IS THE WHO CHILD GROWTH STANDARD APPROPRIATE FOR GROWTH MONITORING IN HONG KONG?

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Outline

- Brief introduction to the WHO Child Growth Standards
- Comparing the height, weight & BMI of representative samples of HK children with those of the WHO CGS sample
- Impact of using the WHO CGS (instead of HK Growth Reference, 1993) on clinical practices
WORLD HEALTH ORGANIZATION
CHILD GROWTH STANDARDS (0 – 5)
[2006]

http://www.who.int/childgrowth/
The WHO Child Growth Standards (CGS)

- **Recognition:**
  - Significant difference between growth pattern of healthy breastfed infants and formula fed infants
  - Growth references are often used as standards

- **Assumption:**
  - Physical growth is principally determined by environment

- **Multicentre Growth Reference Study (MRGS; 1997-2003)**
  - Samples drawn from 6 sites with a diversity of ethnic and cultural backgrounds: Brazil (S. America), Ghana (Africa), India (Asia), Norway (Europe), Oman (Middle East), & USA (N. America)
  - Growth data collected from 8,500 children (0 – 5):
    - Longitudinal (0-24m); Cross-sectional (18-71m)
    - Brought up in optimal conditions with no environmental or economic constraint on growth
    - Parents followed recommended practices and behaviours, e.g. no maternal smoking; exclusive BF for 4 months, then up to 12 m with complementary foods
The WHO Child Growth Standards (CGS)

- WHO Child Growth Standards published in 2006
  - Height-for-age; weight-for-age; weight-for-height; BMI-for-age; head circumference-for-age; etc.
  - Establishes breastfeeding as the biological norm & breastfed infants as the standard for measuring healthy growth
  - Describes how healthy children in optimal environment *should* grow (a standard), rather than how children are growing (a reference)
Difference in Linear Growth between Children of 1993-HKGR & WHO-CGS
The Hong Kong Growth Survey 1993

- Territory wide cross-sectional growth survey
- Participants: newborn to 18 years
- 24,709 Participants
  - Less than 3 years of age: 8 randomly selected MCHCs
  - 3 to 18 years of age: 1 kindergarten, 1 primary school and 1 secondary school were randomly selected from each of the 18 districts

- Grouping of age ranges
  - 1st 6 months – age range of 1 month (+5 days)
  - 2nd 6 months – 2 monthly (+7 days)
  - 1 to below 3 years – 3 monthly
  - 3 years or older - half yearly

- Measurement:
  - Weight – measured in lightest clothing
  - Supine length – below 3 years measured by Harpenden infanometer
  - Standing Height – 3 years or above measured by Harpenden stadiometer
Z-Scores of Height at $P_{50}$ of the 1993 HK Growth Reference with respect to the WHO CGS

<table>
<thead>
<tr>
<th>Age (mo)</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 mo</td>
<td>-0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>12 mo</td>
<td>-0.03</td>
<td>0.10</td>
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<tr>
<td>18 mo</td>
<td>-0.28</td>
<td>-0.16</td>
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<tr>
<td>24 mo</td>
<td>-0.50</td>
<td>-0.40</td>
</tr>
<tr>
<td>36 mo</td>
<td>-0.50</td>
<td>-0.47</td>
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<tr>
<td>48 mo</td>
<td>-0.46</td>
<td>-0.53</td>
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<tr>
<td>60 mo</td>
<td>-0.43</td>
<td>-0.46</td>
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</tbody>
</table>
Z-Scores of Height at $P_{50}$ of the 1993 HK Growth Reference with respect to the WHO CGS

Female
Male
Difference in Linear Growth between Children from More Recent Birth Cohorts & WHO-CGS
Objective:
- to investigate the impact of second-hand smoking on health

Participants:
- 8327 infants born in April and May of 1997, recruited from Maternal & Child Health Centres (MCHCs) * Over 90% newborns register with MCHCs
- Exclusion: twins, pre-term, non-ethnic Chinese

Data collection:
- *Routine growth data* retrieved from MCHC Child Health Records

Data set:
- N=7,416 children (3880 boys; 3536 girls)
- Longitudinal growth (height & weight) data

