Measuring Obesity in Children

Dr. Non Thomas (Senior Lecturer, UWIC)
Dr. Mike Kingsley (Senior Lecturer, SU)
1 Why Measure Obesity in Children?
   - Childhood obesity and co-morbidities
   - Progression to adult obesity
   - Obesity Epidemic

2 Determination of Body Composition
   - Laboratory-based methods
   - Field-based methods

3 Anthropometry
   - BMI
   - Waist circumference
1 Why Measure Obesity in Children?

**Overweight** – moderate degree of excess wt-for-ht

**Obesity** – excess adiposity accumulated to such an extent health adversely affected
• Overweight – more likely to result from behavioural factors such as poor dietary habits and physical inactivity

• Obesity – stronger behavioural, metabolic and possibly genetic aetiology

  (Bouchard, 2000)

• Primary cause of increase related to energy balance
• Varied criteria for defining overweight and obesity

• Inconsistencies in definitions – major obstacle in studying global trends

• Need understanding of global situation to:
  (i) provide useful insights on causes of epidemic
  (ii) assist planning and development of meaningful collaborations and programmes
• Childhood obesity is a multi-system disease

• Cardiovascular, endocrine, pulmonary, musculoskeletal, psychological, neurological, hepatic, renal……
Specifically linked to:

• hypertension
• dyslipidaemia
• chronic inflammation
• metabolic syndrome
• endothelial dysfunction
• type 2 diabetes
• hyperinsulinemia
• polycystic ovary syndrome
• precocious puberty
• sleep apnoea
• asthma
• poor self esteem
• depression
• eating disorders
Overweight and obesity in adolescence are associated with:

- an 8.5 fold increase in hypertension
- a 2.4 fold increase in prevalence of elevated TC
- a 3 fold increase in elevated LDL-C
- an 8-fold increase in low HDL-C

in adults aged 27-31 years

(Srinivasan et al. 1996)

- Overweight children now have 50% chance of becoming overweight adults (BMA, 2003)
• ~ 2 million UK children overweight

• ~ 700,000 are obese

• By 2010 number of overweight children across EU:
  >26 million (rise by ~ 1.3 million per year)
  (~6.4 million – obese ~ rise of 350,000 per year)

(International Obesity Task Force, 2006)
Obesity prevalence in 11-14 year old in South Wales

- Boys $n = 230$; girls $n = 229$

- Wt/ht/waist circumference (WC)

- IOTF criteria (Cole et al. 2000) (BMI): 32% overweight or obese; 8.3% obese

- McCarthy et al. (2003) (WC) - 98th percentile – 19.4% obese

- De Ferranti et al. (2004) (WC) – 75th percentile – 54.5% obese
• Estimates of obesity prevalence highly dependent on method used
2 Measurement of Obesity

Body Composition

Laboratory-based techniques:
- Densiometry
  - Hydrostatic Weighing
  - Air-displacement Plethysmography (BodPod)
- Radiographic Techniques
  - Dual-energy X-ray Absorptiometry (DXA)
  - X-Ray, Magnetic Resonance Imaging, Computed Tomography

Field-based techniques:
- Bioelectrical Impedance Analysis (BIA)
- Near infra-red interactance (NIR)
- Skinfold thickness
Hydrostatic Weighing

**Principle:**
- Archimedes’ Principle (Densiometry)

**Technique:**
- Determine subject mass
- Weigh submerged subject
- \( \Delta \text{weight} \) proportional to volume
- Calculate residual air (lungs and GI)
- Calculate density of body
- Calculate %BF using specific equations

**Disadvantages:**
- Subject compliance (during test)
- Technical expertise
- High cost – time and resources
Validity: HW v MRI

Dual-energy X-ray Absorptiometry (DXA)

Principle:
- Radiographic Imaging

Technique:
- Subject lies supine as scanner moves over
- Two low-energy X-ray beams penetrate body
- Detector probes quantify absorbance
- Software reconstructs image of tissues & from density values can provide fat mass

