

# Childhood obesity

## Definitions and reference populations



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Centers for Disease Control and Prevention  
National Center for Health Statistics

SAFER • HEALTHIER • PEOPLE™



# Children and teens, 2-19 years, 2007-2008

- 16.9% obese
  - About 12.5 million children
- 31.7% Overweight or obese
  - ~23.4 million children

# Defining Obesity and Overweight

# Obesity

- Excess adipose tissue
  - Often impractical to measure
- Excess weight for height
  - Easy to obtain
  - A proxy for adiposity, highly correlated
  - Various indices

# Body mass index (BMI)

- $\text{BMI} = \text{weight (kg)}/\text{height (m)}^2$
- Measure of weight adjusted for height
- Does not distinguish between body fat and muscle
- Recommended for adults, adolescents & children

# Using BMI in childhood

- BMI varies with age and sex
- Unlike in adults, no risk based cutoffs exist
- Statistical definition
  - BMI-for-age
  - Percentiles from a reference population
  - Often the 2000 CDC growth charts

# Recommended cut points & labels, 1990s

2-19 years

$\geq 85^{\text{th}}$  but  $< 95^{\text{th}}$  percentile

“At risk for overweight”

$\geq 95^{\text{th}}$  percentile

“Overweight”

Guidelines for Overweight in Adolescent Preventive Services (Am J Clin Nutr 1994;59:307-316)

Obesity Evaluation and Treatment: Expert Committee Recommendations (Pediatrics 1998 ;(102)3:e 29)

# “Overweight”

... children who were overweight by this definition should be screened for possible obesity-related conditions...



# “At risk for overweight”

Children who were at risk for overweight using this definition.... should be referred to a second level screen. ... If youths are positive on ... the second level screen they should be referred for further medical assessment.

# New recommendations in 2007

- No change in cut points
- Change in labels
  - $\geq 95^{\text{th}}$  percentile: “Obese” more effectively conveys the seriousness, urgency, and medical nature of this concern than does the term “overweight,” thereby reinforcing the importance of taking immediate action.
  - $\geq 85^{\text{th}}$  but  $< 95^{\text{th}}$  percentile: “Overweight”

# HHS has adopted these new labels

## Stating

...Although these cut points are not diagnostic criteria, elevated BMI among children most often indicates increased risk for future adverse health outcomes and/or development of disease.



# Prevalence (SE) of high body mass index (BMI), US children 2-19 years

<i>Definition</i>	<u>2005-2006</u>	<u>2007-2008</u>
<b>BMI-for-age <math>\geq</math> 95<sup>th</sup> percentile*</b>		
Old terminology: Overweight	<b>15.5 (1.3)</b>	<b>16.9 (1.3)</b>
New terminology: Obese	<b>15.5 (1.3)</b>	<b>16.9 (1.3)</b>
<b>BMI-for-age <math>\geq</math> 85<sup>th</sup> percentile*</b>		
Old terminology: At risk for overweight or overweight	<b>30.1 (1.6)</b>	<b>31.7 (1.2)</b>
New terminology: Overweight or obese	<b>30.1 (1.6)</b>	<b>31.7 (1.2)</b>

Source: CDC/NCHS, National Health and Nutrition Examination Survey

\*On the sex specific CDC growth charts

# Infants birth to 2 years of age

- No agreed upon definition
- $\geq 95^{\text{th}}$  percentile of weight-for-recumbent length of CDC growth charts often used in US
  - No BMI curves for birth-2 years on CDC charts

# Reference Populations

- CDC growth charts, birth-19 years
- WHO growth standards, birth-4 years
- WHO growth references, 5-19 years
- IOTF international references, 2-18 years
- Countries have their own growth references

# Workshop, June 2006

- Here at NCHS
- Co-sponsored by
  - CDC (NCHS, NCCDPHP), NIH, and AAP
- Discussed
  - Differences between CDC and WHO charts (birth-4 years)
  - Potential use of the WHO charts (birth-4 years) in US
- Outcomes:
  - Descriptive MMWR currently in press
  - Recommendations



# CDC 2000 growth charts

- Infants, birth-36 mo
  - Head circumference-for-age
  - Weight-for-age
  - Length-for-age
  - Weight-for-length
- 2-4 years
  - Weight-for-stature
- 2-20 years
  - Weight-for-age
  - Stature-for-age
  - BMI-for-age

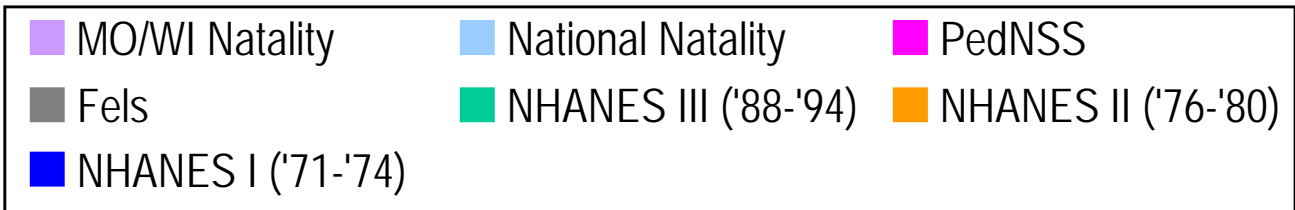
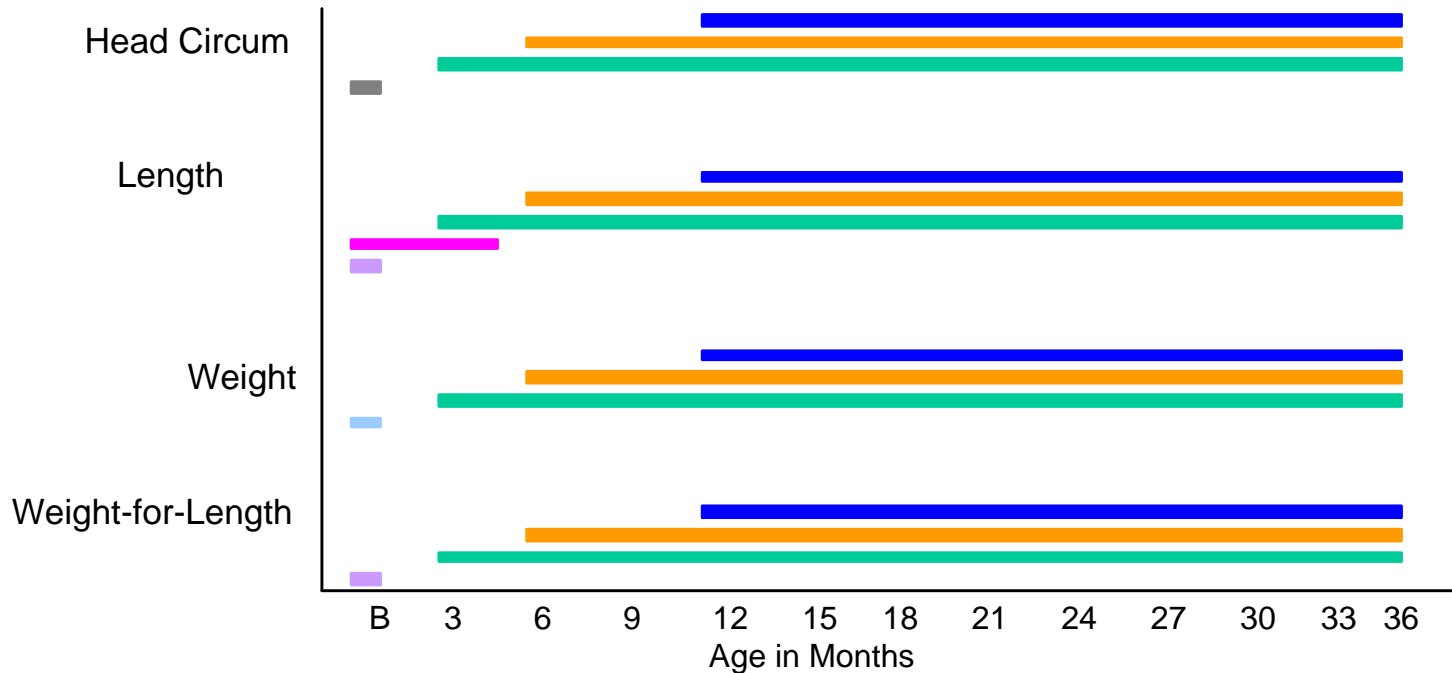
# Data

- US population 60s-early 90s
  - Excluded VLBW infants
  - Excluded weight data from 1988-94 for ages 6+
  - Additional supplemental data
- Racially and ethnically diverse
- Distribution of breast feeding 60s-early 90s
- General reference not a standard

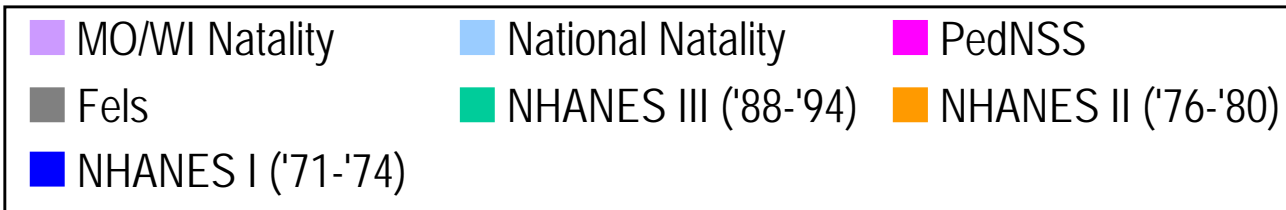
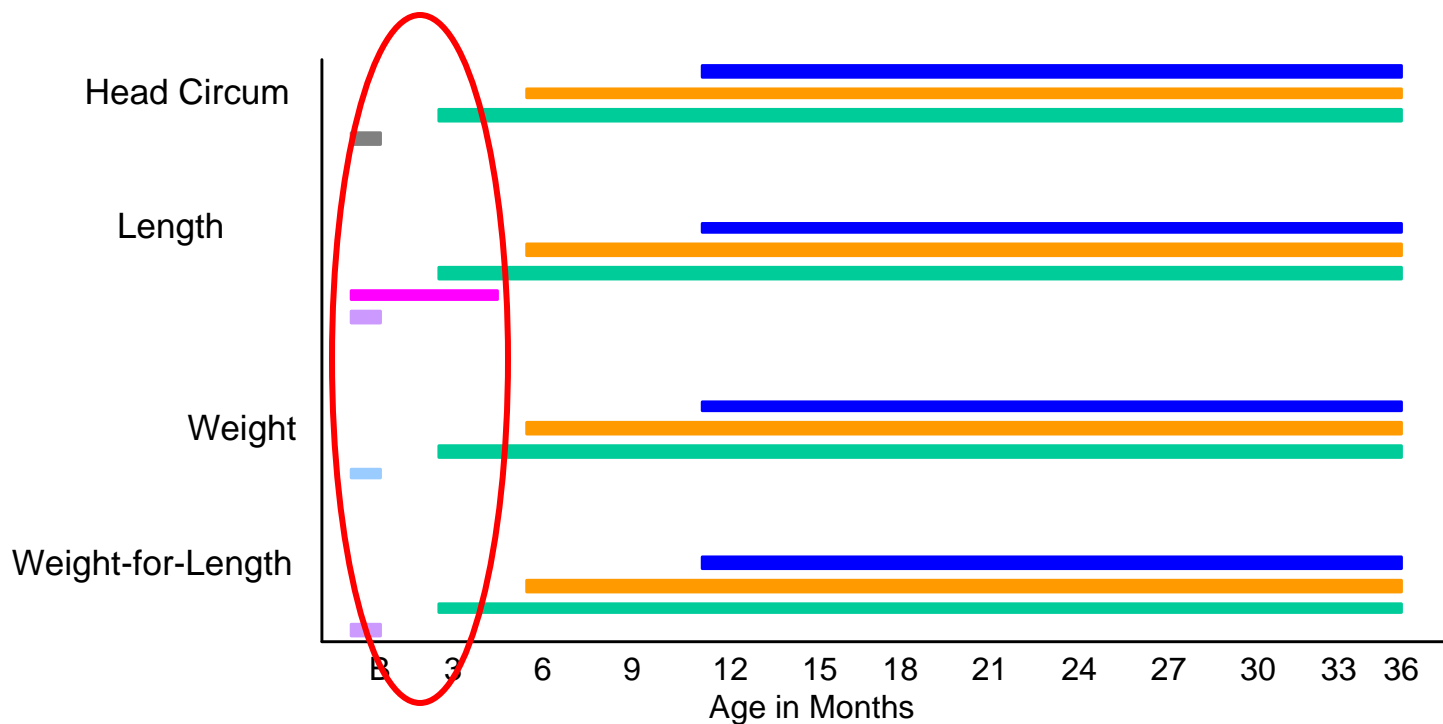
# Specific data sources

- National Health Examination Survey (NHES)
  - cycle 2 1963-65
  - cycle 3 1966-70
- National Health and Nutrition Examination Survey
  - NHANES I 1971-74
  - NHANES II 1976-80
  - NHANES III 1988-94 (<6 years weight; length/stature)
- National birth weight distribution
- Wisconsin and Missouri birth length
- Fels head circumference at birth
- Pediatric Nutrition Surveillance System (PedNSS)
  - length data <5 months

