



Body Mass Index: For Better or Worse

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Body Mass Index (BMI)



Adolphe Quetelet (1796-1894)

§ Belgian statistician/sociologist

§ **A Treatise on Man and the Development of His Faculties**
(1842, English translation)

§ Described rationale for wt/ht^2

§ Called Quetelet Index, now BMI

Photo from Eknoyan (2008)



BMI

- n Weight (kg)/Height (m)²
- n Index of weight-for-height
 - n Not necessarily an index of adiposity
- n A screening tool
 - n Widely used as an indicator of overweight and obesity - elevated weight-for-height
 - n Also used as an indicator of thinness - low weight-for-height



Criteria

- n Adults – WHO criteria

- n $>25.0 \text{ kg/m}^2$, overweight

- n $>30.0 \text{ kg/m}^2$, obese

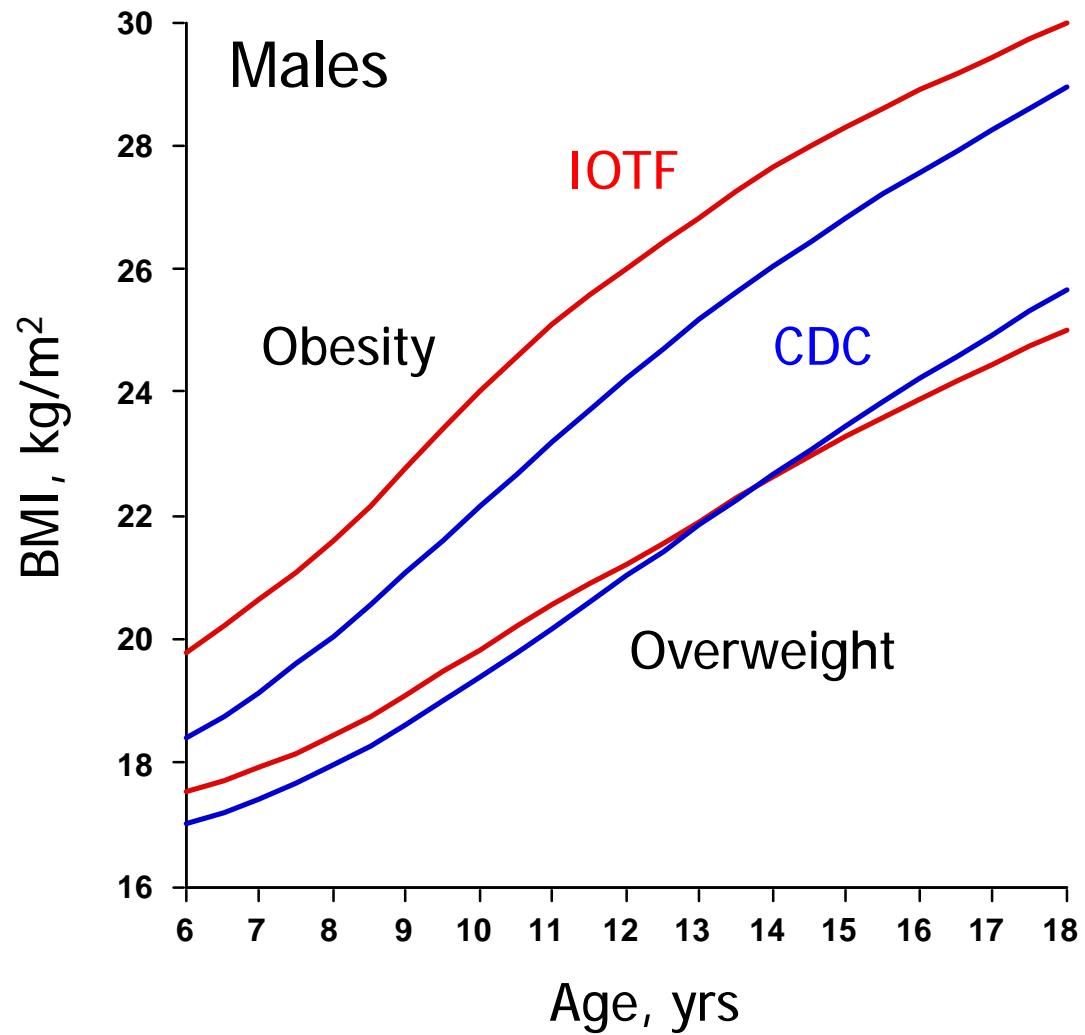
- n Children and Adolescents

- n CDC: $\geq 85^{\text{th}} < 95^{\text{th}}$ (Owt), $\geq 95^{\text{th}}$ (Ob)

