Definition of overweight/obesity

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Definitions

Overweight

- Total body weight in excess of a specified threshold for weight

Obesity

- Excess body fat (excess adiposity--total, regional)

Measures

Total body fat

- Indirectly estimated using various body composition techniques (UWW, DXA, ADP, BIA, SF, etc.)
- Directly measured through chemical analysis of cadavers

Total body weight

- Measured with a weight scale

Body Mass Index [Wt (kg)/ht $(m)^2$]

- Index of body weight, adjusted for stature
- Measurement validity and reliability are good
- Easy to calculate with a hand calculator
- Accepted in U.S. & internationally as an index of overweight & obesity among adults
- Various definitions and criteria exist for overweight

Kuczmarski & Flegal, AJCN, 2000

Body Mass Index

- In adults, BMI is correlated with adverse health outcomes (insulin resistance, hypertension, dyslipidemias, etc.)
- BMI is not a quantitative measure of adiposity (or obesity)
- A clinical screening tool -- should not be used as the sole diagnostic clinical criterion for obesity in adults or children (misclassification potential)

What is the role of BMI in children?

- BMI has a close relationship to body fatness—indicates high or low levels of body fat
- Correlation with body fatness in children ranges from ~ 0.50 to 0.90
- Depends on the criterion method used to assess body fatness and the age and sex of subjects
- Children with highest BMI have body fat > 30%

ietz & Bellizzi, AJCN, 1999; Ellis, J Nutr, 2001

Total body fat mass (BMI & DXA)

	R	R^2
New Zealand		
White girls (4-16 yr)	.93	.87
Italy		
White Girls (5-19 yr)	.85	.72
White boys (5-19 yr)	.89	.79
Pima boys & girls (5-19 yr)	.96-.98	.92-.96

Pietrobelli, J Pediatr, 1998; Goulding et al, Int J Obes, 1996; Lindsay et al, J Clin Endo & Metab, 2001

For children & adolescents, why use BMI instead of weight-for-stature?

Weight-for-stature

Advantage

- Can be used without knowledge of child's age

Disadvantages

- Specific for a particular set of reference data
- No units (unlike BMI, where 20 kg/m^2 is not related to reference data)
- 1977 prepubescent growth charts (boys 145 cm [4'9"]--11yrs; girls 137 cm [4'6"] --10.5 yrs.)

Why use BMI for children?

- Works for ages where weight-for-stature previously did not -- provides a reference not previously available for adolescents
- Can be used to rank individuals from early childhood beginning at 2 years through adolescence into adulthood (continuity)
- There is a correlation between child and adult BMI levels (*tracking* increases >8 yrs)
- *Adiposity rebound* may be predictive of future overweight

Why use BMI for children?

- Can be put on a single chart
- Has been used in epidemiological analyses
- It is a metric measure, therefore it is not population dependent (can compare studies)

Why use BMI for children?

- Childhood BMI may indicate or predict current or future health
  - Obesity at age 7 yr associated with metabolic syndrome in adulthood
  - In children with BMI > 95 percentile, 60% have $\geq$ 1 & 20% have $\geq$ 2 CVD risk factors
  - Emerging findings with increased BMI & T2D

Vanhala. et al., Int. J. Obes., 1999

Comparisons of wt-for-stature & BMI-for-age with adiposity measures

- Sensitivity & specificity analyses for average of triceps & subscapular skinfolds with BMI from NHANES III
- Repeated analyses on series of data sets with body fat measured by DXA

Mei et al., AJCN, 2002

Comparisons of wt-for-stature & BMI-for-age, NH3 (age < 20 yrs)

- For ages 2-5 yr, BMI-for-age & wt-for-stature assigned similar percentiles
  - 95% of children within 10 percentile points
  - 75% of children within 5 percentile points
- For ages 6-11, 12-19 yrs, BMI had a higher sensitivity than wt-for-stature
- Conclusion: In predicting overweight, performance of weight-for-stature & BMI-for-age are equal to <6 yrs., but better for BMI-for-age ≥ 6 yrs.

