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MEETING PROTEIN REQUIREMENTS OF YOUNG CHILDREN IN TROPICAL AND SUBTROPICAL AREAS*

by

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It is now fully recognized that protein deficiency, particularly in young children, is one of the most widespread nutritional problems in technically underdeveloped areas (SCRIMSHAW and BEHAR, 1959). Great efforts are being made to correct the deficiency on national as well as international levels, but limited availability of protein-rich foods, particularly of animal origin, is still a major problem. Furthermore, knowledge of the protein requirements of populations, particularly of small children, is still incomplete. Notwithstanding, progress is being made in an endeavour to solve some of the problems of protein malnutrition. The following report discusses some of the ways in which present knowledge is being applied in areas where protein deficiency is prevalent. The discussion is limited to children 0 to 5 years of age, the group most seriously affected by protein malnutrition.

THE NATURE OF PROTEIN REQUIREMENTS

In areas where the supply of proteins is adequate and the consumption ample, the recommended protein intakes for children have been based mainly on the protein content of diets of children who are considered to be adequately nourished. The 1958 recommendations of the Food and Nutrition Board of the United States (NATIONAL RESEARCH COUNCIL, 1958) listed no protein allowances for infants under 6 months. Table I gives the latest N.R.C. figures. The Board stated that "breast feeding is the best and desired procedure for meeting protein requirements in the first months of life." It also affirmed that the allowances may be greater than are necessary, but that even higher protein intakes, frequent in some areas, have not proved harmful.

TABLE I. NRC daily dietary allowances for protein. (Revised 1958).

	Age Years	Protein gm.	Protein gm./kg.
Infants	0/12-6/12	—	—
	7/12-12/12	36	4
Children	1-3	40	3.3
	4-6	50	2.8
	7-9	60	2.2
	10-12	70	2.0

In developing areas, on the other hand, where proteins are more difficult to acquire, the minimal safe amount of proteins that populations should consume, in order to be adequately nourished, should be determined and recommended. This minimal safe amount can be estimated only through knowledge of protein requirements.

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In the case of most nutrients, the requirements can be estimated and expressed in terms of the amount of the nutrient or of its precursor needed. Unfortunately, this is not true for proteins. Proteins are needed to supply the essential amino acids as well as non-essential amino acid nitrogen, but the various proteins differ in their content of these components. Knowledge is now growing rapidly on human requirements of amino acids and helps in the more accurate specification of protein requirements. This answer involves many complicating factors, some of which will be discussed in this paper.

Estimating Protein Requirements

One way of estimating the body protein requirement is to select a reference protein, either a hypothetical ideal protein or a natural protein of high biological value, and assume that the diet is adequate in all other respects, for maximum nitrogen utilization. Using such a reference, the following are three such estimations of protein requirements :

(1) The Princeton Conference (Waterlow and Stephen, 1957), based its recommendations for ages 0 to 12 months on the protein normal infants get from mother's milk. Using milk protein as the reference, the recommendations for 1 to 5 year old children were for progressively decreasing amounts of protein per kg. of body weight as the age of the child increased.

(2) The FAO Expert Committee (1957) estimated the protein requirements of children 0 to 5 years on the basis of all available information, including intake of breast-fed infants, determinations of amino acid requirements and the results of nitrogen balance and growth studies. These requirements were expressed in terms of a theoretical protein which would provide what was considered to be an ideal pattern of essential amino acids.

(3) Hegsted (1957) calculated protein requirements on a theoretical basis, adding up the amount considered necessary for body maintenance and the needs for growth, and allowing for the normal loss of non-absorbed protein. His figures are expressed in terms of a hypothetical protein with a biological value of 100 per cent.

Fig. 1 gives these three estimations with the recommended allowances of the National Research Council for comparison. In all three cases, the estimations are for average minimum requirements. Although following somewhat different approaches, they all arrive at remarkably similar conclusions. This similarity would be even greater if correction had been made for the biological value of milk protein which was used as reference by the Princeton Conference.

Although the conditions on which these estimations are based are purely theoretical, it is feasible to think that these figures can be accepted as the minimum requirements provided the diet is adequate in all other respects. More important, they can serve as a guide to applied nutrition programmes, especially in tropical and subtropical areas. Additional factors, such as infections, modifying these estimated requirements, will be discussed.

Factors Affecting Protein Requirements;

(a) *Dietary Factors.* Among the important dietary factors affecting protein requirements is the amino acid composition of the protein. For optimal utilization, as was previously mentioned, a definite pattern of the essential amino acids is necessary. A deficit of one or more of the essential amino acids will reduce proportionately the utilization of the others, even if they are present in adequate amounts. The biological value of a given protein or of a mixture of proteins, therefore, may be estimated on the basis of the proportions of its limiting amino acids as compared with those of an adequate amino acid

