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PROTEIN REQUIREMENTS OF PRE-SCHOOL CHILDREN*

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Before discussing in more detail the protein requirements of children of pre-school age, I would like to make some considerations about protein requirements in general.

First, we must make a clear distinction between *requirements* and *allowances*. *Requirement* is a physiological term. The amount of protein necessary to compensate for the obligatory losses of nitrogen from the body, plus, in the child, the nitrogen required to accumulate the amount of protein compatible with normal growth. In pregnancy and lactation additional proteins are necessary to permit the increase in mass and normal milk production respectively. The components of this equation are the urinary losses, the fecal losses, the skin and integumental losses plus the growth or milk production need.

Nobody will disagree with the fact that the values given to those components are estimates whose error is in most cases only vaguely known. Nevertheless, they are the best we have, and furthermore, they are subject to revision, as better information becomes available. Here, I want to emphasize that these values will not be improved significantly by discussion only, but instead research will determine the extent to which they are in error.

The result of the application of this so-called "factorial approach" by the National Research Council of the U.S. (NRC)[1] is shown in Table 1. You may notice the last column in which 30% of the average requirement has been added. This I believe, is an appropriate time to define *allowances*. Allowances are suggested intakes proposed mostly on the basis of practical considerations. They are the result of policy decisions which modify the average *requirement* figure to make their applicability

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En: Proceedings of the First Asian Congress of Nutrition held at Hyderabad, India, 28 January to 2 February, 1971. P.G. Tulpule and Kamala S. Jaya Rao (Eds.). Calcutta, India, N.K. Gossain & Company Private Limited, 1972, p. 350-357.

TABLE 1

Protein requirements of humans in grams per kilogram of body weight per day

Males

Age	Daily weight gain (g)	Protein gain (g/kg)	Basal Metab. (Cal/kg)	Maintenance protein (g/kg)	Average requirement of "Ideal Protein" (g/kg)	Average requirement of "Ideal Protein" +30% (g/kg)
15.0 months	8.3	0.12	61.5	1.23	1.35	1.75
21.0 months	8.8	0.12	53.4	1.07	1.19	1.55
2.5 years	6.7	0.08	48.3	0.97	1.05	1.37
3.5 "	6.8	0.07	42.8	0.86	0.93	1.21
4.5 "	7.1	0.06	40.1	0.80	0.86	1.12
5.5 "	8.3	0.06	39.8	0.80	0.86	1.12
6.5 "	9.9	0.07	39.5	0.79	0.86	1.12
7.5 "	10.7	0.06	39.6	0.79	0.85	1.11
8.5 "	10.0	0.05	37.1	0.74	0.79	1.03
9.5 "	11.1	0.05	35.1	0.70	0.75	0.97
10.5 "	11.7	0.05	33.1	0.66	0.71	0.92
11.5 "	12.8	0.05	31.1	0.62	0.67	0.87
12.5 "	16.9	0.06	29.2	0.58	0.64	0.83
13.5 "	17.0	0.05	29.3	0.59	0.64	0.83
14.5 "	13.5	0.04	28.5	0.57	0.61	0.81
15.5 "	11.4	0.03	27.7	0.53	0.56	0.73
16.5 "	9.4	0.02	25.8	0.52	0.54	0.70
17.5 "	5.5	0.01	25.0	0.50	0.51	0.66
Adult	—	—	25.0	0.50	0.50	0.65

"safer" under specific circumstances. For example, to cover 97.5% of the population the NRC proposed the mentioned addition of two standard deviations, one standard deviation being accepted as 15% of the mean. WHO/FAO, using older supporting data had considered one standard deviation as 10%. The variability factor, therefore, was set by them as 20%[2]. Further modification of the requirements to transform them into *allowances* applicable to a particular situation, comes from the introduction of a correction factor for the per cent utilization of the dietary protein when this is not *reference* or *ideal* protein which by definition is 100% utilized. These utilization factors are mostly derived from experiments in rapidly growing rats and their applicability to humans, and even more, to humans of all ages, is fairly open to serious question.

The second part of my presentation is intended to illustrate the most of the trouble with the figures proposed as requirements does not lie in the figures themselves, but rather on their interpretation and use. Table 2 shows the estimated protein requirements of infants. We notice general agreement in the early part of infancy, but the agreement is somewhat disrupted later. Some of the NDpCal % resulting from these estimates are markedly lower than that for human milk, but I am not prepared to say how wrong they may be.