GAPS screening, identification, classification criteria

- Adolescents (11-21 yrs.)
- "Overweight" (BMI-for-age $\geq$ 95th percentile)
  - Family history: + FH of T2D, CVD; parental obesity or hypercholesterolemia
  - Child: high BP, high total cholesterol
- "At risk of overweight" ($\geq$85th BMI-for-age < 95th percentile of NHANES I smoothed BMI): refer for second level screen

GAPS second level screen criteria

- Family history: + FH of T2D, CVD; parental obesity or hypercholesterolemia
- Child:
  - High BP, High Total Cholesterol
  - Large increment in BMI (increase over previous year of 2 BMI units)
  - Personal concern about weight status

Himes & Dietz, AJCN, 1994

Others recommending BMI-for-age to screen for overweight

- MCHB (Bright Futures)
- AAP
- AAFP

Avoiding “obesity” label

- Recommend “overweight” & “at risk of overweight”
- Risk of misclassification for child growing linearly-- may grow out of it
- BMI is highly correlated with body fatness, but is not a measure of body fat (obesity = excess adiposity)
- Little known about immediate health implications for children at specific BMI cutoff values

Avoiding “obesity” label

- Potential social stigma associated with labeling child as obese (obesity as a disease)
- Concern about triggering eating disorders & inappropriate behaviors (smoking, laxatives, purging, etc.) – not well reported; may be unjustified
- Concern about triggering or exacerbating inappropriate psychological responses (depression, social withdrawal, etc.)

Obese label implies need for treatment, but PCPs generally lack:

- Proper training in weight management
- Efficacious treatment options
- Adequate time
- Sufficient reimbursement for services
- Sufficient referral channels (RD, PT, etc.); community resource referrals
- Skills of a behaviorist, or access to skilled behaviorist

What is current reference for U.S. & how was it derived?

Derivation of BMI cutoff points for youth

- Adults have “fixed” stature
- Boys & girls grow (mature) at different rates
- Weight & stature are dynamic & changing with age & there are sex-specific differences
- Need to have sex- and age-specific BMI references

2000 CDC growth charts

- Growth chart = “a tool for providing a common basis for purposes of comparison” (WHO)
- Set of smoothed curves for selected percentiles
- Percentile is a value for which P% of total sample has a smaller value
- BMI data sources

  NHES II – 1963-65; NHES III – 1966-70;

  NHANES I – 1971-74; NHANES II – 1976-80;

  NHANES III – 1988-94

Derivation of growth chart percentiles

- Excluded weight values for ages ≥ 6 yrs. measured after 1988 (positive trend in weight considered undesirable—would have led to under classification of overweight because percentiles shifted upward)
- For 2000 CDC BMI charts, BMI calculated by individual month of age; subjects grouped to 6 month age groups & estimates plotted against midpoints of the age ranges (e.g., 2.25 yrs = 2.0-2.49 yrs…19.5-20.0 = 19.75 yrs)

Derivation of growth chart percentiles

- Empirical (observed) percentile estimates plotted against median value of each age group
- Smoothing--plots of empirical percentile estimates show irregular patterns across ages
  - Smoothing procedures used to fit curves to the estimates to reduce irregularity
  - Under-fit—curve is smooth, but doesn't accurately reflect biological change with age
  - Over-fit—curve goes through nearly all empirical points, but doesn't reduce irregularity

Interpretation

- Growth charts are a screening tool—they are not intended to be the sole clinical diagnostic instrument for assessment of overweight or obesity or overall health status
- Comparisons between the plotted data and reference percentiles show the approximate level for a child, relative to other children of matching age & sex, who belong to a well-defined population that provided data for construction of the charts

Standard vs. reference

Standard

- "What should be"
- Clinical ideal (tells where a child's size should be)
- A measure that embodies a norm or target (WHO

Reference

- "What is"
- Presentation of observed values in a well-defined population—without clinical judgment

Interpretation

- Accepted “normal” ranges are determined by boundaries of outlying percentiles
- 3^{rd} & 97^{th}; 5^{th} & 95^{th}; $\pm$ 2 Z (indicate risk association for pathological conditions)
- Caution: values outside normal range may be observed in healthy children; values within normal range may be observed in children with serious disease

Interpretation

- Growth assessment is not a diagnostic tool
- Potential for misclassification
- Serial data desirable to determine growth patterns
- Should consider other influences on growth (parental size, environmental factors e.g., SES status, nutritional status/food availability, etc.)

What are racial/ethnic considerations for BMI charts?