(Hui LL et al. Arch Dis Child 2008; 93: 561-565)
An MCHC Sample of the 2002 Birth Cohort

Objective:
- To study the impact on clinical services of using HK 1993-Growth Reference vs WHO-CGS, conducted in 2007

The sample: 2-stage cluster sampling
- Random selection of 13 MCHCs from each of 4 regions
- Random sample of children born in 2002 from the registry of these MCHCs
- Exclusion: preterm; congenital abnormalities; medical conditions; non-ethnic Chinese; less than 2 records available

Data collection:
- *Routine growth (weight & height) data* retrieved from Child Health Records

Data set:
- N = 1,276 (620 boys; 656 girls)
  - n = 107 (8.4%) had full / exclusive BF for 4 to 6 months
- Longitudinal data (0 to 4 years)
The 2007 Survey

Objective:
- To study the prevalence of overweight & obesity in preschool children

Participants: recruited through systematic sampling
- attended 15 MCHCs for vision screening between 1 May & 15 June 2007
- Exclusion: non-ethnic Chinese; medical conditions

Prospective data collection
- Standardisation of equipments & measurement techniques
- Measurement of Height & weight

Data set:
- N=1032 (Boys 531; Girls 501)
- Cross-sectional height & weight data
An MCHC Sample of the 2006 Birth Cohort

- A computerised Growth Database was established in MCHCs since February 2011
- Weight & Height measurement:
  - Instruments & methods re-standardised in 2007
- Data collection:
  - Routine growth data from 4-year-old (48 to 60m) children who attended MCHCs for vision screening from February to December, 2011
- Data set
  - N = 3,691 (1,922 boys; 1,769 girls)
  - Cross-sectional weight & height data
### Mean z-score for Length / Height of 4 HK Samples wrt HKGR 1993

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<thead>
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<tbody>
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<td>Boys</td>
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Mean z-score for Length / Height of 4 HK Samples wrt WHO CGS

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<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
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<tr>
<td><strong>Length</strong></td>
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<tr>
<td>3 m</td>
<td>-0.18</td>
<td>-0.05</td>
<td>-0.04</td>
<td>0.13</td>
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<tr>
<td>9 m</td>
<td>-0.19</td>
<td>-0.02</td>
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<tr>
<td><strong>Height</strong></td>
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<tr>
<td>36 – 47 m</td>
<td>-0.34</td>
<td>-0.38</td>
<td>-0.19</td>
<td>-0.34</td>
</tr>
<tr>
<td>48 – 59 m</td>
<td>-0.23</td>
<td>-0.32</td>
<td>-0.27</td>
<td>-0.35</td>
</tr>
</tbody>
</table>
Mean z-scores of Height of Hong Kong 3 to 4 year-old children fall within the range of $\pm 0.5$ (considered as normal site variation by the MRGS)
Impact on Clinical practice

- Growth Monitoring in MCHCs
  
  Schedule for routine Weight & Length / Height Measurement at MCHCs:

<table>
<thead>
<tr>
<th></th>
<th>1st Visit</th>
<th>1 month</th>
<th>2 months</th>
<th>4 months</th>
<th>6 months</th>
<th>12 months</th>
<th>18 months</th>
<th>48 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
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<td>Length / Height</td>
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<td>*</td>
</tr>
</tbody>
</table>
Short stature

Height Monitoring
Identifying Children with Short Stature

<table>
<thead>
<tr>
<th>Height Z-Score</th>
<th>MCHC Sample of the 2002/03 Birth Cohort (2007 Growth Survey Data) [4-year-olds]</th>
<th>MCHC Sample of the 2006 Birth Cohort (2011 Routine Growth Data) [4-year-olds]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WHO-CGS</td>
<td>1993-HKGR</td>
</tr>
<tr>
<td>&lt; - 2</td>
<td>2.13%</td>
<td>0.68%</td>
</tr>
<tr>
<td>&lt; - 2.65</td>
<td>0.29%</td>
<td>0</td>
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<td>[ &lt; P_{0.4} ]</td>
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</tbody>
</table>
Summary