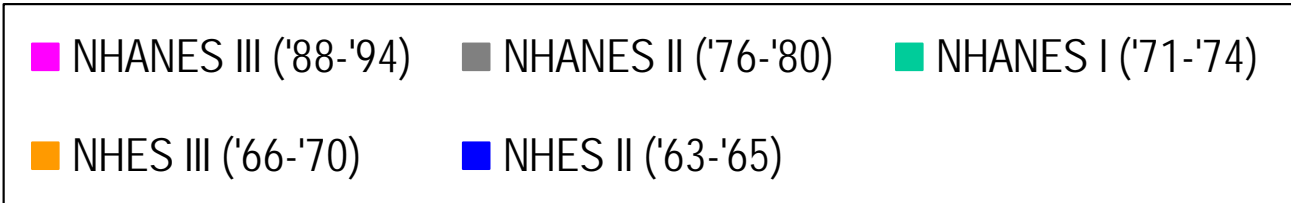
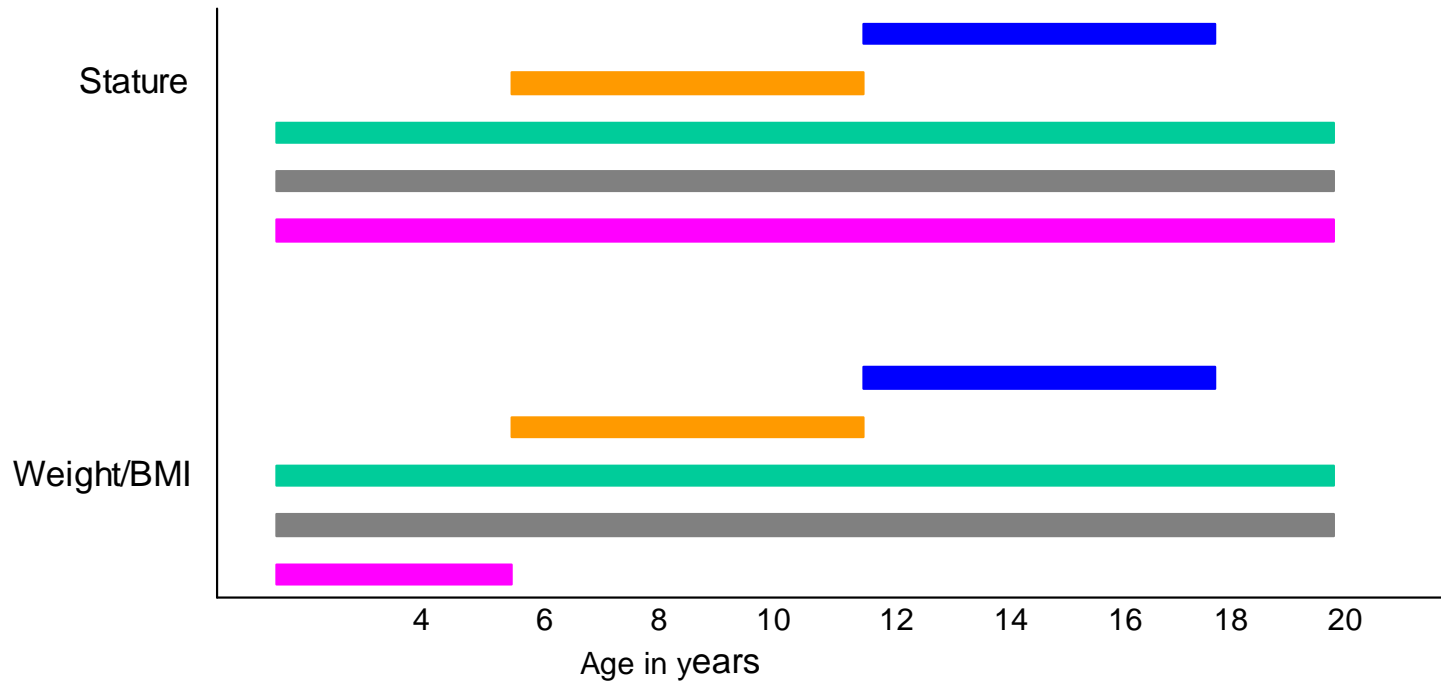
# Reference Data Sets: Birth to 36 Months



# Reference Data Sets: Birth to 36 Months



# Reference Data Sets: 2 to 20 Years



# CDC growth charts, concerns

- Lack of data from birth-2 months
- PedNSS data added for length

# 2006 WHO growth charts, birth-4 years

- Multicentre growth reference study (MGRS)
- Prescriptive reference or standard
  - Describes how children should grow



# Prescriptive approach

- Optimal Nutrition
  - Breastfeeding
  - Appropriate complementary feeding
- Optimal Environment
  - Clean water & plumbing
  - No smoking
- Optimal Care
  - Immunization
  - Pediatric well care visits

# 2006 WHO growth charts

- Birth-4 years
  - Length/height-for-age
  - Weight-for-age
  - Weight-for-length/height
  - Body mass index-for-age
  - Head circumference-for-age
  - Mid-upper arm circumference-for-age
  - Subscapular skinfold-for-age
  - Triceps skinfold-for-age
  - Motor development milestones

# Study Design

## Two Components

- Longitudinal study (0-24 months)
  - frequent assessments of feeding and growth (21)
  - strong breastfeeding support
- Cross-sectional study (18-71 months)
  - feeding mode no longer critical for curve
  - overlap to improve merging of two curves

# Site selection

- Pelotas, Brazil
- Accra, Ghana
- South Delhi, India
- Oslo, Norway
- Muscat, Oman
- Davis, CA, USA

# Eligibility of Study *Population*

- Relatively high SES
- Altitude < 1,500 m
- Low mobility in the population
- Minimum 20% of moms follow feeding recommendations
- Breastfeeding support system exist
- Collaborative institutions

# Eligibility of *Individuals*

- No health, environmental, economic constraints on growth
- Lack of significant perinatal morbidity
- Mother willing to follow feeding recommendations
  - Predominant breast feeding for at least 12 months
  - Complementary foods introduced between 4 & 6 mo
- Non smoking mothers (before and after delivery)
- Term birth
- Single birth

**Table 1** Total sample and number of compliant children in the longitudinal component

Site	N	Compliant <sup>a</sup>		
		Boys	Girls	Total
Brazil	309	29	37	66
Ghana	328	103	124	227
India	301	84	89	173
Norway	300	75	73	148
Oman	291	73	76	149
USA	208	64	55	119
All	1737	428	454	882

<sup>a</sup> Compliant with infant-feeding and no-smoking criteria and completed the 24-month follow-up.

**Table 1 Total sample and number of compliant children in the longitudinal component**

Site	N	Compliant <sup>a</sup>		
		Boys	Girls	Total
Brazil	309	29	37	66
Ghana	328	103	124	227
India	301	84	89	173
Norway	300	75	73	148
Oman	291	73	76	149
USA	208	64	55	119
All	1737	428	454	882

**51%**

<sup>a</sup> Compliant with infant-feeding and no-smoking criteria and completed the 24-month follow-up.



# 2006 WHO Data Exclusions

- Longitudinal
  - Observations falling above  $+ 3$  SD or below  $- 3$  SD of the sample median (weight-for-length)
- Cross sectional
  - Observations falling above  $+ 2$  SD (weight-for-stature)

# CDC versus WHO charts

- Data
  - Reference v standard
- Methods
  - Smoothing different but some similarities (LMS parameters)
- Comparison of actual curves
  - Different in first 2 years of life
  - Not so different after age 2-3 years

# Sample selection

- **CDC**
  - Primary data from 5 US national surveys
  - Supplementary data at birth and in first months of life
- **WHO**
  - 6 sites
  - High SES
  - No health constraints to growth
  - Singleton, term births
  - No maternal smoking
  - Feeding
    - CS: breastfeeding at least 3 months
    - LS: mother willing to follow feeding recommendations

# Exclusions

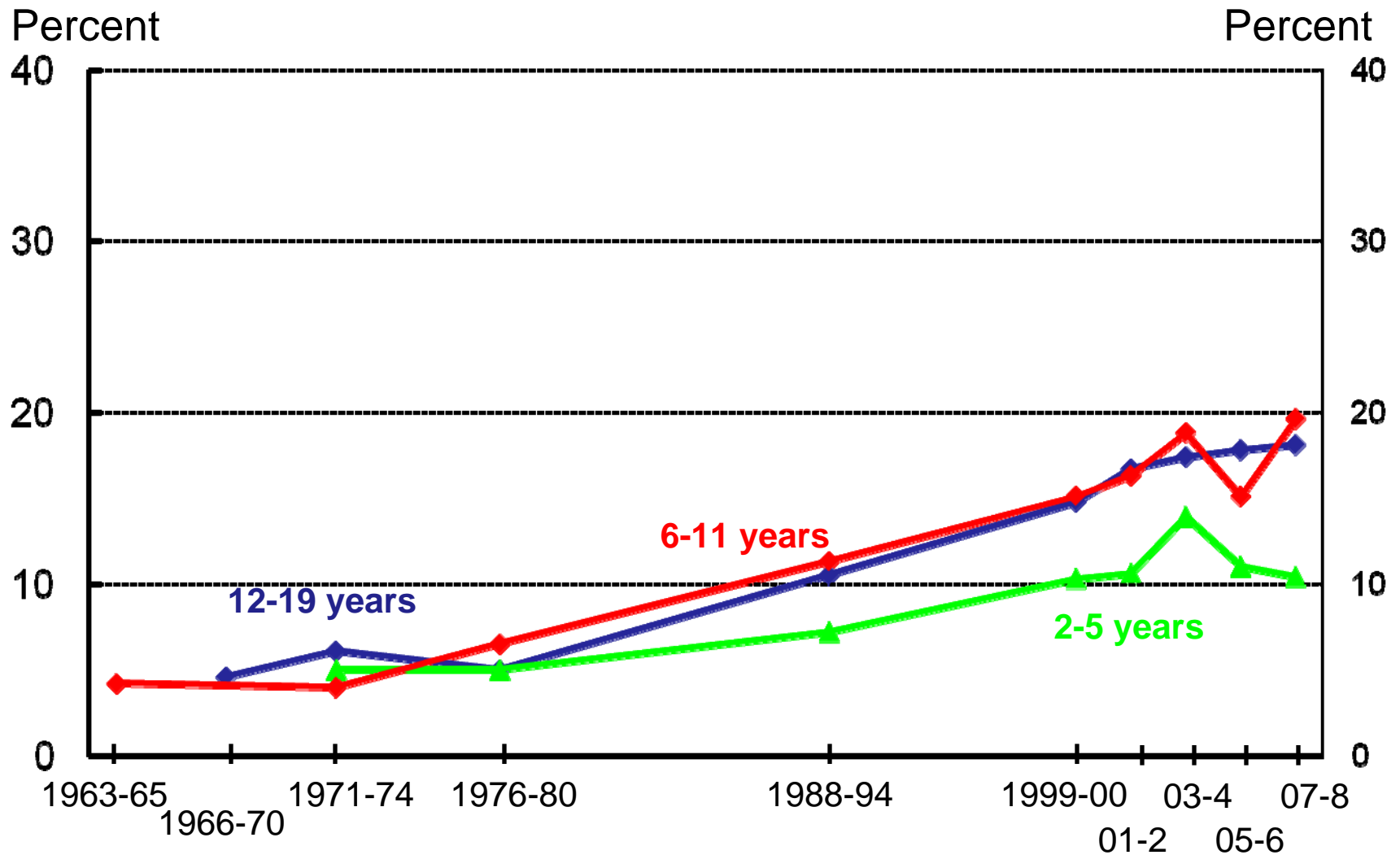
- CDC
  - Very low birth weight (<1500 g)
  - Weight, children 6+ years, NHANES III (1988-1994)
  - 13 children for large length-stature discrepancies (n=11) or outlying influential points (n=2)
- WHO
  - + 2 SD weight-for-height CS
  - +/- 3 SD weight-for-length LS

# Main difference

- DATA
  - Sample selection
- Reference versus standard

Thank you

# Trends in obesity\* among children and adolescents



\*Obesity defined as body mass index (BMI)  $\geq$  gender and age specific 95th percentile from the 2000 CDC Growth Charts.

Source: National Health Examination Surveys II (ages 6-11) and III (ages 12-17), National Health and Nutrition Examination Surveys I, II, III and 1999-2008, NCHS, CDC.