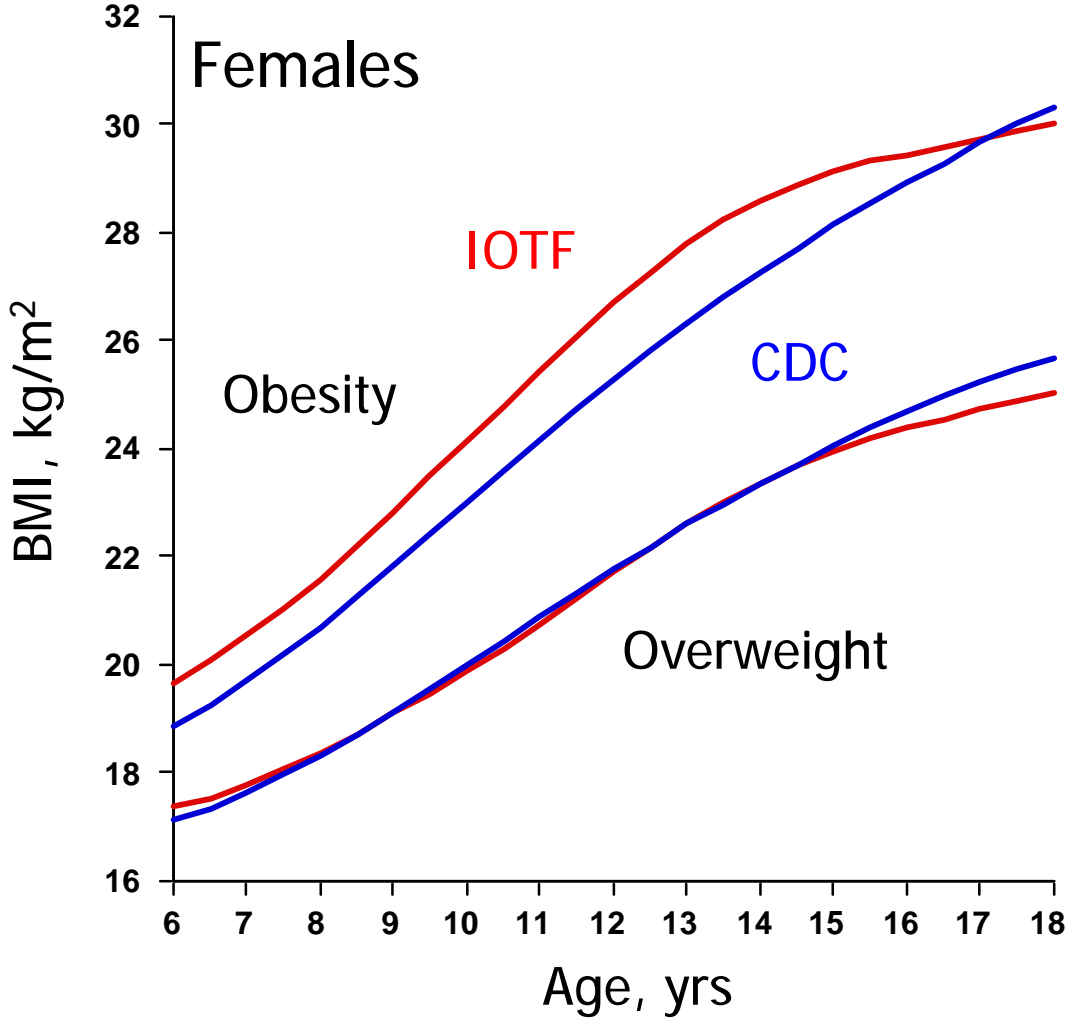
- n NB: Weights from NHANES III 1988-1994 not used

- n IOTF: use adult criteria and retrofitted data from 6 cross-sectional surveys: Brazil, Great Britain, Hong Kong, Netherlands, Singapore, U.S.

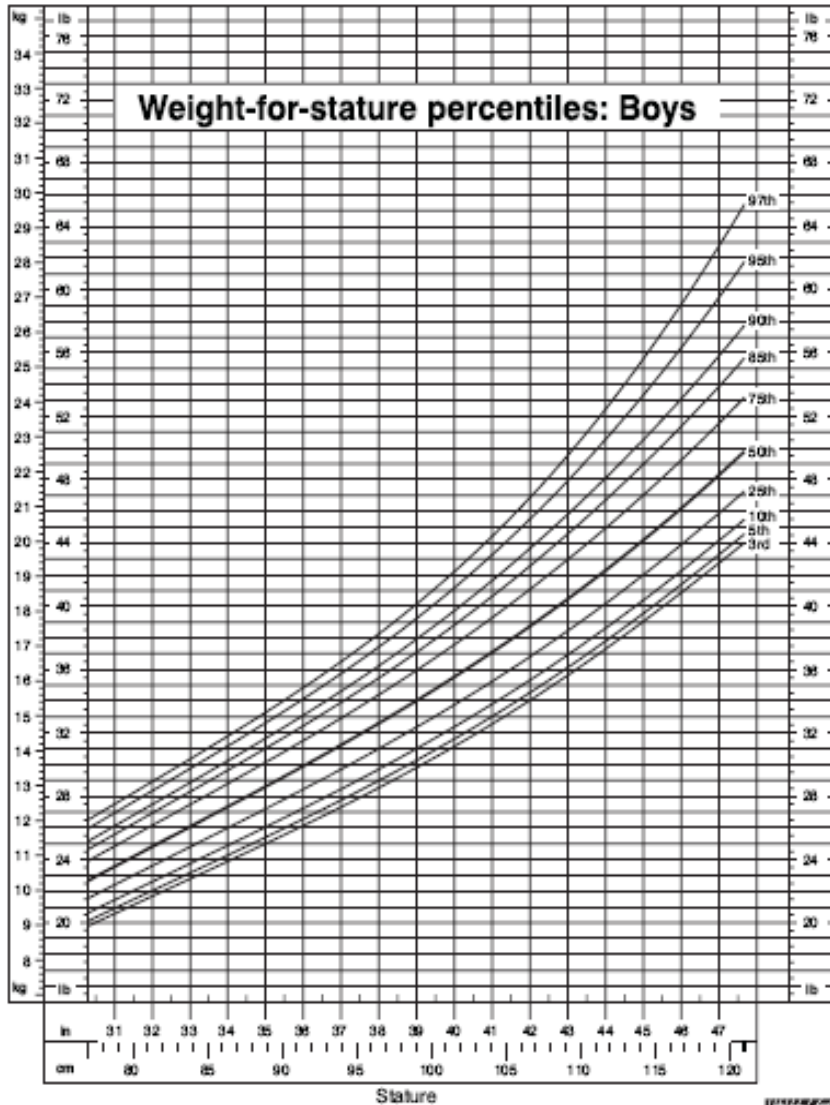
CDC vs IOTF Criteria:



