Protein and amino acid requirements in human nutrition
Report of a joint FAO/WHO/UNU expert consultation
WHO 2007

The three key objectives of this report were;

1). To review, revise and update protein and amino acid requirements for all age groups

2). To review and develop recommendations on protein requirements in health and disease, including their implications for developing countries

3). To develop recommendations on protein quality and labelling, with respect to new requirement levels, for use worldwide

In the next section we summarise the main features of these objectives in relation to infants and children, with a special focus on catch-up growth.

Protein and amino acid requirements of infants & children:
"The protein requirement of infants and children can be defined as the minimum intake that will allow nitrogen equilibrium (at an appropriate body composition during energy balance at moderate physical activity), plus the needs associated with the deposition of tissues consistent with good health" (WHO/FAO 2007).

- **Calculation of protein requirements:**

Requirements are expressed as grams per kilo according to the age of the child (e.g. 0.97g for a 2year old). This is then multiplied by the actual weight, or in the absence of actual weight, the median weight-for-age of the child from the WHO tables (1994) (e.g. 0.97g/kg/day).

It should be realised however, that the protein requirements of infants and children given in this report are *safe levels of protein intake* i.e. the absolute minimum. In fact the protein recommendations/requirements given for infants in the report are below the level provided by breast milk. Therefore they should be considered in the right context and not taken as optimal for healthy growth and development or upper limits. In addition, these recommendations do not apply to 'sick' infants and children.

Protein requirements for catch-up growth
As an international guideline this report considered all populations, including those from developing countries where severe malnutrition is common. They indicate that up to 60% of pre-school children in developing countries are stunted, that its prevalence is highest in the 2 year old, and that it is associated with increased morbidity and mortality.

The report also gives recommendations for protein and energy intake for *wasted* infants and children in need of rapid weight gain [based on malnourished wasted infants e.g. Spady et al 1976]. Further they emphasise factors contributing to body composition changes [i.e. fat versus lean tissue/body mass].

They indicate that protein and energy needs for catch-up growth in wasted infants are dependent on both the *rate and composition* of weight gain. A rate of weight gain of 10g/kg/day requires at least 8.9 energy percent of protein (PE%) to achieve an appropriate composition of lean to fat tissue [i.e.14% protein gain with 27% fat gain]. For the same rate of weight gain a lower PE%, of 6.0, results in higher fat to lean tissue deposition [9.6% protein gain with 50% fat]. For higher rates of weight gain, such as 20g/kg/day, at least 11.5PE% is needed to achieve this composition of lean tissue [i.e. 14% protein gain with 27% fat gain] (see table 38 below).

Table 38
Protein and energy needs for catch-up growth at different rates of weight gain

	Typical composition of weight gain[a]	High rate of fat deposition[b]
Net growth costs (kcal/g)[c]	**3.29**	**5.12**
Gross growth costs (kcal/g)[d]	**4.10**	**5.99**

	Dietary requirements					
Rate of gain (g/kg per day)	Protein[e] (g/kg/day)	Energy[f] (kcal/kg/day)	Protein/ energy (%)	Protein[g] (g/kg/day)	Energy[h] (kcal/kg/day)	Protein/ energy (%)
1	1.02	89	4.6	1.0	91	4.2
2	1.22	93	5.2	1.1	97	4.5
5	1.82	105	6.9	1.5	115	5.2
10	2.82	126	8.9	2.2	145	6.0
20	4.82	167	11.5	3.6	205	6.9

[a] 73:27 lean:fat equivalent to 14% protein and 27% fat.
[b] 50:50 lean:fat equivalent to 9.6% protein and 50% fat.
[c] Based on 5.65 kcal/g protein and 9.25 kcal/g fat.
[d] Net costs adjusted for a 90% and 73% metabolic efficiency of fat and protein deposition respectively (*28, 29*), plus metabolizable energy of additional non-utilized protein.
[e] 14% deposited tissue adjusted for a 70% efficiency of utilization plus the safe level of maintenance at 1.24×0.66 g/kg per day = 0.82 (see section 11).
[f] Maintenance energy at 85 kcal/g (which includes maintenance protein energy) + gross energy costs at 4.10 kcal/g weight gain.
[g] 9.7% deposited tissue adjusted for a 70% efficiency of utilization plus the safe level of maintenance at 1.24×0.66 g/kg per day = 0.82 g/kg per day; 1.27×0.58 g/kg per day = 0.737 (see section 11).
[h] As in footnote "f" except that gross energy costs are 5.99 kcal/g weight gain.

