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Comparison of the 2005 growth charts for Saudi children and adolescents to the 2000 CDC growth charts

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BACKGROUND AND OBJECTIVES: The 2000 CDC growth charts for the United States, a revision of the National Center for Health Statistics/World Health Organization (NCHS/WHO) growth charts, were released in 2002 to replace the NCHS/WHO charts. We evaluated the differences between the CDC growth charts and the Saudi 2005 reference to determine the implications of using the 2000 CDC growth charts in Saudi children and adolescents.

SUBJECTS AND METHODS: The Saudi reference was based on a cross-sectional representative sample of the Saudi population of healthy children and adolescents from birth to 19 years of age. Measurements of the length/stature, weight and head circumference were performed according to expert recommendations. The CDC charts from birth to 20 years were based on a cross-sectional representative national sample from five sources collected between 1963 and 1994. The data from the CDC study including the 3rd, 5th, 50th, 95th, and 97th percentiles were plotted against the corresponding percentiles on the Saudi charts for the weight for age, height for age, weight for height for children from 0 to 36 months and weight for age, stature for age and body mass index for children 2 to 19 years of age.

RESULTS: There were major differences between the two growth charts. The main findings were the upward shift of the lower percentiles of the CDC curves and the overlap or downward shift of the upper percentiles, especially for weight, weight for height, and BMI.

CONCLUSIONS: The use of the 2000 CDC growth charts for Saudi children and adolescents increases the prevalence of undernutrition, stunting, and wasting, potentially leading to unnecessary referrals, investigations and parental anxiety. The increased prevalence of overweight and obesity is alarming and needs further investigation.

Growth parameters in the form of weight for age, height for age, weight for height and body mass index (BMI) are important tools for the assessment of the nutritional status of children. Many countries have established their own reference growth charts for children and adolescents.[1-3] In Saudi Arabia, the National Center for Health Statistics (NCHS) growth charts are commonly used, based on the recommendation of the World Health Organization (WHO).[4] A survey based on a nationally representative sample of Saudi children younger than 5 years of age was completed in 1995.[5] The results of that study, as well as others,[6-8] pointed out important differences with the NCHS reference.[9] The recognition of the limitations of the NCHS/WHO reference led to a major revision, addressing most of the deficiencies and resulting in the development and release of the Centers for Disease Control (CDC) growth chart reference for the United States in 2002.[10] Similarly, a nutritional survey to establish a national growth chart for healthy Saudi children and adolescents from birth to 19 years of age was completed in 2005 and reported in 2007.[11] Because of the widespread use of the 2000 CDC growth charts in hospitals and clinics in Saudi Arabia, this report provides a comparison of the new Saudi reference with the CDC charts, emphasizing the implications of the continued use of the 2000

CDC growth charts for the assessment of the nutritional status of Saudi children and adolescents.

SUBJECTS AND METHODS

The details of the design and methodology of the 2005 Saudi study have been reported elsewhere.[11] Briefly, well-established guidelines and criteria were followed in the determination of the sample size.[12] The study sample was selected by multi-stage probability sampling procedure from a stratified listing based on the population census available at the time of the study. Accordingly, the sample is representative of all the socioeconomic strata and consists of a majority of children with prolonged mixed breast and milk formula feedings. A pilot study was designed to test all components of the project before the data collection and workshop training for the members of the field teams was conducted in each of the 13 regions of Saudi Arabia. Data collection was made by house-to-house visits where primary care physicians and nurses completed a survey questionnaire, clinical examination and body measurements. After correcting or deleting incomplete and inaccurate data, a statistical analysis was performed using the lambda-mu-sigma (LMS) methodology.[13-15]

The details of the methods and development of the 2000 CDC growth charts were reported in 2002[10] and are available on the CDC website (*www.cdc.gov/growthcharts*). Briefly, the study sample was cross-sectional and representative of the US population. It was drawn from five sources. The main sources came from two national surveys: NHANES II (1976-1980) and NHANES III (1988-1994). Because these surveys did not collect data from birth to 2-3 months, supplementary data was needed for this age group. The latter consisted of data from the US vital statistics birth certificates and from the Pediatric National Surveillance System (PedNSS). The data were analyzed using the LMS statistical methods. For comparison of the growth patterns in boys and girls in both studies, the 3rd, 5th, 50th, 95th, 97th percentiles were selected for the weight for age, length for age and weight for length from birth to 36 months, and weight, stature and body mass index for age for the 2-19 years age groups.