- Children of the 1993 HKGR are shorter than those of the WHO CGS
  - The maximum z-score for P_{50} length / height of 1993 HKGR w.r.t. WHO CGS is -0.53
- Representative samples of children born in 1997, 2002/2003 and 2006 are shorter than those of the WHO CGS, but taller than children of the 1993 HKGR
  - A secular trend in height is evident
  - Mean z-score for height (at 4 years) for birth cohorts in the 2000s w.r.t. WHO CGS is around -0.25 (boys) & -0.35 (girls)
  - No larger than the “Standardised Site Effects” of the 6 MGRS sites
- Height Monitoring (using the WHO CGS)
  - Proportion of children identified as having short stature (indicated for further assessment / investigations) is within expectation
Weight Growth of HK Children
Birth Weights in Hong Kong
## Mean Birth Weight 1984-2009

<table>
<thead>
<tr>
<th>Year</th>
<th>Male Mean birth weight</th>
<th>Male WHO weight z score</th>
<th>Female Mean birth weight</th>
<th>Female WHO weight z score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>3.23</td>
<td>-0.24</td>
<td>3.13</td>
<td>-0.23</td>
</tr>
<tr>
<td>1989</td>
<td>3.25</td>
<td>-0.20</td>
<td>3.15</td>
<td>-0.18</td>
</tr>
<tr>
<td>1994</td>
<td>3.25</td>
<td>-0.20</td>
<td>3.14</td>
<td>-0.20</td>
</tr>
<tr>
<td>1999</td>
<td>3.24</td>
<td>-0.22</td>
<td>3.14</td>
<td>-0.20</td>
</tr>
<tr>
<td>2004</td>
<td>3.23</td>
<td>-0.24</td>
<td>3.12</td>
<td>-0.25</td>
</tr>
<tr>
<td>2006</td>
<td>3.21</td>
<td>-0.28</td>
<td>3.11</td>
<td>-0.27</td>
</tr>
<tr>
<td>2008</td>
<td>3.21</td>
<td>-0.28</td>
<td>3.11</td>
<td>-0.27</td>
</tr>
<tr>
<td>2009</td>
<td>3.21</td>
<td>-0.28</td>
<td>3.10</td>
<td>-0.29</td>
</tr>
</tbody>
</table>
An MCHC Sample of the 2008 Birth Cohort

- **Objective:** Biennial infant feeding survey for monitoring breastfeeding rates in Hong Kong
- **Study period:** 13\textsuperscript{th} to 31\textsuperscript{st} July 2009
- **Participants:** Children who visited 31 MCHCs for MMR vaccination (Total N = 2,540)
- **Data set:**
  - 2244 term infants (1173 boys & 1071 girls),
    - 298 (13.3\%) infants, exclusively breastfed for 4 to 6m (155 boys & 143 girls)
  - Routine longitudinal weight data retrieved from records (0 – 18 m)
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<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
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<tr>
<td>Birth</td>
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<td>2 m</td>
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<td>0.53</td>
<td>0.52</td>
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<td>3 m</td>
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<td>6 m</td>
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<td>0.13</td>
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<td>9 m</td>
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<tr>
<td>12 m</td>
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<td>-0.01</td>
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<td>18 m</td>
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<td>0.21</td>
<td>0.07</td>
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<tr>
<td>36 m</td>
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<td>48-59 m</td>
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<td>0.23</td>
<td>0.26</td>
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</table>
## Mean z-score for weight of 5 HK Samples w.r.t WHO CGS

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<tbody>
<tr>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
</tr>
<tr>
<td>Birth</td>
<td>-0.16</td>
<td>-0.14</td>
<td>-0.17</td>
<td>-0.13</td>
</tr>
<tr>
<td>2 m</td>
<td></td>
<td>0.04</td>
<td>0.05</td>
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<tr>
<td>3 m</td>
<td>0.10</td>
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<tr>
<td>6 m</td>
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<td>0.02</td>
<td>0.05</td>
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<tr>
<td>9 m</td>
<td>0.15</td>
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<tr>
<td>12 m</td>
<td>-0.04</td>
<td>0.08</td>
<td>0.00</td>
<td>0.01</td>
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<tr>
<td>18 m</td>
<td>0.02</td>
<td>0.11</td>
<td>0.04</td>
<td>0.05</td>
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<tr>
<td>36 m</td>
<td>-0.06</td>
<td>-0.14</td>
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<tr>
<td>48-59 m</td>
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<td></td>
<td>-0.05</td>
<td>-0.16</td>
</tr>
</tbody>
</table>

