Protein quality, amino acids and growth

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PROTEIN CALORIES AS % OF TOTAL CALORIES FOR ADULTS

- VARIABLE CORRECTION depending on dietary protein quality

LONG TERM DATA 1975 - 1977 MIT (HEALTHY CAUCASIANS)

MILK OR EGG PROTEIN

PROTEIN REQUIREMENT FAO/WHO 1973

FIG. 1
Protein Quality Related Health Outcomes

Short term outcomes

- Growth and tissue repair (wasting and stunting)
- Immune function and host defense system (prevalence and severity of infection)
- Muscle and skeletal Mass (capacity for physical work and athletic performance)
- Mental performance, mood, sleep patterns?
- Detoxification of chemical agents and antioxidant systems

Long Term Outcomes

- Life course events, linear growth, menarche, aging
- Age related functional losses: muscle, bone strength, immunity, cognitive decline
- Nutrition related chronic diseases: CVDs, Cancer, Hypertension, oxidative damage, repair systems

Physiologic/Metabolic Responses

- Absorption-Digestibility
- Metabolic Utilization
- Nitrogen Balance
- Lean mass/Muscle/Bone Tissue turnover
- Secretory Proteins
- Host defenses/Immunity
- Growth & Maturation Tissue Repair

Genetic

- Monogenic
- Polygenic

Epigenetic

- Receptors
- Genes
- Protein Metabolism
- Hormones
Nutrient/Hormones Effects on Growth

- **Hyperplasia**
  - Insulin, IGF1/BP3
  - Cortisol
  - Leptin, GH
  - T3/T4

- **Brain length**

- **Bone / aminoacids**
  - I, Fe, Cu, Zn,
  - Na, K, P,
  - Energy
  - n-6 & n-3 EFA

**Hypertrophy Adipose tissue/ weight**
Present efforts in infant/child nutrition should “not only” improve survival (avoid low weight for age) but must also aim that all children have the opportunity to be educated, be healthy and productive as adults, extending life and preventing disability beyond the reproductive cycle (marked by length and BMI for age).

We should aim for “longer”, “healthier” and “happier” lives while preventing functional losses.

These goals are essential for human, economic and social development as well as for global peace.
Nutrient Effects on Growth

- Any essential nutrient can condition abnormal embryonic & organ growth and development (Folate, I, Vit A, E, Fe, Zn, EFA, EAA Pr/Energy)
- Timing of nutrient deficit or excess is crucial in effect: cell replication/migration/apoptosis/maturation
- Genetic polymorphism affecting nutrient metabolism transport or tissue levels can modulate effects.
- Nutrients & toxicants (retinoic acid, Pb, Zn, folate) interact in defining normal or abnormal growth.
171 million children under 5 are stunted

Source: WHO Global Database on Child Growth and Malnutrition, May 2009
Global and regional prevalences of stunting, wasting and overweight

Source: Department of Nutrition, World Health Organization
Stunting prevalence and number affected in developing countries

Source: Department of Nutrition, World Health Organization
Mean z-scores for age all 54 studies, relative to the WHO standard

Milk/Animal source foods interventions improve linear growth

1930s UK: Boyd Orr: feeding trials of surplus milk disposal to school children: significant increase in height, improvement in “general appearance”.

India: Aykroyd and Krishnan (1937) skimmed milk supplemented school children grew faster in height


US: Fomon et al. (1977): skimmed milk (low energy, high protein)-fed infants showed same length growth but less weight gain than high energy formula.

Bangladesh: Kabir et al (1992/3): ASF protein at 15% energy increases IGF-1 and linear growth cf 7.5% protein in children recovering from shigellosis
Maternal protein flux and neonatal Length

Length of the newborn at birth and maternal protein synthesis in mid pregnancy for 26 women

Sarah L. DUGGLEBY* and Alan A. JACKSON
Stunting

Most common form of undernutrition (PE/micronutrients)

Affects infants before and early after birth

Linked to maternal size, nutrition during pregnancy & fetal growth

Length that is lost early on is rarely recovered

Stunted have less lean body mass (lower RMR per kg bw)
Nutrition and height growth: specific nutrients

Protein ➔: strong experimental evidence in animals
           Good indirect data in humans

Zinc ➔: Good experimental evidence in animals
           Good meta analysis data in humans (weak effect)

Calcium & Phosphate: Length growth not thought to be limited by mineral supply in general

Other micronutrients:
I, Fe, Mn, Ca, vitamin A, Vit D all potentially involved but specific deficiency signs & symptoms would be observed.

Infection/stress: Good experimental and epidemiological evidence mediated by pro inflammatory cytokines & cortisol
Mechanisms by which nutrition conditions linear growth

- Gene Expression (transcription factors, single or multiple genes)
- Hormones receptors, binding proteins and signal transduction
- Cell growth and turnover during critical periods
Assessment of protein adequacy in developing countries: quality matters

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Data Sources

- Food balance sheet data for 180 countries (FAO STAT) - year 2005
  - For each country FBS provides amount of listed commodity available for food consumption

- Stunting data from UNICEF for 116 countries – year 2005
  - “Moderate to Severe Stunting” (referred to as “stunting”) is defined by UNICEF as the percentage of children under five years of age in a particular country who fall below -2 and -3 standard deviations for height-for-age z-score.

- Data on Gross Domestic Product (GDP) from UNDP Human Development report

- Nutrient database developed on basis of USDA food composition tables

- Protein digestibility data from FAO/WHO 1991 protein quality evaluation and literature
Data calculations

- Estimation of nutrient availability from FBS commodity data
- Calculation of PDCAAS for each country (diet) using WHO prescribed methodology and utilizable protein
- Estimation of prevalence of inadequacy
  - Adult protein requirement 0.66 g/kg body weight, 60 kg
  - 2525 kcal total energy calculated for a moderately actively adult (PAL 1.75, average for moderately active adult male and female)
  - Amino acid reference pattern for lysine (30 mg/kg body weight/day), tryptophan (4 mg/kg body weight/day), SAA (15 mg/kg body weight/day) and threonine (15 mg/kg body weight/day) (1, 26).
  - Country level availability as mean protein availability, intake distribution based on CV 25%
  - Energy deficit- 10% increased need in protein requirement
  - Increased need for protein during and after 8 episodes per year illness (recovery), 10% for total days ill and recovery weighted over year
Comparison of total protein to utilizable protein by region (g/capita/day and prevalence of inadequacy)
Percent risk of protein inadequacy calculated from total and utilizable protein, and with increased requirements based on low energy availability and infection in countries with under 2000 kcal/capita/day.
Percent risk of protein inadequacy calculated from total and utilizable protein, and with increased requirements based on low energy availability and infection in countries with between 2000-2500 kcal/capita/day

<table>
<thead>
<tr>
<th>Country</th>
<th>Based on total protein</th>
<th>Based on utilizable protein</th>
<th>Based on increased requirements</th>
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<tr>
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</tbody>
</table>
Percent risk of protein inadequacy calculated from total and utilizable protein, and with increased requirements based on low energy availability and infection in countries with over 2500 kcal/capita/day.
Percent risk of protein inadequacy, by country in 2005
Percent risk of protein inadequacy, by country in 2005
Percent of children under 5 that are moderately and severely stunted by country in 2005
Percent risk of protein inadequacy and percent of children under 5 who are stunted by country in 2005
Percent risk of protein inadequacy and percent of children under 5 who are stunted by country in 2005

Prev inadequacy (60kg 25%CV)

Stunting

No data