RESULTS

Details of the socioeconomic status of the families in the Saudi study were reported elsewhere.[11,16] In brief, 73% of the households in the study sample were in urban settlements. Most of the families (69%) lived in owned houses. About 50% of the heads of households had completed at least 12 years of education. The gestational age of the children was estimated by a history taken from

mothers. All children with a gestational age younger than 8 months (0.9%) were excluded from body measurements. Similarly, low birthweight children (<2.5 kg, 3.2%) were excluded. A history of breastfeeding was positive in 91.6% of the children younger than 3 years of age and the first breastfeed was started between birth and 3 hours in 50.5% of the children. In addition to breast milk, formula feeding was started between 1 to 2 months in 52% of the children and solid food was introduced between 4 to 6 months in 81.9% of the children.

The 0 to 36 months age group

Comparison of the weight for age percentiles is depicted in Figure 1a for boys and Figure 1b for girls. For boys, there was an overlap of the lower percentiles (3rd, 5th) and the higher percentiles (95th, 97th) in the first 3 and 8 months of age, respectively, followed by a gradual upward shift of the CDC curves across all percentiles. The pattern of change in the length for age is presented in Figure 2a for boys and Figure 2b for girls. For boys, there was an upward shift of the CDC lower percentiles starting early by the end of the first month of age and gradually increasing with age. The pattern in the higher percentiles indicates an overlap during the first 3 months, followed by a mild downward shift up to 30 months, where an overlap occurs again. Comparison of the weight for length is shown in Figure 3a for boys and Figure 3b for girls. For boys, there was a marked upward shift of the CDC lower percentiles for all age groups. For the higher percentiles, after an overlap in the first 56 cm, a downward shift continued. The pattern of weight for age, height for age and weight for height variations for girls was similar to that of boys (Figures 1b, 2b, 3b).

The 2 to 19 years age group

Comparision of the weight for age curves shows a continuation of the upward shift of the lower percentiles of the CDC curves as shown in Figure 4a for boys and Figure 4b for girls. For boys, however, the upward shift of the upper percentiles gradually decreases to overlap between 13 to 16 years of age. For the stature for age, there is a continuation of the upward shift of the lower percentiles for boys in the CDC curves with a gap increasing with age. The higher percentiles, however, show a mild downward shift up to 7 years of age when the shift takes an upward direction that increases with age (Figures 5a for boys and 5b for girls). Finally, the pattern of body mass index for age is shown in Figure 6a for boys and 6b for girls. For boys, the 85th percentiles show an overlap of the CDC curves up to 4 years of age, then upward from 4 to 8 years and a gradual downward shift from 9 to 19 years. The 95th percentiles, however,
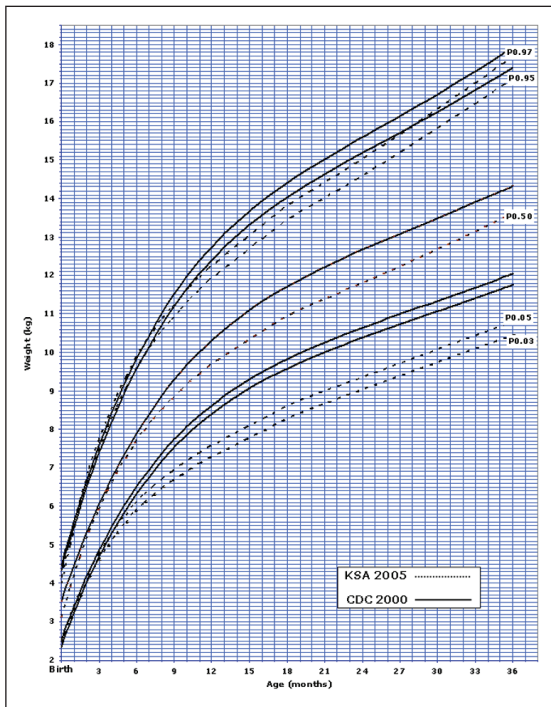
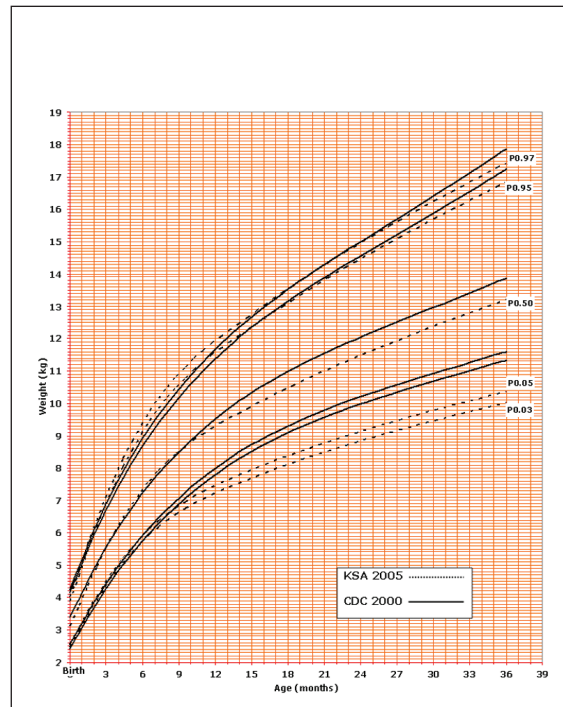**Figure 1a.** Weight for age percentiles for 0 to 36 months for boys.

