# Growth Charts in an Ethnically Diverse Refugee Population

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D. Taylor Williams

## Introduction

Patient EP is a 9-year-old female who presents to clinic for a three-month follow-up visit for weight gain. She is a refugee who came to the United States with her family from a refugee camp in Thailand, and she belongs to the Karen ethnic minority group, one of many ethnic minorities in Thailand and Myanmar. Many such families were forced to leave their homes and seek safety due to direct military attacks from the Burmese military regime, destruction of homes and crops, or forced labor.[1] Like many refugee families from around the world, her family came to the United States from a vastly different cultural background – adapting to the U.S. healthcare system is just one of the many difficult adjustments to be made during the years following arrival here. EP has been in a local school for a few years now and can communicate well in English, but for her mother who brings her to this clinic visit, interpretation is provided through a telephone service.

"Do you know why your daughter is here today?" As the interpreter relays the question in her native Karen language, EP's mother glances toward EP to make sure she's not looking, furtively motions to her arm as if receiving a shot, and responds as causually as she can, "Just a routine checkup, right?" The truth is, EP is not here to receive any shots nor really for a routine checkup, but this visit is specifically for a weight and growth check. Her mother had expressed concern about her growth several months prior, and by standardized growth metrics, EP has been measuring small. Although she eats a full and balanced diet, is very active with lots of energy, and mom expresses no concerns about her daughter's health on this visit, it's hard to ignore the fact that EP measures at the 3rd percentile by weight and the 2nd percentile by height for girls her age according to the CDC 2-20 years data.

Her story prompts the questions: can the growth charts from the CDC data be applied broadly to all patients, including refugee populations from around the world? If not, are there other growth charts by which such patients should be evaluated?

## Brief History of Growth Charts

Even prior to the generalized use of growth charts in the U.S., people have been interested in tracking growth patterns, dating back as early as the 18th century to the first serial recordings of growth and the creation of growth charts.[2] Since 1977, a regular part of most pediatric and adolescent visits to a U.S. doctor's office has been measurement of the height and weight, with subsequent plotting of the data onto a growth curve.[3] These standardized measures have consistently been used to assess childrens' growth and to screen for nutritional, environmental, or pathological deterrents of the child's health.

Some revisions have been made to growth charts over time to more accurately represent the population or to align more directly with recommendations regarding healthy practices. The CDC adjusted growth charts in the year 2000 to reflect new nationally representative survey data and add BMI charts, and the WHO adopted new growth charts for children from birth to five years old in 2006. Regarding the new WHO standard, the Multicentre Growth Reference Study states that it "breaks new ground by describing how children *should* grow when not only free of disease but also when reared following healthy practices such as breastfeeding and a non-smoking environment."[4] It additionally states that it "is also unique because it includes children from around the world: Brazil, Ghana, India, Norway, Oman and the USA."[4] The CDC currently recommends that health care providers use the WHO growth standards to monitor infants and children ages 0 to 2 years of age and the CDC growth charts for children age 2 years and older in the U.S.[5]

## Benefits and Possible Risks of Growth Charts

The purpose of growth monitoring in children is to have an objective way to evalute growth parameters in comparison to the population, revealing deviations from the expected pattern. Slow or rapid growth may indicate an underlying medical condition, a genetic disorder, poor nutrition, abuse, neglect, recurrent infectious disease, or presence of a chronic disease. When detected early, some of these causes can be reversed or alleviated with interventions that allow the child to maximize his or her growth and development potential. While all of the causes mentioned above are especially pertinent for the refugee population, one of the major considerations in evaluating refugee growth is the possibility of malnutrition. A 2014 survey of refugees from Syria showed a statistically significant increased prevalance of chronic malnutrition (stunting) in children in the refugee camp compared to those outside the camp. The report suggested, "Nutrition policies aimed at ensuring optimal child and maternal micronutrient status and addressing the underlying risk factors for anemia, especially among

refugees in camps, are likely to result in improved health outcomes."[6] Many have pointed to malnutrition as the primary responsible cause for growth differences in refugee populations, which if corrected will also correct growth differentials among ethnic groups. Growth charts allow one way to monitor for this possibility.

Not all positive screenings will reveal a reversible cause of growth abnormalities. The CDC Methods and Development explanation of the 2000 Growth Charts states, "A variety of health conditions such as Down syndrome, cerebral palsy, Turner syndrome, and others affect growth status. There are specialized charts that may be considered for use with children affected by these conditions."[7] Thus, even for those who may not have a reversible cause of growth impairment, specialized charts can still provide a means of following expected growth patterns and can be a benefit to the patient.

The risks of growth monitoring are largely social and economic, and they are the risks of any screening test. Once the test has been done, or the growth parameters measured, the clinician is left with a decision whether or not to act based on the result. Treatment decisions are often influenced by the clinician's personal philosophy regarding how aggressively to pursue interventions. The risk to patients may include the financial burden of unnecessary workup and the emotional distress of worrying about inaccurate diagnoses. Especially in a group of patients already overwhelmed by drastic cultural shifts and dramatic differences in health care systems, these challenges may result in patients being lost to medical follow-up. Emphasizing the socioeconomic effect of growth charts, the authors of a systematic review related to worldwide growth variation contributed, "Insurance companies and national healthcare systems often use [standard deviation] cut-offs as criteria for coverage of growth hormone therapy. Thus, it is critically important that clinicians use curves with centiles that accurately reflect a child's expected pattern of growth."[8]

## Growth in International Populations

Regarding racial-ethnic considerations in the 2000 CDC data, the CDC Methods and Development explanation states, "Children of all major racial-ethnic groups appear to have similar growth potential. Studies have demonstrated the genetic effects on growth are small compared with the effects of the environment, nutrition, and health. Regardless of racial-ethnic status, children provided with good nutrition, access to health care, and good social and general living conditions have similar growth patterns."[7] This statement suggests that all children can be evaluated by the same growth metrics. The WHO growth standards account for ethnic diversity by aggregating data from populations in single cities of six countries (Brazil, Ghana, India, Norway, Oman and the USA). Because their goal was to develop a standard for ideal growth, they identified populations with socio-economic characteristics in which a child's "growth was not environmentally constrained."[4] However, not all studies agree that the CDC analysis and WHO diversity efforts are adequate.

A systematic review of published literature regarding worldwide variation in human growth compared WHO data with that of studies from 55 countries or ethnic groups. The authors concluded that "Height and weight curves may not be optimal fits in all cases. The differences between national or ethnic group head circumference means were large enough that using the WHO charts would put many children at risk for misdiagnosis of macrocephaly or microcephaly. Our findings indicate that the use of a single international standard for head circumference is not justified."[8] The study, published in 2014, further argued that "Many recent studies have found growth patterns of economically advantaged children that differ from the MGRS [Multicentre Growth Reference Study] means. These studies were rigorous. Unfortunately, however, they focus on no more than two countries or ethnic groups, do not compare their data with the MGRS data, were published before the MGRS curves or are written in local languages. To date, no one has carried out a large-scale comparison of data from the MGRS and different studies. As a result, the magnitude of international differences in growth is not fully evident."[8] As these authors point out, the current worldwide data regarding growth patterns of various ethnic groups are not easily comparable, making it difficult to evaluate individual children based on the most appropriate parameters.

One of the studies evaluated in the sytemic review was a 2008 study of growth curves for Turkish children comparing data on Turkish children with Swedish values and the 2000 CDC growth references. This study reported, "In our comparison, Swedish children were much taller than US and Turkish children, differences in height exceeding 1 cm after age 3 years and 3 cm at age 5 years. The weight values of Turkish infants were higher than those of Swedish and US values until 6 months of age. At 5 years of age, the Turkish children weighed less than the Swedish children. Weight for age values in Swedish children was also higher than those of the US growth references. Head circumference values of girls and boys were similar to the old data, particularly after age 6 months, but were higher than the US and Swedish values. All these findings led us to think that

population differences exist in pre-pubertal years and even at very young ages."[9] While this example illustrates some interesting differences in growth trends for Turkish children compared with American and Swedish counterparts, it also illustrates the difficulty in determining exactly what growth curves to use.

As another example of the eclectic worldwide data on children's growth, a British study from 2006 evaluated infant birth weights and weight at 9 months among a variety of ethnic groups in a sample size of 12,903 term infants. Among the authors' conclusions they stated, "Marked differences were seen between ethnic groups, with Asian (Pakistani, Bangladeshi and Indian) infants lighter and more slow growing than their white counterparts. Black infants were also lighter than white infants at birth, but by 9 months they were heavier and faster growing."[10] These studies, including the systematic review, reveal a lack of uniformity in child growth data among ethnic groups; the differences are significant enough to consider the possibility that the current growth data are not always appropriately applied to every patient.

