canadian setting would be required. Suitable alternatives are the training modules from the United States Department of Health and Human Services, Maternal and Child Health Bureau and the CDC on the techniques for accurate weighing and measuring of infants and children.[64,65,102]

For efficiency, and to ensure consistent practice, we encourage:

2. leadership at the national and/or provincial/territorial levels to create multimedia training tools and resources for use by individuals and organizations across Canada
3. ensuring accessibility to resources, including portable, accurate measuring equipment
4. a call for collective advocacy for a Canadian Paediatric Nutrition Surveillance System to monitor breastfeeding rates and growth and nutritional status of our children.

ACKNOWLEDGEMENTS

This position paper was developed collaboratively with Dietitians of Canada, Canadian Paediatric Society, The College of Family Physicians of Canada and Community Health Nurses of Canada. The Public Health Agency of Canada is gratefully acknowledged for funding support. Recognition is given to the following for their contributions.

Collaborative Statement Advisory Group:

Author – Donna Secker PhD, RD, FDC, The Hospital for Sick Children, Toronto, Ontario

- Cheryl Armistead RN, MScN, Community Health Nurses of Canada [CHNC]
- Lynda Corby MSc, MEd, RD, FDC, Dietitians of Canada [DC]
- Margaret de Groh PhD, Public Health Agency of Canada [PHAC]
- Valerie Marchand MD, FRCPC Chair, Nutrition and Gastroenterology Committee, Canadian Paediatric Society [CPS]
- Leslie L Rourke MD, CCFP, MClinSc, FCFP, FAAFP, College of Family Physicians of Canada [CFPC]
- Eunice Misskey MCEd, RD, Dietitians of Canada Liaison to the Canadian Paediatric Society Nutrition and Gastroenterology Committee [DC/CPS]

We acknowledge Annie Dupuis PhD, Data Analyst in the Child Health Evaluative Services Department, The Hospital for Sick Children Research Institute for providing statistical guidance and analysis of the Canadian Regional Databases.

Dietitians of Canada Reviewers:

British Columbia Region: Catherine Atchison RD and Nicole Mireau RD on behalf of the 0-6 years subcommittee, Community Nutritionists' Council of British Columbia; Shefali Raja RD, Kristen Yarker-Edgar MSc, RD

Alberta/Territories Region: Carlota Basualdo MEd, RD; Kim Brunet MSc, RD; Debra Buffum RD; Rhonda Chartrand MEd, RD; Tanis Fenton PhD, RD; Kristyn Hall MSc, RD; Bodil Larsen PhD, RD; Diana Mager PhD, RD; Kaley Moran RD; Cheryl Ryan RD; Joan Silzer MSc, RD, IBCLC

Saskatchewan, Manitoba, NW Ontario: Eunice Misskey MCEd, RD

Southern Central Ontario: Lorrie Hagen RD; Andrea Nash MSc, RD

Quebec, Eastern, NE Ontario: Lee Rysdale MEd, RD

Atlantic Region: Claire Gaudet-LeBlanc RD; Suzanne Clair RD; Isabelle Hall RD; Renee Cool MSc, RD; Tina Swinamer MSc, PDt; Janine Woodrow PhD, RD

DC External Reviewers:

Jean-Pierre Chanoine MD; Leah Feist RN, BScN; Brenda George RN, MN, CCHN(c), IBCLC; Chantal Martineau MSc, RD; Jennifer McCrea RD

Canadian Paediatric Society Reviewers:

Canadian Paediatric Society Nutrition and Gastroenterology Committee – Jeff Critch MD, FRCPC; Manjula Gowrishankar MD, FRCPC; Valérie Marchand MD, FRCPC; Sharon L Unger MD, FRCPC; Robin C Williams MD, DPH, FRCPC; Liaisons: Genevieve Courant NP; George Davidson MD, FRCPC; Eunice Misskey MCEd, RD; Frank Greer MD, FAAP; Jennifer McCrea RD; Christina Zehaluk MSc; Consultant: Jae Hong Kim MD, FRCPC

The College of Family Physicians of Canada Reviewers:

Leslie L Rourke MD, CCFP, MClinSc, FCFP, FAAFP

Community Health Nurses of Canada Reviewers:

Cheryl Armistead RN, MScN; Ruth Schofield RN, MScN, on behalf of the Community Health Nurses Initiative Group and Childbirth Nurses Interest Group of the Registered Nurses Association of Ontario; Joanne Gilmore RN, BScN, MEd; Nancy Watters RN, BScN, MScN, IBCLC

Competing interests: The statement was developed independent of influence from commercial or other interest groups.