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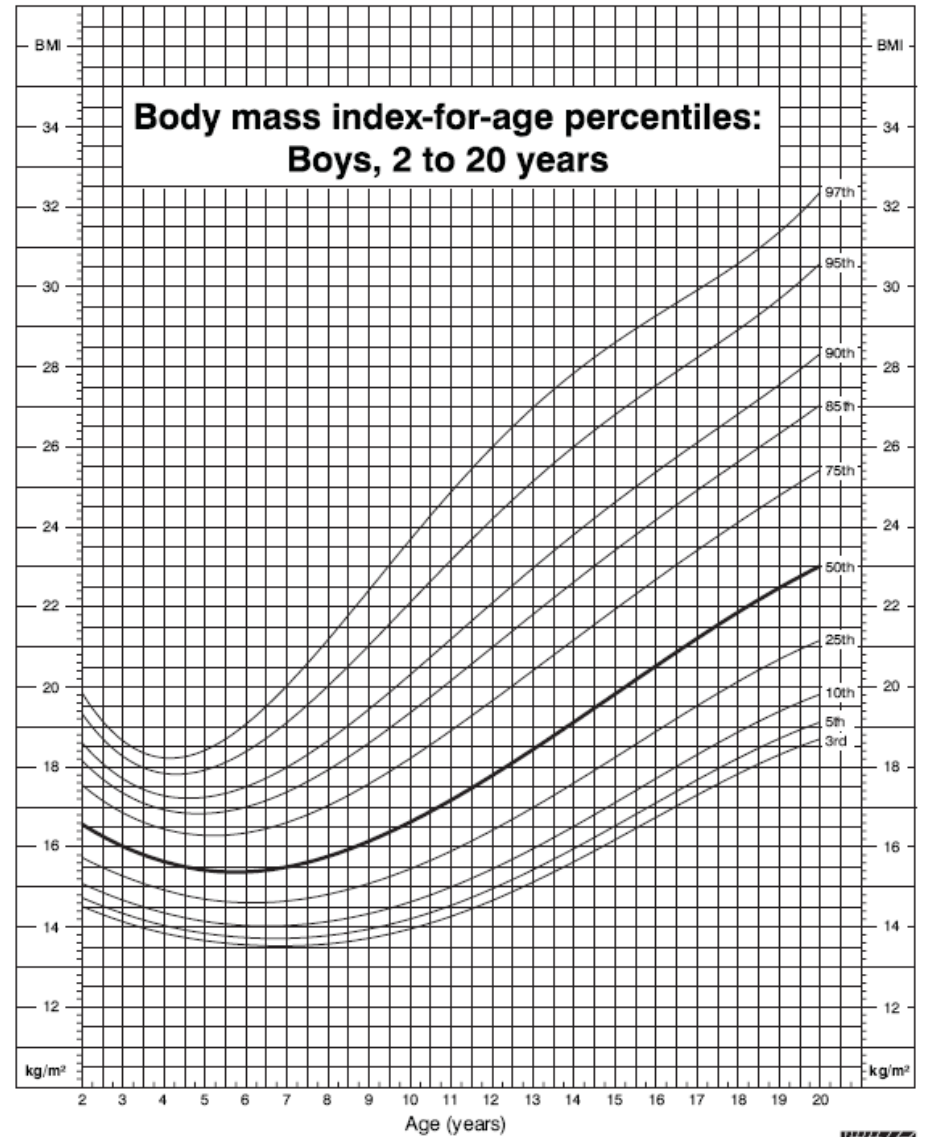
CDC Growth Charts: United States



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).



