Practical Application of BMI in the Pediatric Clinical Setting

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The current recommendation is that BMI and the BMI percentile by age and sex be used to evaluate adiposity in children and adolescents.
It is recommended that BMI be determined at each health maintenance visit and for most other healthcare encounters.
Body Mass Index in Clinical Settings

- While BMI is not a perfect measure of adiposity, it works well in most clinical settings for most patients.

- Its ease of use is also an important point in its favor.
Body Mass Index in Clinical Settings

- For some patients, especially those with increased muscle mass, it may overestimate adiposity.
- BMI percentiles have limitations for patients with severe obesity.
- It is difficult to use in patients for whom height and weight are difficult to determine (wheelchair).
- It does not provide a regional view of adiposity.
- It can be difficult to explain to patients and parents.
Definitions

“Overweight”
85-95th BMI % for age

“Obese”
> 95th BMI % for age
Beyond BMI…

- Recommend *against* routine use of **skinfolds**
  - Lack of evidence for ↑ accuracy beyond BMI for fatness & risk factors
  - Difficulty of accurate measurements
  - Lack of readily available reference data

- Unable to recommend use of **waist circumference** for routine clinical use
  - Additional value over BMI for fatness, risk factors
  - Lack of readily available reference data
  - No guidelines for clinical application
Some physicians do not believe an adiposity measure is needed in practice.

Obesity is like pornography: “I know it when I see it.”
As the population of children and adolescents has become more overweight, our perception of “normal” weight or BMI has shifted.
Early Identification—BMI versus Visual Diagnosis

85-95th %  ≈ 95th %  >> 95th %ile
Body Mass Index in Clinical Settings

- Perception and height/weight charts may not always work in an optimum manner.
Perrin et al (J of Peds 2004) compared height/weight charts to BMI percentile charts in the evaluation of obesity.
Table II. Level of concern of hypothetical child’s weight by type of growth chart provided

<table>
<thead>
<tr>
<th></th>
<th>Mean level of concern*</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ht and Wt Group</td>
<td>BMI Group</td>
<td>P value</td>
<td></td>
</tr>
<tr>
<td>Medical consequences</td>
<td>4.57</td>
<td>4.96</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>of weight now</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychological consequences of weight now</td>
<td>5.14</td>
<td>5.75</td>
<td>&lt; .0001</td>
<td></td>
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<tr>
<td>Medical consequences of weight in the future†</td>
<td>6.13</td>
<td>6.48</td>
<td>&lt; .0001</td>
<td></td>
</tr>
<tr>
<td>Psychological consequences of weight in the future†</td>
<td>5.88</td>
<td>6.13</td>
<td>.004</td>
<td></td>
</tr>
</tbody>
</table>

*Level of concern: 1 = not at all concerned, 7 = very concerned.
†Wilcoxon rank-sum test was used to determine significance.
What is most useful about body mass index?

—Utility

» Requires only standard equipment
» Derived from routine measurements
» Relatively easy to use
Body Mass Index in Clinical Settings

◆ What is most problematic about using BMI?

— It is not perfect in assessing adiposity
  » Football players: lean versus fat mass
  » False negatives/false positives
Body Mass Index in Clinical Settings

Problems with BMI

– Not useful for patients under 2 years of age.
  » This is increasingly important as obesity seems to be presenting at a younger and younger age.

– Alternative: weight for length
  » What cut point to use for overweight, obesity?
Children < 24 months

- Weight-for-length percentile
  - >95th %ile = “overweight”
  - No cut point defined for obesity at this age
BMI percentile is not optimum for severe obesity.
### 2 to 20 years: Boys

**Body mass index-for-age percentiles**

<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>Weight</th>
<th>Stature</th>
<th>BMI</th>
</tr>
</thead>
</table>

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

**“Obese”**

**“Overweight”**

**SOURCE:** Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000). [https://www.cdc.gov/pnharcharts](https://www.cdc.gov/pnharcharts)
Body Mass Index in Clinical Settings

Severe Obesity
Body Mass Index in Clinical Settings

- Alternatives for severe obesity
  - 99th percentile
  - Z scores
  - Percent above the 95th percentile
Characterizing Severe Obesity

“Severe Obesity”
(BMI ≥ 99%)

BMI ≥ 99%

- Advantages of the 99th percentile
  » Strongly associated w/ co-morbidities
  » Excess adiposity
  » Persistence
  » Influence therapy
Disadvantages of the 99th percentile

- Statistically very unstable
- Accordion effect
- Does not have clear definition above the 99th percentile
Body Mass Index in Clinical Settings

◆ Alternatives to Percentiles
  – BMI z-score

  » Advantages
    ◆ is continuous across the range of BMI
    ◆ based on standard deviations

  » Disadvantages
    ◆ same statistical issues as the 99th percentile
    ◆ not currently well understood in clinical practice
    ◆ would need educational program for physicians and patients
Severe Obesity

- Definition based on percent above the 95th percentile
  - 120% of the 95th percentile: emerging as the best way to define severe obesity.
Body mass index (BMI) curves from Centers for Disease Control and Prevention (CDC) reference growth charts associated with the newly proposed definition for severe obesity for boys (A) and girls (B).
Prevalence of Severe Obesity

- BMI $\geq 120\%$ of 95th percentile
  - Overall
    » NHANES 1999-2006
      - 4.6%
Prevalence of Severe Obesity

BMI ≥ 120% of 95th percentile

- By Age

   » NHANES 1999-2006
   - 2-5 years: 2.2%
   - 6-11 years: 4.6%
   - 12-17 years: 5.8%
Prevalence of Severe Obesity by Race/Ethnicity