*Note: Numbers in parentheses indicate the difference from the previous age point.*
Mean weight z score & 95% confidence interval w.r.t. WHO CGS (2002 cohort)

- Birth
- 1m
- 2-4m
- 4-6m
- 6-9m
- 12-15m
- 18-24m

Mean weight z score & 95% confidence interval w.r.t. HKGR 1993 (2002 cohort)

- Birth
- 1m
- 2-4m
- 4-6m
- 6-9m
- 12-15m
- 18-24m

Mean weight z score & 95% confidence interval w.r.t. WHO CGS (2008 cohort)

- Birth
- 1-2m
- 2-4m
- 4-6m
- 6-9m
- 12-15m
- 18-24m

Mean weight z score & 95% confidence interval w.r.t. HKGR 1993 (2008 cohort)

- Birth
- 1-2m
- 2-4m
- 4-6m
- 6-9m
- 12-15m
- 18-24m
Mean weight z score & 95% confidence interval w.r.t. WHO CGS 2006
2008 cohort — children exclusively BF for at least 4 months

Mean weight z score & 95% confidence interval w.r.t. HKGR 1993
2008 cohort — children exclusively BF for at least 4 months

Mean weight z score & 95% confidence interval w.r.t. HKGR 1993
2008 cohort — formula fed children or EBF < 4 months
Under-weight & weight faltering

Weight Monitoring
“overweight” for age

The proportion of children identified as “overweight” for age (Weight z-score >2)

<table>
<thead>
<tr>
<th></th>
<th>MCHC Sample of the 2002 Birth Cohort</th>
<th>MCHC Sample of the 2008 Birth Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WHO-CGS</td>
<td>1993-HKGR</td>
</tr>
<tr>
<td>1 m</td>
<td>0.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>2 m</td>
<td>0.9%</td>
<td>5.1%</td>
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<tr>
<td>4 m</td>
<td>1.5%</td>
<td>4.0%</td>
</tr>
<tr>
<td>6 m</td>
<td>1.5%</td>
<td>2.6%</td>
</tr>
<tr>
<td>12 m</td>
<td>1.8%</td>
<td>2.1%</td>
</tr>
<tr>
<td>18 m</td>
<td>2.0%</td>
<td>2.8%</td>
</tr>
</tbody>
</table>
Under-weight

The proportion of children identified as underweight for age (Weight z-score < -2)

<table>
<thead>
<tr>
<th></th>
<th>MCHC Sample of the 2002 Birth Cohort</th>
<th>MCHC Sample of the 2008 Birth Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WHO-CGS</td>
<td>1993-HKGR</td>
</tr>
<tr>
<td>1 m</td>
<td>1.3%</td>
<td>2.1%</td>
</tr>
<tr>
<td>2 m</td>
<td>0.6%</td>
<td>0.6%</td>
</tr>
<tr>
<td>4 m</td>
<td>1.3%</td>
<td>1.3%</td>
</tr>
<tr>
<td>6 m</td>
<td>1.3%</td>
<td>1.9%</td>
</tr>
<tr>
<td>12 m</td>
<td>0.8%</td>
<td>2.0%</td>
</tr>
<tr>
<td>18 m</td>
<td>0.8%</td>
<td>1.7%</td>
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</tbody>
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Weight Faltering

- During the first few weeks of life
  - may be associated with underfeeding, especially due to problems in breastfeeding
  - Skilful assessment of the mother-baby dyad by medical practitioners
    - History – feeding, elimination
    - Physical examination – baby & mother
    - Observation of breastfeeding
  - Expert management by medical practitioner
    - ± Coaching by experienced nurses / lactation consultants
  - Close weight monitoring is important
    - Growth chart may not be useful for such purpose
Weight Faltering

- After the first few weeks
  - Detected through routine weight monitoring
  - Defined as a fall through > 2 centile spaces (>1.33 z-score) in the weight chart
  - An indication for medical assessment
Weight Faltering