REFERENCES

1. de Onis M, Habicht JP. Anthropometric reference data for international use: recommendations from a World Health Organization Expert Committee. Am J Clin Nutr 1996;64. Available from: www.ajcn.org/cgi/content/abstract/64/4/650
2. Griffiths M, Dickin K, Favin M. Promoting the Growth of Children: What Works. Tool #4, World Bank Nutrition Toolkit. Washington, DC; 1996.
3. Yeung DL, Pennell MD, Leung M. Growth and development of infants in Toronto and Montreal. Can J Public Health 1982;73:278-82.
4. Farkas LG, Wood MM. Height and weight in Caucasian school children in Central Canada. Can J Public Health 1982;73:328-34.
5. Canadian Paediatric Society Indian and Inuit Health Committee. Growth charts for Indian and Inuit children. CMAJ 1987;136:118-9.
6. Guo S, Roche AF, Yeung DL. Monthly growth status from a longitudinal study of Canadian infants. Can J Public Health 1990;81:215-21.
7. Schlenker J, Ward R. Development and application of a pediatric anthropometric evaluation system. Can J Diet Prac Res 1999;60:20-6.
8. A Collaborative Statement of Dietitians of Canada, Canadian Paediatric Society, College of Family Physicians of Canada, and Community Health Nurses Association of Canada. The use of growth charts for assessing and monitoring growth in Canadian infants and children. Can J Diet Prac Res 2004;65:22-32.
9. Centers for Disease Control and Prevention. CDC Growth Charts: United States. [cited 2009 20 Mar]; Available from: www.cdc.gov/growthcharts. 2000.
10. Habicht JP, Martorell R, Yarbrough C, Malina RM, Klein RE. Height and weight standards for preschool children: how relevant are ethnic differences in growth potential? Lancet 1974;1:611-5.
11. Mei Z, Yip R, Trowbridge F. Improving trend of growth of Asian refugee children in the USA: Evidence to support the importance of environmental factors on growth. Asia Pacific J Clin Nutr 1998;7:111-6.
12. Martorell R, Medoza FS, Castillo RO. Genetic and environmental determinants of growth in Mexican-Americans. Pediatrics 1989;85:864-71.
13. Garza C, de Onis M. A new international growth reference for young children. Am J Clin Nutr 1999[cited 2009 20 Mar];70 (suppl):169S-72S. Available from: www.ajcn.org/cgi/content/full/70/1/169S
14. Kuzcmarski RJ, Ogden CK, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, Wei R, Curtin LR, Roche AF, Johnson CL. 2000 CDC growth charts for the United States: methods and development. Vital Health Stat 11. 2002 [cited 2009 20 Mar]; May; (246):1-190. Available from: www.cdc.gov/growthcharts/
15. Pinyerd BJ. Assessment of infant growth. J Pediatr Health Care 1992;6:302-8.
16. Ashworth A, Shrimpton R, Jamil K. Growth monitoring and promotion: review of evidence of impact. Maternal Child Nutr 2008;4:86-117.
17. Garner P, Panpanich R, Logan S. Is routine growth monitoring effective? A systematic review of trials. Arch Dis Child 2000 [cited 2009 20 Mar];82:197-201. Abstract available from: www.adc.bmj.com/cgi/content/abstract/82/3/197
18. Chen RS, Shiffman RN. Assessing growth patterns-routine but sometimes overlooked. Clin Pediatr 2000 [cited 2009 20 Mar];39:97-102. Abstract available from: http://cpj.sagepub.com/content/39/2/97.short
19. Bunting J, Weaver LT. Anthropometry in a children's hospital: a study of staff knowledge, use and quality of equipment. J Human Nutr Dietet 1997 [cited 2009 20 Mar];10:17-23. Abstract available from: www.ingentaconnect.com/content/bsc/jhnd/1997/00000010/00000001/art00003
20. Spencer N, Lewando-Hundt G, Kaur B, Whiting K, Hors C. Routine weight monitoring and length measurement in child health surveillance: facilities, equipment and professional knowledge. Ambulatory Child Health 1996;2:3-13.
21. Cooney K, Pathak U, Watson A. Infant growth charts. Arch Dis Child 1994;71:159-60.
22. World Health Organization. Physical Status: The Use and Interpretation of Anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series 854. Geneva: World Health Organization Tech Rep Ser 854; 1995.