Race/ethnic-specific charts

- Sample sizes for NCHS surveys didn't meet statistical requirements for precise estimates of outlying percentiles--requires large samples—difficult to obtain for dispersed groups
- Differences in growth potential between NH-B, W, & M-A appear to be small
- Only small differences in stature and weight between upper SES groups from various populations—suggests environmental influence

Race/ethnic-specific charts

- Lack of clear evidence that differences in growth for these groups are genetically determined
- Reasonable to use a combined national reference for surveys or public health screening & group-specific charts (if available) for individual assessments
- Ethnicity & race are imprecise and ambiguous terms (resulting from ancestral heterogeneity and geographic origins)

Race/ethnic-specific charts

- Difficult to develop and apply ethnic-specific charts since many children have ethnically-diverse parents
- Mean values for particular group may not be indicative of health (e.g., MA)
- However: At a given BMI, body fat in white children > black children (ages 7-17 years); Don’t know enough about Asians & others

Daniels, et al., Pediatrics, 1997

What are useful characteristics of BMI in longitudinal studies?

Useful characteristics of BMI growth charts in longitudinal studies

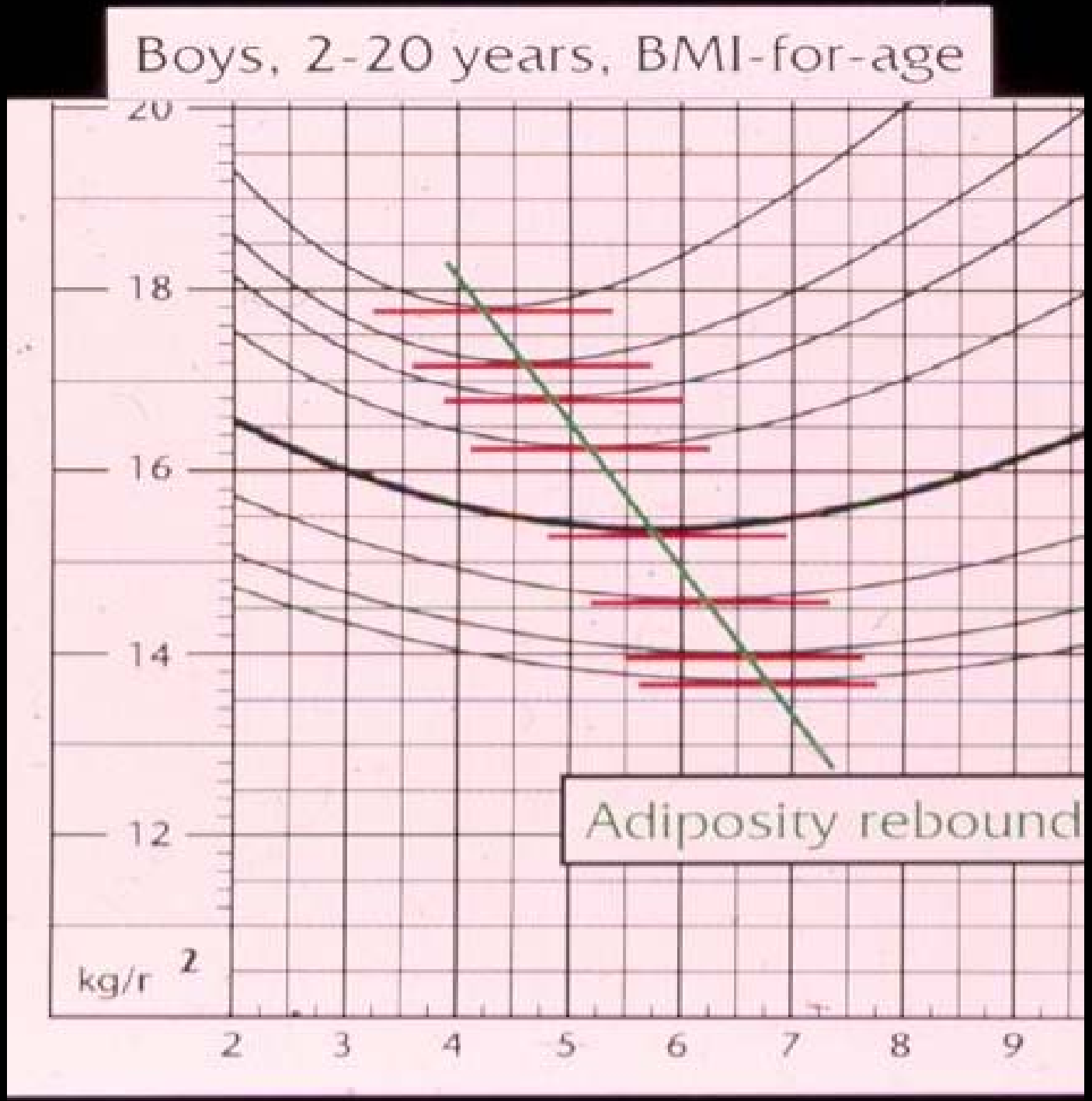
Adiposity (BMI) rebound