Proportion of children identified as having Weight Faltering (Fall through 2 centile spaces (1.33 SD) between 2 & 12m)

<table>
<thead>
<tr>
<th>MCHC Sample of 2002 Birth Cohort</th>
<th>MCHC Sample of the 2008 Birth Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO-CGS</td>
<td>1993-HKGR</td>
</tr>
<tr>
<td>1.59%</td>
<td>9.86%</td>
</tr>
<tr>
<td></td>
<td>WHO-CGS</td>
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<tr>
<td></td>
<td>2.09%</td>
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<tr>
<td></td>
<td>1993-HKGR</td>
</tr>
<tr>
<td></td>
<td>10.96%</td>
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<tr>
<td></td>
<td>EBF</td>
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<td>4.91%</td>
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<td></td>
<td>Others</td>
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<td></td>
<td>1.65%</td>
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<td>9.38%</td>
</tr>
</tbody>
</table>

*The proportion of 2 UK cohorts meeting this definition was 1.7% and 1.6% respectively (Wright C, UK)*
Summary

- The weight growth pattern of Hong Kong children fits better with the WHO-CGS than the 1993-HKGR, especially for breastfed infants.

- On the WHO-CGS (vs 1993-HKGR):
  - Fewer infants from 1 to 6 months are classified as “overweight” for age (z-score > 2), especially for BF infants.
  - No. of children identified as underweight (z-score < -2) is similar.
  - Significantly fewer children will be identified as having “weight faltering” between 2 & 12 m.
Over-weight & Obesity
(Population Surveillance)
Surveillance of 4-year-old Children for Overweight and Obesity

<table>
<thead>
<tr>
<th></th>
<th>MCHC Sample of the 2002/03 Birth Cohort (2007 Survey Data)</th>
<th>MCHC Sample of the 2006 Birth Cohort (2011 Routine Data)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>With reference to WHO CGS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk of overweight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 &lt; BMI ≤ 2</td>
<td>11.92%</td>
<td>15.78%</td>
</tr>
<tr>
<td>Overweight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 &lt; BMI ≤ 3</td>
<td>3.00%</td>
<td>4.17%</td>
</tr>
<tr>
<td>Obese</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI &gt;3</td>
<td>1.36%</td>
<td>0.83%</td>
</tr>
<tr>
<td><strong>International Obesity Task Force (IOTF) Definition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≡ Adult BMI ≥ 25 &lt; 30</td>
<td>8.25%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Obese</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≡ Adult BMI ≥ 30</td>
<td>2.52%</td>
<td>2.6%</td>
</tr>
</tbody>
</table>
Global Prevalence of Overweight and Obesity
## Overweight and Obesity in 4-year-old Children of EU Countries

<table>
<thead>
<tr>
<th></th>
<th>England</th>
<th>Spain</th>
<th>Italy</th>
<th>Czech</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>With reference to WHO CGS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk of overweight 1&lt; BMI ≤ 2</td>
<td>26.6%</td>
<td>33.3%</td>
<td>21.7%</td>
<td>14.5%</td>
</tr>
<tr>
<td>Overweight 2 &lt; BMI ≤ 3</td>
<td>7.7%</td>
<td>8.6%</td>
<td>6.1%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Obese BMI &gt;3</td>
<td>2.6%</td>
<td>4.3%</td>
<td>4.1%</td>
<td>1.5%</td>
</tr>
<tr>
<td><strong>International Obesity Task Force (IOTF) Definition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight ≡ Adult BMI ≥25 &lt; 30</td>
<td>15.5%</td>
<td>24.7%</td>
<td>14.4%</td>
<td>8.2%</td>
</tr>
<tr>
<td>Obese ≡ Adult BMI ≥30</td>
<td>5.7%</td>
<td>7.5%</td>
<td>7.8%</td>
<td>3.7%</td>
</tr>
</tbody>
</table>

Global Prevalence & Trends of Overweight and Obesity among Preschool Children

- WHO Global Database on Child Growth and Malnutrition
- 450 national representative surveys from 144 countries
- Estimated prevalence of overweight and obesity (>2SD from weight-for-height median) in children 0 – 5 years based on WHO CGS

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed Countries</td>
<td>7.9%</td>
<td>9.7%</td>
<td>11.7%</td>
</tr>
<tr>
<td>Eastern Asia</td>
<td>4.8%</td>
<td>5.0%</td>
<td>5.2%</td>
</tr>
</tbody>
</table>

De Onis, Blossner & Borghi Am J Clin Nutr 2010; 92: 1257-64
Is the WHO CGS appropriate for Growth Monitoring in HK?