Let us instead look at Table 3. Using the factorially determined average protein *requirements* and the average FAO caloric requirements, I have calculated the ratio of protein calories to total calories, (expressed as NDpCal % values) given in the second column from the right. The magnitude of the figures is in reasonably good agreement with those proposed by Payne and Miller[3]. But let us see what happens if we take the initial steps to make them into *allowances* by adding the variability factor. The result is the higher figures on the last column. It may be observed that these figures of NDpCal % are markedly higher than 4 which is the value estimated by Payne and Miller for maintenance[3]. The fact is that these higher values are erroneous because for the numerator of the fraction, the protein requirement already increased by the addition of the variability factor of 30%* has been used, while for the denominator, the plain average calorie requirement has been taken. This overlook has led to unjust criticism of the protion requirements derived by the "factorial method".

TABLE 2

Average reference protein and calorie requirement of infants proposed by different Expert Groups and the resulting NDp Cal %

Age (months)	NRC	ICMR	FAO—OMS	Swaminathan
0	(1) (2)			
1	2.2—120	2.3—120	2.3—120	2.4—120
	(3)			
2	(7.2)	(7.7)	(7.7)	(8.0)
3				
4	2.2—110	1.8—110	1.8—110	2.1—110
5	(7.2)	(6.6)	(6.6)	(7.6)
6				
7		(4)		
8		1.8—100	1.5—110	1.8—100
9	1.8—100	(5.0)	(5.4)	(7.6)
10	(7.2)	(4)		
11		1.5—100	1.3—100	1.5—100
12		(4.2)	(5.2)	(6.0)

(1) Gram protein/kg/d. (2) Calories/kg/d. (3) NDp Cal % (4) NPU=70%

TABLE 3

Derivation of NDp Cal % on the bases of average FAO Calorie requirements and NRC average reference protein requirements
(Per kg per day)

Age (yrs)	Weight (kg)		Calorie requirement		Protein Req. (g)		NDp Cal %	NDp Cal % + 30 %
	M	F	M	F	M	F	Both sexes	Both sexes
1.5	11.43	11.11	101	104	1.27	1.38	5.2	6.8
2.5	13.61	13.43	96	97	1.05	1.16	4.6	6.0
3.5	15.56	15.38	93	94	0.93	1.06	4.3	5.6
4.5	17.42	17.46	89	89	0.86	0.99	4.2	5.6
5.5	20.26	19.96	82	85	0.86	0.97	4.4	5.6
6.5	23.22	20.64	80	90	0.86	0.94	4.3	5.6
7.5	25.90	25.04	75	78	0.85	0.90	4.6	5.6
8.5	28.62	27.67	73	76	0.79	0.86	4.4	5.6
9.5	31.30	30.44	72	74	0.75	0.82	4.3	5.6
10.5	33.93	33.79	69	70	0.71	0.79	4.3	5.6
11.5	36.74	37.74	68	66	0.67	0.74	4.2	5.6
12.5	40.23	42.37	66	62	0.64	0.71	4.3	5.6
13.5	45.50	47.04	65	56	0.64	0.62	4.2	5.6
14.5	51.66	50.35	60	52	0.61	0.59	4.3	5.6
15.5	56.65	52.30	57	49	0.56	0.54	4.2	5.6
16.5	60.33	53.57	57	46	0.54	0.52	4.2	5.6
17.5	62.41	54.20	57	44	0.51	0.49	4.0	5.6
Adult	65.00	55.00	49	42	0.50	0.50	4.4	5.6

Based on average NDp Cal % of 4.3

Table 4 shows the problems one may get into when playing with figures. Combining calorie requirements from FAO[4] or NRC[1] with average protein requirements, body weight, and NDpCal %, we introduce more variability and more confusion. One may, however, make a choice and select among these data, one of them, either because it may be a favourite or simply for the sake of argument. Table 5 is self-explanatory of what happens and presents a theoretical puzzle.

The next part of this paper is intended to emphasize the point made earlier in this talk, that is, the need for research, especially of ultimately testing the proposed requirement figures as directly as possible, on the subjects who are to consume them, and not only in rats or chicks. I will describe briefly work which is going on in INCAP's laboratories for this purpose.