# CDC charts, features

- Descriptive reference not standard
- No race/ethnic specific charts
- Include BMI-for-age
  - 85<sup>th</sup> percentile included
- Percentiles and z-scores agree
- Correction of disjunction
- 3rd and 97th percentiles included



# 2000 CDC charts

- General reference
- Exclusions
  - Very low birth weight infants (<1500 grams)
  - 1988-1994 weight data for 6 years and older  
(All weight related charts)

# PedNSS

- Primarily from clinical records of the Special Supplemental Nutrition Program for Women, Infants and Children (WIC)
  - Low income
- Subset of clinics
  - 213 clinics
  - 1975-1995
  - Mean length and weight  $\pm 0.5$ cm and  $\pm 0.5$  kg of mean from NHANES II and III by month of age
  - SD within  $\pm 0.2$ cm and  $\pm 0.2$ kg
  - Skewness in weight  $\pm 10.3$ kg of skewness

# Breast feeding

- Include both breast and formula fed infants proportional to the distribution in the population at time of data collection
  - ~ 50% of infants received some breast milk
  - ~ 33% were breast fed for 3 months or more
- Most recent data (1999-2001) in US\*
  - 66% breast fed
- National Survey of Child Health (2003-04)
  - ~17% of 1-5 year olds breast fed for 12+ months

# WHO (2007) Reference, 5-19 years

- Data
  - HES II, HES III, NHANES I (from 1978 version)
- Methods
  - Smoothing identical to that used in the standards
  - Includes same exclusions based on same ‘outliers’
- Smooth transition between standard and reference
  - Included some data from sectional study of MGRS

# WHO growth charts

- 2006 standards for birth to age 5 based on Multicentre growth reference study (MGRS)
  - Prescriptive reference or standard
  - Describes how children should grow
- 2007 school age and teen reference

# How do the charts compare?

- Visually
- Data
- Exclusions
- Smoothing
- Use of charts
  - Cut-points

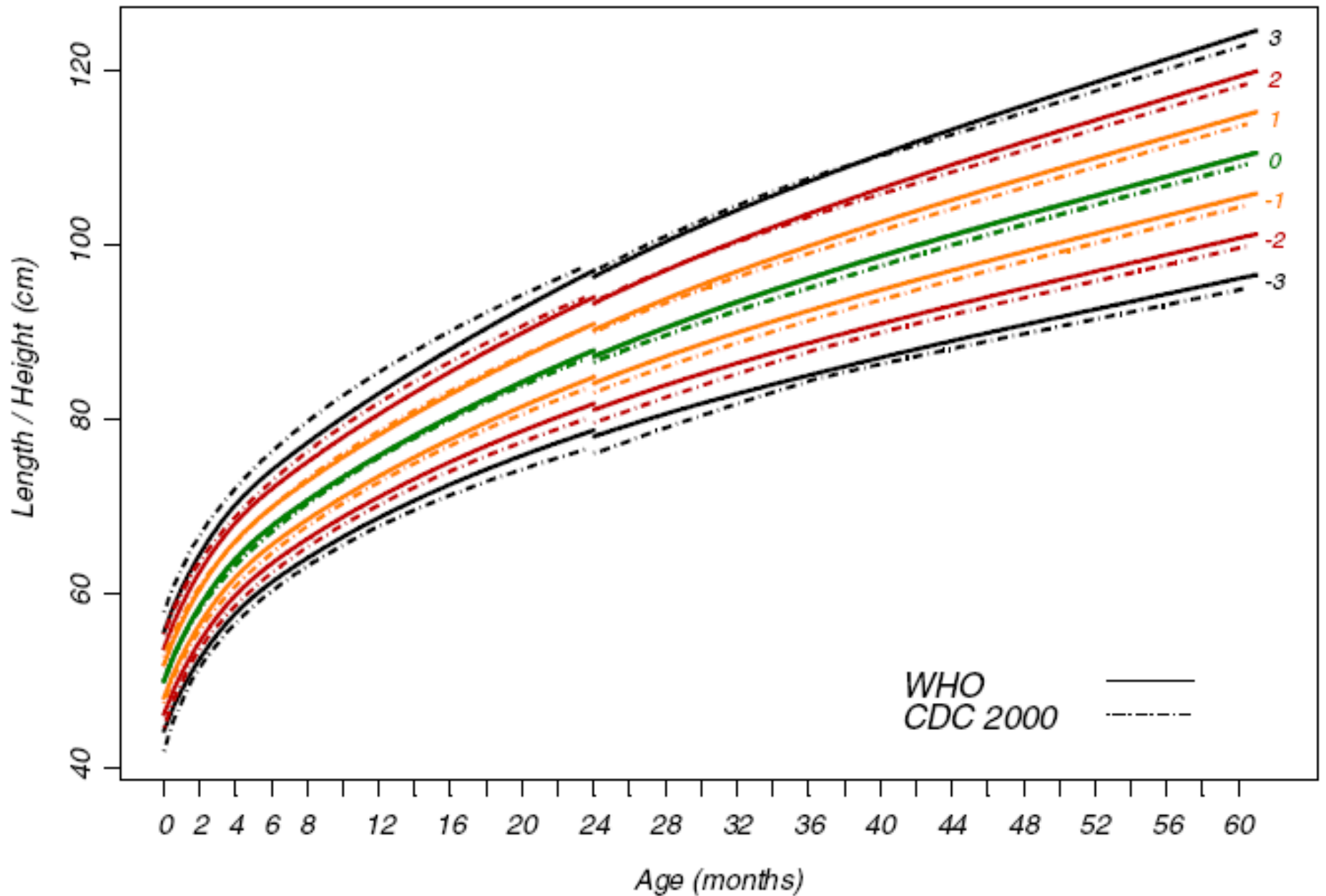


Figure 16 Comparison of WHO with CDC 2000 length/height-for-age z-scores for boys