23. Henry JJ. Routine growth monitoring and assessment of growth disorders. J Pediatr Health Care 1992 [cited 2009 20 Mar];6:291-301. Abstract available from: www.ncbi.nlm.nih.gov/pubmed/1453284
24. Using the CDC Growth Charts: Accurately Weighing & Measuring: Equipment. [cited 2009 20 Mar]; Available from: www.cdc.gov/growthcharts/
25. Using the CDC Growth Charts: Accurately Weighing and Measuring: Technique. 2001. [cited 2009 20 Mar]; Available from: at www.cdc.gov/growthcharts/
26. Voelker R. Improved use of BMI needed to screen children for overweight. JAMA 2007;297:2684-5.
27. Wright CM, Booth IW, Buckler JM, et al. Growth reference charts for use in the United Kingdom. Arch Dis Child 2002;86:11-4.
28. World Health Organization. A growth chart for international use in maternal and child health care: guidelines for primary health care personnel. Geneva, Switzerland: WHO; 1978.
29. Hamill PVV, Drizd TA, Johnson CL, Reed RR, Roche AF, Moore WM. Physical growth: National Center for Health Statistics Percentiles. Am J Clin Nutr 1979 [cited 2009 20 Mar];32:607-29. Available from: www.ajcn.org/cgi/reprint/32/3/607.pdf
30. CDC Growth Charts: United States. Centers for Disease Control and Prevention, 2000. [cited 2009 20 Mar]; Available from: www.cdc.gov/growthcharts.
31. The WHO Child Growth Standards. 2006. [cited March 20 2008]; Available from: www.who.int/childgrowth/standards/en/index.html
32. World Health Organization Multicentre Study Group. WHO Child Growth Standards based on length/height, weight and age. Acta Paediatr 2006 [cited 2009 20 Mar];Suppl 450:76-85. Available from: www.who.int/childgrowth/standards/Growth_standard.pdf
33. de Onis M, Onyango A, Van den Broeck J, Chumlea W, Martorell R, for the WHO Multicentre Growth Reference Study Group. Measurement and standardization protocols for anthropometric used in the construction of a new international growth reference. Food and Nutrition Bulletin 2004;25:S27-36.
34. de Onis M, Garza C, Victora C, et al. The WHO Multicentre Growth Reference Study: Planning, study design, and methodology. Food and Nutrition Bulletin 2004;25:S15-26.
35. World Health Organization. Global Strategy for Infant and Young Children Feeding. Optimal Duration of Exclusive Breastfeeding. 2001. Geneva. [cited 2008 11 Mar]. Available from: www.who.int/nutrition/publications/infantfeeding/optimal_duration_of_exc_bfeeding_review_eng.pdf
36. WHO Multicentre Growth Reference Study Group. Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study. Acta Paediatrica 2006[cited 2009 20 Mar];95:56-65. Available from: www.who.int/childgrowth/standards/Difference_linear_growth.pdf
37. WHO Anthro for personal computer, version 2: Software for assessing growth and development of the world's children. Geneva: WHO. [cited 2009 20 Mar]. Available from: www.who.int/entity/childgrowth/software/who_anthro_pc.pdf
38. Horta B, Bahl R, Martines J, Vicora C. Evidence of the long-term effects of breastfeeding: Systematic reviews and meta-analyses. Geneva. Switzerland: Department of child and Adolescent Health and Development, World Health Organization 2007. [cited 2009 20 Mar]. Available from: www.who.int/child_adolescent_health/documents/9241595230/en/index.html
39. Ip S, Chung M, Raman G, et al. Breastfeeding and Maternal and Infant Health Outcomes in Developed Countries. Evidence Report/Technology Assessment No. 153 (Prepared by Tufts-New England Medical Center Evidence-based Practice Center, under Contract No. 290-02-0022). AHRQ Publication No. 07-E007. Rockville, MD.
40. Kramer MS, Matush L, Vanilovich I, et al. Effects of prolonged and exclusive breastfeeding on child height, weight, adiposity, and blood pressure at age 6.5 y: evidence from a large randomized trial. Am J Clin Nutr 2007 [cited 2009 20 Mar];86:1717-21. Available from: www.ajcn.org/cgi/reprint/86/6/1717
41. Michels K, Willet W, Graubard B et al. A longitudinal study of infant feeding and obesity throughout life course. Int J Obes 2007 [cited 2009 20 Mar]; 24 Apr. Available from: www.nature.com/ijo/journal/v31/n7/full/0803622a.html

