Addressing the Double Burden of Malnutrition

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Rising prevalence of diabetes in India

(V Mohan, Diabetologia 2006; 49: 1175-78)
Prevalence of Undernutrition & Overweight/Obesity among Indian Adults

Under nutrition (BMI < 18.5)  % Overweight/ obese (BMI > 25)

NFHS-3, 2005-06
NFHS-4, 2015-16
Cardio-metabolic risk in non-obese adults - high fat phenotype

- Reduced muscle mass, visceral mass
- Preserved subcutaneous & abdominal fat
Regional Body Composition of Indian Women from a Low-Income Group and Its Association with Anthropometric Indices and Reproductive Events

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National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India

(N = 278)

Mean age: 40 y; BMI: 22 kg/m²; Body fat %: 33
Table: Sensitivity and specificity of different levels of BMI for identifying subjects with high body fat cutoffs of 30 and 35%, using ROC analysis

<table>
<thead>
<tr>
<th>BMI cutoff points</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Correct classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF% of &gt;30%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>94.4%</td>
<td>61.2%</td>
<td>84.9%</td>
</tr>
<tr>
<td>20</td>
<td>85.9%</td>
<td>82.5%</td>
<td>84.9%</td>
</tr>
<tr>
<td>21</td>
<td>76.3%</td>
<td>90.0%</td>
<td>80.2%</td>
</tr>
<tr>
<td>22</td>
<td>61.6%</td>
<td>95.0%</td>
<td>71.2%</td>
</tr>
<tr>
<td>23</td>
<td>46.5%</td>
<td>98.7%</td>
<td>61.5%</td>
</tr>
<tr>
<td>24</td>
<td>35.9%</td>
<td>98.7%</td>
<td>54.0%</td>
</tr>
<tr>
<td>25</td>
<td>26.8%</td>
<td>100%</td>
<td>47.8%</td>
</tr>
<tr>
<td>BF% of &gt;35%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>100%</td>
<td>31.8%</td>
<td>61.9%</td>
</tr>
<tr>
<td>20</td>
<td>99.1%</td>
<td>56.4%</td>
<td>73.7%</td>
</tr>
<tr>
<td>21</td>
<td>92.9%</td>
<td>67.3%</td>
<td>77.7%</td>
</tr>
<tr>
<td>22</td>
<td>82.3%</td>
<td>80%</td>
<td>80.9%</td>
</tr>
<tr>
<td>23</td>
<td>69.0%</td>
<td>90.9%</td>
<td>82.0%</td>
</tr>
<tr>
<td>24</td>
<td>57.5%</td>
<td>95.8%</td>
<td>80.2%</td>
</tr>
<tr>
<td>25</td>
<td>46.0%</td>
<td>98.8%</td>
<td>77.3%</td>
</tr>
</tbody>
</table>
BMI Body Fat Relationship

Body fat %

BMI

BMI Body Fat Relationship
Body composition in the tertiles of height (cm)

Mean Body weights
T1 - 44.4 kg, T2 - 49.0 kg, T3 - 53.6 kg
Childhood Growth & Optimal Body Composition

JCK Wells (2007) Early Human Development
Foetal Undernutrition

Brain sparing
Down regulation of growth
Altered body composition
Fat ↑
Muscle ↓

Early maturation
Cortisol ↑

Impaired development
(Liver, pancreas, blood vessels etc.)

Hyperlipidaemia
Hypertension

Insulin resistance

Central Obesity

Type 2 diabetes & CVD

Fall CHD Indian Pediatr 2003; 40:480-502
New Delhi Birth Cohort (born 1969-1972)

- Measured every year to age 21 y
- Body comp assessment at age 30 y
- \( n = 1526 \)

BMI & BMI gain in infancy & early childhood

Related to adult LBM

BMI & BMI gain in late childhood

Related to adult fat mass & central adiposity.

Follow-Up Studies of Nutrition Supplementation Trials
INCAP study - Guatemala (1969-77)

- Assessed impact of nutrition supplementation in pregnancy & early childhood on growth & development
- Follow-up study 1988-89 (age 14-20 y)
- Body composition by anthropometry

Lean Body Mass; N=460

(Martorell R. J Nutr 1995; 125: 1127S-1138S)
To assess the long term impact of early life food supplementation & other environmental risk factors on cardio-metabolic disease risk.