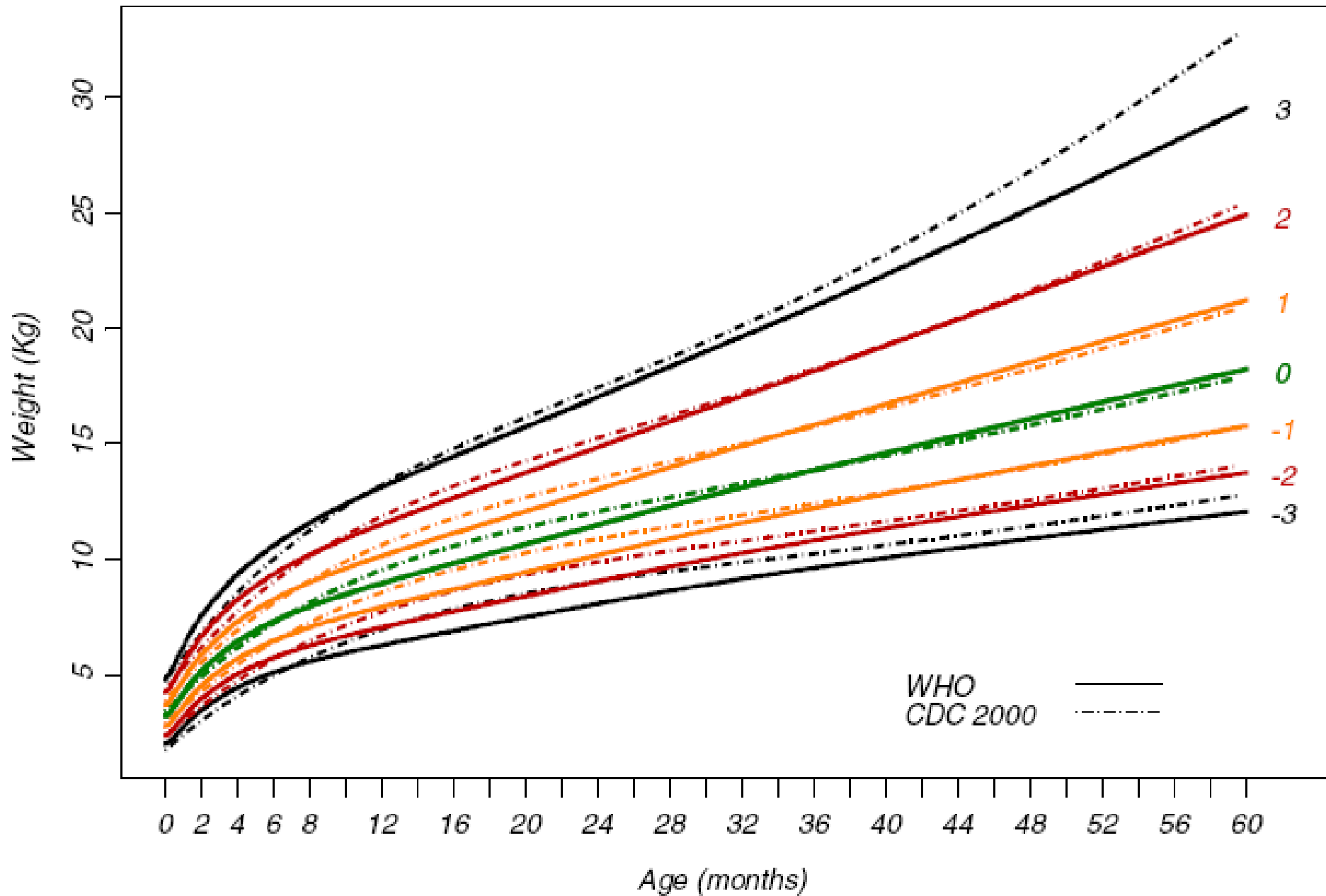


Figure 59 Comparison of WHO with CDC 2000 weight-for-age z-scores for girls



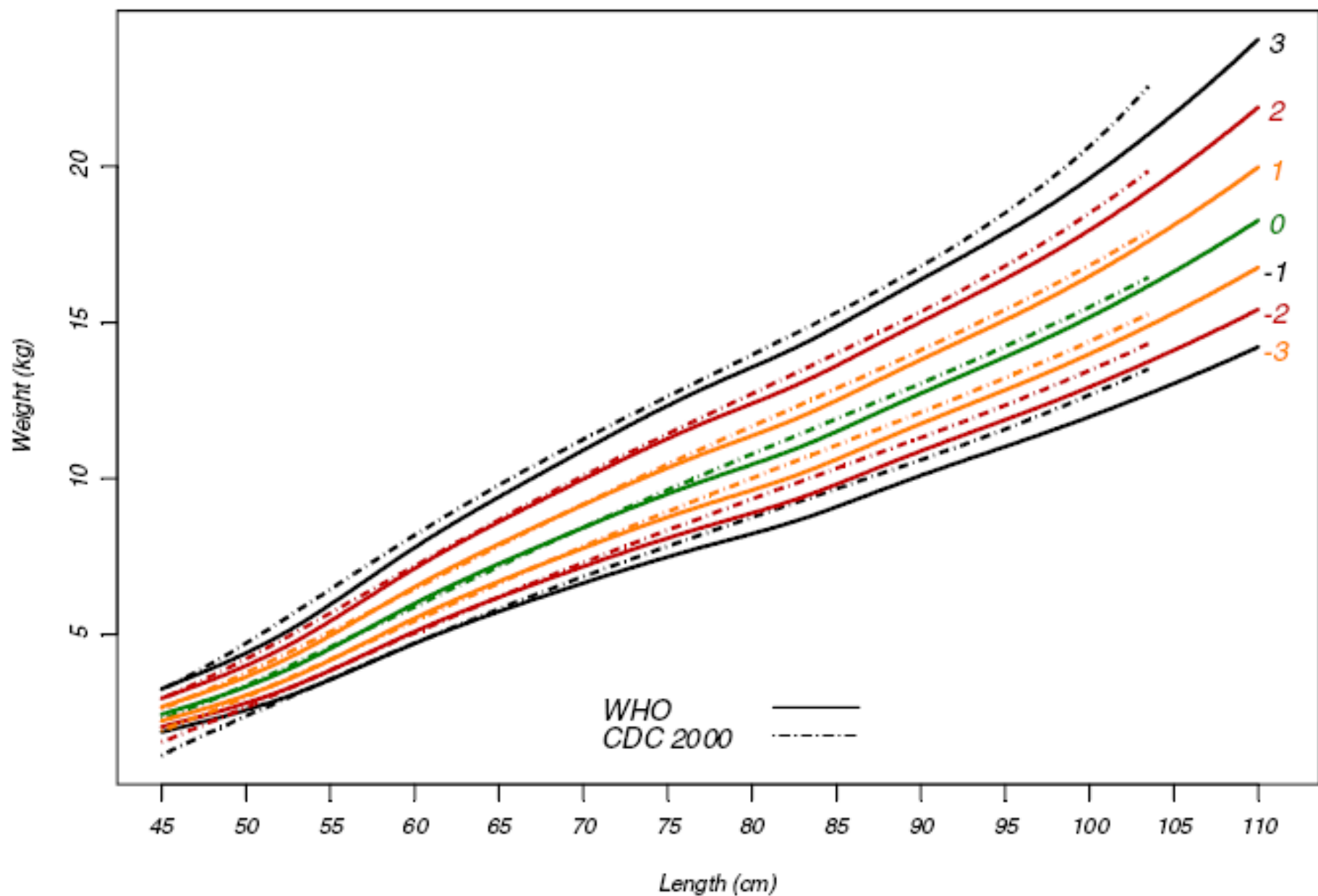


Figure 77 Comparison of WHO with CDC 2000 weight-for-length z-scores for boys

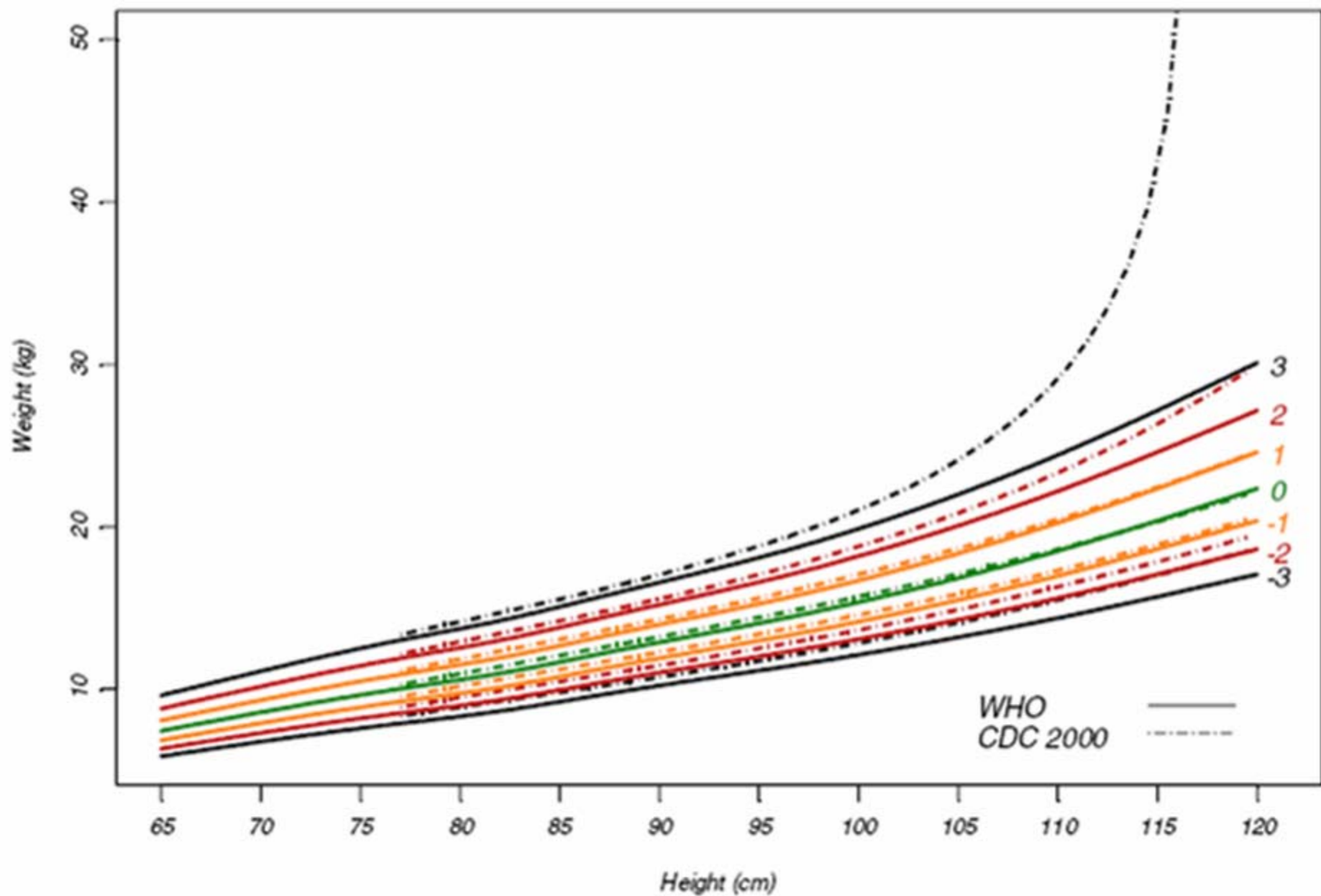


Figure 78 Comparison of WHO with CDC 2000 weight-for-height z-scores for boys

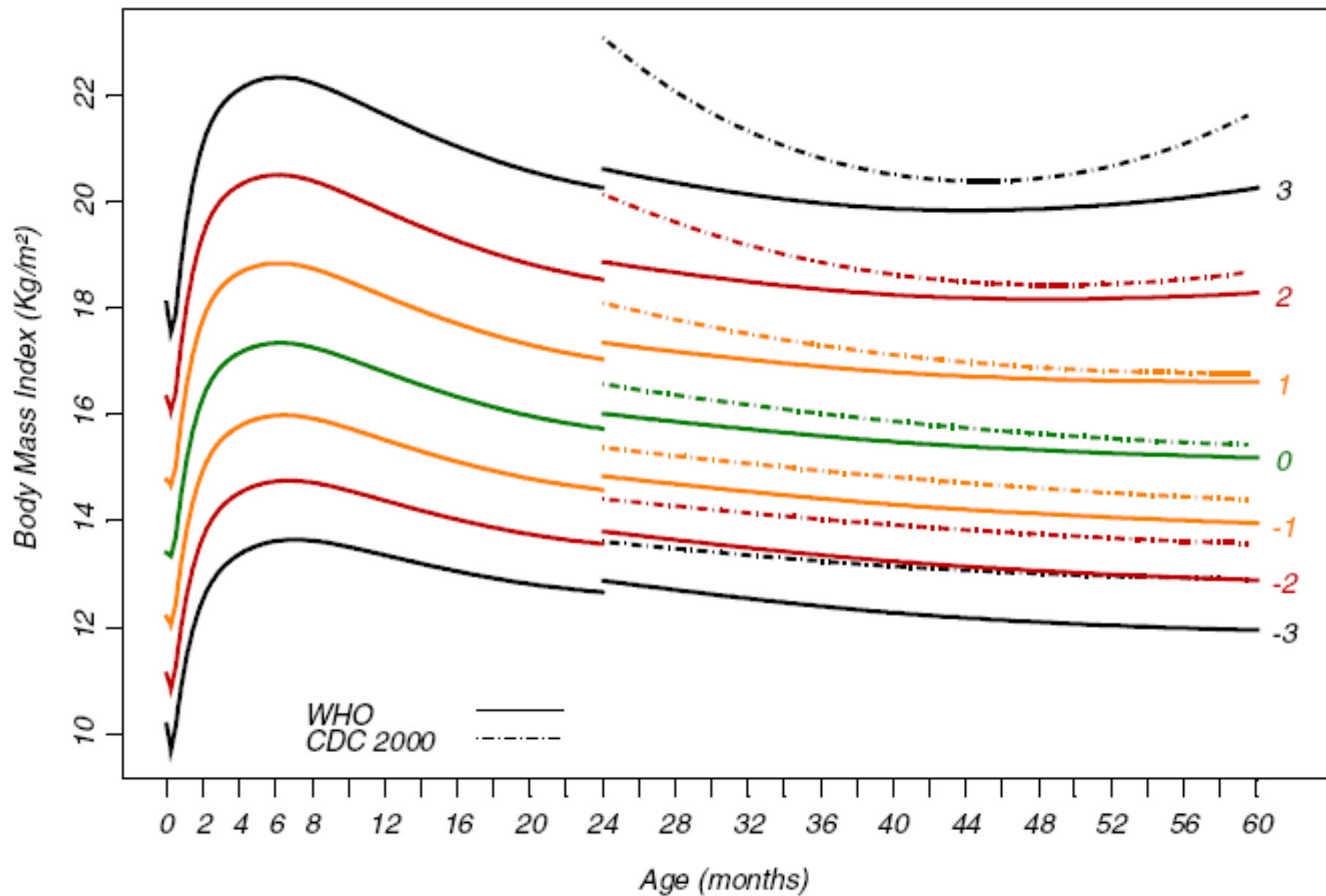


Figure 115 Comparison of WHO with CDC 2000 BMI-for-age z-scores for boys

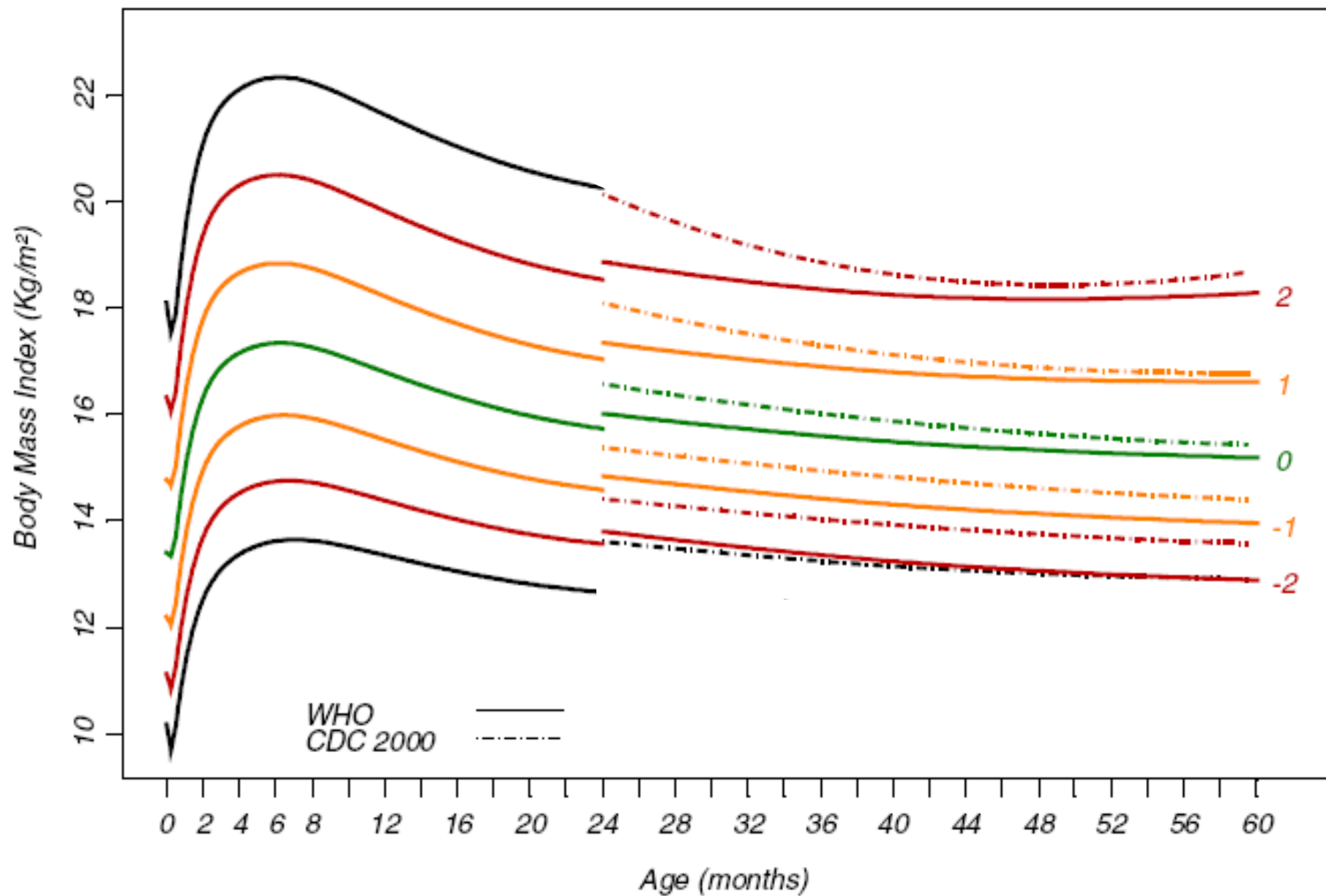


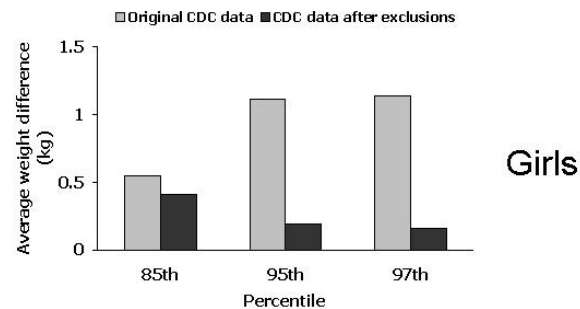
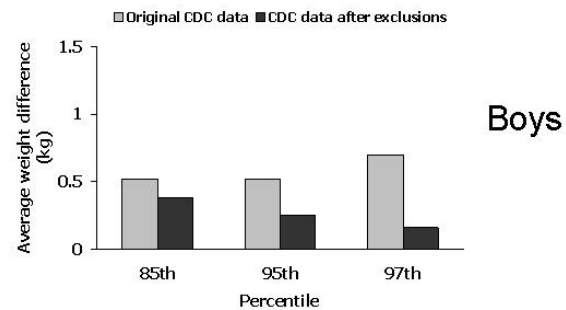
Figure 115 Comparison of WHO with CDC 2000 BMI-for-age z-scores for boys

# Effect of applying the $\pm 2$ SD criterion to the CDC sample

Agreement with the WHO charts was better at higher percentiles with the recalculated values

# Difference in weight between WHO and CDC charts with and without data exclusions

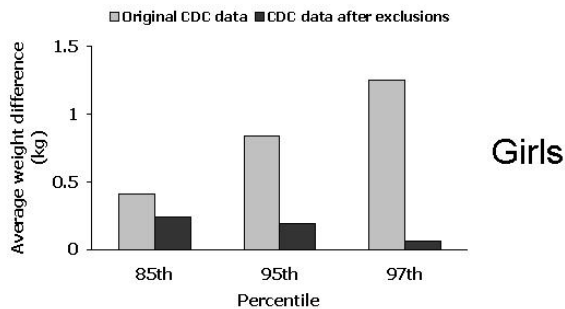
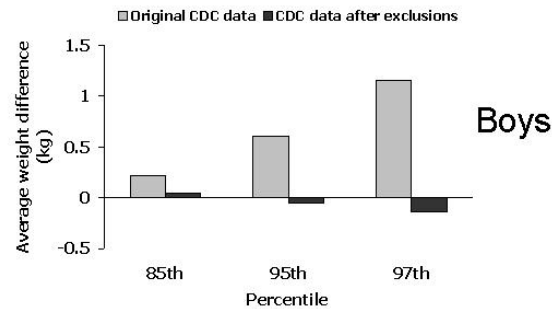
## 1. Weight for length