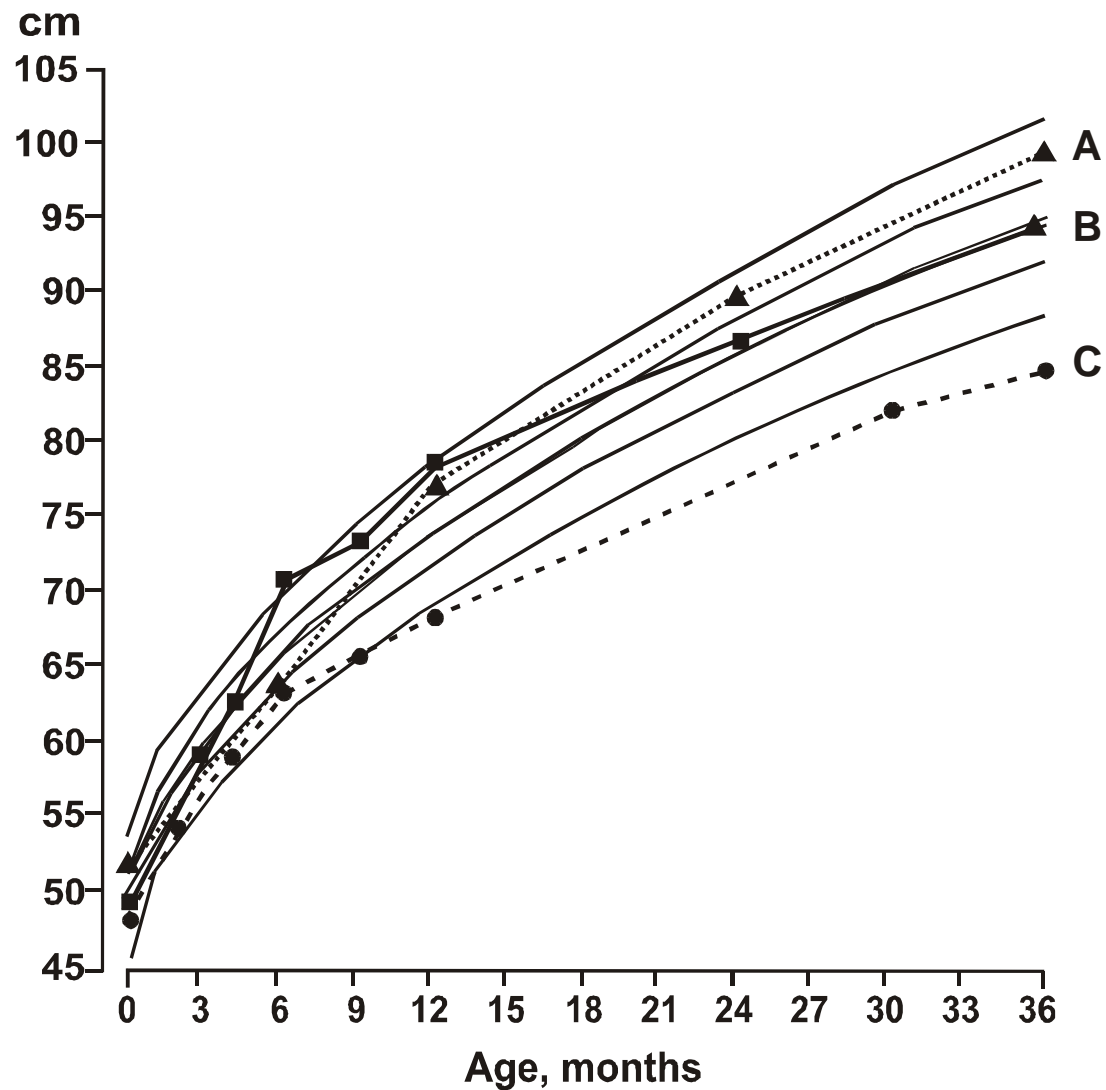
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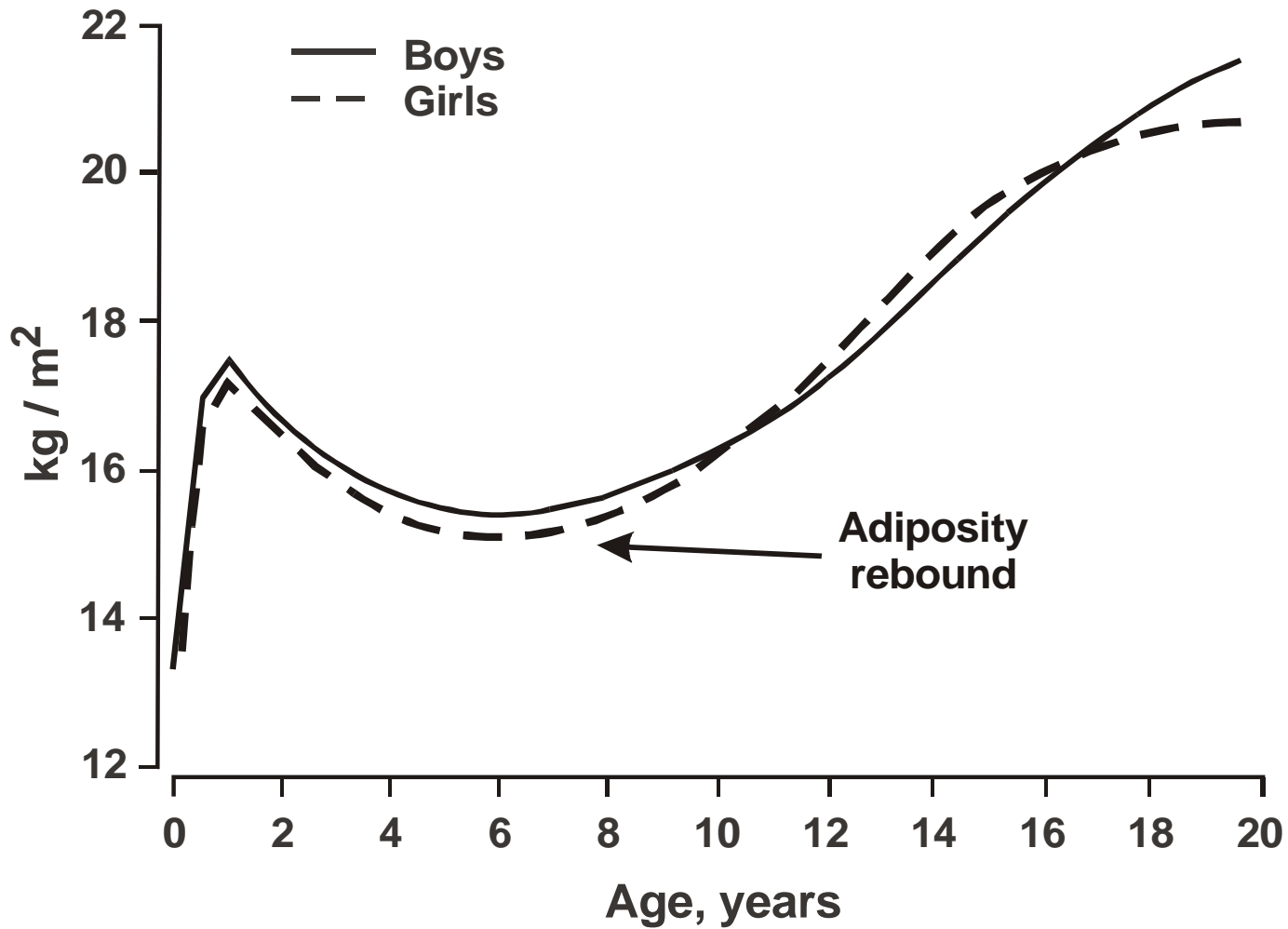


Longitudinal Observations on Growth in Length of Three Girls



From Malina, Bouchard and Bar-Or (2004)

Growth Curve for BMI



Drawn after Rolland-Cachera et al. (1991), from Malina et al. (2004)



Implication of Adiposity Rebound

§ Earlier the rebound, the greater the risk of later overweight/obesity (Rolland Cachera et al., 1987)

| Age Rebound | Young adult BMI at 21±3 yrs: | |
|-------------|------------------------------|------------------|
| ≤5.5 yrs | Males 23.2±2.8 | Females 21.3±2.6 |
| 6.0-6.5 yrs | 21.5±2.3 | 20.8±2.8 |
| ≥7.0 yrs | 20.3±2.0 | 19.6±2.2 |

§ Is the period of the “rebound” a potential window for intervention?

§ Children 4-11 years: more active had less fatness in early adolescence and may also have had a later adiposity rebound (Moore et al., 2003)