Note however that these recommendations *do not* account for stunting or additional needs* i.e. increased energy and protein turnover (due to infection, inflammation, acute phase response etc.), or increased losses (due to vomiting) [personal communication Prof. B Koletzko]. In fact, the WHO report specifically states that the protein requirement for catch-up in height, in stunted infants and children, is greater than the recommendations for catch-up in wasted infants and children. Therefore infants/children who are stunted and/or have additional needs probably require even higher levels of protein (PE%). This was confirmed by Kabir et al (1992, 1993) who

*Additional needs in this document = disease or conditions leading to higher protein and energy needs as indicated above

showed increased linear growth in 2-4 year old (stunted and stressed) children when increasing the PE% from 7.5 to15%. Whilst Fjeld et al (1989) reported faster linear growth with 11PE% compared with 8PE%.

However, (as this report states) it is not possible to clearly identify the optimal dietary level of protein in stunted infants and children without proper dose-response and intervention studies. As this is extremely difficult to do, one could assume a reference level for practice purposes, based on the above data as well as data from others [Jackson 1990; Dewey et al 1996], i.e. between 9 -15PE%. The lower levels of this range applicable only to wasting (e.g. 9 -11.5PE %) and the upper levels for those with stunting, and/or with additional needs. Another practical approach could be to use the stress factors used for calculating energy needs in adults (e.g. 9-11.5PE% plus 25 ~ 40%) depending on the particular condition (Barak et al 2002). A critical consideration (pointed out in this report) is, when an increase in calories is indicated, proteins should also be increased to prevent excess fat rather than lean body tissue gain.

In conclusion, it would appear that for wasted infants/children [without additional needs] at least 9PE% to 11.5PE% is needed to provide an adequate *rate and composition* of weight gain. Whilst for infants/children who are stunted and/or have additional needs a higher PE% (up to15PE %) is needed to achieve an adequate *rate and composition* of weight gain.

Recommendations on protein quality

Adjustments for protein quality should be made using a digestibility factor and amino acid score, to ensure that infants and children meet their requirements of all the essential amino acids. When adjusting for amino acid score and digestibility of the protein then actual protein requirements will be somewhat higher than the protein requirements in this report.

In the 1985 report specific recommendations for infants and children were made for essential amino acids (mg/g protein/d and mg/kg/d). In the current report these recommendations have been slightly modified, some reduced whilst others increased. Remarkably, they now separate methionine and cysteine recommendations for adults (previously these sulphur amino acids were combined) but not for children. For infants and children they still give a combined recommendation for these two amino acids (see table 36 below).

Table 36

Amino acid requirements of infants, children and adolescents (males and females combined)

			His	Ile	Leu	Lys	SAA	AAA	Thr	Trp	Val
Tissue amino acid pattern[a]			27	35	75	73	35	73	42	12	49
Maintenance amino acid pattern[b]			15	30	59	45	22	38	23	6	39
Protein requirements (g/kg per day) for			Amino acid requirements (mg/kg per day)[d]								
Age (years)	Maintenance	Growth[c]									
0.5	0.66	0.46	22	36	73	64	31	59	34	9.5	49
1–2	0.66	0.20	15	27	54	45	22	40	23	6.4	36
3–10	0.66	0.07	12	23	44	35	18	30	18	4.8	29
11–14	0.66	0.07	12	22	44	35	17	30	18	4.8	29
15–18	0.66	0.04	11	21	42	33	16	28	17	4.5	28
>18	0.66	0	10	20	39	30	15	25	15	4.0	26
			Scoring pattern (mg/g protein requirement)[e]								
0.5			20	32	66	57	28	52	31	8.5	43
1–2			18	31	63	52	26	46	27	7.4	42
3–10			16	31	61	48	24	41	25	6.6	40
11–14			16	30	60	48	23	41	25	6.5	40
15–18			16	30	60	47	23	40	24	6.3	40
>18			15	30	59	45	22	38	23	6.0	39

His, histidine; Ile, isoleucine; Leu, leucine; SAA, sulfur amino acids; AAA, aromatic amino acids, Thr, threonine, Trp, tryptophan; Val, valine.

[a] Amino acid composition of whole-body protein (*37*).

[b] Adult maintenance pattern (see section 8).

[c] From Tables 32 and 33, calculated as average values for the age range growth adjusted for protein utilization of 58%.

[d] Sum of amino acids contained in the dietary requirement for maintenance (maintenance protein x the adult scoring pattern) and growth (tissue deposition adjusted for a 58% dietary efficiency of utilization x the tissue pattern).

[e] Amino acid requirements/protein requirements for the selected age groups.

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