TABLE 4

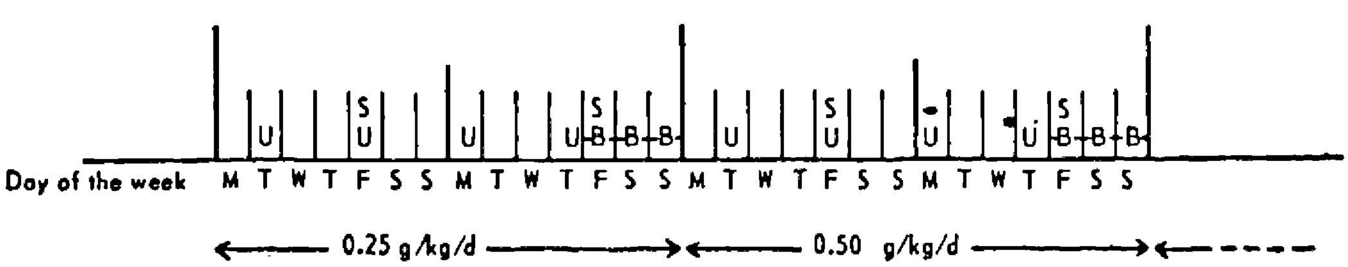
Effect of Expert Groups on the NDpCal % and Protein and Calorie requirement of adults

	Body weight (kg)	Calorie Requirement		Reference Protein Requirement (g/kg/d)	NDp Cal %
		Per day	kg/day		
		MEN			
FAO-OMS	65	3200	49	0.59	4.8
NRC	70	2800	40	0.50	5.0
FAO-OMS/NRC	—	—	49	0.50	4.1
PAYNE-MILLER/FAO	65	3250	50	0.50	4.0
PAYNE-MILLER/NRC	70	3500	50	0.50	4.0
		WOMEN			
FAO-OMS	55	2300	42	0.59	5.6
NRC	58	2000	34	0.50	5.9
FAO-OMS/NRC	—	—	42	0.50	4.8
PAYNE-MILLER/FAO	55	2750	50	0.50	4.0
PAYNE-MILLER/NRC	58	2900	50	0.50	4.0

Underlined figures used as bases for calculation.

FIG. 1

GRAPHIC REPRESENTATION OF TWO TYPICAL DIETARY PERIODS OF TWO WEEKS EACH. SAMPLING FOR BLOOD AND URINE



U — Casual midmorning urine specimen

B-B-B — Three consecutive 24 hour urine and fecal collections

S — 10 ml venous blood sample

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TABLE 5

Average requirement of ideal protein for a 70 kg man. 35 g/d (NRC, 1968) 0.50 g/kg/d
From that figure one can calculate his ideal *energy expenditure* or caloric requirement, based on a NDp Cal %=4.0

$$\frac{100 \times 0.50 \times 4}{X} = 4; \qquad X = 50 \text{ Cal/kg}$$

$70 \times 50 = 3500$ Cal/day

Presently, NRC requirement is 2800 Cal/day.

Conclusion : The man has to either consume a diet much more concentrated in protein (higher NDp Cal %) or increase his consumption of the diet with NDp Cal % of 4.0. In the latter case he would have to increase his physical activity about 75% if he does not want to get obese.