- The variance of linear growth between HK children & WHO CGS is acceptable

- Clinical use:
  - Reasonable tool: Growth standard with breastfed infants as the norm
  - Education of health professionals is important

- Public Health use:
  - BMI at 4 years
    - Indicator of preschool childhood overweight / obesity
    - Indicator of effectiveness of population-based intervention programme
  - Allows comparability between countries
  - Supports promotion of breastfeeding
Issues to sort out

Continuity with

- Reference for prenatal growth & birth weight
- Reference for children 6 years and beyond
Acknowledgement: Dr. WY Luk: Data analysis

Thank You!
ASSESSMENT OF DIFFERENCES IN LINEAR GROWTH AMONG POPULATIONS IN THE WHO MULTICENTRE GROWTH REFERENCE STUDY

WHO MGRS GROUP

ACTA PAEDIATRICA, 2006; SUPPL 450: 56-65
The Appropriateness of a Single International Standard

1. Variance component analysis of length measurements in the longitudinal sample (0-24m)

   - Results
     - Individuals within sites: 70% of variance
     - Among sites: 3.4% of variance
     - Random error: 26.6%
2. Assessment of “Standardised Site Effects”
   • Method
     ○ “Site mean – Pooled mean ÷ SD of pool mean” of each site at these ages
       • Birth, 6m, 12m, 18m, 24m (length)
       • 24-26m, 36-38m, 48-59m & 60-62m (height)
     ○ Pre-determined that pooling would be appropriate if differences < ± 0.5 SD
• Results
  ○ “Standardised Site Effects” values
    • Length: - 0.33 to + 0.49 SD
    • Height: - 0.41 to + 0.46 SD
    • Oman accounted for the most negative values
    • Norway & Brazil accounted for the most positive values
  ○ Excluding individual sites from the pooled sample resulted in minimal impact on the pooled statistics

○ Conclusion: Appropriate to pool data from all 6 sites
Table III. Pooled and individual site sample sizes ($n$), means and standard deviations (SD) for length (cm).