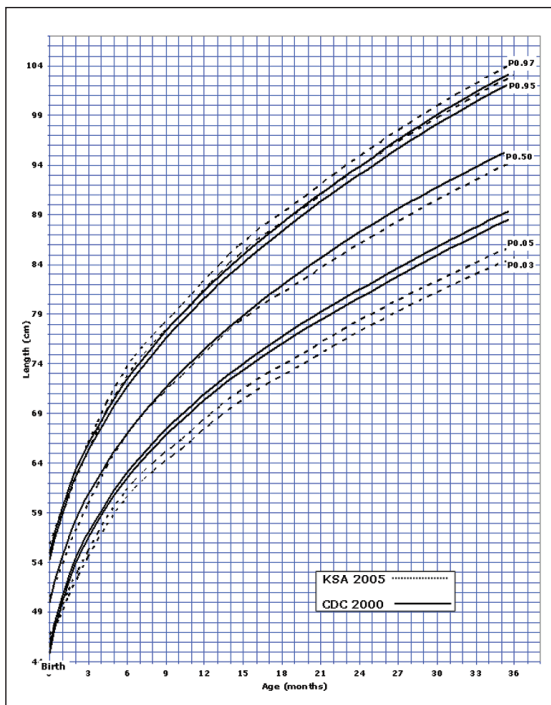**Figure 1b.** Weight for age percentiles for 0 to 36 months for girls.

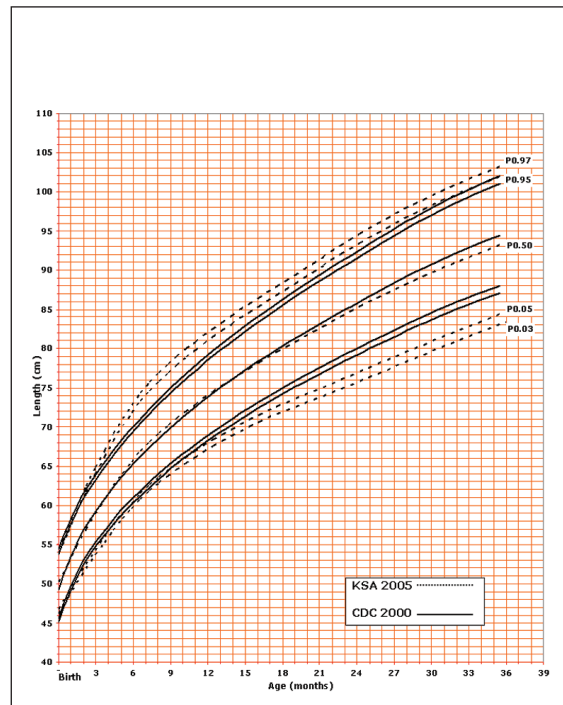**Figure 2a.** Height for age percentiles for 0 to 36 months for boys.

Figure 2b. Height for age percentiles for 0 to 36 months for girls.