## Looking Beyond the CDC and WHO Growth Charts

An additional study from 2011 provides some valuable insight into how growth curves may be developed and used in assessing growth among various ethnic groups. A Japanese group, motivated by many of the issues presented previously, determined to produce growth charts for several ethnic minority groups in Thailand and Myanmar. The authors relate that from their experience it would seem absurd for Japanese and Chinese children to be evaluated on the same growth curves, and likewise, other ethnicities should have individualized data. They state, "If possible, it would be ideal to evaluate children's growth and nutrition based on growth standards specific to their particular ethnic group."[11] To that end, this group gathered measurements from nearly 24,000 children ages 6-18 years old in Thailand and Myanmar. These individuals were clustered into 12 ethnic groups that most closely represented them, and the data were aggregated to create growth charts specific to this population. The result is a series of growth charts for male and female children ages 6-18 years that can be used to assess the growth of individual patients based on a population that fits their own ethnic background, minimizing variation to provide a more accurate assessment of their growth trends. The authors state that "as always, physical growth research is a response to a practical need…and is indispensible to both international cooperation, and international and humanitarian aid activities."[11] Copies of their growth

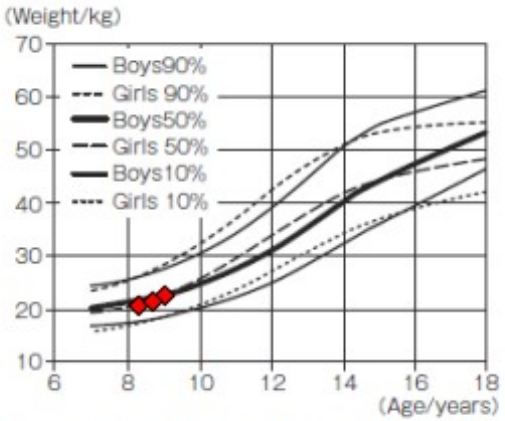


Figure 5 10th, 50th and 90th percentile charts of "Karen" in Thailand

charts are included in the additional materials of this paper.

Looking at a specific example using the data presented in this study, the young patient EP described in the introduction fits into the "Karen" ethnic minority group, one of the 12 groups studied. Based on her measurements in clinic, she falls on the 3rd percentile for weight by CDC standards, and the 4th percentile by WHO standards. However, when analyzed with other children from her own ethnic group, in three consecutive measurements over almost a year she is near the 40th percentile as shown in the figure above. For many refugees of other ethnic groups, the variation may be less significant, but in her case, the difference is drastic. If the data from this study is truly representative of healthy growth among the Karen group, EP's current measurements are very reassuring and fit well with her clinical presentation. Her example illustrates how this or similar data may be useful to a clinician evaluating a refugee patient if reliable data were available.

## Challenges In Applying Growth Charts for Individal Patients

The difference of opinion regarding use of generic growth charts for children of international backgrounds creates a challenge for U.S. clinicians seeing refugee patients. In speaking of the creation of the 2000 growth charts, the CDC states, "Given the evidence that differences in growth are primarily due to environmental and socioeconomic constraints, in combination with insufficient data for each racial-ethnic group, the development of separate racial-ethnic growth charts for various groups that constitute the U.S. population was neither justified nor practical. Even if sufficient data were available, it would be difficult to develop and to apply ethnic-specific growth charts because many

children are ethnically diverse."[7] Since the publication of the 2000 CDC charts, much research has been done to gather data on growth of children all around the world; however, as shown in several examples above, the lack of standardized charting methods, different age ranges, metrics, and languages all provide ongoing difficulties in the production of useable growth charts.

## Summary

In an ethnically diverse refugee population, growth charts have the potential to be beneficial to children and their families, but they also have the potential to create unnecessary worries and generate unnecessary cost to the patient or health system. When applied by the diligent clinician, they are a helpful screening tool to find true environmental or organic causes for stunted growth, but to truly meet their purpose they must be used within the context of the individual, accounting for parental characteristics and the patient's ethnicity.

The currently accessible data on human growth worldwide is not sufficient to represent every racial-ethnic group who come to the U.S. as refugees or immigrants; more research and population studies are needed to determine accurate growth standards for international populations. A few examples of growth charts from around the world are included in the appendix below, but many of these are significantly limited by sample size, age range, or statistical analysis inconsistent with other growth data. In the absence of an appropriate or well-established standard for any particular group, the WHO guidelines and CDC charts offer a satisfactory starting point. For children of ethnically diverse backgrounds who differ significantly from CDC or WHO standards, before ordering an extensive workup the clinician may benefit from pausing to look at other growth chart data to see if the patient's growth fits expected curves when evaluated with children of their own ethnicity. This may provide helpful reassurance and the opportunity for watchful waiting. If a clear deviation from the standard exists by multiple standards, the physician can proceed confidently knowing that the workup is a good use of resources that may very well provide great benefit to the patient.

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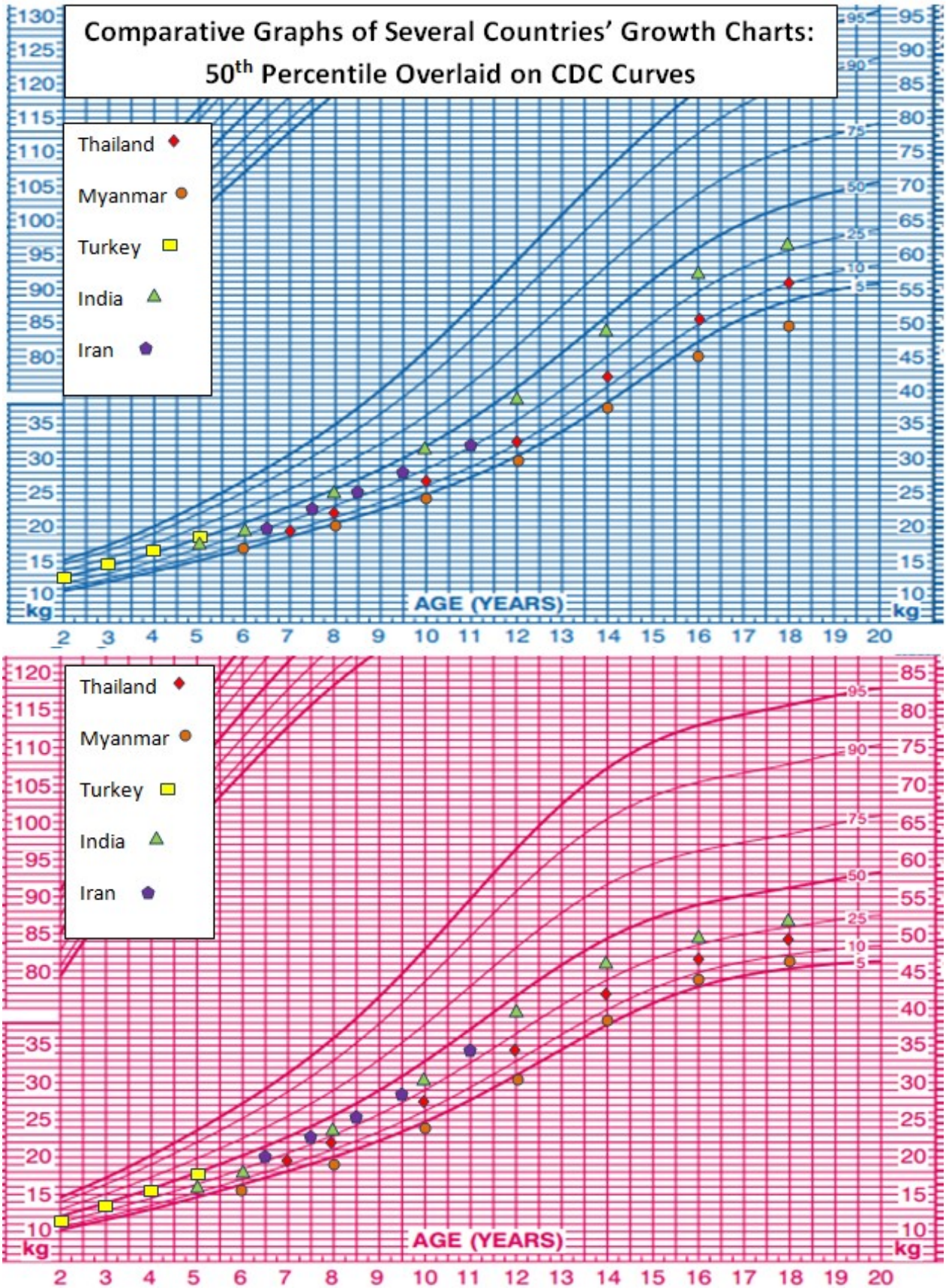
## Appendix: Examples of Growth Charts from Different Populations