42. Exclusive Breastfeeding Duration: 2004 Health Canada Recommendation. 2004. [cited 2009 20 Mar]. Available from: www.hc-sc.gc.ca/fn-an/nutrition/infant-nourisson/excl_bf_dur-dur_am_excl-eng.php

43. Dewey KG, Peerson JM, Brown KH, et al. Growth of breast-fed infants deviates from current reference data: a pooled analysis of US, Canadian, and European data sets. World Health Organization Working Group on Infant Growth. Pediatrics 1995 [cited 2009 20 Mar];96:495-503. Abstract available from: www.ncbi.nlm.nih.gov/pubmed/7651784

44. WHO Multicentre Growth Reference Study Group. Breastfeeding in the WHO Multicentre Growth Reference Study. Acta Paediatr 2006 [acited 2009 20 Mar] Suppl 450: 16-26. Available from: www.who.int/childgrowth/standards/Breastfeeding.pdf

45. de Onis M, Garza C, Onyango A, Borghi E. Comparison of the WHO child growth standards and the CDC 2000 growth charts. J Nutr 2007 [cited 2009 20 Mar];137:144-8. Available from: http://jn.nutrition.org/cgi/content/full/137/1/144

46. WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. Geneva: World Health Organization. 2006. [cited 2009 20 Mar]; Available from: www.who.int/childgrowth/standards/technical_report/en/index.html

47. Wang Y, Morena LA, Caballero B, Cole TJ. Limitations of the current World Health Organization growth references for children and adolescents. Food Nutr Bull 2006; 27 (4): S175-88.

48. Onyango A, de Onis M, Caroli M, et al. Field-testing the WHO Child Growth Standards in four countries. J Nutr 2007 [cited 2009 20 Mar];137:149-52. Available from: http://jn.nutrition.org/cgi/reprint/137/1/149.pdf

49. Butte N, Garza C, de Onis M. Evaluation of the feasibility of international growth standards for school-aged children and adolescents. J Nutr 2006 [cited 2009 20 Mar];137:153-7. Available from: http://jn.nutrition.org/cgi/content/full/137/1/153

50. Butte Nr, Garza C, Ed. Development of an international growth standard for preadolescent and adolescent children. Food Nutr Bull 2006; 27 (4): S169-326.

51. de Onis M, Onyango A, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bulletin of the World Health Organization 2007 [cited 2009 20 Mar];85:660-7. Available from: www.who.int/bulletin/volumes/85/9/07-043497/en/

52. WHO AnthroPlus for personal computers Manual: Software for assessing growth of the world's children and adolescents. Geneva: WHO, 2009. [cited 2009 20 Mar]; Available from: www.who.int/growthref/tools/en/

53. Lau D, Douketis J, Morrison K, et al. 2006 Canadian clinical practice guidelines on the management and prevention of obesity in adults and children. CMAJ 2007 [cited 2009 20 Mar];176:Online-1-117. Available from: www.cmaj.ca/cgi/content/full/176/8/S1