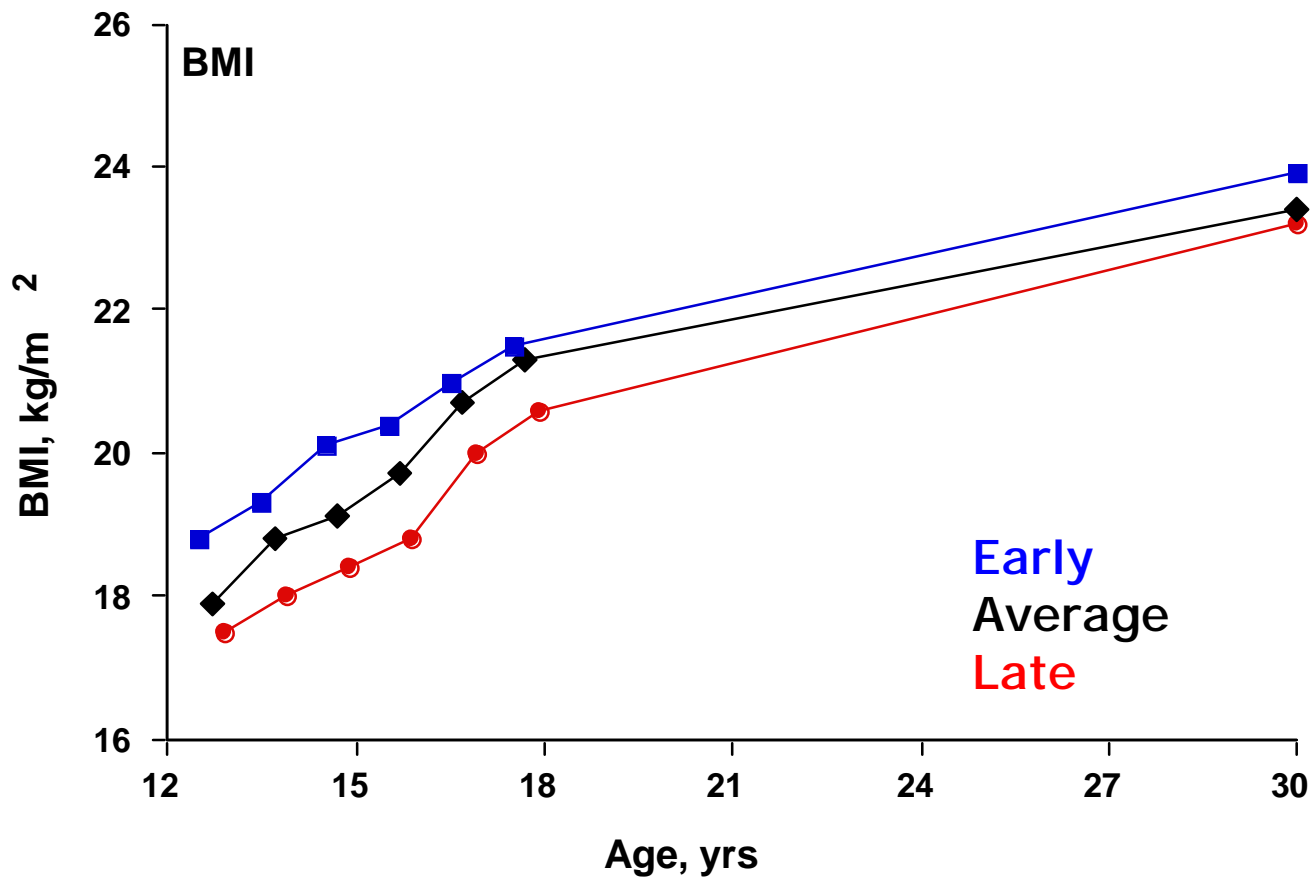


Adolescent Growth Spurt and Sexual Maturation - INDIVIDUALITY

- n Differential timing of growth spurts: height first, then weight; legs first, then trunk
 - n Require longitudinal data spanning adolescence
- § Individual differences in timing and tempo of growth and maturation
- n Commonly used maturity indicators vary in utility
 - n Age at PHV, age at menarche – timing
 - n Breasts, pubic hair, genitals – maturity status at time of observation

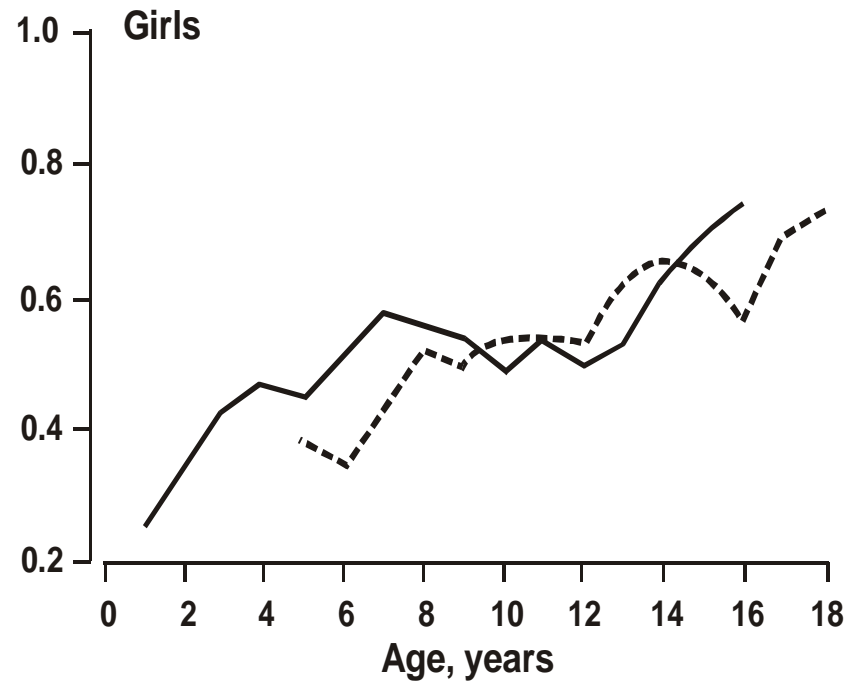
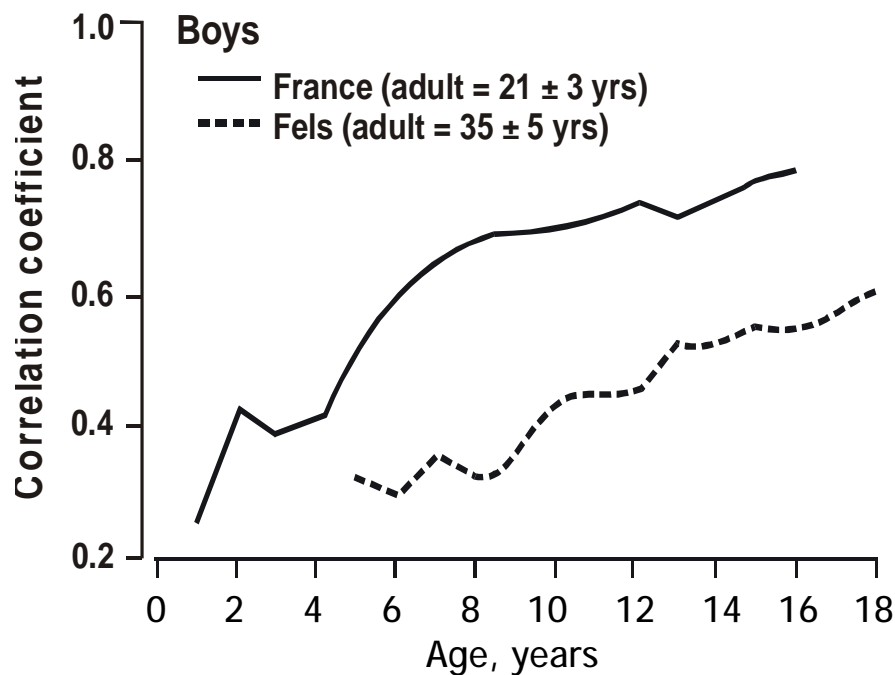
Belgian Boys

longitudinal 12-18 yrs, follow-up at 30 yrs
maturity groups – based on age at PHV