Higher birth weight: I vs C

**F1**: Adolescence: Intervention group taller by 14 mm

**F2**: Age: 18-21y

Current diet / PA : more important determinant of LBM

*(S Kinra, BMJ 2008; 337: a605 ; B Kulkarni, Am J of Epidemiol 2014;179:700-9)*
Maternal undernutrition

↓ size at birth

↓ Childhood growth

Altered body composition

↓ adult LBM & muscle mass

Reduced REE

Impaired fat oxidation

Poor physical activity

Adipose / low muscle mass phenotype

Increased cardio-metabolic risk

Accumulation of risks during life course:
- Sub-optimal diets
- Low intake of milk & other ASFs
- Protein, zinc, calcium, vitamin D

Developmental programming
- Altered hormones
- Epigenetic changes

(Kulkarni B et al. Nutr Rev 2014;72:190–204)
Inter-generational cycle of malnutrition

- Impaired fetal development
- Stunted undernourished mother
- Transition
  - Excess adiposity
- Weight gain
- Undernourished infant and child
  - Long-term effects:
    - ↓ Bone mass, stunting
    - ↓ Muscle mass
    - ↑ Adiposity
    - ↑ Insulin resistance
- Low birth weight ‘Thin-fat’ phenotype

Intervening at each point in the life cycle will help positive change
Optimizing nutrition during life cycle

- **Pre-conception**
  a. Diet diversification by adding MN rich foods

- **During pregnancy**
  b. Fortification of staple foods with MN
  c. Balanced protein energy suppl/multiple MNs

- **Infancy**
  d. For children & pregnant women: Specially formulated fortified food supplements: both micro & macronutrients (EFAs & protein)

- **Early childhood**
  e. For young children: increasing the energy density of foods

**Nutrition education & counseling:** limited impact when provided without food suppl
**Balanced protein energy supplementation during pregnancy & risk of SGA births**

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Weight</th>
<th>Risk Ratio</th>
<th>Risk Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IV, Fixed, 95% CI</td>
<td>IV, Fixed, 95% CI</td>
</tr>
<tr>
<td>Blackwell 1973</td>
<td>4.4%</td>
<td>0.56 [0.21, 1.48]</td>
<td></td>
</tr>
<tr>
<td>Ceesay 1997</td>
<td>49.4%</td>
<td>0.65 [0.49, 0.87]</td>
<td></td>
</tr>
<tr>
<td>Elwood 1981</td>
<td>14.8%</td>
<td>0.88 [0.52, 1.50]</td>
<td></td>
</tr>
<tr>
<td>Girija 1984</td>
<td>0.5%</td>
<td>0.09 [0.01, 1.45]</td>
<td></td>
</tr>
<tr>
<td>Mora 1978</td>
<td>7.5%</td>
<td>0.78 [0.37, 1.65]</td>
<td></td>
</tr>
<tr>
<td>Rush 1980</td>
<td>23.3%</td>
<td>0.70 [0.46, 1.07]</td>
<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>100.0%</td>
<td><strong>0.69 [0.56, 0.85]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Chi² = 3.31, df = 5 (P = 0.65); I² = 0%

Test for overall effect: Z = 3.56 (P = 0.0004)

*Imdad & Bhutta BMC Public Health 2011, 11(S 3):S17
Kramer, Cochrane Database Syst Rev. 2003*
Meta-analysis of the effects of antenatal MMN vs IFA suppl on birth outcomes in 12 RCTs in developing countries


<table>
<thead>
<tr>
<th>Birth outcome</th>
<th>Pooled effect size (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight, g</td>
<td>22.4 (8.3, 36.4)</td>
</tr>
<tr>
<td>Low birth weight (&lt;2500 g)</td>
<td>0.89 (0.81, 0.97)</td>
</tr>
<tr>
<td>Small for gestational age</td>
<td>0.90 (0.82, 0.99)</td>
</tr>
<tr>
<td>Large for gestational age</td>
<td>1.13 (1.00, 1.28)</td>
</tr>
<tr>
<td>Gestational age, days</td>
<td>0.17 (−0.35, 0.70)</td>
</tr>
<tr>
<td>Preterm delivery (&lt;37 weeks)</td>
<td>1.00 (0.93, 1.09)</td>
</tr>
<tr>
<td>Stillbirths</td>
<td>1.01 (0.88, 1.16)</td>
</tr>
<tr>
<td>Perinatal mortality</td>
<td>1.11 (0.93, 1.33)</td>
</tr>
<tr>
<td>Early neonatal mortality</td>
<td>1.23 (0.96, 1.59)</td>
</tr>
<tr>
<td>Late neonatal mortality</td>
<td>0.94 (0.73, 1.23)</td>
</tr>
</tbody>
</table>