- BMI percentile values increase steeply to ~ 8-9 months then decrease rapidly after 1 year until a nadir is reached at ~ 4-6 years
- Increase in BMI after the nadir is called a rebound
- To be meaningful, children must be measured at frequent intervals to determine nadir

Useful characteristics of BMI growth charts in longitudinal studies

Adiposity (BMI) rebound

- Earlier the age of BMI rebound, more likely child is to track at a higher BMI percentile
- When rebound occurs before age 4 yrs., tends to be associated with higher BMI in adolescence and adulthood—early warning alarm for prevention
- Increase in BMI from nadir to post-pubescence is inversely related to age at rebound; at age 21 BMI is largest in early rebound group (<5 yrs) and smallest in late rebound group (>7 yrs)


Boys, 2-20 years, BMI-for-age
20
18
16
14
12
kg/m 2
2
3
4
5
6
7
8
9
Adiposity rebound

Useful characteristics of BMI growth charts in longitudinal studies

Tracking (tendency to retain the rank order of values across time)

- BMI performs better for tracking than other screening indices (e.g., skinfolds, waist/hip ratio)
- < 3 years, parental obesity stronger predictor than child's weight status
- Children ≥3 yrs. with BMI > 85th percentile at 3 yrs. have higher odds of being > 85th percentile in young adulthood

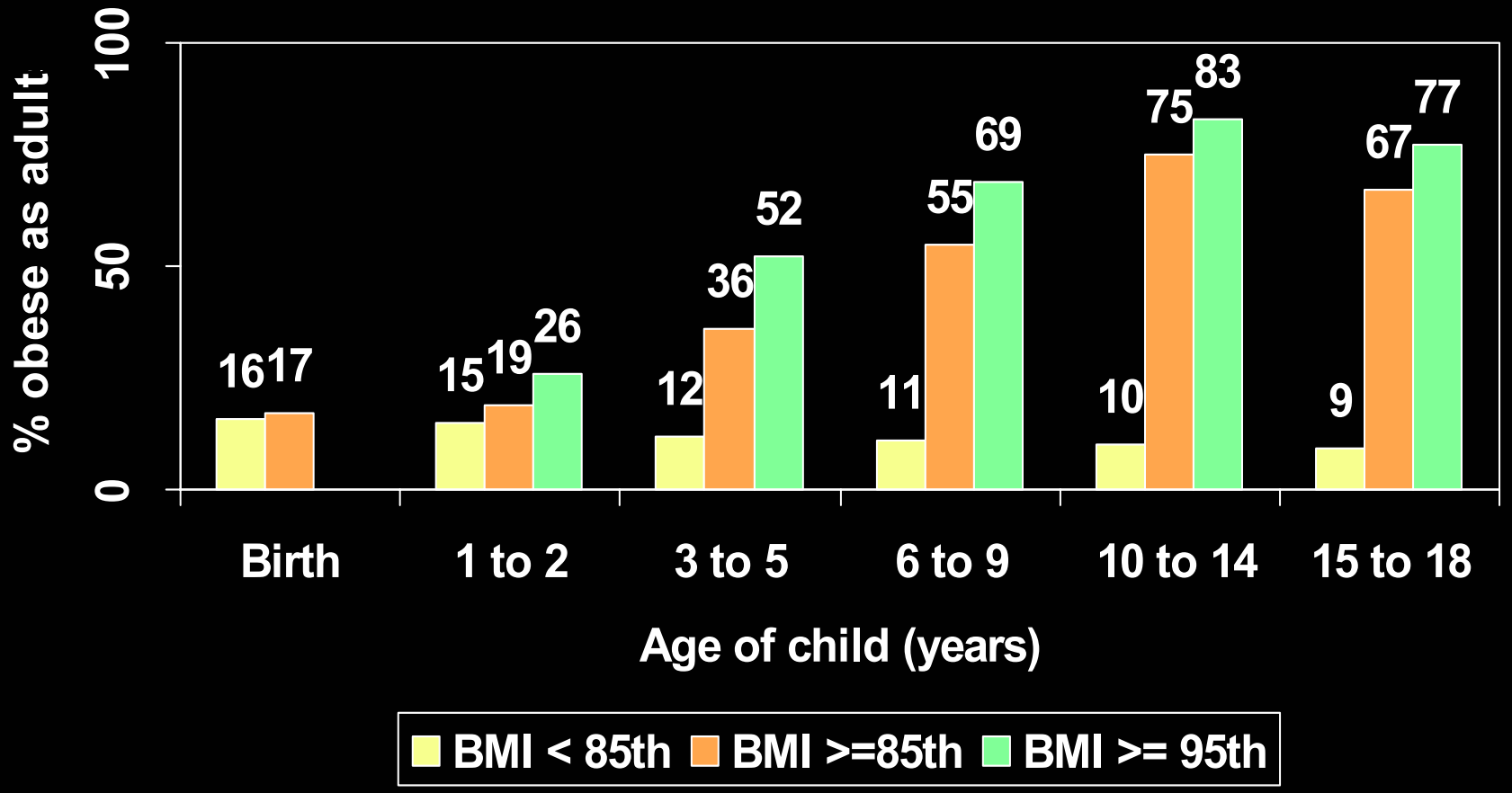
Useful characteristics of BMI growth charts in longitudinal studies