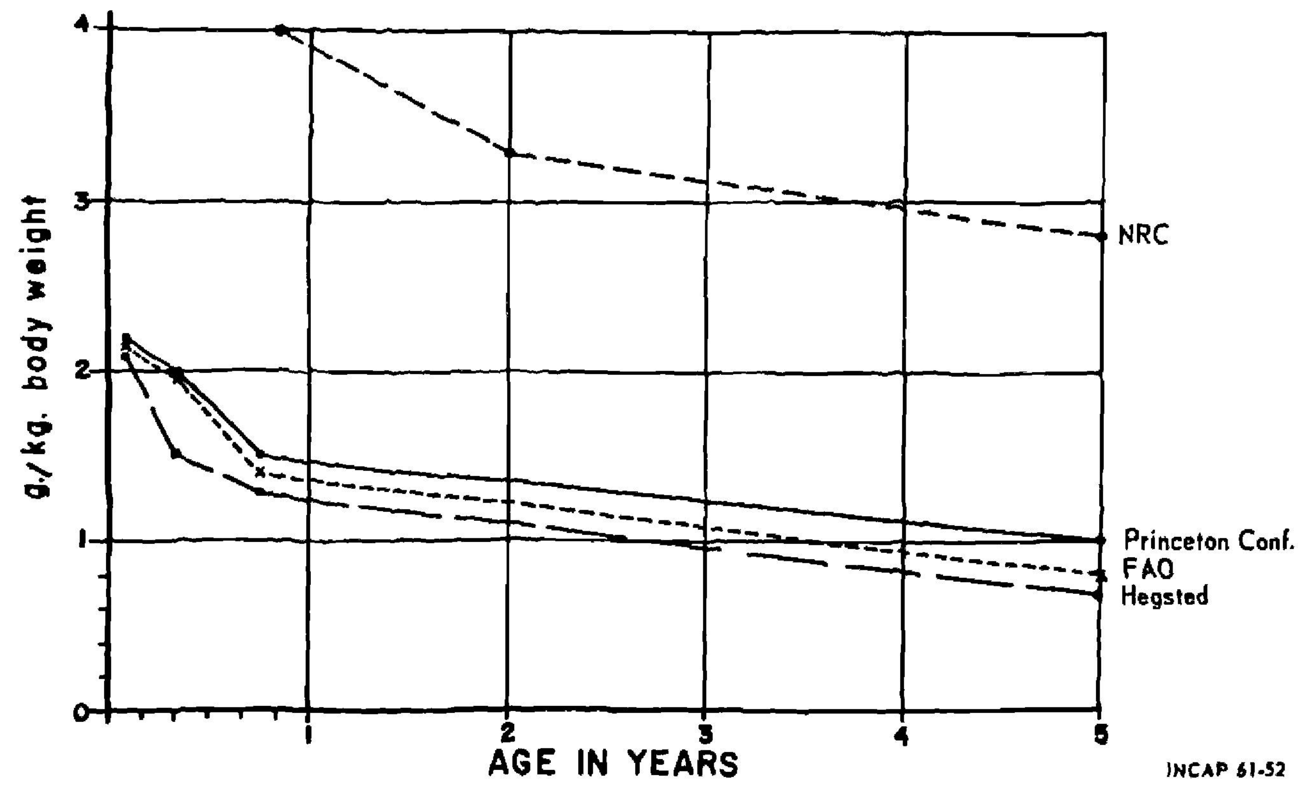

FIG. 1. Daily allowances (NRC) and estimated requirements for protein.

pattern. In comparing proteins with the widely-used FAO pattern, it has been found that the concentration of the first limiting amino acid, expressed as a per cent. of the amount present in the pattern, tends to agree well with the biological value of the protein. This value has been called the protein score (FAO, 1957).

An excess of one or more amino acids can also affect the biological value of a protein and may interfere with the utilization of, or increase the need for, others. All of these possibilities, which have been described as unbalances or antagonism of amino acids, must be considered in evaluating the protein value of foods.

A second important factor is the availability of the amino acids during the digestive process and the rate of their liberation; for, unless all the essential amino acids are available at the same time, they will not be fully utilized. This availability can be affected by methods of food preparation. Lysine, for example, becomes non-available when it combines with sugars or other substances as happens in the "browning reaction." In the case of two or more proteins which are mutually supplementary, maximum utilization of their amino acids can be obtained only if they are given simultaneously. The foregoing are some of the reasons why the chemical protein score may not agree with the actual biological value of a given protein or mixture of proteins.

Other dietary factors, not directly related to the protein itself, may also affect its biological value. One of these is the physical nature of the food. For example, the proteins of a cereal are utilized better when the cereal is finely ground than when it is coarse. Moreover, an excess of crude fibre or a mineral deficiency, the presence of interfering substances such as the antitrypsin substance of raw soya beans and other legume seeds, all interfere with maximum protein utilization. The calorie adequacy of the diet and the type and relative proportion of carbohydrates and fats also affect the biological value of a protein.

(b) *Human Factors.* Individual variability must be taken into account in order to estimate the protein needs of the large majority of a given population, or ideally, of all its members. Sufficient data are not available to calculate the magnitude of this variability, but an increment of protein intake of 25 to 30 per cent. for infants and of 50 per cent. for children has been recommended arbitrarily to cover it (FAO, 1957).