54. Whitaker RC, Wright JA, Pepe MS, Seider KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. N Engl J Med 1997 [cited 2009 20 Mar];337:869-73. Available from: http://content.nejm.org/cgi/content/full/337/13/869

55. Guo SS, Chumlea Wc. Tracking BMI in children in relation to overweight in adulthood. Am J Clin Nutr 1999 [cited 2009 20 Mar]; 70(suppl);145S-8S. Available from: www.ajcn.org/cgi/reprint/70/1/145S?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&author1=Guo&fulltext=BMI+children&searchid=1&FIRSTINDEX=0&sortspec=relevance&resourcetype=HWCIT

56. Wadden T, Stunkard A. Social and psychological consequences of obesity. Ann Intern Med 1985; 103:1062-7.

57. Wright JA, Ashenburg CA, Whitaker RC, Comparison of methods to categorize undernutrition in children. The Journal of Pediatrics 1994 [cited 2009 20 Mar]; 124: 944-6. Abstract available from: www.ncbi.nlm.nih.gov/pubmed/8201483?dopt=Abstract

58. Olsen EM, Petersen J. Skovgaard AM, Weile B, Jorgensen T, Wright CM. Failure to thrive: the prevalence and concurrence of anthropometric criteria in a general infant population. Arch Dis Child 2007 [cited 2009 20 Mar]; 92: 109-114. Abstract available from: http://adc.bmj.com/cgi/content/abstract/92/2/109

59. Mei Z, Grummer-Strawn LM, Pictrobelli A, Goulding A, Goran MI, Dietz WH. Validity of body mass index compared with other body-composition screening indexes for the assessment of body fatness in children and adolescents. Am J Clin Nutr 2002 [cited 2009 20 Mar]; 75: 978-85. Available from: www.ajcn.org/cgi/content/full/75/6/978

60. Zhang Z, Lai HJ. Comparison of the use of body mass index percentiles and percentage of ideal body weight to screen for malnutrition in children with cystic fibrosis. Am J Clin Nutr 2004 cited 2009 20 Mar];80:982-91. Available from: www.ajcn.org/cgi/content/full/80/4/982

61. Cole T. Body mass index cut offs to define thinness in children and adolescents: international survey. BMJ 2007;doi:10.1136/bmj.39238.39944455.

62. Cole TJ, Freeman JV. Preece Ma. Body mass index reference curves for the UK. 1990. Arch Dis Child 1995; 73(1): 25-9.

63. vant Hof MA, Haschke F. Euro-Growth references for body mass index and weight for length. Eur-Growth Study Group. J. Pediatr Gastroenterol Nutr. 2000; 31 Supp 1: S48-959.

64. United States Department of Health and Human Services. Maternal and Child Health Bureau. Using the CDC Growth Charts: Accurately Weighing & Measuring: Equipment. Electronic training module. [cited 2009 20 Mar]. Available from: www.cdc.gov/growthcharts/. 2001

65. United States Department of Health and Human Services. Maternal and Child Health Bureau. Using the CDC Growth Charts: Accurately Weighing and Measuring: Technique. Electronic training module. [cited 2009 20 Mar]. Available from: www.cdc.gov/growthcharts/. 2001

66. Klein S, Kinney J, Jeejeebhoy K, et al. Nutrition support in clinical practice: review of published data and recommendations for future research directions. Summary of a conference sponsored by the National Institutes of Health, American Society for Parenteral and Enteral Nutrition, and American Society for Clinical Nutrition. JPEN 1997;21:133-56.

67. Flegal KM, Wei R, Ogden C. Weight-for-stature compared with body mass index-for-age growth charts for the United States from the Centers for Disease Control and Prevention. Am J Clin Nutr 2002 [cited 2009 20 Mar];75:761-6. Available from: www.ajcn.org/cgi/content/full/75/4/761

68. Poustie VJ, Watling RM, Ashby D, Smyth RI. Reliability of percentage ideal weight for height. Arch Dis Child 2000; 83: 183-4.