Source: NHANES 1999-2004; Flegal et al under review

# Difference in weight between WHO and CDC charts with and without data exclusions

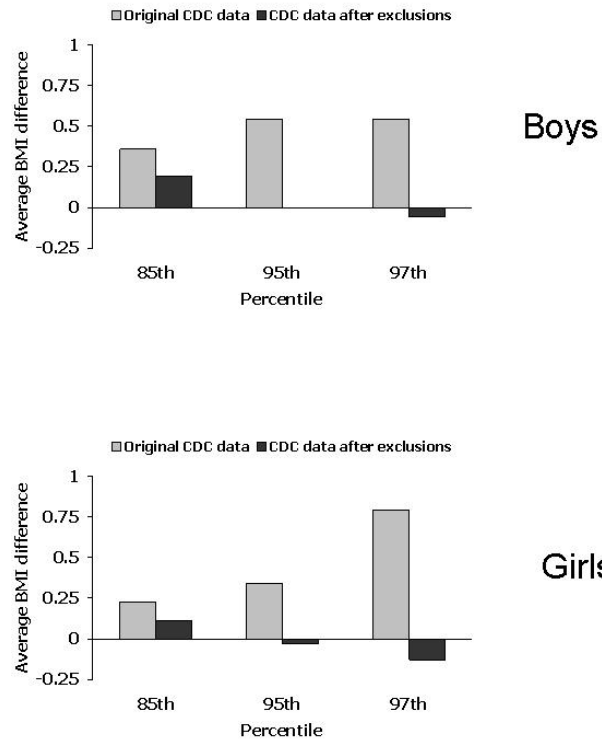
## 2. Weight for height



Source: NHANES 1999-2004; Flegal et al under review

# Difference in BMI between WHO and CDC charts with and without data exclusions

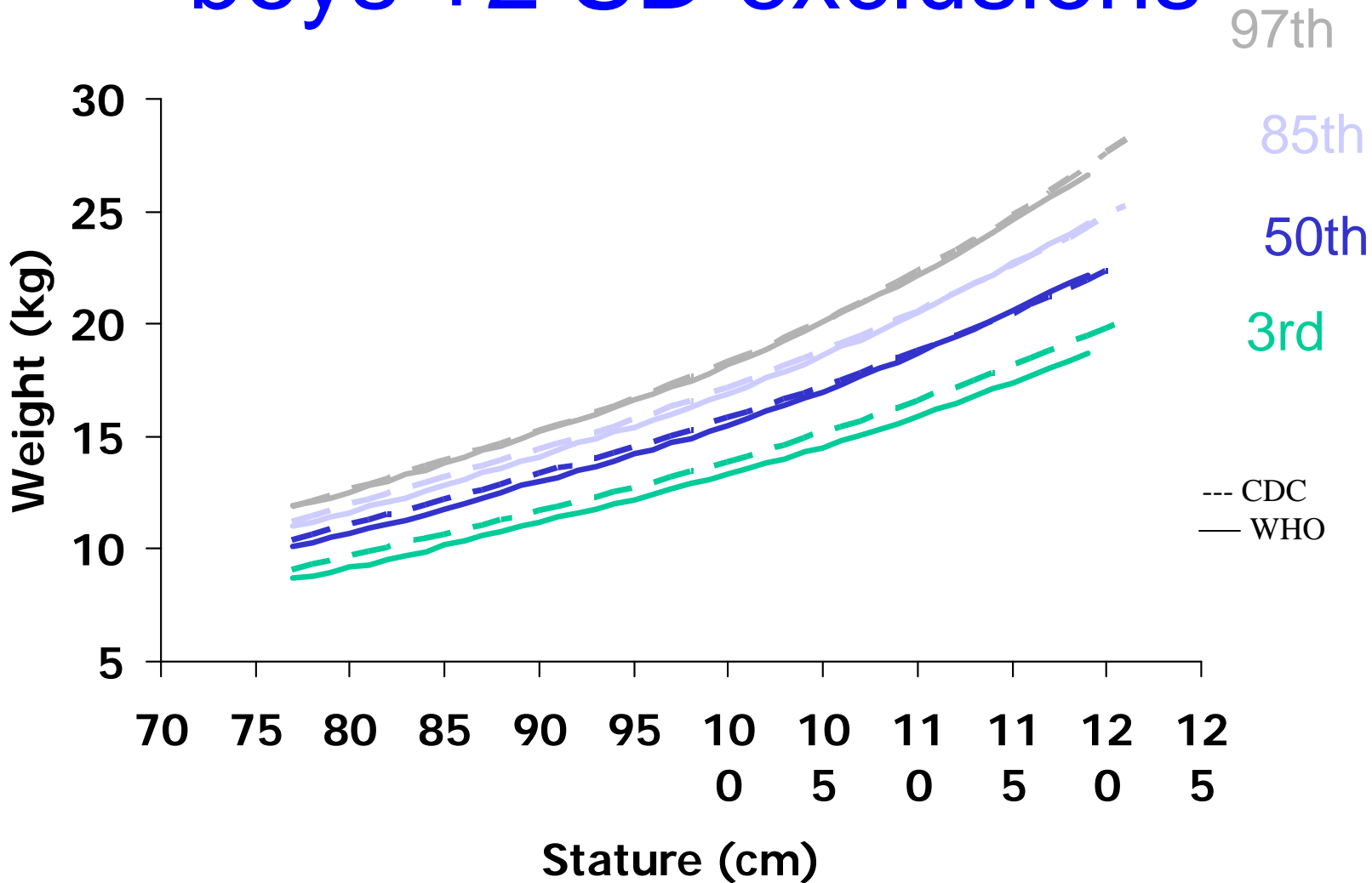
## 3. BMI-for-age



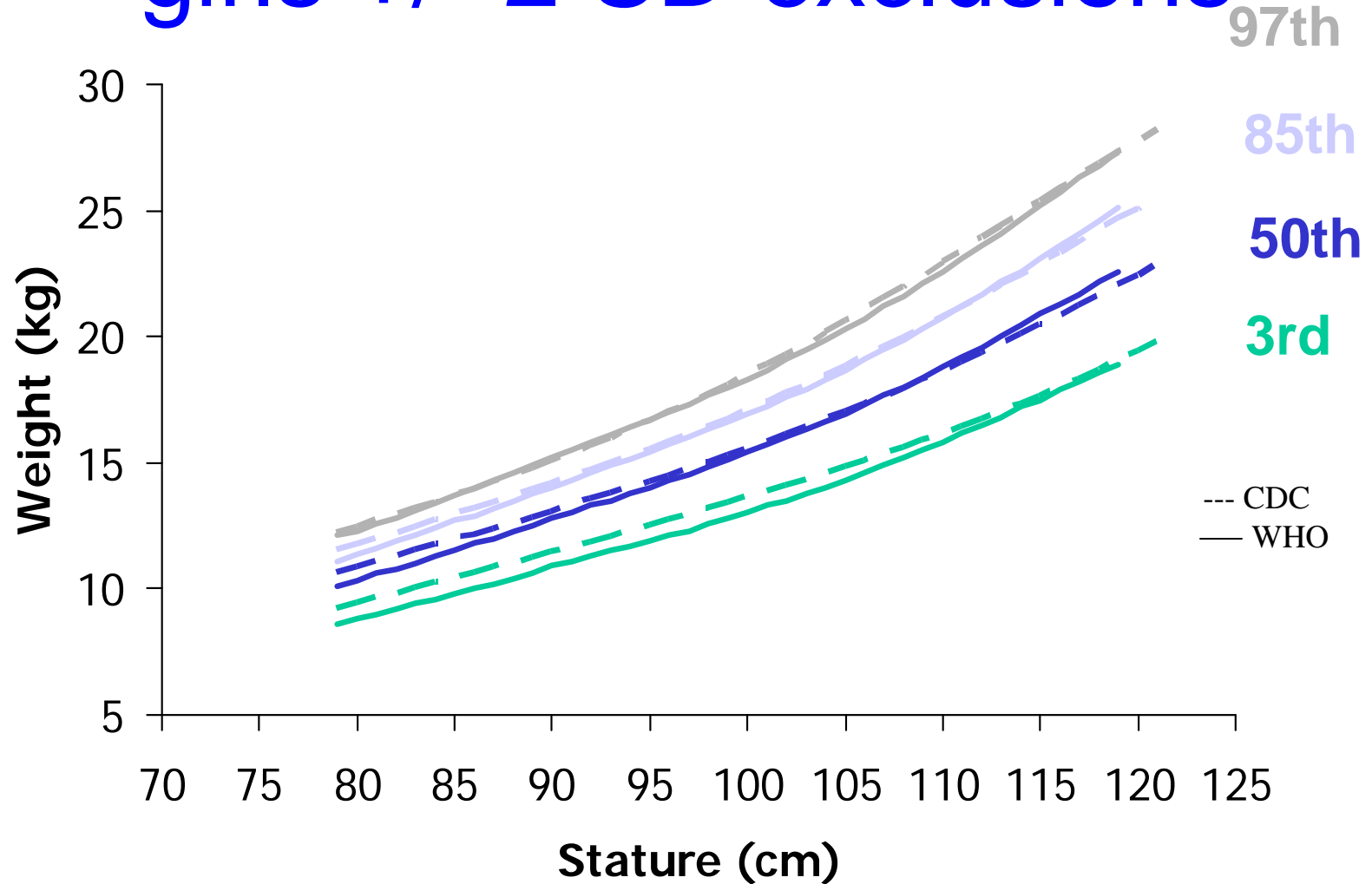
Source: NHANES 1999-2004; Flegal et al under review



# Weight for height boys +2 SD exclusions



# Weight for height girls +/- 2 SD exclusions



# Smoothing methods

The WHO standards ... employed LMS-based methods that fit skewed data adequately and generate fitted curves that follow closely the empirical data. Like the WHO standards, construction of the CDC 2000 growth charts was also based on the LMS method and, therefore, differences between this reference and the WHO standards are largely a reflection of differences in the populations on which the two sets of curves were based.”

» Technical report, p xviii

# Using the charts: cut-offs for abnormal growth

- Cut-off values are statistical and not functional definitions
- Any desired cut-offs can be used with any chart
- CDC uses percentile cut-offs suggested by expert committees and/or used by federal programs

# Crossing centiles

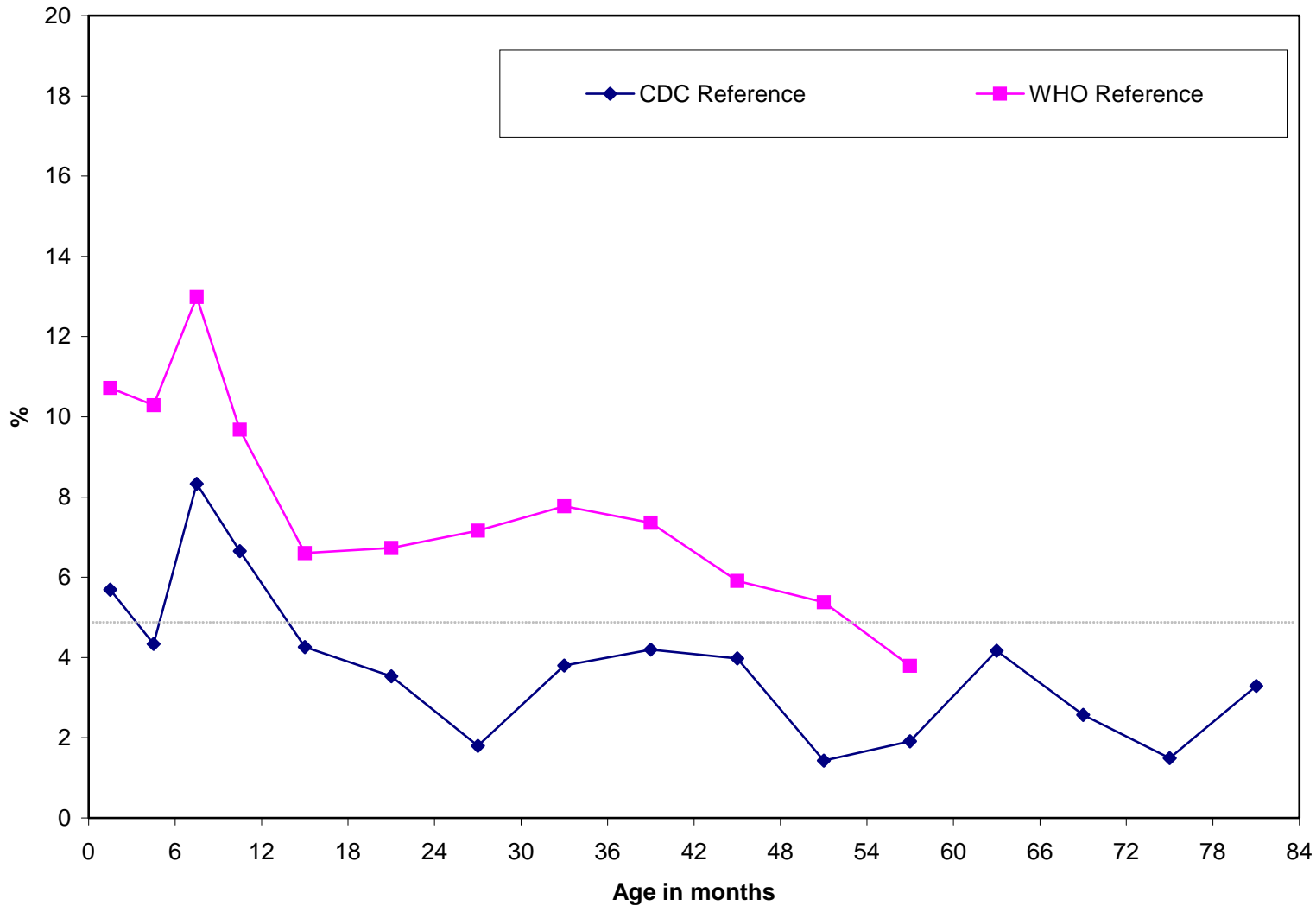
---

- **Height-for-age:**
  - more “falling off” between 0-6mos. using WHO
- **Weight-for-age:**
  - more “falling off” between 0-6mos. using WHO
  - much more “falling off” between 6-12mos. Using CDC
- **BMI-for-age:**
  - more “falling off” between 24-30mos. Using WHO
  - more “excessive growth” for all ages (24-60mos) using CDC