## Thailand and Myanmar[11]

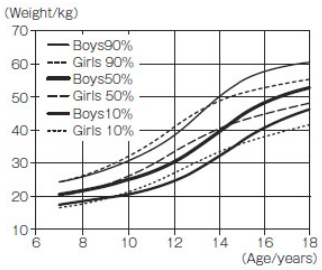



Figure 2 10th, 50th and 90th percentile charts of "Akha" in Thailand

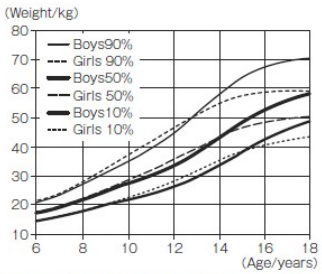



Figure 3 10th, 50th and 90th percentile charts of "Chin Ho" in Thailand

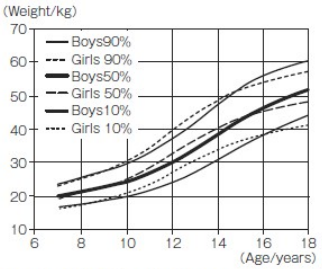



Figure 6 10th, 50th and 90th percentile charts of "Lahu" in Thailand

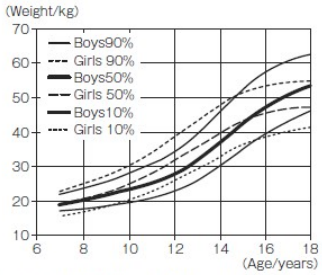



Figure 7 10th, 50th and 90th percentile charts of "Lisu" in Thailand

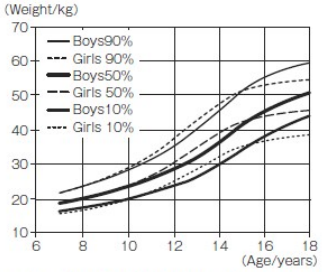



Figure 4 10th, 50th and 90th percentile charts of "Hmong" in Thailand

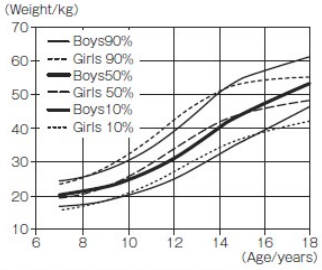



Figure 5 10th, 50th and 90th percentile charts of "Karen" in Thailand

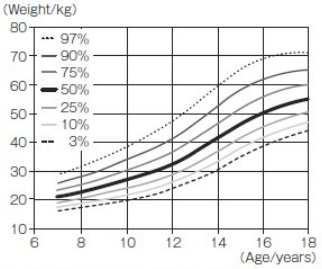



Figure 8 7 percentile charts of Thailand boy's weight

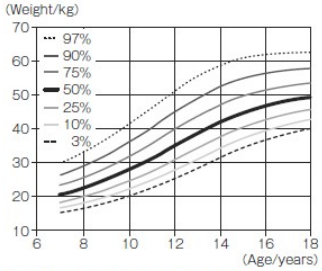



Figure 9 7 percentile charts of Thailand girl's weight

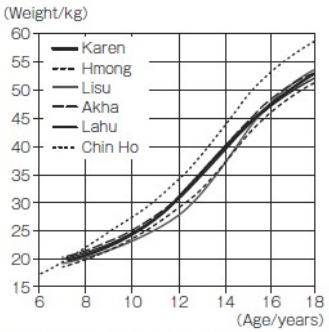



Figure 10 Comparative 50th percentile charts of 6 ethnic groups in Thailand (boy)

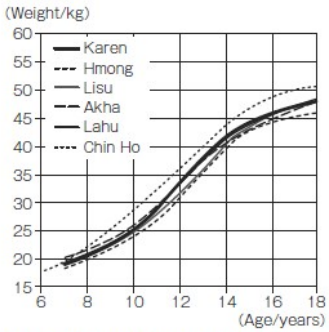



Figure 11 Comparative 50th percentile charts of 6 ethnic groups in Thailand (girl)

Table 2 Percentile values of Thai boy's and girl's weight by age

| Thai Boys Weight | | | | | | | | Thai Girls Weight | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 3% | 10% | 25% | 50% | 75% | 90% | 97% | Age | 3% | 10% | 25% | 50% | 75% | 90% | 97% |
| 7 | 16.1 | 17.3 | 18.9 | 20.9 | 23.2 | 25.6 | 28.5 | 7 | 15.0 | 16.5 | 18.2 | 20.5 | 23.2 | 26.1 | 29.7 |
| 8 | 17.1 | 18.5 | 20.2 | 22.4 | 25.1 | 27.9 | 31.2 | 8 | 16.4 | 18.0 | 19.9 | 22.4 | 25.5 | 28.8 | 32.8 |
| 9 | 18.3 | 20.1 | 22.0 | 24.5 | 27.5 | 30.8 | 34.6 | 9 | 18.1 | 19.9 | 22.1 | 24.9 | 28.5 | 32.2 | 36.8 |
| 10 | 19.8 | 21.7 | 23.9 | 26.8 | 30.2 | 34.0 | 38.5 | 10 | 20.1 | 22.2 | 24.6 | 28.0 | 31.9 | 36.3 | 41.5 |
| 11 | 21.5 | 23.6 | 26.1 | 29.3 | 33.2 | 37.5 | 42.7 | 11 | 22.6 | 24.9 | 27.7 | 31.4 | 35.8 | 40.7 | 46.5 |
| 12 | 23.8 | 26.2 | 28.9 | 32.5 | 36.9 | 41.7 | 47.6 | 12 | 25.5 | 28.1 | 31.1 | 35.2 | 39.9 | 45.2 | 51.5 |
| 13 | 27.0 | 29.7 | 32.8 | 36.9 | 41.8 | 47.3 | 53.9 | 13 | 28.7 | 31.5 | 34.7 | 39.0 | 44.0 | 49.4 | 55.9 |
| 14 | 30.9 | 34.0 | 37.4 | 41.9 | 47.2 | 53.2 | 60.3 | 14 | 31.8 | 34.6 | 38.0 | 42.3 | 47.3 | 52.7 | 59.0 |
| 15 | 35.0 | 38.2 | 41.9 | 46.6 | 52.2 | 58.4 | 65.7 | 15 | 34.5 | 37.3 | 40.7 | 44.8 | 49.7 | 54.9 | 60.9 |
| 16 | 38.8 | 42.1 | 45.8 | 50.6 | 56.2 | 62.2 | 69.2 | 16 | 36.7 | 39.6 | 42.8 | 46.8 | 51.5 | 56.4 | 61.8 |
| 17 | 41.8 | 44.9 | 48.5 | 53.2 | 58.6 | 64.2 | 70.7 | 17 | 38.5 | 41.2 | 44.4 | 48.2 | 52.6 | 57.1 | 62.2 |
| 18 | 44.4 | 47.3 | 50.8 | 55.3 | 60.1 | 65.3 | 71.1 | 18 | 40.1 | 42.9 | 45.8 | 49.4 | 53.6 | 57.9 | 62.4 |

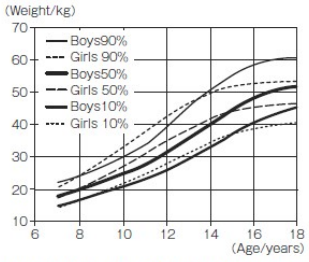



Figure 12 10th, 50th and 90th percentile charts of "Kayin" in Myanmar

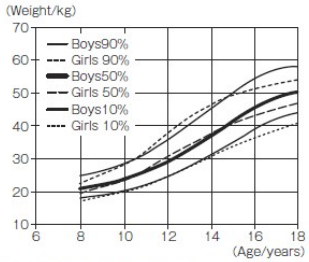



Figure 13 10th, 50th and 90th percentile charts of "Mon" in Myanmar

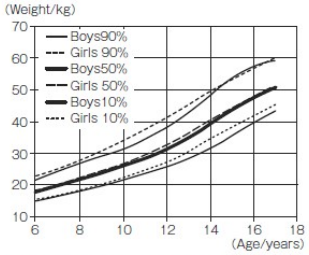



Figure 14 10th, 50th and 90th percentile charts of "Paoh" in Myanmar

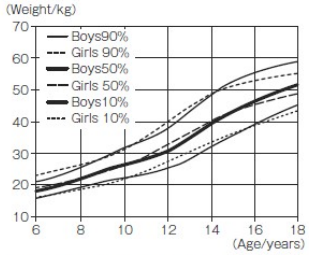



Figure 15 10th, 50th and 90th percentile charts of "Shan" in Myanmar

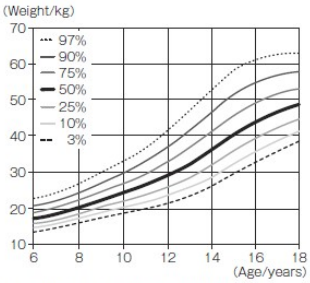



Figure 16 7 percentile charts of Myanmar boy's weight

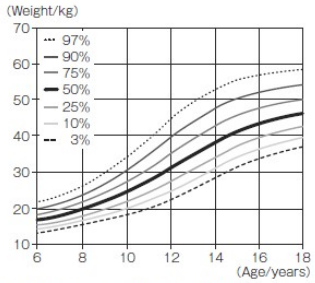



Figure 17 7 percentile charts of Myanmar girl's weight

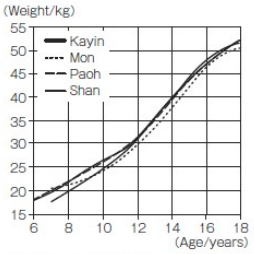



Figure 18 Comparative 50th percentile charts of 4 ethnic groups in Myanmar (boy)