69. Philips S, Edibeck A, Kirby M. Goday P. Ideal body weight in children. Nutr Clin Prac 2007; 22: 240-5.

70. Barlow S, and the Expert Committee. Expert Committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. Pediatrics 2007 [cited 2009 20 Mar];120:S164-92. Available from: http://pediatrics.aappublications.org/cgi/content/full/120/Supplement_4/S164

71. Mei Z, Ogden CK, Flegal KM, Grummer-Strawn LM. Comparison of the prevalence of shortness, underweight and overweight among US children aged 0 to 59 months by using the CDC 2000 and the WHO 2006 growth charts. J Pediatr 2008 [cited 2009 09 Sept]; 153: 622-8. Available from: www.jpeds.com/article/S0022-3476(08)00478-2/abstract

72. Kramer MS, Platt RW, Wen SW, et al. A new and improved population-based Canadian reference for birth weight for gestational age. Pediatrics 2001[cited 2009 20 Mar];108(2):e35. Available from: http://pediatrics.aappublications.org/cgi/content/full/108/2/e35

73. Collaborative Statement Advisory Group. Determining the Best Use of WHO Growth Standards and Growth References Within the Canadian Context. Technical Report and Recommendations. March, 2008. [cited 2009 20 Mar]. Available from: www.dietitians.ca/news/highlights_positions.asp

74. United States Department of Health and Human Services. Centers for Disease Control and Prevention. Epidemiology Program Office. Division of Public Health Surveillance and Informatics. NutStat: A nutritional anthropometry program. Epi InfoTM Version 3.2.2. [cited 2009 20 Mar]; Available from: www.cdc.gov/epiinfo/MANUAL/NutStat.htm. 2005

75. Wright C, Lakshman R, Emmett P, Ong KK. Implications of adopting the WHO 2006 Child Growth Standard in the UK: two prospective cohort studies Arch Dis Child 2008 [cited 2009 20 Mar]; July 93(7):549-51. Abstract available from: www.ncbi.nlm.nih.gov/pubmed/17908712