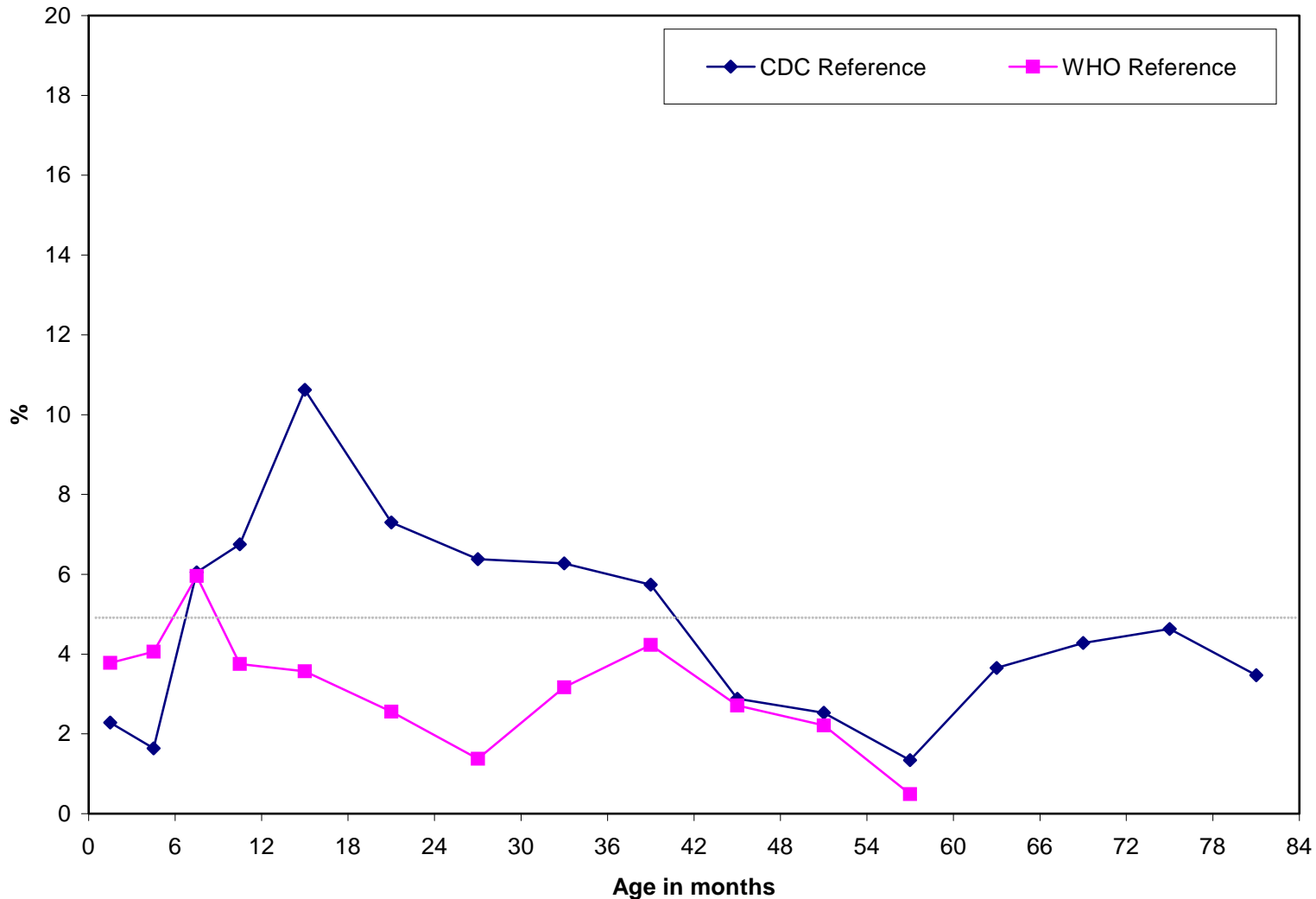
# Cut-offs for abnormal growth

	<b>CDC 2000</b>	<b>WHO 2006</b>
Low	<5 <sup>th</sup> percentile (-1.645 z-score)	<-2 z-score (2.3 <sup>th</sup> percentile)
High	>=95 <sup>th</sup> percentile (1.645 z-score)	>2 z-score (97.7 <sup>th</sup> percentile)

# Length/height-for-age <5<sup>th</sup> percentile

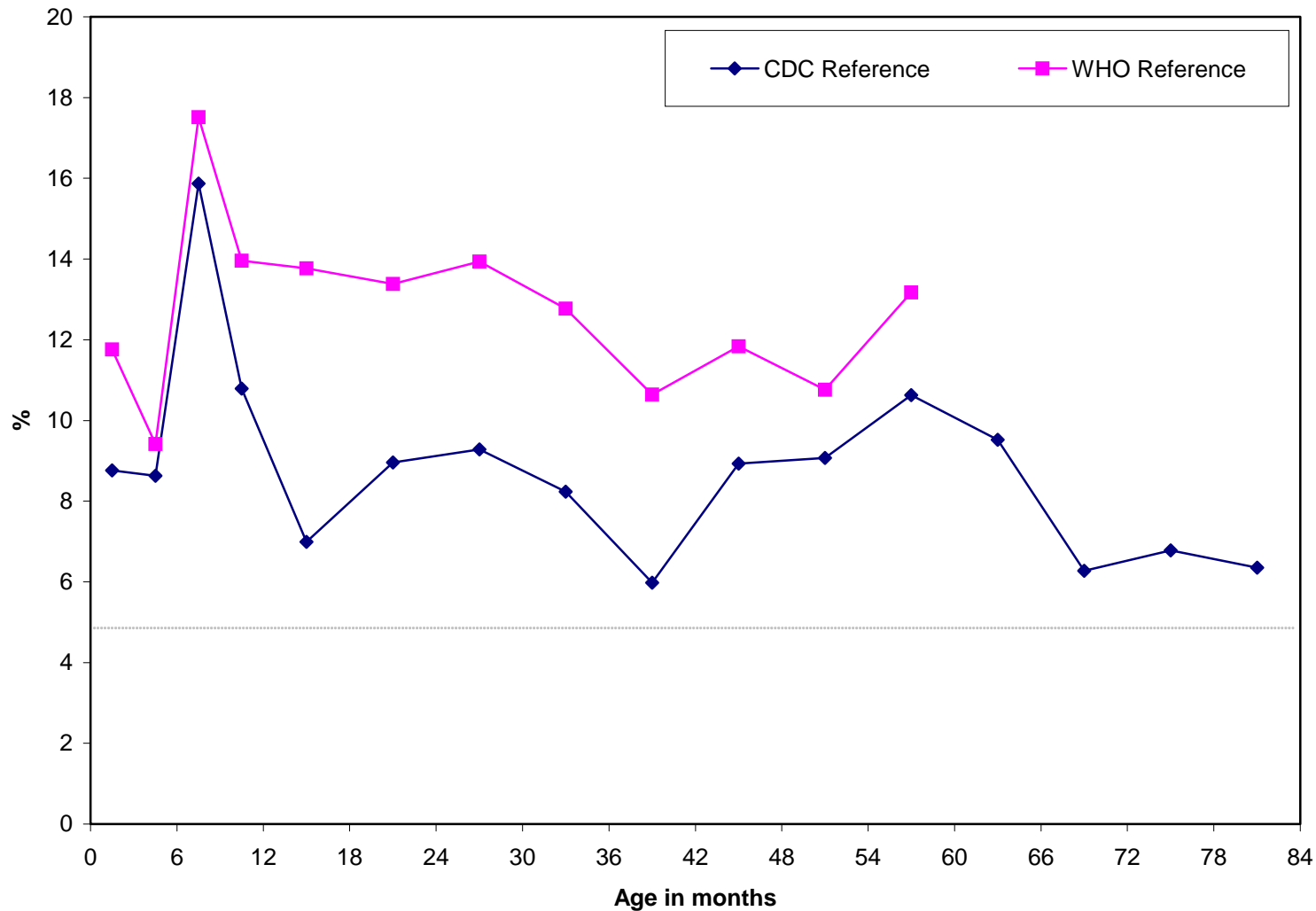


# Weight-for-age <5<sup>th</sup> percentile

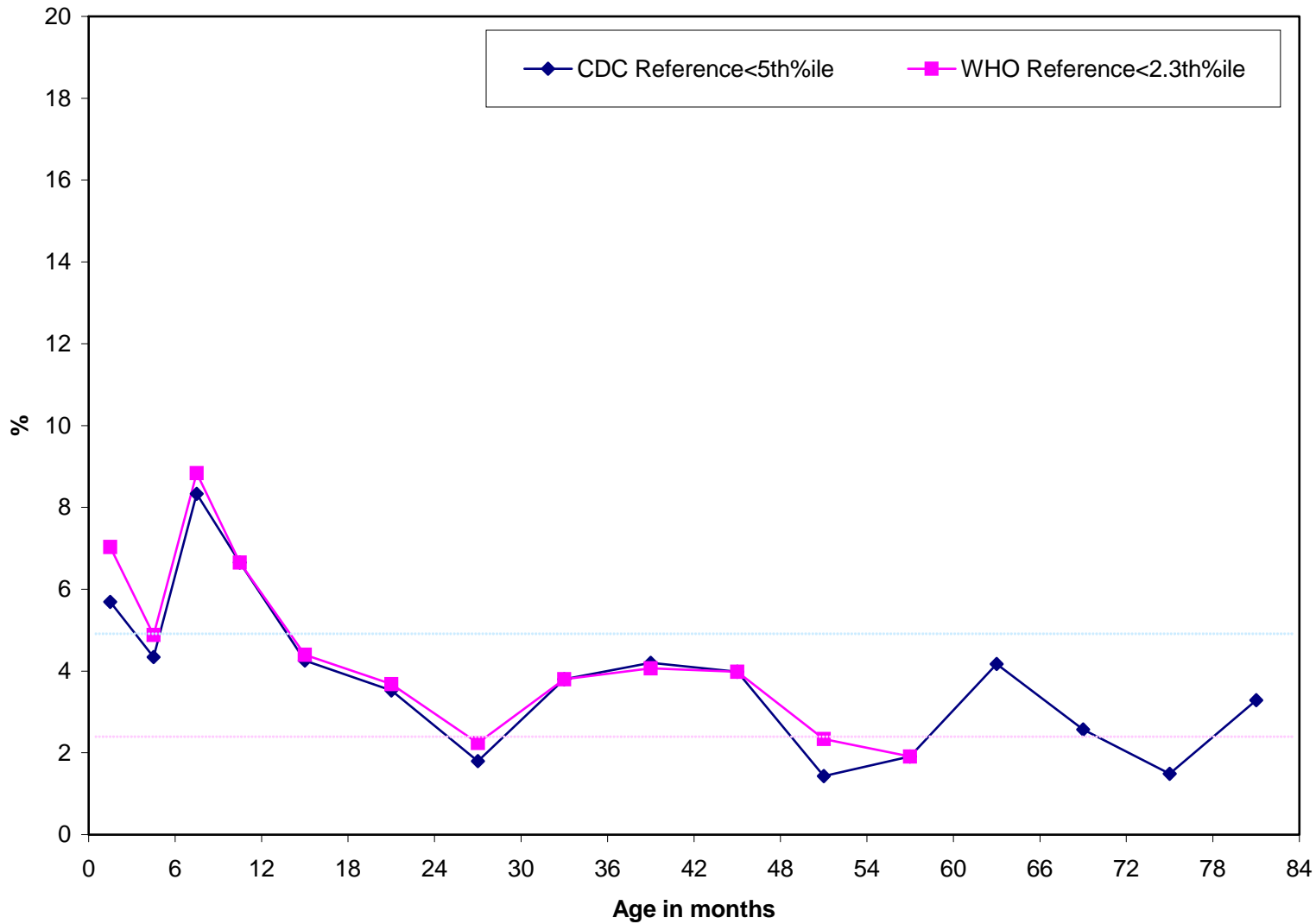




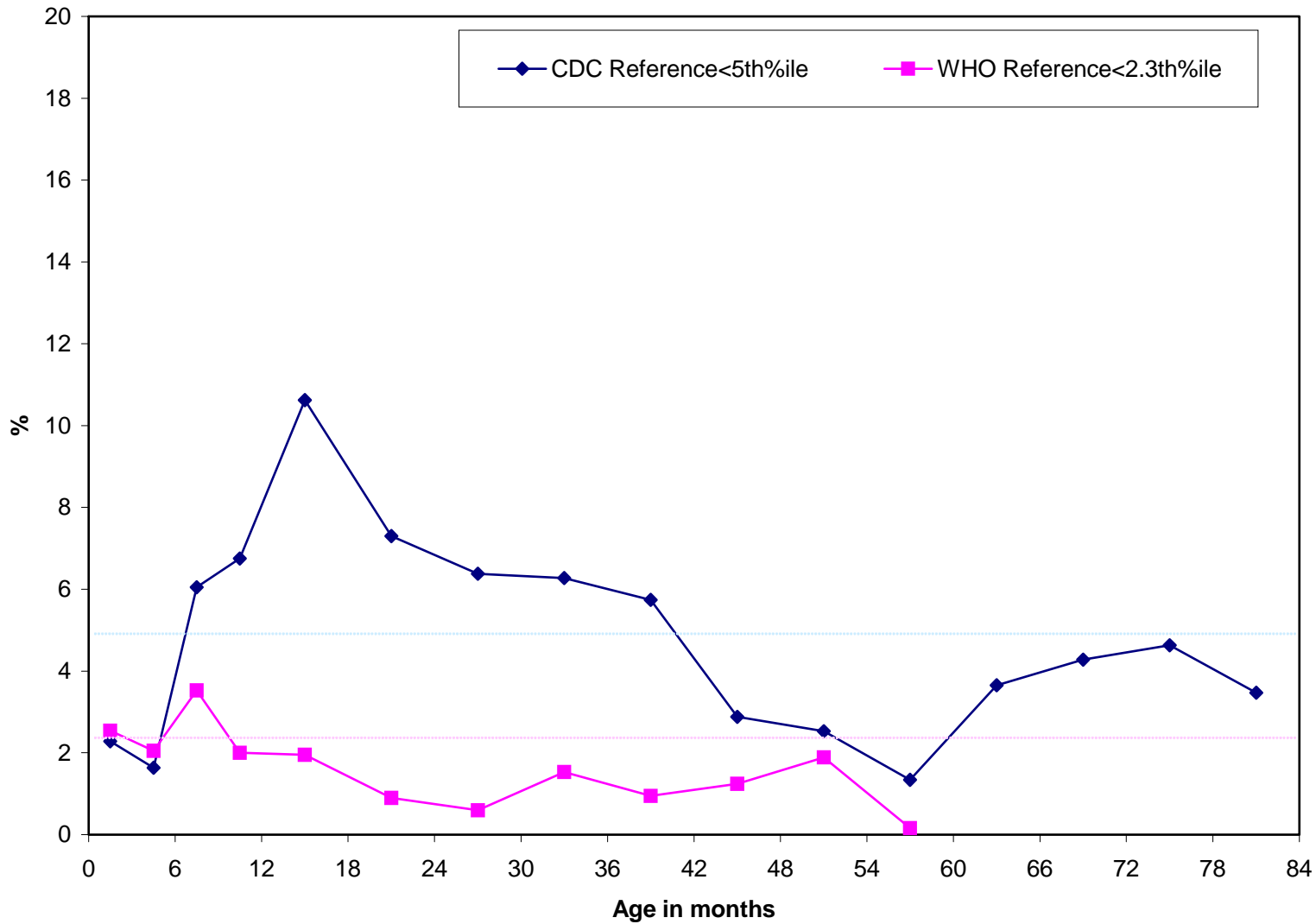
# Weight-for-length/height $\geq 95^{\text{th}}$ percentile