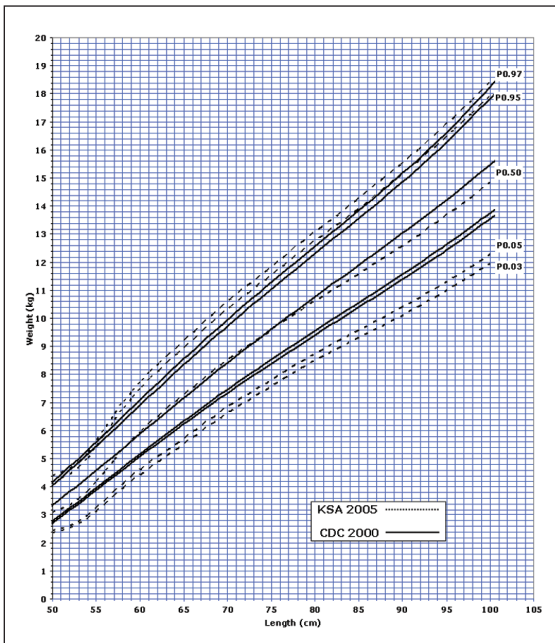Curves represent 3rd, 5th, 50th, 95th and 97th percentiles.

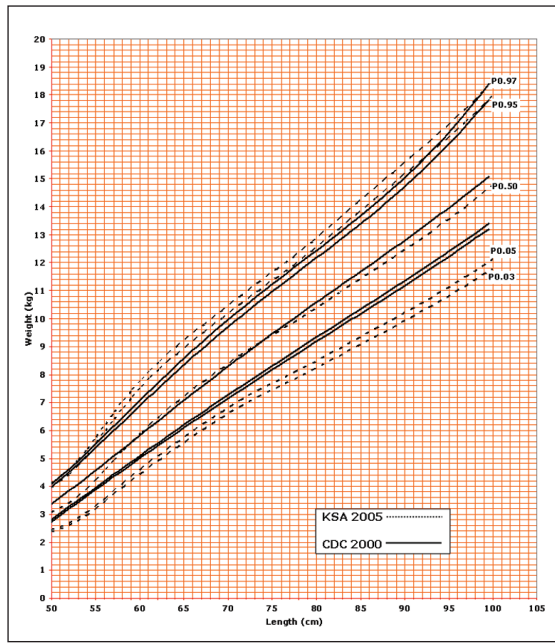**Figure 3a.** Weight for height percentiles for 0 to 36 months for boys.

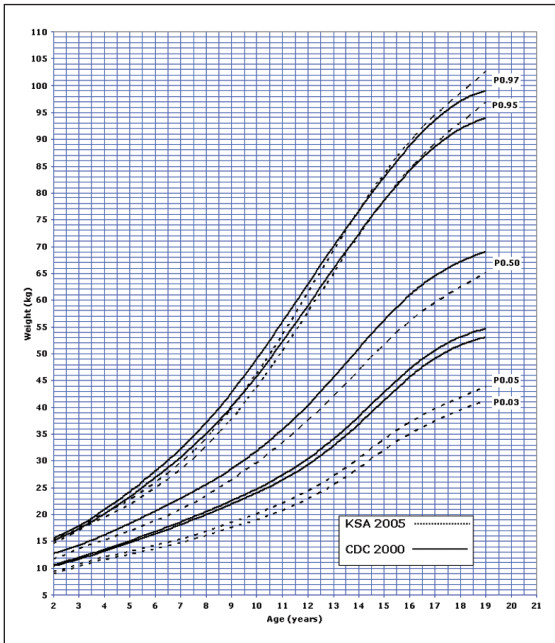**Figure 3b.** Weight for height percentiles for 0 to 36 months for girls.

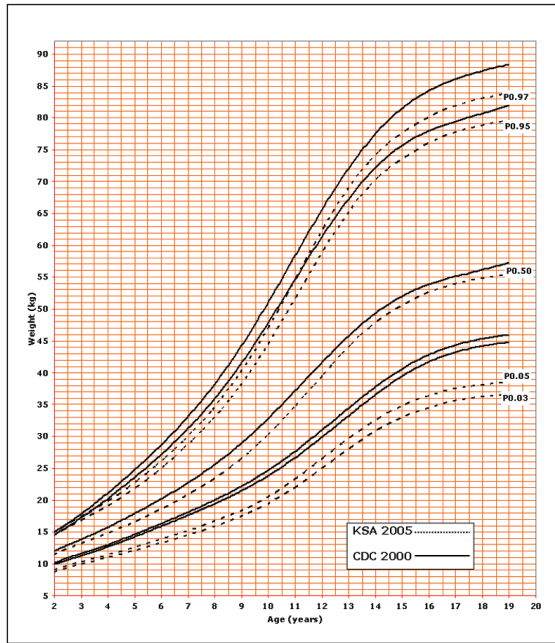**Figure 4a.** Weight for age percentiles for 2 to 19 years for boys.