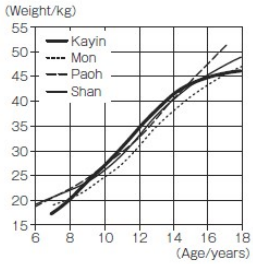
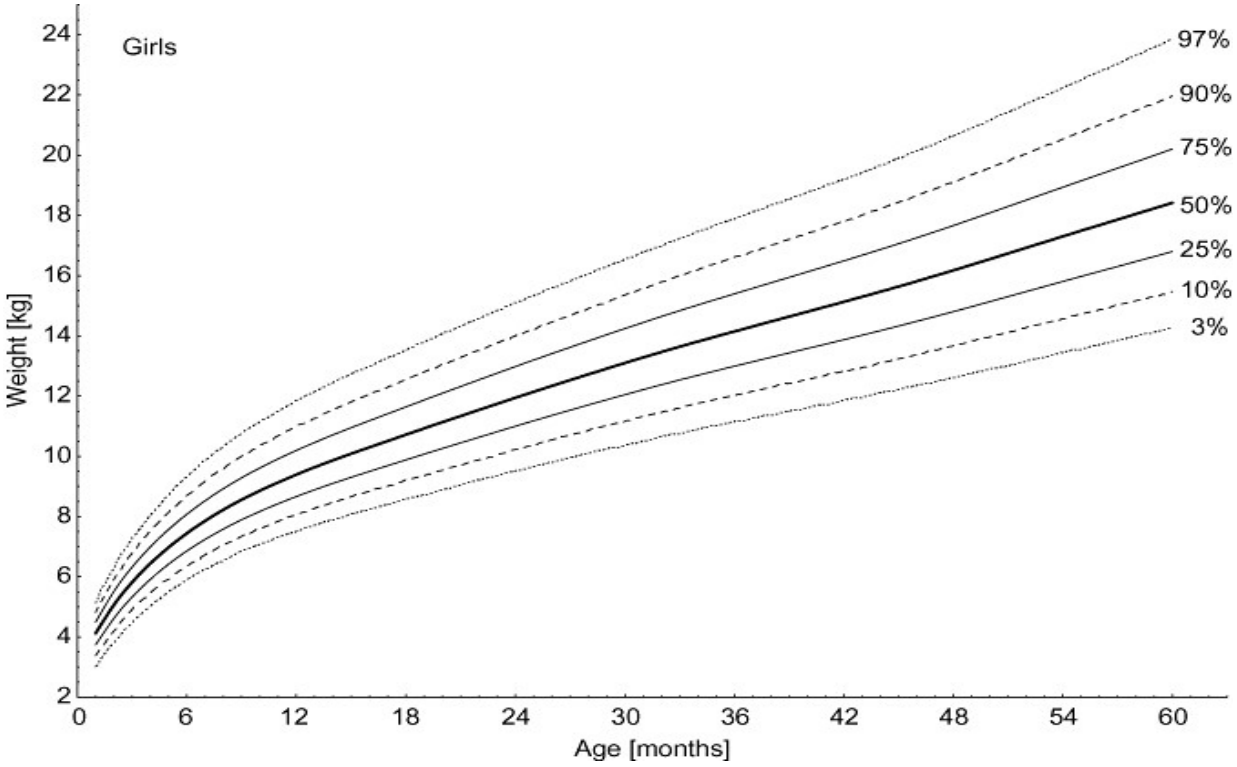


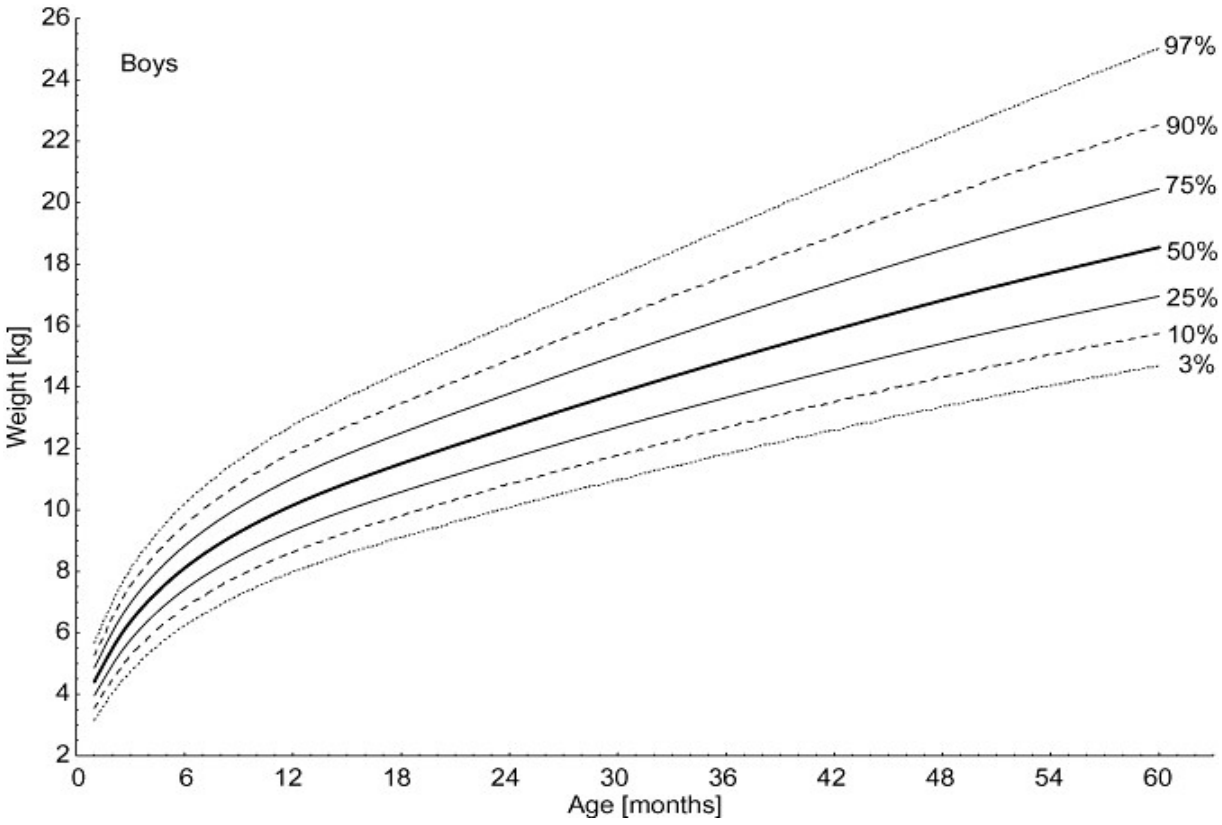

Figure 19 Comparative 50th percentile charts of 4 ethnic groups in Myanmar (girl)