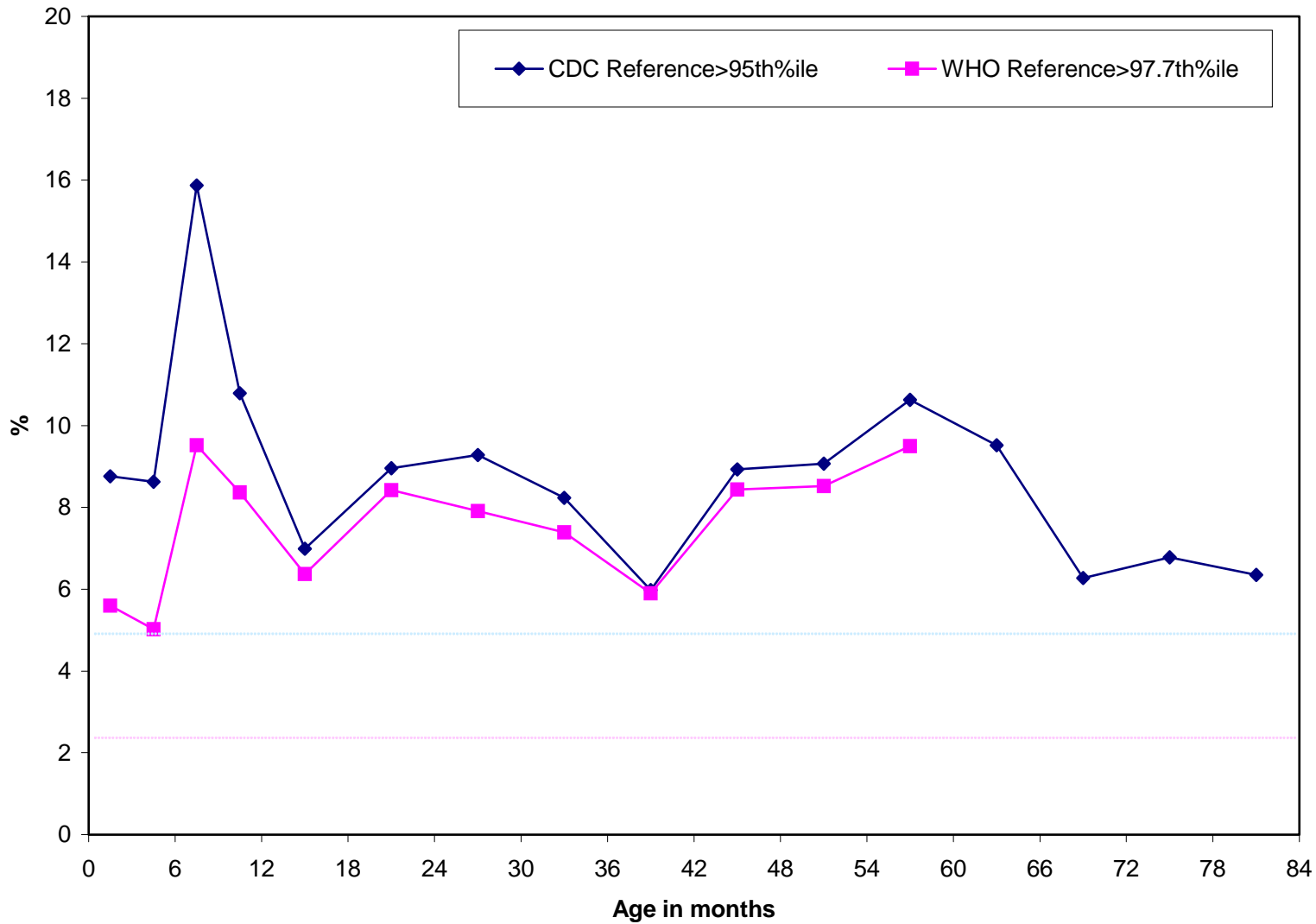
# Low length/height-for-age



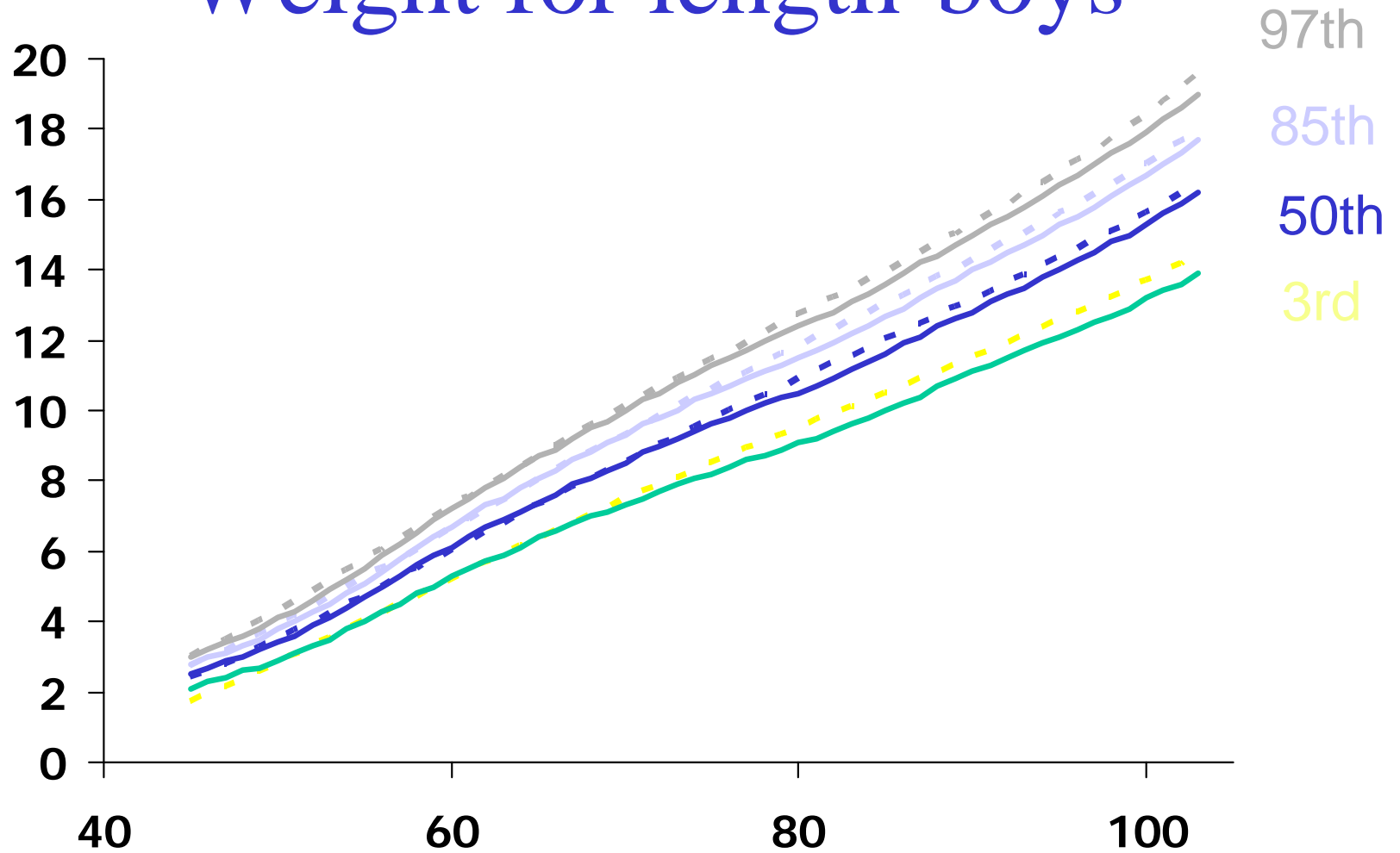
# Low weight-for-age



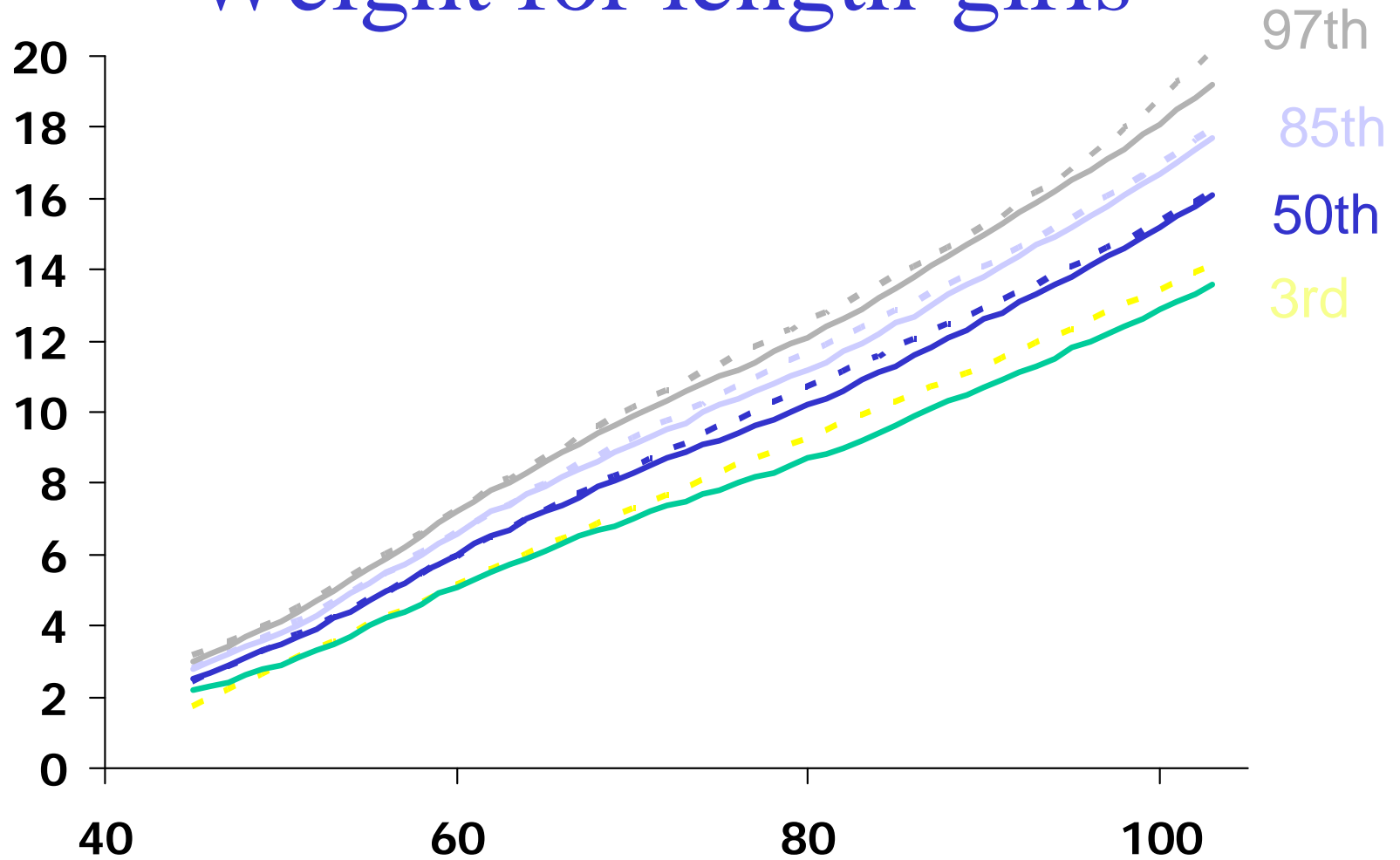
# High weight-for-length/height



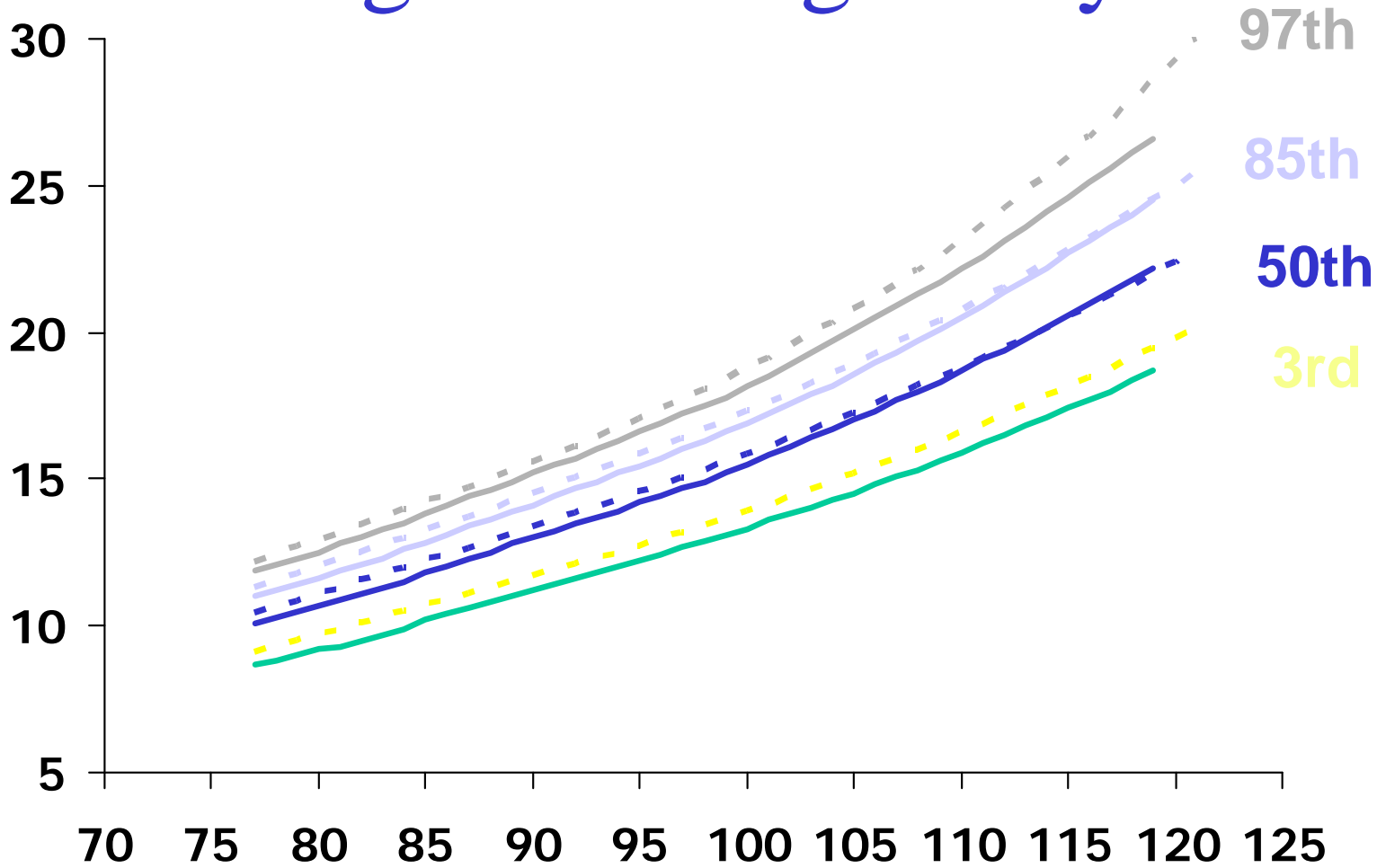
# Weight for length-boys



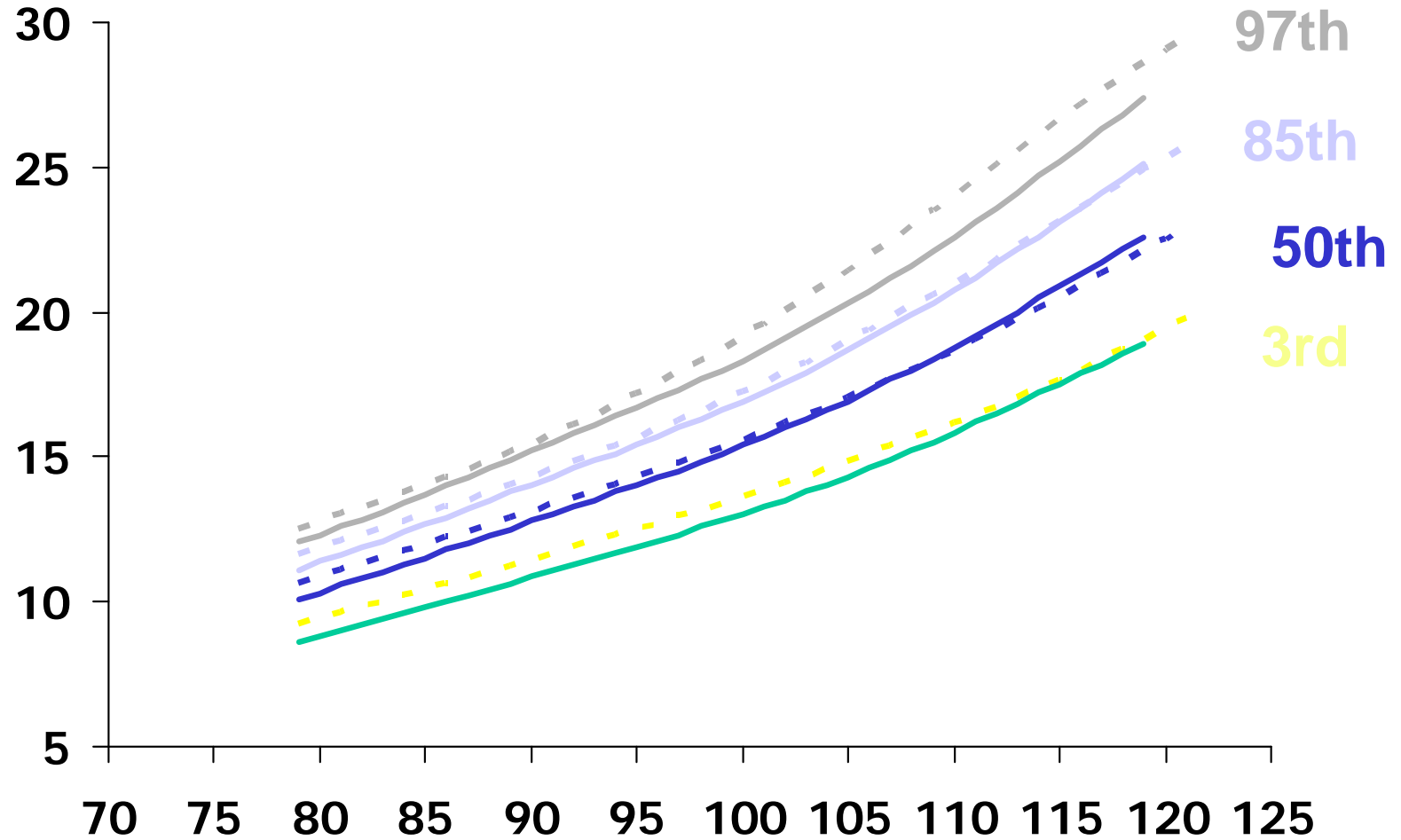
# Weight for length-girls



# Weight for height-boys



# Weight for height-girls





# Outlying percentiles

CDC: The outermost percentiles that were smoothed were the 3<sup>rd</sup> and 97<sup>th</sup> percentiles. The modified LMS values were not calculated using any percentiles outside those limits (approximately equivalent to a z-score of +/- 1.88). Caution is urged when trying to generate percentiles beyond those limits using the CDC LMS values.

# Length or stature for age

- At younger ages, WHO length for age has a slightly narrower distribution than the CDC length for age
- At older ages, CDC length/stature for age percentiles are almost always slightly lower than the corresponding WHO percentiles
- Suggests that at older ages the CDC sample is slightly shifted to the left relative to the WHO sample
- Differences are slight

# Weight for age

- In early infancy (up to ~8 months), WHO weight for age percentiles are higher than the corresponding CDC percentiles
- From 8 mo to ~30 months, CDC weight for age percentiles tend to be higher than the corresponding WHO percentiles
- After ~30 months, the percentiles are almost identical on the two charts

# Body mass index for age

- The CDC BMI-for-age percentiles are higher than the corresponding WHO percentiles
- The differences become smaller with age
- The median and the 85<sup>th</sup> percentile agree closely at the older ages
- Suggests that the WHO sample is slightly shifted to the left relative to the CDC sample

# Weight for length/stature

- The CDC weight for length/stature percentiles are higher than the corresponding WHO percentiles