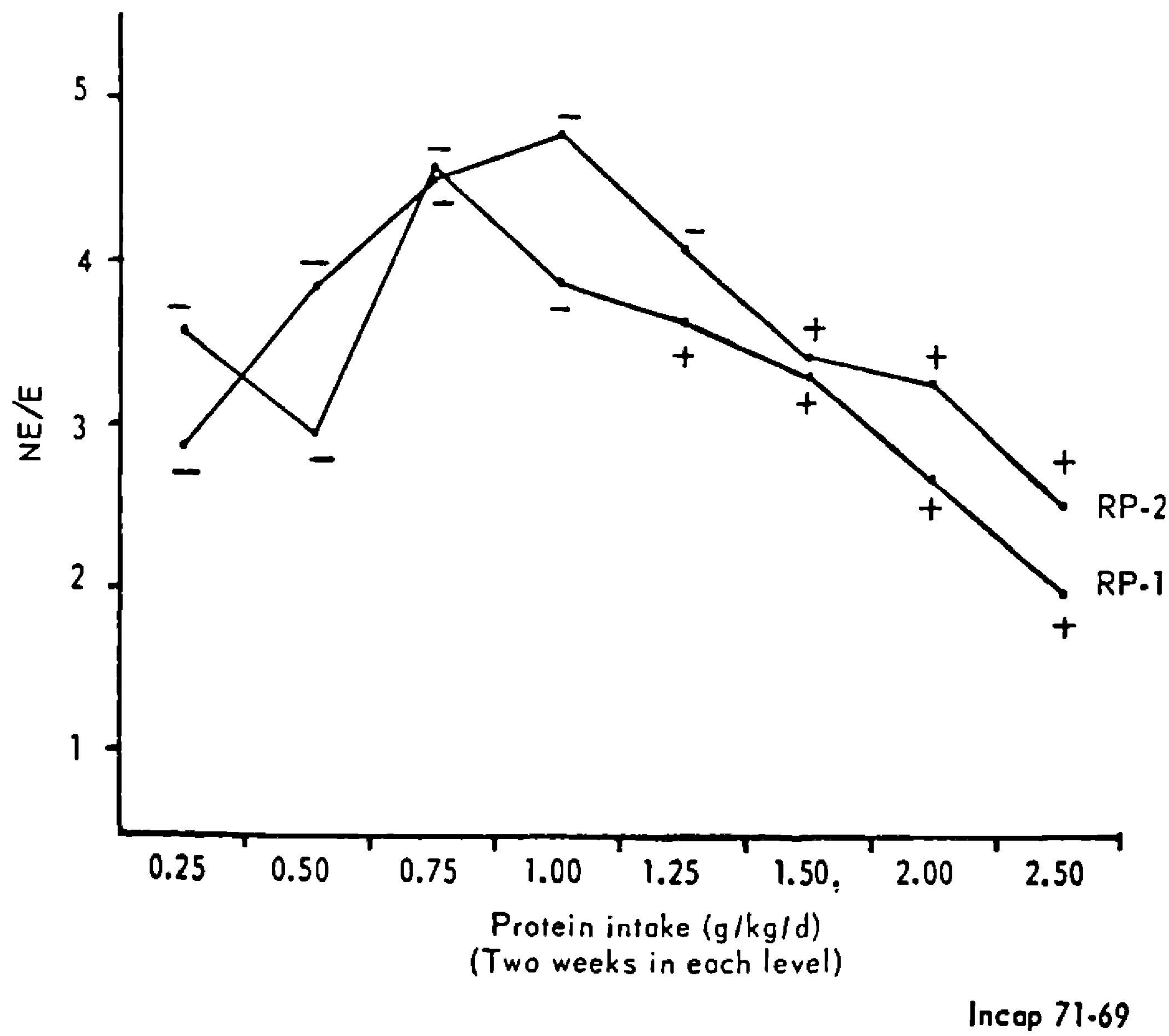

Fig. 2. Effect of level of protein intake on the serum non-essential/essential (NE/E) amino acids and on the nitrogen balance (+positive nitrogen balance, —negative nitrogen balance).

Children 2-3 years of age in an adequate state of nutrition were interned in the metabolic ward. They had normal weight for height and fully developed muscle mass as judged by a creatinine/hight index[5] of over 95%. At the start they were free of any clinical evidence of disease.