Figure 4b. Weight for age percentiles for 2 to 19 years for girls.

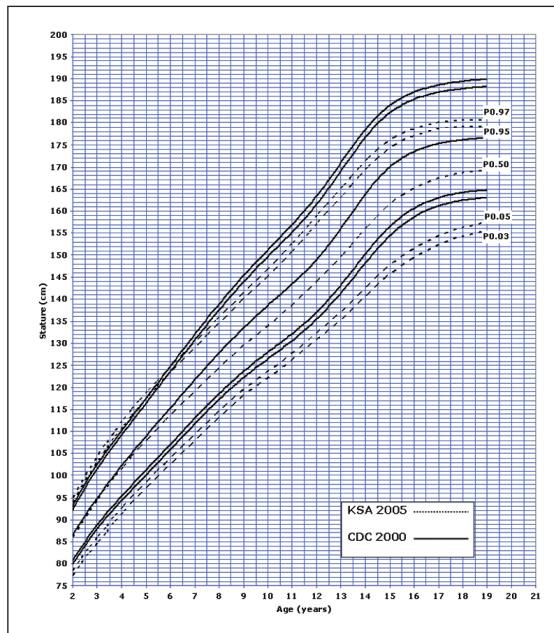Curves represent 3rd, 5th, 50th, 95th and 97th percentiles.

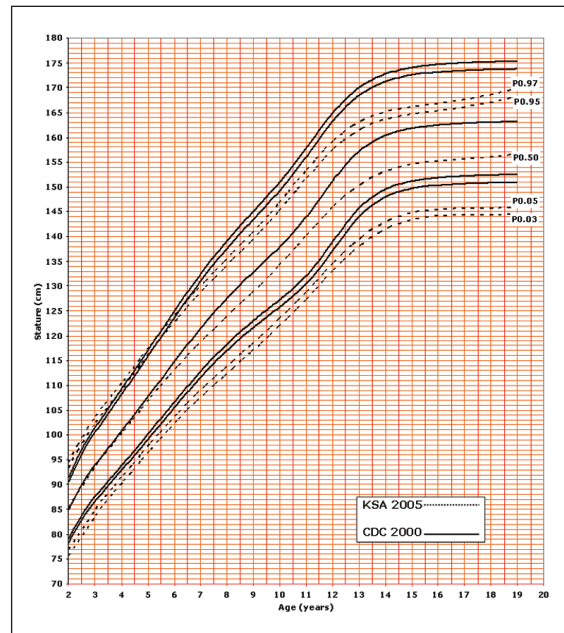**Figure 5a.** Stature for age percentiles for 2 to 19 years for boys.

Figure 5b. Stature for age percentiles for 2 to 19 years for girls.
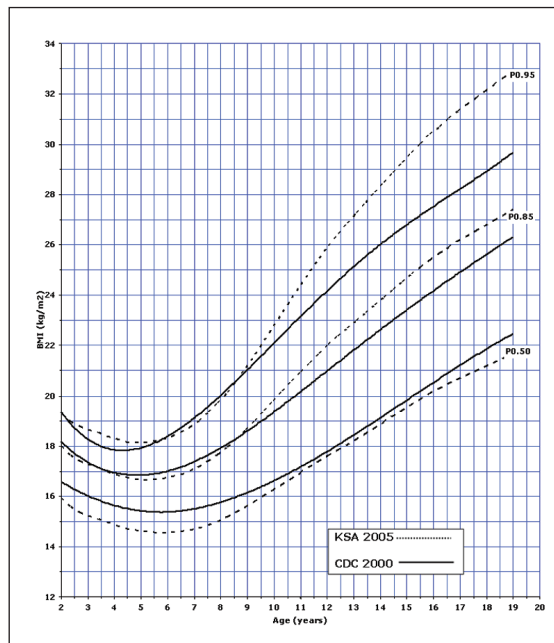