<table>
<thead>
<tr>
<th>Age</th>
<th>Sample</th>
<th>$n$</th>
<th>Mean (cm)</th>
<th>SD</th>
<th>Standardized site effects$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>Pooled</td>
<td>1742</td>
<td>49.55</td>
<td>1.91</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>309</td>
<td>49.61</td>
<td>1.89</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Ghana</td>
<td>329</td>
<td>49.45</td>
<td>1.92</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>301</td>
<td>48.99</td>
<td>1.79</td>
<td>-0.29</td>
</tr>
<tr>
<td></td>
<td>Norway</td>
<td>300</td>
<td>50.40</td>
<td>1.86</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>Oman</td>
<td>295</td>
<td>49.18</td>
<td>1.72</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>208</td>
<td>49.74</td>
<td>1.96</td>
<td>0.10</td>
</tr>
<tr>
<td>6 mo</td>
<td>Pooled</td>
<td>1648</td>
<td>66.72</td>
<td>2.35</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>296</td>
<td>66.75</td>
<td>2.35</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
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<td>306</td>
<td>66.57</td>
<td>2.29</td>
<td>-0.06</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>287</td>
<td>66.60</td>
<td>2.28</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
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<td>286</td>
<td>67.88</td>
<td>2.37</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Oman</td>
<td>274</td>
<td>66.07</td>
<td>2.04</td>
<td>-0.27</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>199</td>
<td>66.30</td>
<td>2.39</td>
<td>-0.18</td>
</tr>
<tr>
<td>12 mo</td>
<td>Pooled</td>
<td>1594</td>
<td>75.02</td>
<td>2.62</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>290</td>
<td>75.39</td>
<td>2.69</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
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<td>301</td>
<td>75.16</td>
<td>2.69</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>279</td>
<td>74.96</td>
<td>2.53</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>Norway</td>
<td>272</td>
<td>75.47</td>
<td>2.55</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
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<td>265</td>
<td>74.43</td>
<td>2.41</td>
<td>-0.22</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>187</td>
<td>74.47</td>
<td>2.73</td>
<td>-0.21</td>
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<tr>
<td>18 mo</td>
<td>Pooled</td>
<td>1535</td>
<td>81.76</td>
<td>2.90</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>285</td>
<td>82.40</td>
<td>2.97</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Ghana</td>
<td>293</td>
<td>81.95</td>
<td>2.84</td>
<td>0.06</td>
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<tr>
<td></td>
<td>India</td>
<td>268</td>
<td>81.50</td>
<td>2.86</td>
<td>-0.09</td>
</tr>
<tr>
<td></td>
<td>Norway</td>
<td>255</td>
<td>82.06</td>
<td>2.77</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Oman</td>
<td>259</td>
<td>80.87</td>
<td>2.73</td>
<td>-0.31</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>175</td>
<td>81.70</td>
<td>3.01</td>
<td>-0.02</td>
</tr>
<tr>
<td>24 mo</td>
<td>Pooled</td>
<td>1524</td>
<td>87.40</td>
<td>3.18</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>280</td>
<td>88.35</td>
<td>3.17</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Ghana</td>
<td>289</td>
<td>87.48</td>
<td>3.04</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>India</td>
<td>269</td>
<td>87.00</td>
<td>3.15</td>
<td>-0.13</td>
</tr>
<tr>
<td></td>
<td>Norway</td>
<td>257</td>
<td>87.75</td>
<td>3.06</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>Oman</td>
<td>260</td>
<td>86.36</td>
<td>3.08</td>
<td>-0.33</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>169</td>
<td>87.38</td>
<td>3.33</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

$^a$ Standardized site effects are the differences between the indicated site means and the corresponding pooled (all sites) mean divided by the pooled standard deviation.
Figure 3. Length (cm) at selected percentiles for the pooled sample (solid line) and the sample following the exclusion of Brazil (dashed lines) from birth to 730 d.
Figure 4. Length (cm) at selected percentiles for the pooled sample (solid line) and the sample following the exclusion of Oman (dashed lines) from birth to 730 d.
The Growth of Children in China in the last 30+ years
The Fourth National Growth Survey of Children under 7 Years in Nine Cities in China

- Conducted in 2005
- Urban & rural areas of 9 cities (From E to W; N to S)
  - Harbin, Beijing, Xian
  - Shanghai, Nanjing, Wuhan
  - Fuzhou, Guangzhou, Kunming
- Total sample = 138,775
  - 22 age groups (n = 100 – 150)
  - Measurement of weight, height/length, sitting height, chest circumference, head circumference
- A new growth reference was constructed based on data from 69,760 urban children
Z-Scores of P50 Weight and Height of the Chinese Growth Reference (2005) on WHO CGS

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>0</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
<th>4.5</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Height (Boys)</strong></td>
<td>0.27</td>
<td>0.4</td>
<td>0.32</td>
<td>0.19</td>
<td>0.23</td>
<td>0.42</td>
<td>0.2</td>
<td>0.2</td>
<td>0.18</td>
<td>0.24</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Height (Girls)</strong></td>
<td>0.30</td>
<td>0.51</td>
<td>0.39</td>
<td>0.29</td>
<td>0.25</td>
<td>0.42</td>
<td>0.15</td>
<td>0.09</td>
<td>0.09</td>
<td>0.12</td>
<td>0.16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>0</th>
<th>0.5</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
<th>4.5</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight (Boys)</strong></td>
<td>-0.05</td>
<td>0.56</td>
<td>0.38</td>
<td>0.3</td>
<td>0.28</td>
<td>0.22</td>
<td>0.18</td>
<td>0.15</td>
<td>0.14</td>
<td>0.18</td>
<td>0.26</td>
</tr>
<tr>
<td><strong>Weight (Girls)</strong></td>
<td>-0.05</td>
<td>0.54</td>
<td>0.40</td>
<td>0.33</td>
<td>0.31</td>
<td>0.22</td>
<td>0.16</td>
<td>0.10</td>
<td>0.04</td>
<td>0.03</td>
<td>0.02</td>
</tr>
</tbody>
</table>