- The differences become smaller with age
- The median and the 85<sup>th</sup> percentile agree closely at the older ages
- Suggests that the WHO sample is slightly shifted to the left relative to the CDC sample

# Why does it matter? – Defining obesity

denverpost.com

[http://www.denverpost.com/ci\\_13530098](http://www.denverpost.com/ci_13530098)

Sign in | Register  
Monday, October 12, 2009

Home News Politics Sports Business Entertainment Lifestyle Opinion Outdoors Multimedia Travel

CLASSIFIEDS JOBS AUTOS REAL ESTATE SHOP

DENVER AND THE WEST

## Heavy infant in Grand Junction denied health insurance

Frustrated parents of a big infant who is being denied insurance view the system as "absurd."

By Nancy Lofholm  
The Denver Post

POSTED: 10/10/2009 01:00:00 AM MDT  
UPDATED: 10/12/2009 07:34:19 AM MDT

GRAND JUNCTION — Alex Lange is a chubby, dimpled, healthy and happy 4-month-old.

But in the cold, calculating numbered charts of insurance companies, he is fat. That's why he is being turned down for health insurance. And that's why he is a weighty symbol of a problem in the health care reform debate.

Insurance companies can turn down people with pre-existing conditions who aren't covered in a group health care plan.

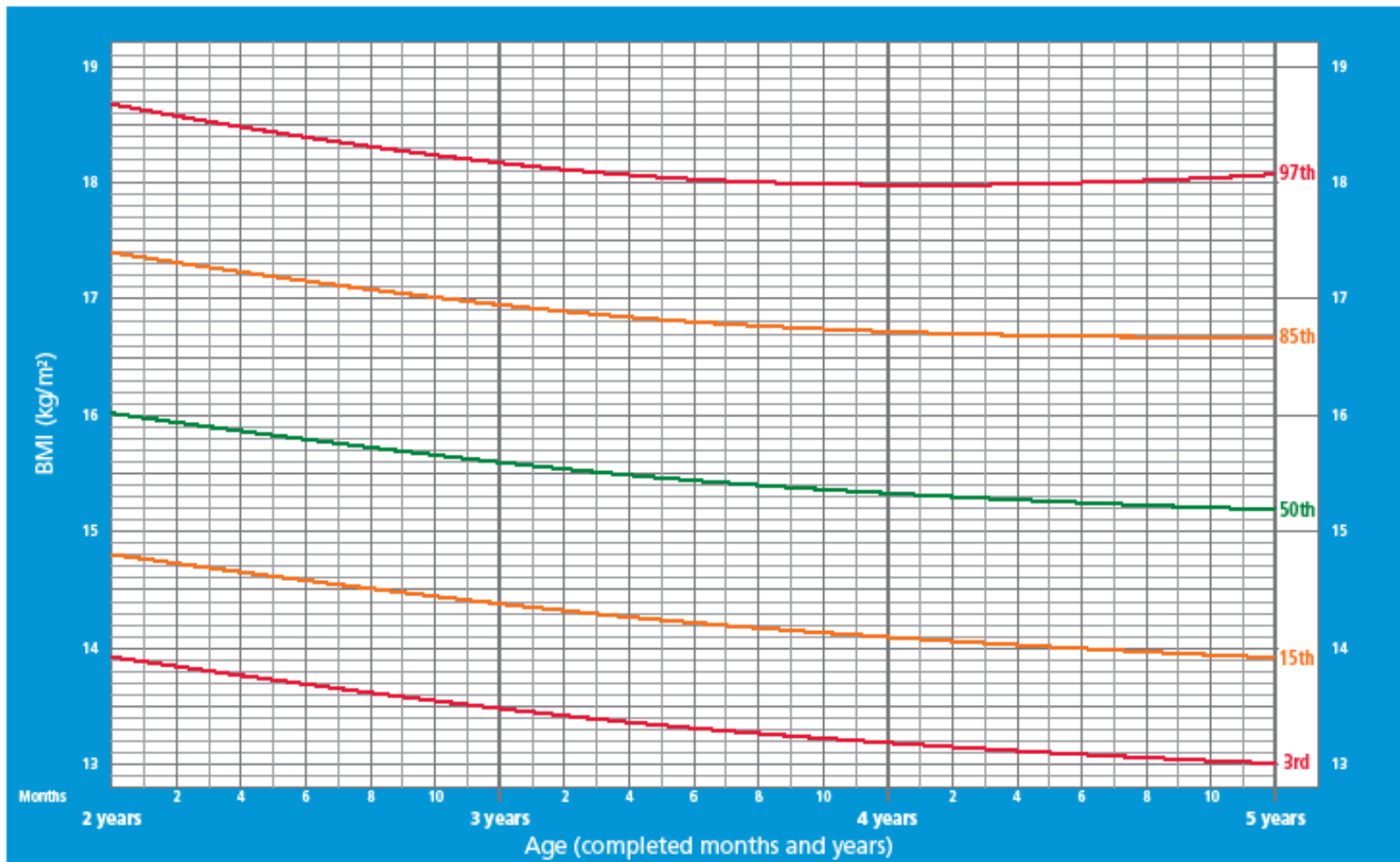
Alex's pre-existing condition — "obesity" — makes him a financial risk.



- Birth weight: Boy, 8 ¼ lb
- Current size: 17 lb, 25"
  - At 4 months of age
  - Being breastfed
- At the 99<sup>th</sup> percentile for weight & height
- Applied for health insurance
  - Rocky Mtn Health Plans
- Parents' application denied because baby too "fat"
- For children, plan refuses coverage at  $\geq 95^{\text{th}}$  percentile ("obese")
- Application accepted after Denver Post article appeared

# BMI-for-age BOYS

2 to 5 years (percentiles)



WHO Child Growth Standards