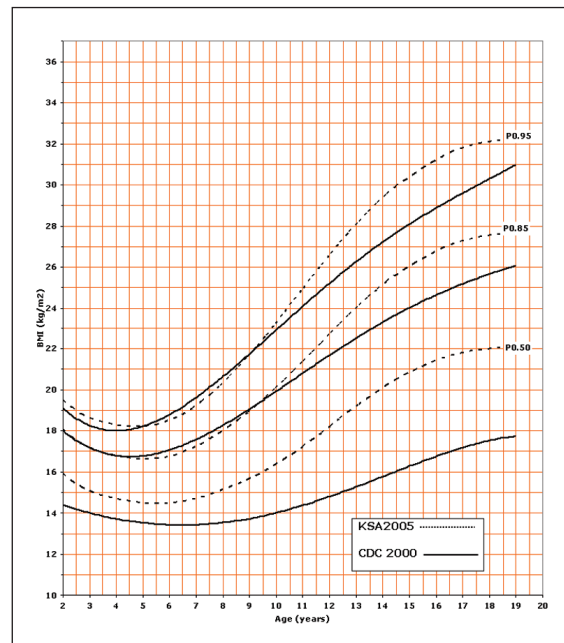**Figure 6a.** Body mass index percentiles for age 2 to 19 years for boys.

Figure 6b. Body mass index percentiles for age 2 to 19 years for girls.

Curves represent 3rd, 5th, 50th, 95th and 97th percentiles.

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show three changes in the direction of the shift of the CDC curves. An initial downward shift until 5.5 years, an upward shift from 6 to 9 years and an increasing downward shift from 9 to 19 years. Apart from small variations, the pattern and direction of shifts for girls (Figures 4b, 5b, 6b) are similar to those of boys.

DISCUSSION

It is well-known that the growth of children as assessed by anthropometric measurements is affected by a combination of genetic and environmental factors. Although studies suggest a minimal role of genetic factors,[17-19] ethnic variations both between individuals and populations cannot be excluded.[20] In most developing countries it is thought that environmental factors in the form of frequent infections and inadequate food are the main causes of growth deficiency in children. However, in others, like Saudi Arabia, improvement in socioeconomic status over the last several decades led to an abundance of food. The improvement of the health of the population in general has lead to improved nutrition.

It is important to discuss the difference between the sample used by the CDC and the Saudi sample: first, the socioeconomic status of the CDC sample is assumed to be higher, thereby affecting the prevalence of underweight, stunting and wasting. Second, there is a difference in the prevalence of breastfeeding. The prevalence of breastfeeding in the CDC sample is proportional to that in the general population at the time. It has been reported that in the two decades preceeding the report, about 50% of all infants received some breast milk and about 1/3 were breastfed for 3 months or more.[21] In contrast, the feeding and nutritional history of Saudi young children indicate that most infants received breast milk and that solid food was started within the appropriate age. The high prevalence of breastfeeding in our sample is supported by two recent surveys from Saudi Arabia indicating a predominence of mixed breastfeeding.[22,23] It is therefore clear that, compared to the CDC, more children in the Saudi sample received breast milk. The known slower growth of breastfed infants may explain some of the slower growth in the lower percentiles of the Saudi reference.

The quality of our sample has been evaluated by means of multiple frequency analysis and use of the anthroprogram and all errors have been corrected or deleted before statistical analysis. Summary statistics showed that standard deviations of the three indices Z score (weight for age, height for age and weight for height) were between 0.92 and 1.03, indicating high quality data.[24,25] Finally, the statistical methodology is similar, excluding any effect on the observed variations.

This report demonstrates important differences between the CDC and the Saudi reference showing that they vary according to the age, growth indicator and percentile. The upward shift of the lower percentiles of the CDC is more expected than the downward shift or even the overlap of the higher percentiles. The latter possibly reflects the increasing overweight and obesity in our population probably as a result of a more sedentary lifestyle with less physical activity and poor dietary habits. In a recent study, the proportion of obese schoolboys jumped from 3.4% in 1988 to 24.5% in 2005.[26]

In conclusion, there are important differences between the 2000 CDC and the new Saudi growth charts. The implications of using the CDC growth charts for Saudi children are considerable. The upward shift of the lower percentiles of the CDC curves for weight for age, length for age and weight for length results in an increased prevalence of undernutrtion, stunting and wasting potentially leading to unnecessary referrals, investigations and parental anxiety. In addition, the overlap and downward shifts of the higher percentiles, especially for the weight, weight for height and BMI are alarming to the increasing overweight and obesity in Saudi children and adolescents.

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