76. Application of the WHO Child Growth Standards in the UK. Report prepared by the Joint SACN/RCPCH Expert group on Growth Standards. August 2007. [cited 2009 20 Mar]. Available from: www.rcpch.ac.uk/doc.aspx?id_resource=2862
77. Nash A, Secker D, Corey M, Dunn M, O'Connor D. Field testing of the 2006 World Health Organization growth charts from birth to 2 years: assessment of hospital undernutrition and overnutrition rates and the usefulness of BMI. J Parenter Enteral Nutr 2008;32:145-53.
78. van Dijk CE, Innis SM. Growth-curve standards and the assessment of early excess weight gain in infancy. Pediatrics 2009 [cited 2009 20 Mar]; 123:102-8. Abstract available from: http://pediatrics.aappublications.org/cgi/content/abstract/123/1/102
79. Sherry B, Mei Z, Grummer-Strawn L, Dietz WH. Evaluation of and Recommendations for Growth References for Very Low Birth Weight (‹=1500 Grams) Infants in the United States. Pediatrics 2003 [cited 2009 20 Mar];111:750-8. Available from: http://pediatrics.aappublications.org/cgi/content/full/111/4/750
80. Casey PH, Kraemer HC, Bernbaum J, Yogman MW, Sells CJ. Growth status and growth rates of a varied sample of low birth weight, preterm infants: A longitudinal cohort from birth to three years of age. J Pediatr 1991;119:599-605.
81. Fenton TR. A new growth chart for preterm babies: Babson and Benda's chart updated with recent data and a new format. BMC Pediatrics 2003 [cited 2009 20 Mar];3. Available from: www.biomedcentral.com/1471-2431/3/13
82. Rao S, Tompkins J. Growth curves for preterm infants. Early Hum Dev 2007;83:643-51.
83. The Infant Health and Development Program. Enhancing the outcomes of low-birth-weight, premature infants. JAMA 1990;263:3035-42.
84. Wang Z, Sauve RS. Assessment of post neonatal growth in VLBW infants: selection of growth references and age adjustment for prematurity. Can J Public Health 1998;89:109-14.
85. Cronk C, Crocker AC, Pueschel SM, et al. Growth charts for children with Down syndrome: 1 month to 18 years of age. Pediatrics 1988 [cited 2009 20 Mar];81:102-10. Abstract available from: http://pediatrics.aappublications.org/cgi/content/abstract/81/1/102
86. Scott BJ, Artman H, Hill LA. Monitoring growth in children with special health care needs. Top Clin Nutr 1997;13:33-52.
87. Krick J, Murphy-Miller P, Zeger. S, E W. Pattern of growth in children with cerebral palsy. J Am Diet Assoc 1996;96:680-5.
88. Lyon AJ, Preece MA, Grant DB. Growth curve for girls with Turner's syndrome. Arch Dis Child 1985; 60: 932-5.
89. Samson-Fang LJ, Stevenson RD. Identification of malnutrition in children with cerebral palsy: poor performance of weight-for-height centiles. Dev Med and Child Neurol 2000;42:162-8.
90. Beaton G, Kelly A, Kevany J, Martorell R, Mason J. Appropriate uses of anthropometric indices in children: a report based on an ACC/SCN Workshop: United Nations Administrative Committee on Coordination/Subcommittee on Nutrition; 1990 December 1990. Report No.: ACC/SCN State-of-the art series Nutrition Policy Discussion Paper No. 7.
91. Mei Z, Grummer-Strawn L, Thompson D, Dietz W. Shifts in percentiles of growth during early childhood: analysis of longitudinal data from the California Child Health and Development Study. Pediatrics 2004 [cited 2009 09 Sept];113:e617-e27. Available from: http://pediatrics.aappublications.org/cgi/content/full/113/6/e617
92. Smith DW, Truog W, McCann JJ, et al. Shifting linear growth during infancy and the genetics of growth in infancy. J Pediatr 1976;89:225-30.
93. Hilliard RI. Nutrition Problems in Childhood. In: Feldman W, ed. Evidence-Based Pediatrics. Hamilton: B.C. Decker Inc; 2000:65-82.
94. World Health Organization. Training Course on Child Growth Assessment . [cited 2009 20 Mar]. Available from: www.who.int/childgrowth/training/en/; 2006
95. Prentice A. Body mass index standards for children. BMI 1998;317:2401-2.
96. Bellizzi MC, Dietz WH. Workshop on childhood obesity: summary of the discussion. Am J Clin Nutr 1999 [cited 2009 20 Mar];70:173-5S. Available from: www.ajcn.org/cgi/content/full/70/1/173S
97. Maynard LM, Wisemandle W, Roche A.F, Chumlea WC, Guo SS, Siervogel RM. Childhood body composition in relation to body mass index. Pediatrics 2001 [cited 2009 20 Mar];107:344-50. Available from: http://pediatrics.aappublications.org/cgi/reprint/107/2/344

98. Rogol AD, Clark PA, Roemmich JN. Growth and pubertal development in children and adolescents: effects of diet and physical activity. Am J Clin Nutr 2000 [cited 2009 20 Mar];72:521S-8S. Available from: www.ajcn.org/cgi/reprint/72/2/521S

99. Daniels SR, Khoury PR, Morrison JA. The utility of body mass index as a measure of body fatness in children and adolescents: differences by race and gender. Pediatrics 1997 [cited 2009 20 Mar];99:804-7. Abstract available from: http://pediatrics.aappublications.org/cgi/content/abstract/99/6/804

100. Hubbard SV. Defining overweight and obesity: what are the issues? Am J Clin Nutr 2000 [cited 2009 20 Mar];72:1067-8. Available from: www.ajcn.org/cgi/reprint/72/5/1067

101. Sachs M, Dykes F, carter B. Feeding by numbers: an ethnographic study of how breastfeeding women understand their babies' weight charts. Int Breastfeed J 2006 [cited 2009 20 Mar]; Dec 22; 1:29. Available from: www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1779265

102. Centers for Disease Control and Prevention. Using the CDC Growth Charts for Children with Special Health Care Needs. Electronic training module. 2002 [cited 2009 20 Mar]. Available from: www.cdc.gov/growthcharts