Tracking

- At 4 years tracking to adulthood is ~20%
- BMI tracks well from adolescence into adulthood (~80%)—highly predictive of adult obesity

Guo, et al. Int J Obes, 2000; AJCN 1994; Whitaker et al, NEJM, 1997

Tracking BMI-for-age from birth to 18 years with percent of overweight children who are obese at age 25



Whitaker et al., NEJM, 1997

Useful characteristics of BMI growth charts in longitudinal studies

Decanalization (marked lack of tracking)

- Unusual growth pattern where serial points for an individual cross $\geq$ 2 major percentile lines
- Points shift from one major canal to a non-contiguous canal

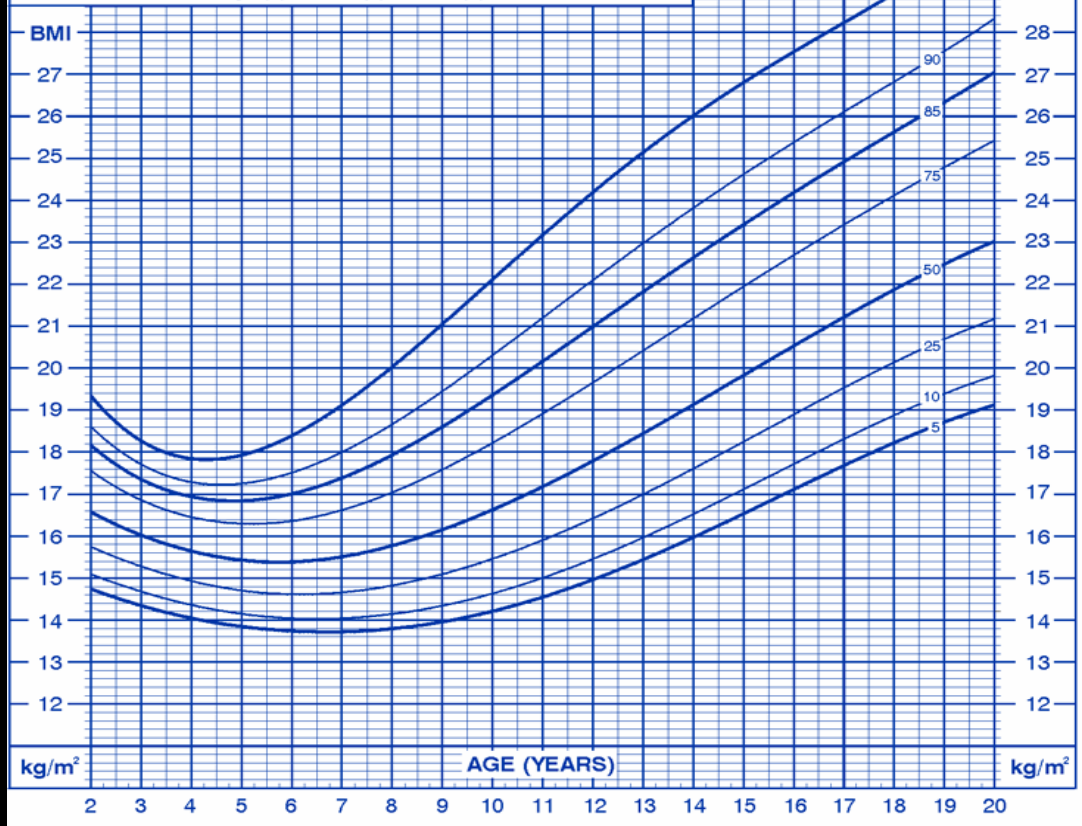
2 to 20 years: Boys
Body mass index-for-age percentiles