Table 3 Percentile values of Myanmar boy's and girl's weight by age

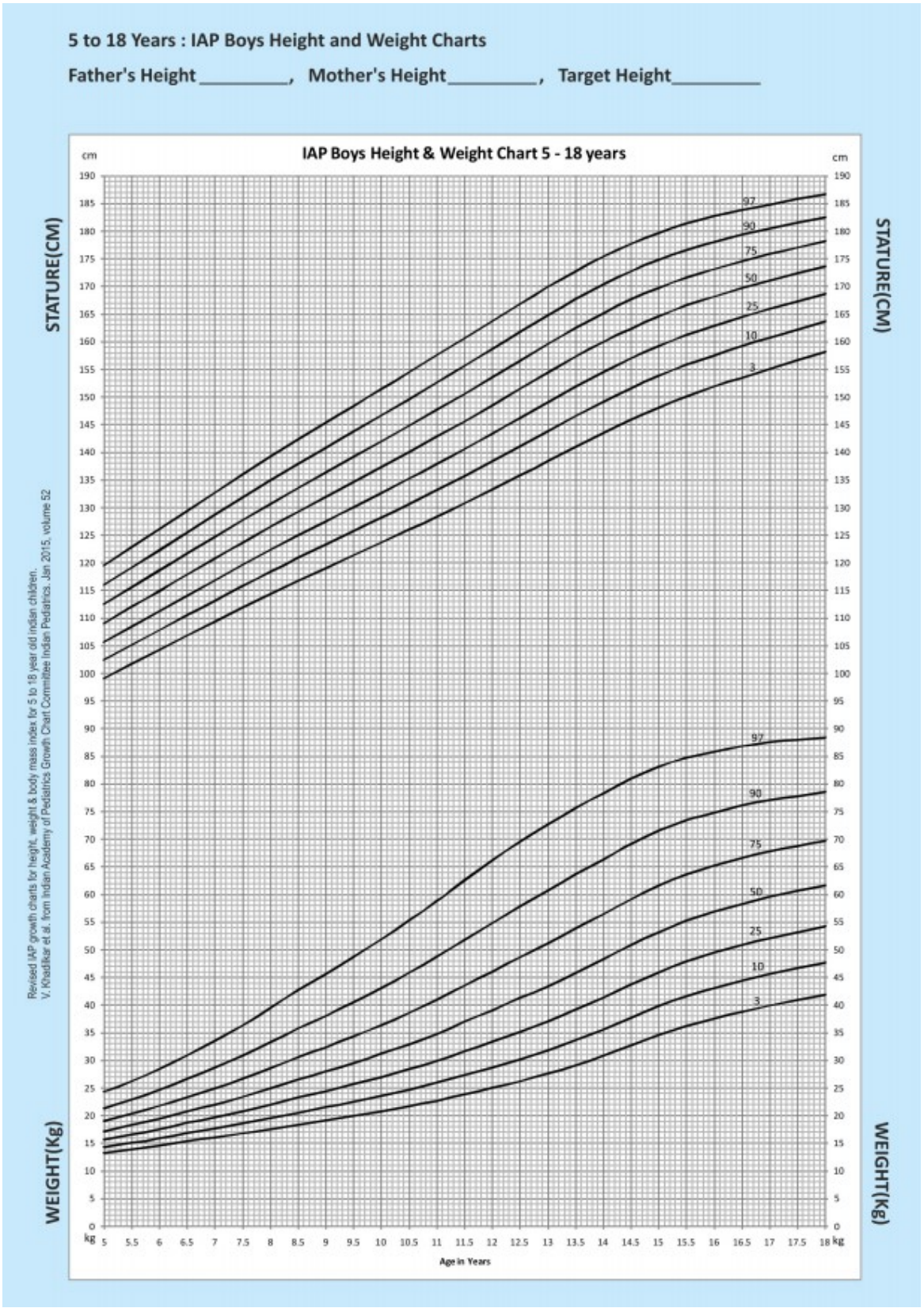
| Myanmar Boys Weight | | | | | | | | Myanmar Girls Weight | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 3% | 10% | 25% | 50% | 75% | 90% | 97% | Age | 3% | 10% | 25% | 50% | 75% | 90% | 97% |
| 6 | 13.0 | 14.2 | 15.4 | 16.9 | 18.7 | 20.5 | 22.5 | 6 | 12.9 | 14.0 | 15.1 | 16.5 | 18.2 | 19.8 | 21.5 |
| 7 | 14.2 | 15.4 | 16.6 | 18.2 | 20.1 | 22.0 | 24.2 | 7 | 13.9 | 15.0 | 16.2 | 17.8 | 19.5 | 21.2 | 23.2 |
| 8 | 15.7 | 17.0 | 18.4 | 20.2 | 22.3 | 24.4 | 26.7 | 8 | 15.1 | 16.4 | 17.8 | 19.6 | 21.6 | 23.6 | 26.0 |
| 9 | 17.4 | 18.9 | 20.5 | 22.5 | 24.8 | 27.3 | 30.0 | 9 | 16.6 | 18.1 | 19.8 | 21.9 | 24.4 | 26.9 | 29.7 |
| 10 | 18.6 | 20.3 | 22.1 | 24.4 | 27.1 | 30.0 | 33.1 | 10 | 18.2 | 19.9 | 22.0 | 24.6 | 27.6 | 30.7 | 34.3 |
| 11 | 20.1 | 22.0 | 24.1 | 26.8 | 30.0 | 33.3 | 37.2 | 11 | 20.0 | 22.2 | 24.6 | 27.7 | 31.4 | 35.2 | 39.6 |
| 12 | 21.8 | 24.0 | 26.4 | 29.7 | 33.5 | 37.6 | 42.4 | 12 | 22.7 | 25.1 | 27.9 | 31.5 | 35.8 | 40.3 | 45.4 |
| 13 | 24.0 | 26.4 | 29.3 | 33.1 | 37.6 | 42.5 | 48.1 | 13 | 25.8 | 28.4 | 31.5 | 35.4 | 39.9 | 44.7 | 50.0 |
| 14 | 27.4 | 30.2 | 33.5 | 37.7 | 42.8 | 48.2 | 54.6 | 14 | 29.2 | 32.0 | 35.0 | 39.0 | 43.6 | 48.3 | 53.5 |
| 15 | 30.7 | 33.6 | 37.1 | 41.6 | 46.9 | 52.5 | 59.2 | 15 | 32.0 | 34.8 | 37.8 | 41.7 | 46.1 | 50.6 | 55.6 |
| 16 | 33.9 | 36.9 | 40.4 | 44.9 | 50.2 | 55.6 | 62.0 | 16 | 34.0 | 36.7 | 39.8 | 43.6 | 47.8 | 52.0 | 56.7 |
| 17 | 37.1 | 40.0 | 43.4 | 47.5 | 52.4 | 57.4 | 63.0 | 17 | 35.7 | 38.4 | 41.3 | 45.1 | 49.0 | 53.1 | 57.6 |
| 18 | 40.0 | 42.8 | 45.9 | 49.7 | 54.0 | 58.4 | 63.2 | 18 | 37.4 | 40.0 | 42.9 | 46.5 | 50.4 | 54.3 | 58.6 |

**Turkey**[9]


Girls
97%
90%
75%
50%
25%
10%
3%
Weight [kg]
Age [months]

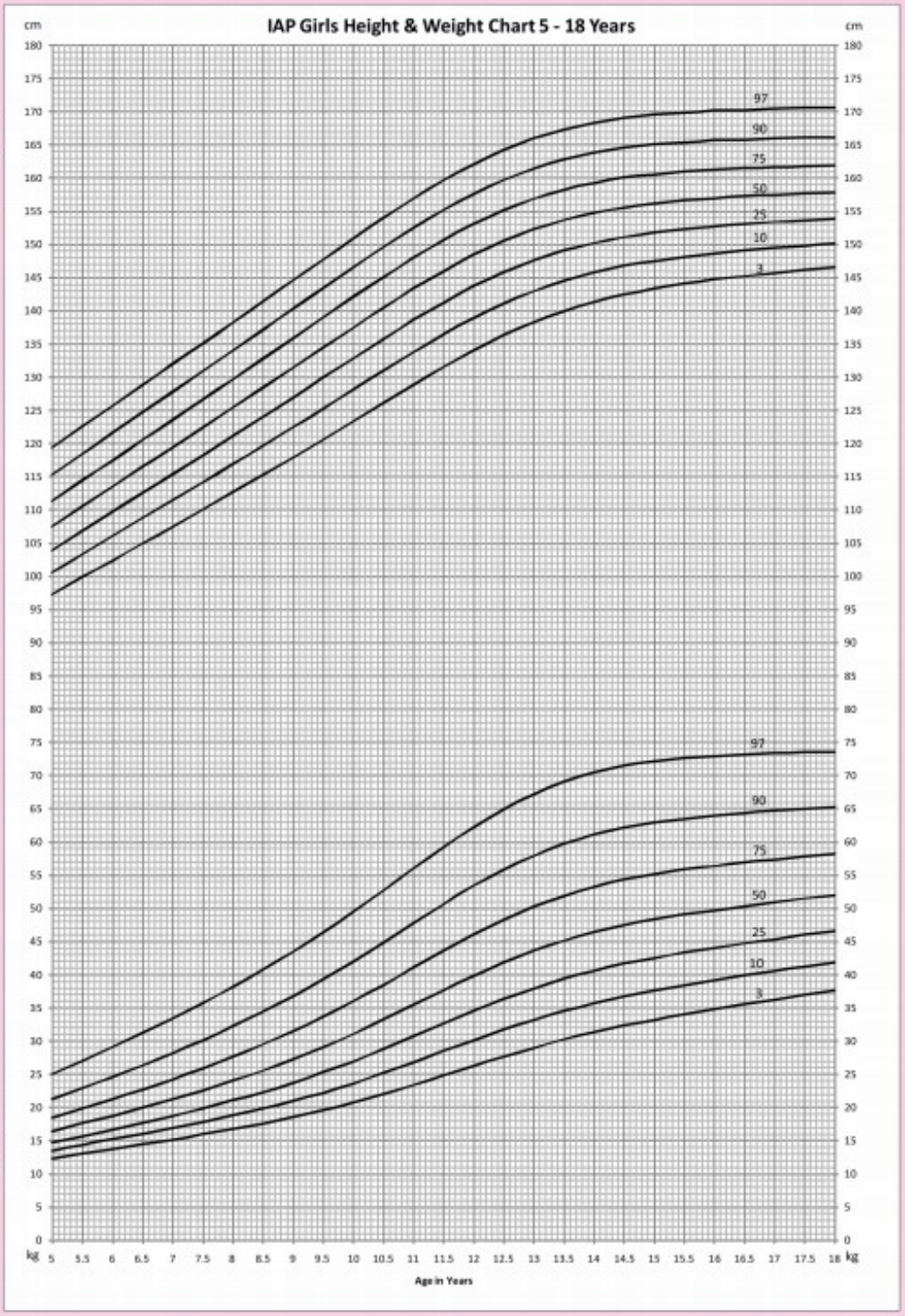

Boys
97%
90%
75%
50%
25%
10%
3%
Weight [kg]
Age [months]