Drawn from data of Beunen et al. (1994)

Correlations between the BMI during childhood and adolescence and the BMI in adulthood



French data are from Rolland Cachera et al. (1991), US (Fels) data are from Guo et al. (1994); as reported in Malina et al. (2004)



BMI and Body Composition in Youth

(partial correlations controlling for age)

| Sample | Age | FFM | FM | %Fat | |
|-------------|-------|------|------|------|-----|
| Males | | | | | |
| Fr Canadian | 8-18 | 0.64 | 0.58 | 0.37 | D |
| Eu White | 10-15 | 0.27 | 0.56 | 0.49 | TBW |
| Mex Am | 9-14 | 0.62 | 0.75 | 0.58 | D |
| Females | | | | | |
| Fr Canadian | 8-18 | 0.61 | 0.81 | 0.61 | D |
| Am White | 9-17 | 0.53 | 0.46 | 0.28 | D |

Data from several sources, adapted from Malina and Katzmarzyk (1999)



BMI and Body Composition in Adults

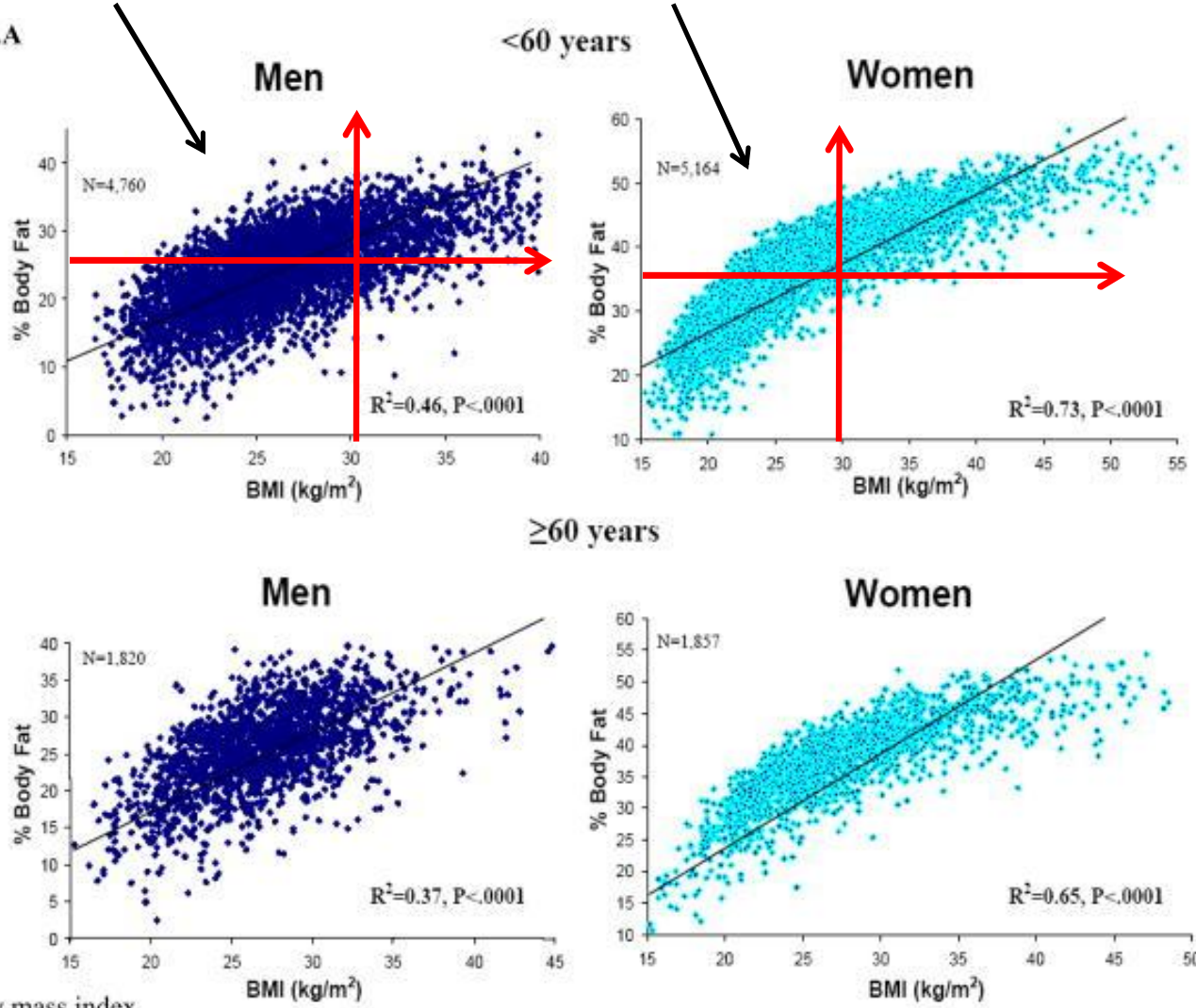
(NHANES III, BIA, correlations by age group and sex)

| Age Grp | Males | | Females | |
|---------|-------|---------|---------|---------|
| | %Fat | FFM, kg | %Fat | FFM, kg |
| 20-29 | 0.70 | 0.72 | 0.86 | 0.71 |
| 30-39 | 0.67 | 0.72 | 0.86 | 0.75 |
| 40-49 | 0.66 | 0.72 | 0.82 | 0.77 |
| 50-59 | 0.65 | 0.75 | 0.84 | 0.77 |
| 60-69 | 0.61 | 0.72 | 0.82 | 0.71 |
| 70-79 | 0.60 | 0.73 | 0.79 | 0.73 |

Converted from R² values reported by Romero-Corral et al. (2008)