BMI ≥ 120% of 95\textsuperscript{th} percentile

- NHANES 1999-2006

- African American
  - Females 9.1%  Males 7.1%

- Hispanic
  - Females 5.1%  Males 6.9%

- White
  - Females 3.5%  Males 4.0%
Severe Obesity

Trends in Prevalence Over Time

- Severe obesity is the fastest growing sub-category of obesity

- Using BMI 99th percentile

  » NHANES
  
  - 1976-1980 0.8%
  - 1988-1994 2.2%
  - 1999-2006 3.8%
BMI in Clinical Settings

Intervention

- Use of BMI in response to a weight management intervention

- If the BMI percentile is decreasing, this can be a motivator to continue behavioral change.
Body Mass Index in Clinical Settings

Intervention

BMI stays steady

- This may decrease motivation for organizing intervention as it appears that no progress is being made.
- Is this really a measure of no progress?
- In this case, a way to measure both fat mass and lean body mass is helpful.
Body Mass Index in Clinical Settings

**Intervention**

- If a patient implements a treatment strategy:
  - Caloric intake
  - Physical activity
  - Fat mass may change
  - Lean mass may change
  - BMI may change
Body Mass Index in Clinical Settings

A Longitudinal View of BMI
Obesity and Cardiovascular Disease

Direct Evidence

- Baker et al (NEJM 2007) studied 276,835 Danish school children who were followed into adulthood
Obesity and Cardiovascular Disease

- Childhood BMI—age 7-13 years
- Adult CVD—from national registers
  - Nonfatal
  - Fatal ages 25-60
Body Mass Index (BMI) in Childhood and the Risk of Coronary Heart Disease (CHD) in Adulthood

The graphs depict the association between childhood BMI and the risk of having a CHD event (nonfatal or fatal) in adulthood. Hazard ratios and 95% confidence intervals are given for a 1-unit increase in BMI z score at each age from 7 to 13 years.

Baker NEJM 2007
Obesity and Cardiovascular Disease

- Higher BMI during childhood is associated with increased risk of CVD in adulthood.

- However, they did not have data on BMI in adulthood. This leaves the question of whether childhood obesity works through adult obesity or also has an independent effect.
Cardiovascular Risk Factors—
A Longer Term Longitudinal View

1) Fels Longitudinal Study

2) International Childhood Cardiovascular Cohort (i3C) Consortium
Childhood Obesity Predicts Adult Metabolic Syndrome

Fels Longitudinal Study
The Fels Study

A longitudinal study begun in the 1920s to evaluate growth and health in families across the lifespan.

- Participants enrolled at birth
- Not selected, but live in Central Ohio and are mostly White, Non-Hispanic
- Children are examined semi-annually (birthdate, 6 month following) until age 18
- Adults are examined biannually.
Childhood Obesity and Adult Cardiovascular Disease

Fels Longitudinal Study

92 men
59 women
with metabolic syndrome

154 adults without metabolic syndrome

Mean age 51 years

Sun et al, J of Pediatrics 2008
## Childhood Obesity and Adult Cardiovascular Disease

The first difference between those with and without MS:

<table>
<thead>
<tr>
<th></th>
<th>BMI</th>
<th>WC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys (age)</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Girls (age)</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

MS = Metabolic Syndrome  
BMI = Body Mass Index  
WC = Waist Circumference

Sun et al. *J of Pediatrics* 2008
Both BMI and WC in childhood predict the presence of metabolic syndrome in adulthood.
Obesity and Cardiovascular Disease

An important issue is whether the impact of obesity in childhood on cardiovascular outcomes is fixed or can be altered.
Juonala et al combined data from the Bogalusa Heart Study, Muscatine Study, Cardiovascular Disease in the Young Finns Study and the Childhood Determinants of Adult Health Study (Australia) to evaluate longitudinal data between childhood (BMI, CVD risk factors) and adulthood (BMI, CVD Risk Factors, carotid IMT).
<table>
<thead>
<tr>
<th></th>
<th>Childhood</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group I</strong></td>
<td>Normal BMI</td>
<td>Non-obese</td>
</tr>
<tr>
<td><strong>Group II</strong></td>
<td>Obese</td>
<td>Non-obese</td>
</tr>
<tr>
<td><strong>Group III</strong></td>
<td>Obese</td>
<td>Obese</td>
</tr>
<tr>
<td><strong>Group IV</strong></td>
<td>Normal BMI</td>
<td>Obese</td>
</tr>
</tbody>
</table>
Conclusions

1) Children who were overweight or obese and remained obese in adulthood (Group III) had increased risk of T2DM, hypertension, dyslipidemia and increased carotid IMT.

2) Overweight or obese children who became non-obese by adulthood (Group II) were similar in CVD risk and carotid IMT to those who were never obese (Group I).

NEJM 2011;365:1876
Conclusions

This means that while prevention of obesity in childhood is optimal, treatment of those children who have become obese is also very important.
BMI in Clinical Settings

- Additional studies once obesity is established
  - Blood pressure
  - Fasting lipid profile
  - Fasting blood glucose
  - AST, ALT

- Other co-morbid conditions can usually be suspected based on a history and physical examination
BMI in Clinical Settings

Conclusions

- BMI and BMI percentiles are very useful in the pediatric clinical setting.
- Crossing BMI percentiles may indicate risk for future obesity.
- Percent above the 95th percentile is a helpful way to evaluate severe obesity.
- Other measures, such as waist circumference, may be useful to assess regional adiposity.
- BMI percentiles can be used to indicate further clinical evaluation when overweight or obesity is identified.
- BMI percentiles can be useful to track progress in weight management, but they are not perfect.