Disadvantages:
- Technical expertise
- Radiation dose (short exposure / low dose)
- High cost – time and resources
Air-displacement Plethysmograph (BodPod)

**Principle:**
- Boyle’s Law (Densiometry)

**Technique:**
- Determine subject mass
- Air pressure of empty BodPod chamber
- Air pressure with subject in chamber
- ∆ Air pressure proportional to subject’s volume
- Manoeuvre to measure mean air in lungs
- From density calculate %BF

**Disadvantages:**
- Subject compliance (before & during test)
- Technical expertise
- High cost – time and resources
**Bioelectrical Impedance Analysis (BIA)**

**Principle:**
- Impedance to electrical current is related to water content and body composition

**Technique:**
- Height/mass of subject
- 2 electrodes on R wrist & ankle
- Small current (800 μA) passed at 50 kHz
- Impedance is proportional to fat mass (low water content cf. muscle)
- Calculation of BF%

**Disadvantages:**
- Subject compliance (before test)
- High cost – time and resources
Near-infrared interactance (NIR)

**Principle:**
- Absorptiometry of infrared light

**Technique:**
- Single site (anterior of bicep)
- Wand delivers low-energy near-infrared light
- Wand has measures intensity of reemitted light
- Uses mass and height to calculate %BF

**Disadvantages:**
- Questionable validity
- High cost – resources
Skinfold thickness

**Principle:**
- Skinfold thickness reflects subcutaneous fat and used to estimate %BF

**Technique:**
- Location of standardised site(s):
  - Tricep, bicep, subscap, suprailiac
- Grasp skinfold (including subcutaneous fat)
- Apply calibrated caliper (e.g., Harpenden)
- Use skinfold values to calculate %BF

**Disadvantages:**
- Technical expertise
- Subject compliance
- Time consuming
3 Measurement of Obesity

Anthropometry

• Body Mass Index (BMI)
  – Body Mass
  – Stature
• Waist Circumference

Body Mass Index (BMI)

Body Mass Index
• Mass (kg) / Stature^2 (m^2)

Disadvantages:
• Does not estimate adiposity
• Relationship (^2) might not be appropriate for all populations
• Overweight/Obesity BMI cut-offs
  – Age / Ethnicity specific

Advantages:
• Based on simple anthropometry
International cut-off points for BMI

• Brazil, Netherlands, Singapore, HK, GB, USA

Others:
Chinn and Rona (2002)
• UK data only
• Lower thresholds

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BMI: Standing Height (Free-Standing Stature)

• Use appropriate stadiometer (e.g., Holtain stadiometer)
• The individual stands feet together (no shoes)
• Heels and upper part of the back against the stadiometer (not necessarily buttocks)
• The head is placed in the Frankfort plane; with Orbitale (lower edge of the eye socket) in the same horizontal plane as the Traglion (the notch superior to the Traglus of the ear)
• Head board is lowered firmly to the Vertex (the most superior point of the skull) when subject has inspired fully
• Record height to nearest 0.001 m
• Diurnal variation ~1% stature
BMI: Body Mass

• Calibrate and zero scales
• Ideally measure body mass with the individual wearing minimal clothing
• Individual stands unsupported in the middle of the scales
• Record body mass to the nearest 0.05 kg

• Diurnal variations ~ 1 kg in children
Waist Circumference

Location:
• Narrowest point between the lower costal border and the iliac crest
• Use mid-point between the lower costal border and the iliac crest if no obvious narrowing exists

Method:
• Abduct the subject’s arms
• Hold tape horizontally at the measurement site
• After the individual has lowered their arms, the measurement is taken at the end of normal expiration
• Record mean of 2 repeat measures <1% difference
Summary: Measuring Obesity in Children

• Primary Outcome
  – Individual (identification of obese children)
  – Population (prevalence of obesity)

• Measurement of an individual’s adiposity
  – Hydrostatic weighing, DXA, BodPod (lab)
  – BIA, NIR? (field)

• Measurement of Obesity in a population
  – BMI, Waist Circumference