%Fat exceeds cutoff, BMI < 30

Figure 2.A



BMI = body mass index

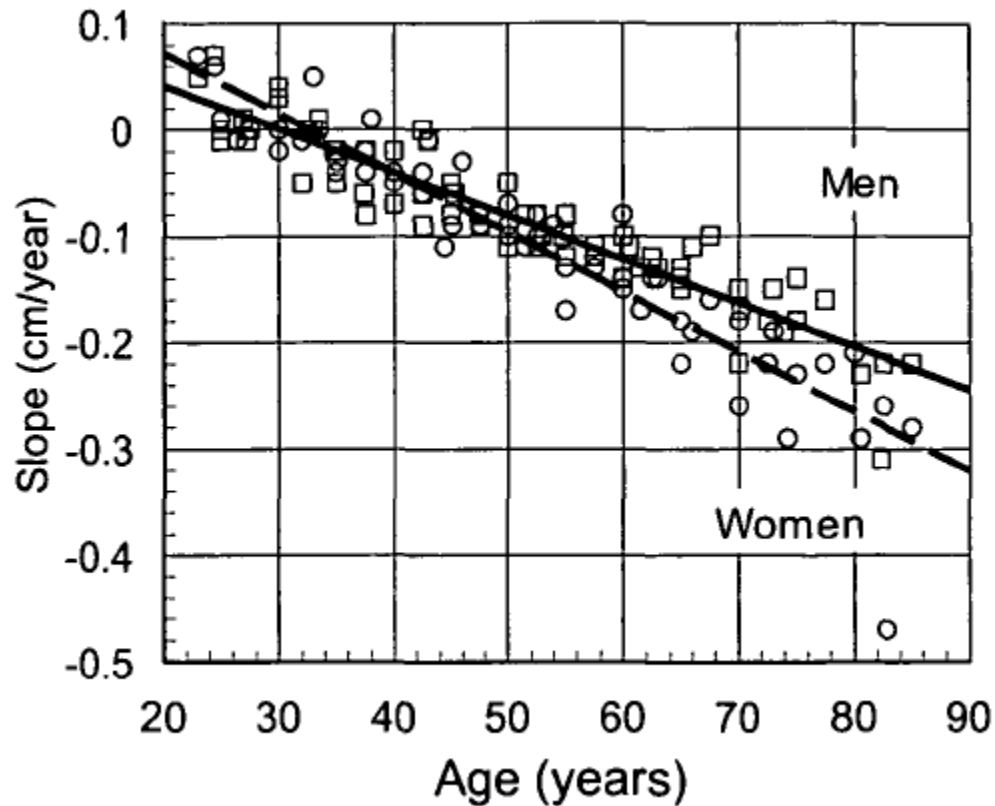
WHO: obesity = >25% in men, >35% in women, NHANES III 1998-1994, % Fat via BIA, adapted from Romero-Corral et al. (2008)



Height Loss with Aging

- n How does height loss with age influence the BMI and associated risks?
- n How does adjusting measured height for estimated loss of height with advancing age influence the prevalence of Owt and Ob?
- n Does it influence interpretation of the BMI?

Age-specific rates of height change



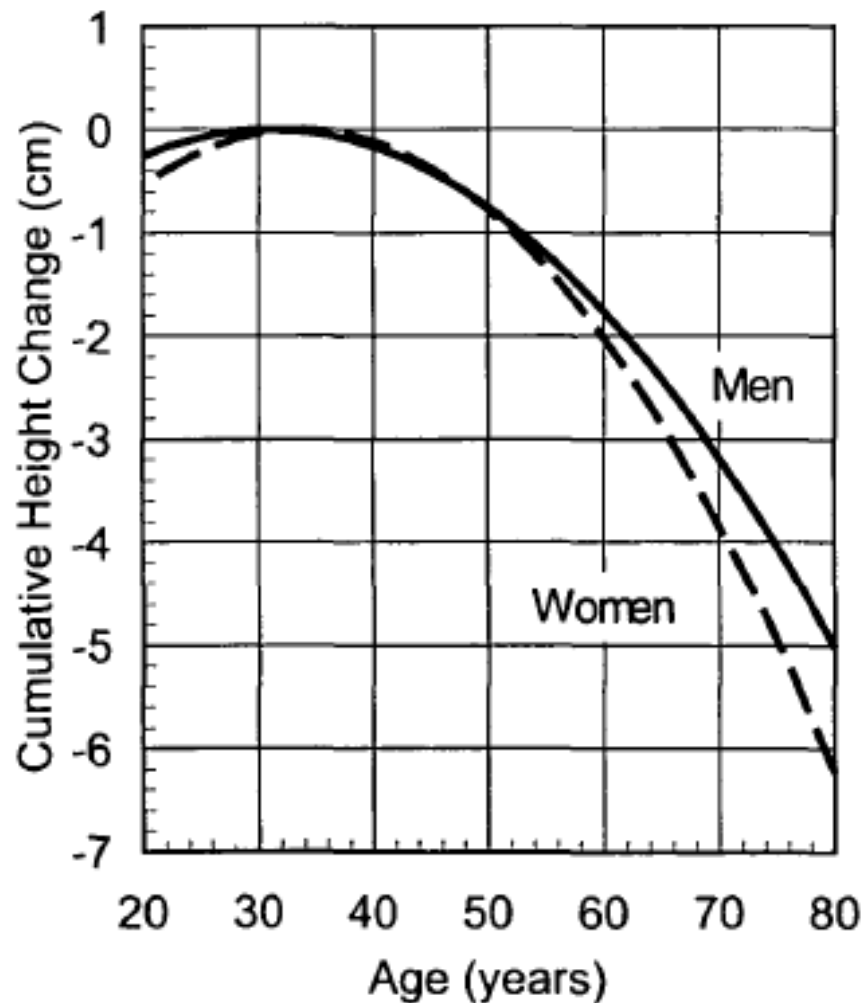
Longitudinal studies, European ancestry (13 men, 11 women)

Consistency with age

Relatively little variation among samples

From Sorkin et al. (1999)

Cumulative height change from young adulthood to old age



ADULT HEIGHT

Increases to 30 yrs

Stable to ~35 yrs, then declines

Similar loss in men and women to ~55 yrs

Then loss accelerates in both sexes but more so in women

From Sorkin et al. (1999)