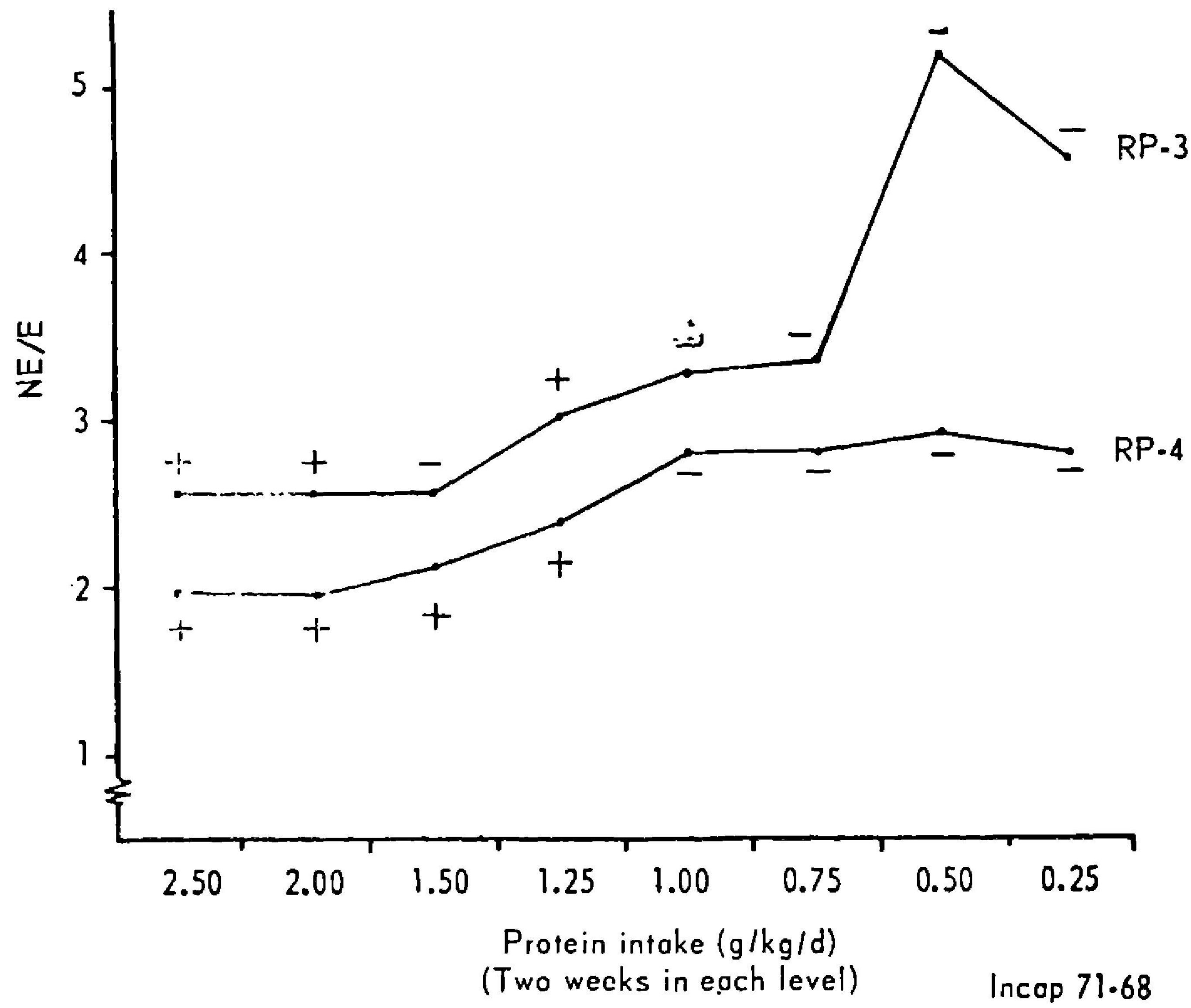

Fig. 3. Effect of level of protein intake on the serum non-essential/essential (NE/E) amino acids and on the nitrogen balance (+positive nitrogen balance, —negative nitrogen balance).

They were fed formula diets supplying variable levels of whole egg protein ranging from 0.25 to 2.5 grams of protein per kg per day, in 8 steps of 15 days duration each. Two typical periods are shown in Figure 1. In the first study., which I am going to report here, 4 children were studied, two in descending and two in ascending manner. Some physical and biochemical measurements were made frequently throughout. I shall submit to your consideration the results of the plasma amino acid ratio and of the nitrogen balance.

These results are given in Figures 2 and 3. At the lower protein intakes, the ratio of non-essential to essential amino acids tends to rise to abnormally high levels. As the protein intake surpasses 1.00 — 1.25 the ratio clearly tends towards normality. Furthermore, 14 out of 16 nitrogen balances done at levels of 1.25 g/kg/d or higher were possitive.

The data indicate responses of clear discriminating power between the low and the high protein levels and suggest that a range of intakes of reference protein around 1.25 g per kilo per day is the *land-mark* on either side of which the children are on an adequate or an inadequate protein intake. Two features are rewarding about these results: (1) They agree well with those previously reported by Waterlow *et al.*[6]; (2) They confirm that the general magnitude of the average protein requirement obtained by the factorial method for this age group is correct although our experimental values seem somewhat higher (see Table 1).

In conclusion, I would like to emphásize the need to test, by direct experiment, the validity of the figures of protein requirements which have been proposed on the basis of the total endogenous nitrogen losses from the body.

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