NAME _____

RECORD # _____

Date	Age	Weight	Stature	BMI*	Comments

***To Calculate BMI:** Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



Published May 30, 2000 (modified 10/16/00).

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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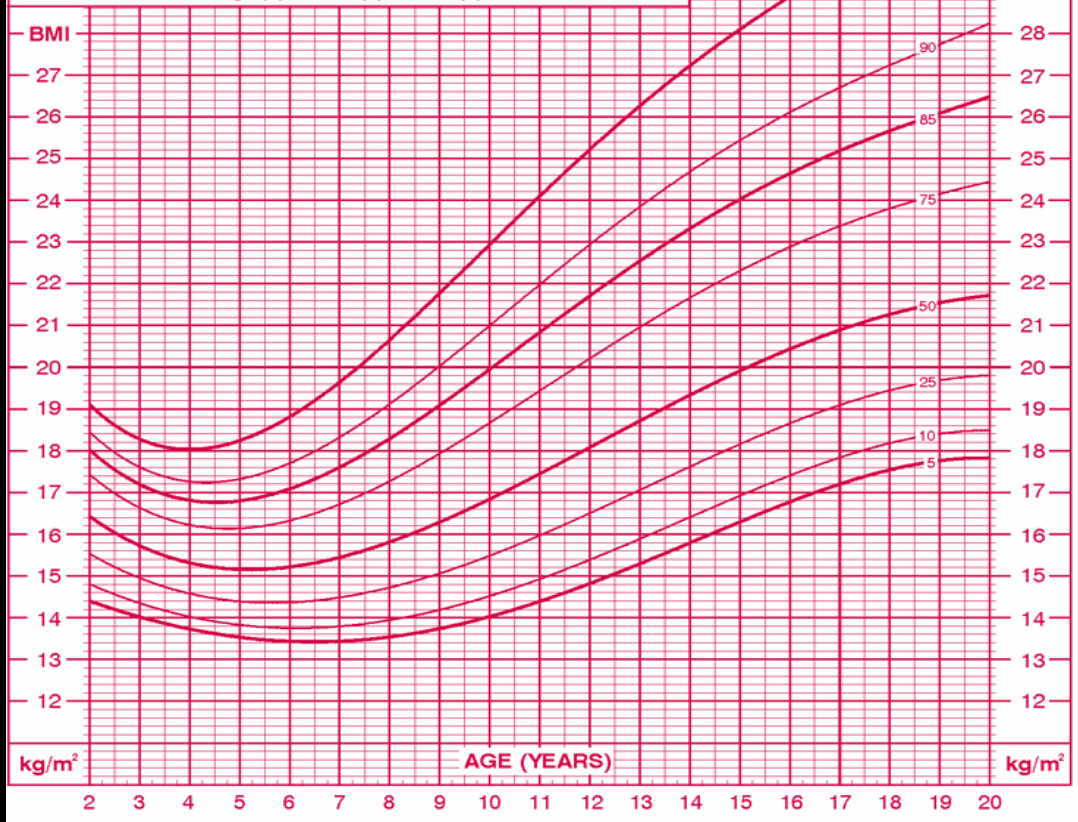
2 to 20 years: Girls
Body mass index-for-age percentiles

NAME _____

RECORD # _____

Date	Age	Weight	Stature	BMI*	Comments

***To Calculate BMI:** Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



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