Interpretation of the BMI

- n BMI - correlated with FFM and % Fat in children, adolescents and adults
- n Height loss with aging
- n Ethnic variation in body composition and use of the BMI as an indicator of Owt/Ob
- n Short stature and proportionally short legs may contribute to elevated BMIs



Proposed criteria for Asian populations

- n Asian populations tend to have a lower BMI but higher % Fat and increased abdominal fat at a lower BMI (Malina, 2005)
- n Proposed criteria for Asian populations:
 - Overweight, BMI ≥ 23.0 kg/m²
 - Obese 1, BMI $\geq 25.0 < 30.0$ kg/m²
 - Obese 2, BMI ≥ 30.0 kg/m²

WHO/IASO/IOTF (2000), cited by Shiwaku et al. (2004)

Does ethnic variation in fat distribution influence interpretation
Of the BMI? School girls, 12-17 yrs, San Diego (Malina et al., 1995)

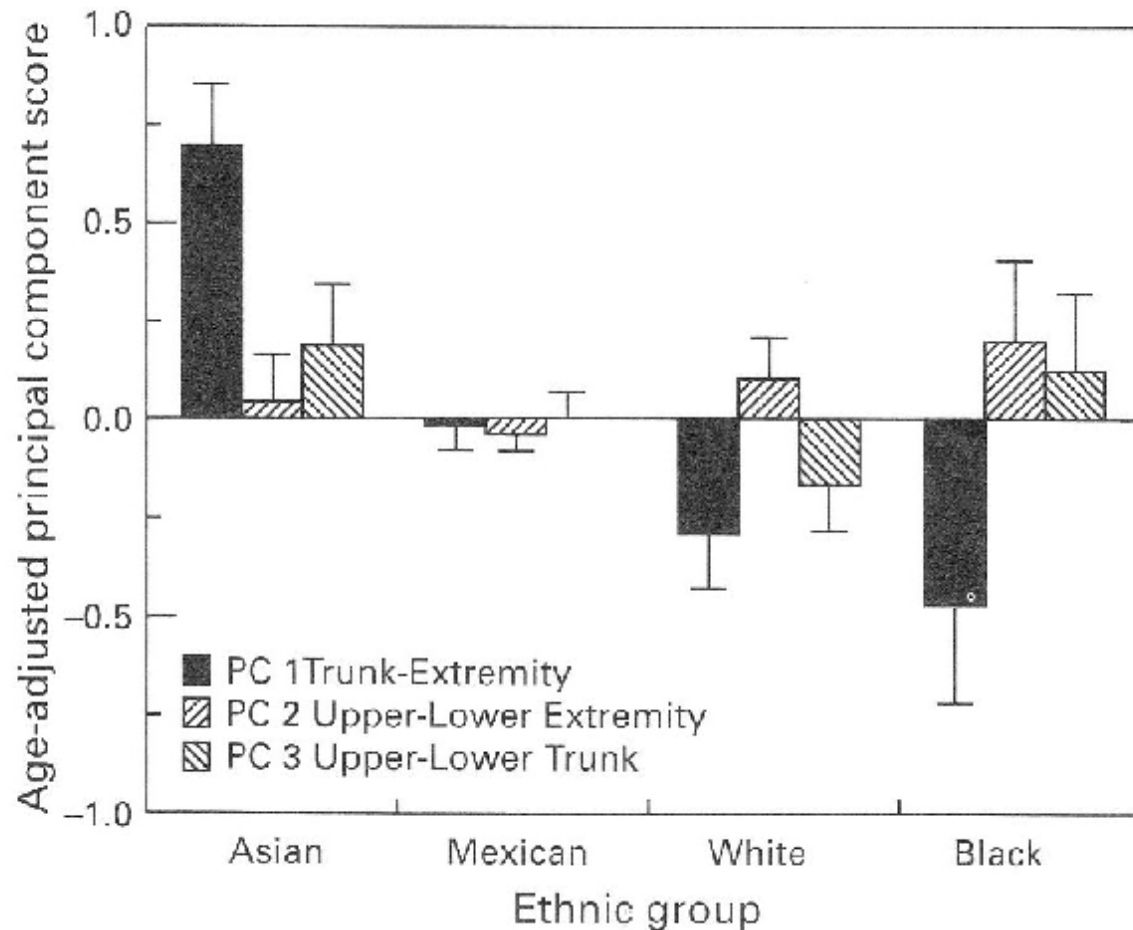


Figure 1 Age-adjusted scores (mean \pm s.e.) for the three principal components by ethnic group.



Short Stature and the BMI

- n Suggested that BMI is not sensitive in short Mexican adults (Lara-Esqueda et al., 2004)
 - n Proposed cut-offs: men ≤ 160 cm, women ≤ 150 cm
- n Indigenous adults, Oaxaca – majority would be classified as short, females more so:
 - n Males 66%
 - n Females 83%



Waist Circumference (WC)

Waist Circ/Height Ratio (W/Ht)

- n WC >102 cm in males, >88 cm in females – indicative of abdominal obesity (Executive Panel, 2001)
 - n Proposed cut-offs for WC (cm) for health risk within categories of the BMI (Arden et al., 2004)

- § W/Ht ratio of 0.50 proposed as a cut-off to identify normal weight and overweight Japanese adults at metabolic risk (Hsieh et al., 2003)



BMI, WC, W/Ht

- n NHANES 1999-2004, adults, % FAT (DXA)
 - n BMI, WC, W/Ht more strongly correlated with each other ($r=0.85$ to 0.97) than with % Fat ($r=0.65$ to 0.87)
 - n r's tend to decline with increasing age

- n Cross-classification based on percentile groups for % Fat vs

| | BMI | WC | W/Ht (% agreement) |
|-------|-----|-----|--------------------|
| Men | 46% | 51% | 53% |
| Women | 49% | 42% | 43% |

Agreement higher within ± 1 percentile category, 91-97%

Adapted from Flegal et al. (2009)



Summary - BMI

- n Easy to calculate
- n Affected by growth and pubertal maturation, aging, ethnicity
- n Good for trends – populations, subgroups
 - n Variable accuracy
- n Need to monitor individuals longitudinally
- n QUESTION: How sensitive is the BMI to physical activity interventions?

THANK YOU