Limited impact of MMN supplementation in pregnancy
Estimated reduction in LBW- 11%
MMN Suppl in Pregnancy & Postnatal Growth of Children U5
(Wei-Ping Luo et al. PLOS One 2014; 9: e88496)
Meta-analysis: 9 trials from different countries

Mean diff in weight over time

Mean diff in height over time

No impact on weight, height & WHZ of children
Mumbai Maternal Nutrition Project

MN-rich food supplement pre-conceptionally & throughout pregnancy; ~ 6,700 women from Mumbai slums


Ingredients of a snack (samosa):
- Dry GLV powder
- Milk powder
- Fruit powder
- Fresh GLV
- Dried fruit
- Chick peas
- Sesame seeds

Birth weight effect:
+48 g in women who started suppl ≥ 3 mo before pregnancy
LBW – 34% vs 41%
Impact higher in women with higher BMI at baseline
Macro + Micro N supplementation may be needed in undernourished women.
Maternal body composition assessed by DXA within 1 mo after delivery (N = 76)

Maternal lean mass – strongest correlation with birth weight of the baby.
Dietary intakes of rural women & children in India: low Diet Diversity (NNMB 2012)

<table>
<thead>
<tr>
<th></th>
<th>Cereals Millets</th>
<th>Legumes</th>
<th>Green leafy veg.</th>
<th>Other veg</th>
<th>Roots Tubers</th>
<th>Nuts Oil seeds</th>
<th>Fruits</th>
<th>Meat poultry</th>
<th>Milk Milk products</th>
<th>Fats Oils</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPNL women (n=9519)</td>
<td>341</td>
<td>28</td>
<td>19</td>
<td>49</td>
<td>70</td>
<td>8</td>
<td>24</td>
<td>21</td>
<td>82</td>
<td>15</td>
</tr>
<tr>
<td>Pregnant (n=322)</td>
<td>354</td>
<td>34</td>
<td>18</td>
<td>47</td>
<td>60</td>
<td>7</td>
<td>32</td>
<td>21</td>
<td>79</td>
<td>16</td>
</tr>
<tr>
<td>Lactating (n=693)</td>
<td>395</td>
<td>34</td>
<td>19</td>
<td>48</td>
<td>70</td>
<td>6</td>
<td>24</td>
<td>16</td>
<td>66</td>
<td>17</td>
</tr>
<tr>
<td>1-3 y children (n=2895)</td>
<td>131</td>
<td>15</td>
<td>7</td>
<td>13</td>
<td>21</td>
<td>2</td>
<td>12</td>
<td>6</td>
<td>86</td>
<td>6</td>
</tr>
</tbody>
</table>

Children (6-23 mo) receiving minimum adequate diet (NFHS 4)
Breastfeeding children : 9%
Non- Breastfeeding children : 14%
ASF supplements increase LBM in Kenyan school children

(544 children; median age 7 y, supplemented for 23 months)

Children with low baseline HAZ:

- Milk-supplemented children gained 1.3 cm ↑ height than controls ($p = 0.05$) &
- 1 cm ↑ height than Meat group

Arm muscle area -
Meat group -
- 80% more ↑ than controls
- Milk and Energy groups - 40% more ↑ than control group.

Positive relation between milk intakes & height of adults (NFHS 3)

Milk consumption ≥ once/week vs < once/week: difference in height +0.65 cm (men) & 0.40 cm (women) (both p<0.001); adjusted for confounders
Intake of other ASFs not associated with height
Cultural importance of milk in India goes beyond nutritive value
SUMMARY

• Double burden of childhood undernutrition & adult-onset adiposity in transitioning societies: public health challenge.

• Sub-optimal LBM- link between these 2 forms of malnutrition

• Positive association of early nutritional status with LBM in later life.

• Nutritional influences throughout the life course impact LBM

• Improving intake of diverse foods especially milk & animal source foods is necessary for optimal body composition

• Interventions focusing on child nutrition should aim at increase in LBM to address the double burden of malnutrition
THANK YOU