**India**[13]


5 to 18 Years : IAP Boys Height and Weight Charts
Father's Height _____, Mother's Height_____, Target Height_____
IAP Boys Height & Weight Chart 5 - 18 years
STATURE(CM)
WEIGHT(Kg)
Age in Years
97
90
75
50
25
10
3
Revised IAP growth charts for height, weight & body mass index for 5 to 18 year old indian children.
V. Khadilkar et al. from Indian Academy of Pediatrics Growth Chart Committee Indian Pediatrics, Jan 2015, volume 52

## 5 to 18 Years : IAP Girls Height and Weight Charts

**Father's Height _____, Mother's Height_____, Target Height_____**




Revised IAP growth charts for height, weight & body mass index for 5 to 18 year old indian children.
V. Khadilkar et al. from Indian Academy of Pediatrics Growth Chart Committee Indian Pediatrics. Jan 2015, volume 52

**Iran**[12]

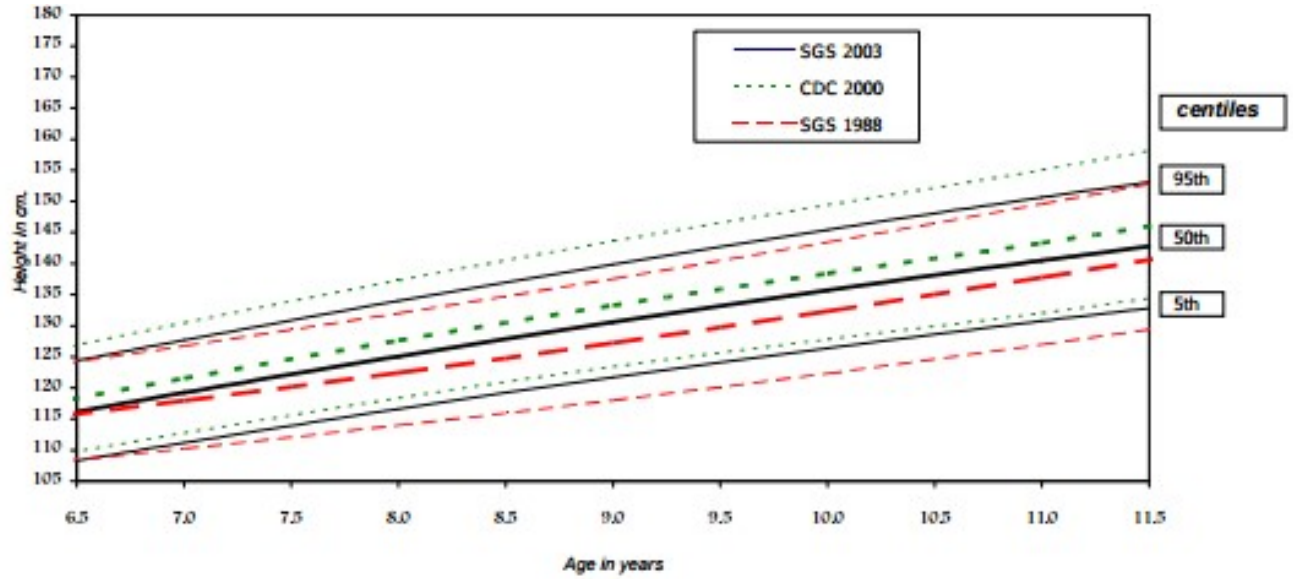



**Figure 1a. Comparison of heights of boys ; Shiraz Growth Study (SGS) 2003 vs1988 and CDC 2000.**

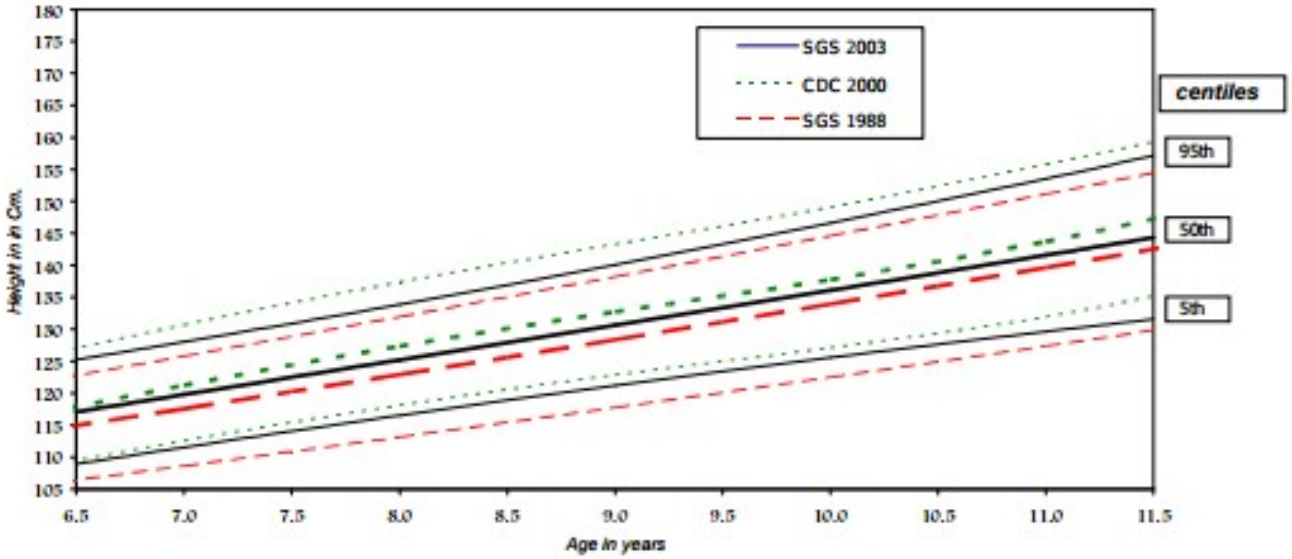



**Figure 1b. Comparison of heights of girls ; Shiraz Growth Study (SGS) 2003 vs1988 and CDC 2000.**

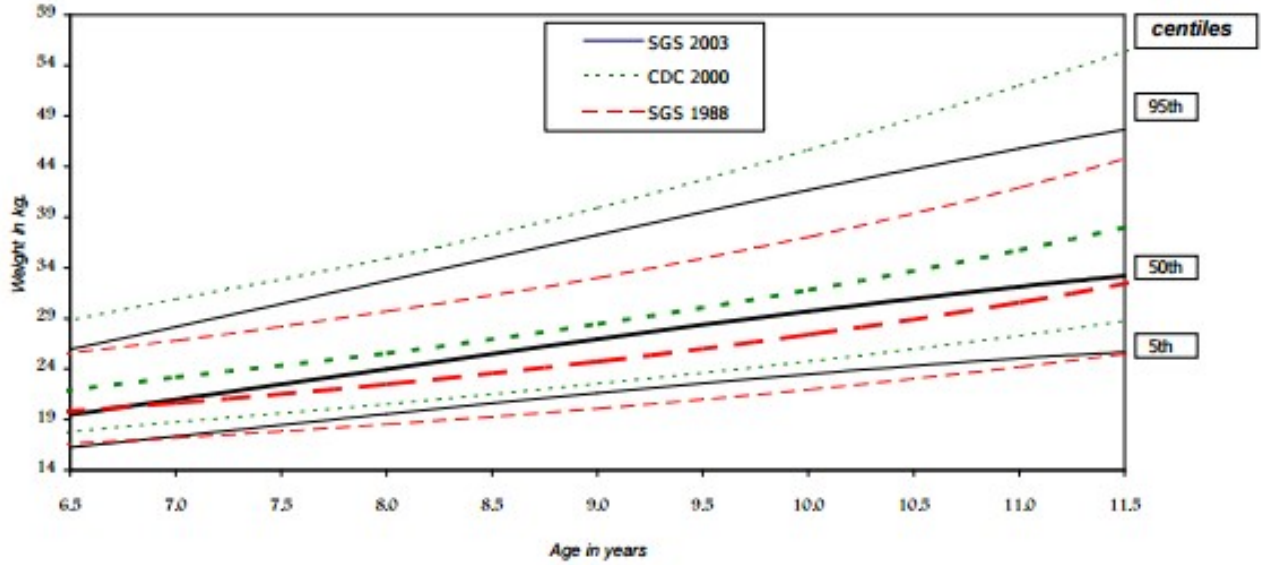



**Figure 2a. Comparison of weights of boys ; Shiraz Growth Study (SGS) 2003 vs1988 and CDC 2000.**

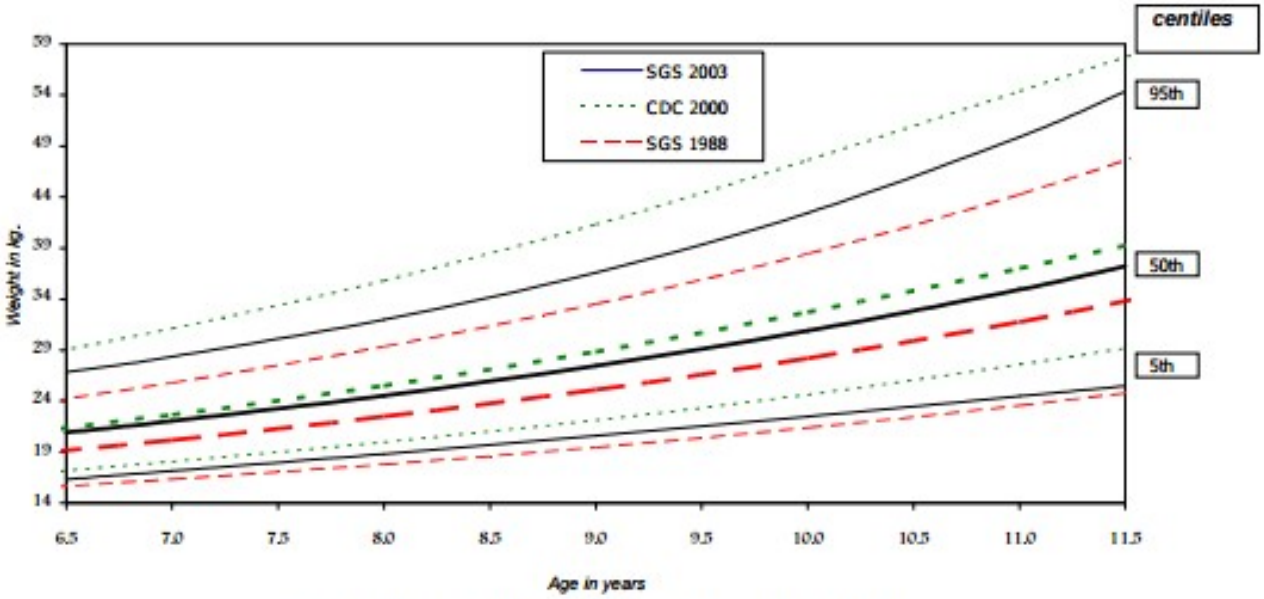
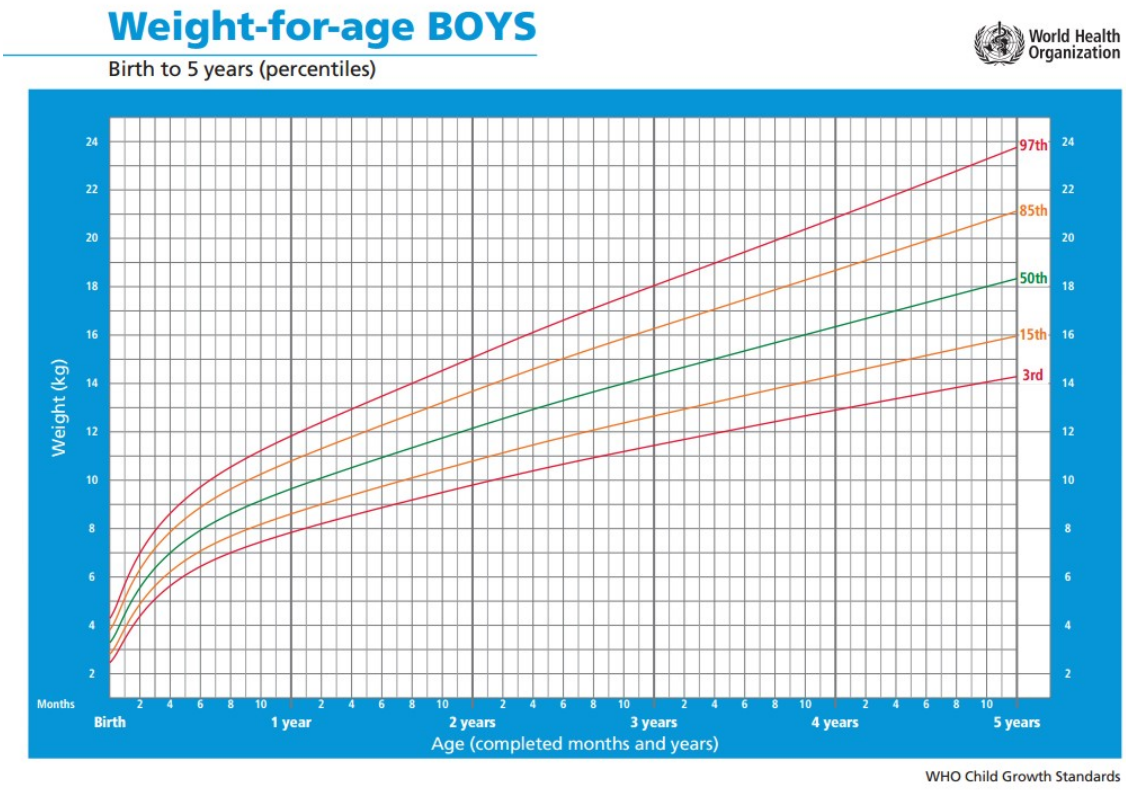
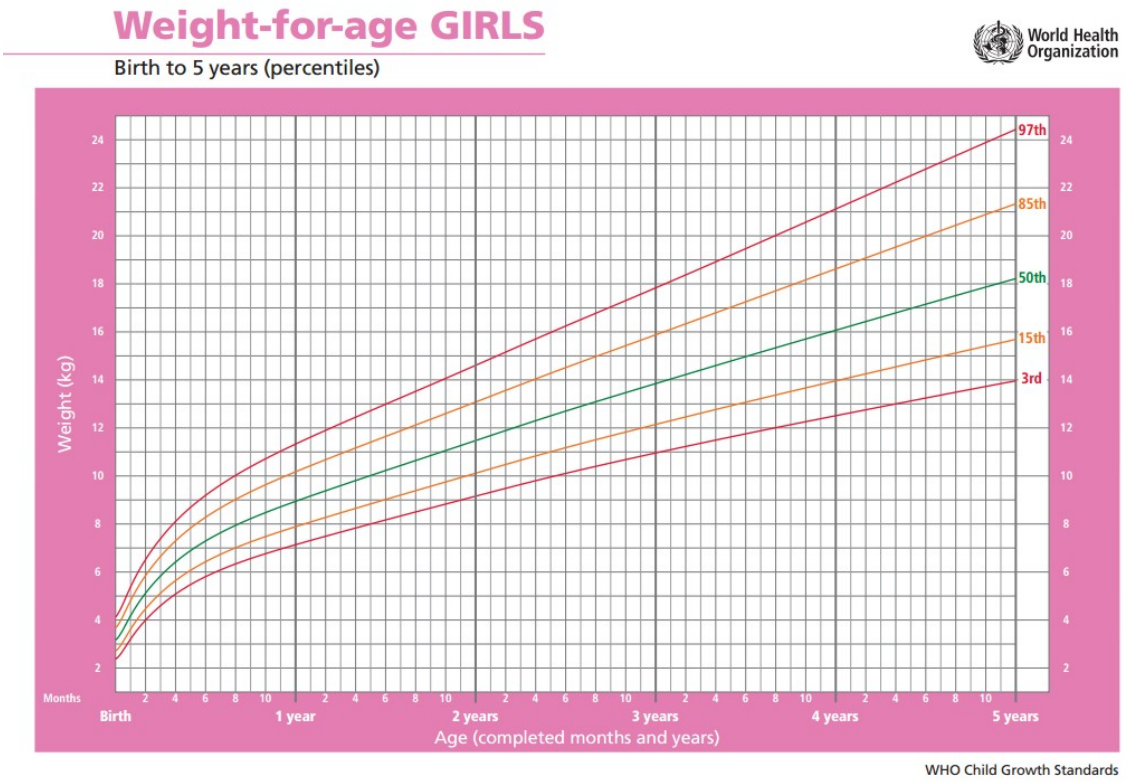