WHO Z-Scores of P50 Height of the Chinese Growth Reference (2005)

WHO Z-Score of P50 Weight of the Chinese Growth Reference (2005)
<table>
<thead>
<tr>
<th>Year Group</th>
<th>1975</th>
<th>1985</th>
<th>1995</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>158,400</td>
<td>152,874</td>
<td>157,362</td>
<td>138,775</td>
</tr>
</tbody>
</table>

### 6 – 7 Year Group: Weight Increment

<table>
<thead>
<tr>
<th>Gender</th>
<th>Increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Boys</td>
<td>3.26 Kg</td>
</tr>
<tr>
<td>Urban Girls</td>
<td>2.88 Kg</td>
</tr>
<tr>
<td>Rural Boys</td>
<td>2.68 Kg</td>
</tr>
<tr>
<td>Rural Girls</td>
<td>2.58 Kg</td>
</tr>
</tbody>
</table>

### 6 – 7 Year Group: Height Increment

<table>
<thead>
<tr>
<th>Gender</th>
<th>Increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Boys</td>
<td>5.3 cm</td>
</tr>
<tr>
<td>Urban Girls</td>
<td>5.0 cm</td>
</tr>
<tr>
<td>Rural Boys</td>
<td>7.6 cm</td>
</tr>
<tr>
<td>Rural Girls</td>
<td>7.5 cm</td>
</tr>
</tbody>
</table>

**U/R height difference (B)**

<table>
<thead>
<tr>
<th>Year Group</th>
<th>1975</th>
<th>1985</th>
<th>1995</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Increment</td>
<td>0.58 Kg</td>
<td>1.02 Kg</td>
<td>1.67 Kg</td>
<td></td>
</tr>
<tr>
<td>Height Increment</td>
<td>1.5 cm</td>
<td>2.0 cm</td>
<td>2.6 cm</td>
<td></td>
</tr>
</tbody>
</table>
Summary

- The growth and nutrition of Chinese children have improved over the past 30 years
- The secular trend in height and weight is continuing (and accelerating)
- The urban and rural difference in growth is significant but reducing
- The weight and height of Chinese children in nine cities have reached or surpassed that of the new WHO child growth standards


Comparing Hong Kong with Mainland Chinese Children

- Comparison between
  - 2007 growth survey data (HK)
  - The Chinese Growth Reference (2005)
- At 4 years, the mean height of Hong Kong boys and girls are 0.45 and 0.44 z-scores shorter than their mainland Chinese counterparts
Height Distribution of the 6 Country Samples and the WHO Pooled Sample

Age in 48 - 50 month (4 years old)

* Not in scale
BMI OF HONG KONG CHILDREN
Mean z-score for BMI of 3 Samples of 3 & 4-year-old Children w.r.t WHO CGS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
</tr>
<tr>
<td>Mean z-score for height</td>
<td>-0.34</td>
<td>-0.38</td>
<td>-0.27</td>
</tr>
<tr>
<td>Mean z-score for weight</td>
<td>-0.06</td>
<td>-0.14</td>
<td>-0.05</td>
</tr>
<tr>
<td>Mean z-score for BMI</td>
<td>0.22</td>
<td>0.14</td>
<td>0.18</td>
</tr>
</tbody>
</table>
### Mean z-score for BMI of 3 Samples of 3 & 4-year-old Children w.r.t HKGR 1993

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
</tr>
<tr>
<td>Mean z-score for height</td>
<td>0.20</td>
<td>0.20</td>
<td>0.33</td>
</tr>
<tr>
<td>Mean z-score for weight</td>
<td>0.23</td>
<td>0.26</td>
<td>0.25</td>
</tr>
<tr>
<td>Mean z-score for BMI</td>
<td>0.14</td>
<td>0.21</td>
<td>0.27</td>
</tr>
</tbody>
</table>
 Given the shorter height of our children, they are heavier than they should be
 Mean BMI is higher with reference to the WHO standard
 If a BMI chart were constructed based on weight & height of HK children and used as a reference, high BMI will be normalised (or under-diagnosed)