**Figure 2b. Comparison of weights of girls ; Shiraz Growth Study (SGS) 2003 vs1988 and CDC 2000.**

**WHO 0-5 Years**:

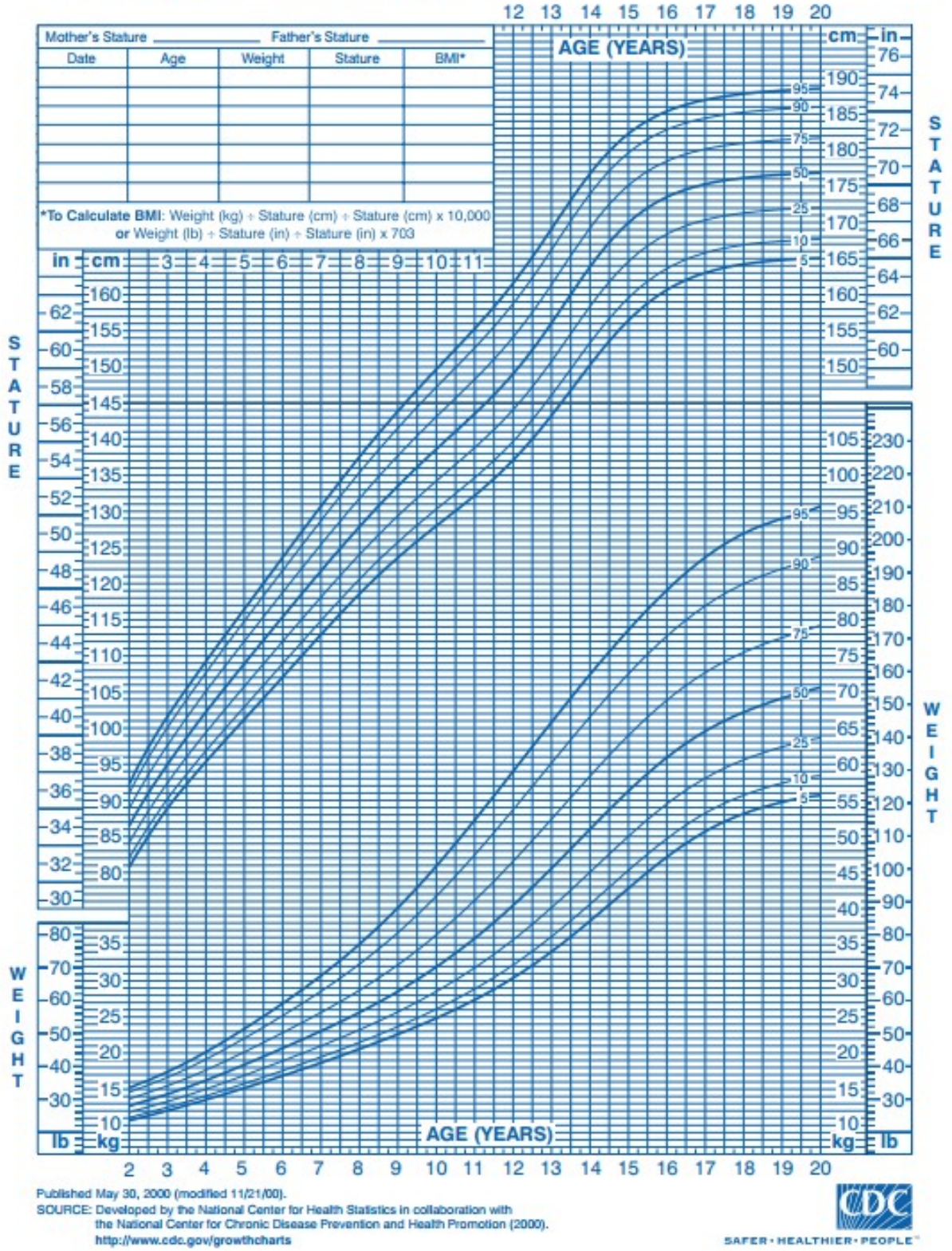

Weight-for-age BOYS
Birth to 5 years (percentiles)
World Health Organization
Weight (kg)
97th
85th
50th
15th
3rd
Months
Birth
1 year
2 years
3 years
4 years
5 years
Age (completed months and years)
WHO Child Growth Standards


Weight-for-age GIRLS
Birth to 5 years (percentiles)
World Health Organization
Weight (kg)
97th
85th
50th
15th
3rd
Months
Birth
1 year
2 years
3 years
4 years
5 years
Age (completed months and years)
WHO Child Growth Standards

## 2 to 20 years: Boys
## Stature-for-age and Weight-for-age percentiles

NAME _____

RECORD # _____




Published May 30, 2000 (modified 11/21/00).

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

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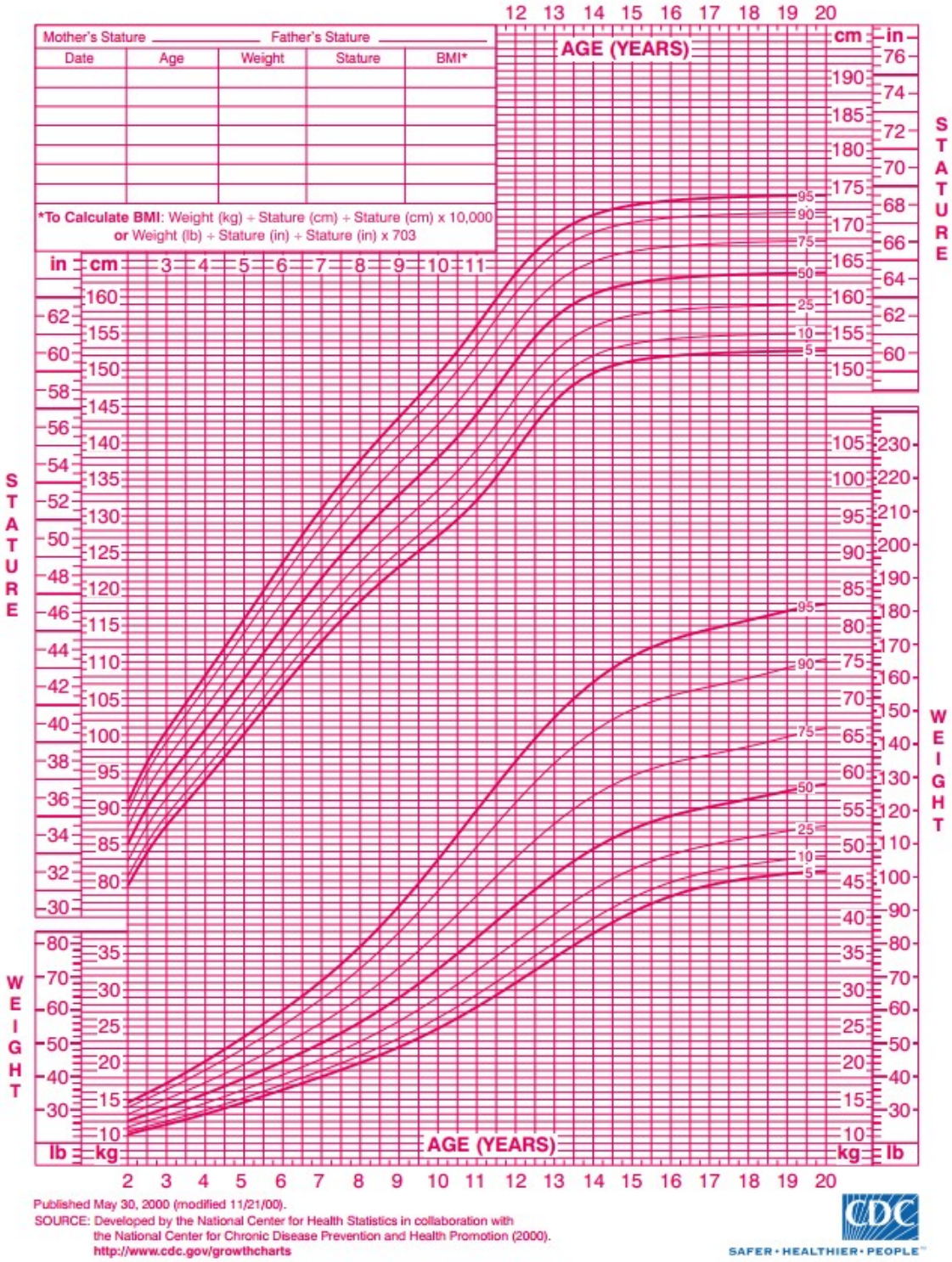
## 2 to 20 years: Girls
## Stature-for-age and Weight-for-age percentiles

NAME _____

RECORD # _____

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CDC
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