Because of its importance in the tropical and subtropical areas, another human factor that should be emphasized is the influence of infectious processes. In these areas protein deficiency is prevalent and infectious diseases are particularly frequent. Preschool age children receive the poorest diets. They are also most frequently affected by infectious processes because at this age they have not yet developed resistance. Infectious diarrhoea, malaria, respiratory infections and the communicable diseases of childhood, such as measles and whooping cough, are among those commonly observed. Children in such circumstances also usually acquire a variety of intestinal parasites early in life.

It is well known that infectious processes affect protein utilization, so that the following mechanisms may be operating simultaneously: first, a reduction in the intake of protein-rich food due both to anorexia of the sick child and to erroneous therapeutic practices of the mother; and second, increase in nitrogen excretion in the urine results in a reduction of nitrogen retention. Table II shows that even a disease as mild as chickenpox frequently results in a period of negative nitrogen balance; Table III shows the same effect from other common infectious diseases (WILSON et al., 1961).

TABLE II. Effect of chickenpox on nitrogen balance in children aged 3-6 years (fed 2-3 gm. protein/kg., 90 cal./kg.)*.

PC No.	N retention before illness % of intake	retention at max. effect % of intake	Duration of effect weeks
82	+20	−17	4**
91	+18	−10	2
92	+27	+ 7	2
97	+28	− 4	1***
98	—	+ 4	1***
99	(+21)°	+ 7	1***
102	—	−10	—

* These intakes usually not achieved during illness due to vomiting. ** Developed shigellosis. *** Increased immediately after exanthema. ° After illness.

TABLE III. Effect of various treated infectious processes on nitrogen balance in children aged 3-6 years. (fed 2-3 gm. protein/kg., 90 cal./kg.)*.

PC No.	Disease	N retention before illness % of intake	N retention at max. effect % of intake	Duration of effect weeks
82	Shigellosis	+20	+ 5	1
91	Asthmatic bronchitis	+18	− 8	1
99	Bronchitis ? Pneumonia	+21	−24	2
95	Tonsillitis	(25)**	+ 4	2
95	U.R.I. with Sinusitis	(25)**	+ 4	1
98	Staph. aureus abscess	—	− 8	—***

* These intakes usually not achieved during illness due to vomiting. ** After illness. *** Complicated by U.R.I. and additional abscess.

It seems, therefore, that as long as the present poor environmental sanitation in the tropical regions persists, the frequent infectious processes must be considered when estimating protein allowances for these areas. Unfortunately, it is impossible to make any quantitative estimate of how much extra protein is needed. An increment of 20 per cent. of the average minimum requirement is probably conservative.

Finally, among the human factors, retardation of growth must be considered because recommendations for protein allowances are usually expressed on a weight basis. Allowances ought to be calculated on the basis of "ideal weight" and not on actual weight. If the retardation is too great, however, the child cannot eat this much food; in this case as much protein as he can eat should be given and the intake should be increased until such time as the amount needed, on a basis of ideal weight, is reached. If the retardation has been too great, this point may never be attained.

Estimation of Recommended Allowances

The preceding considerations should be applied in estimating recommended protein allowances for small children in the tropical and subtropical areas. It then becomes possible to evaluate means of satisfying these allowances under present conditions. Guatemala will serve as a workable example because of the extensive data obtained by the Institute of Nutrition of Central America and Panama (INCAP).

Recent dietary surveys in Guatemala (Flores—unpublished data) have measured the intake of small children in three rural villages where protein malnutrition is prevalent, as evidenced by growth retardation, high mortality and morbidity rates and the frequent occurrence of kwashiorkor (Table IV). Because these children are markedly retarded in growth, their intake has also been calculated in terms of gm./kg. of ideal weight as indicated in the last column. After making this correction, the amounts are relatively high and should be enough to cover requirements according to the previous discussion if the biological value of the protein is not considered.

Table IV. Protein intake of pre-school children in three Guatemalan rural villages.

Year-age group	No.	Protein Intake	
		gm./kg. actual wt. $\bar{x}$	gm./kg. ideal wt. $\bar{x}$
2	9	2.0	1.4
3	27	2.3	1.6
4	23	2.4	1.6
2-4	59	2.3	1.6

It was found in these surveys, however, that only 15 per cent. of the protein consumed was of animal origin and that corn and beans were the major sources of proteins. The amino acid composition of these diets has been calculated and on this basis the protein score, using the FAO reference pattern, was found to be on an average only 55 per cent. Tryptophan was the first limiting amino acid.

The average intake of 2.3 gm. of protein per kg. of actual body weight becomes only 0.9 gm./kg. of ideal weight when necessary corrections for the biological value and weight retardation are made. This figure is below the minimal average requirement that was discussed and explains the prevalence of protein malnutrition when the quality of the protein is also taken into consideration. As discussed previously, other factors lower this value still further.

Preventing Protein Malnutrition

For children two years of age, the minimal average requirement discussed previously, plus the amount estimated to cover individual variability and additional 20 per cent. to cover the stress of frequent infections, results in a daily recommended intake of about 2 gm./kg. body weight, if the protein had a biological value of 100 per cent. This amount should be increased to 3.7 gm./kg., if a diet is of the quality consumed in Guatemalan villages. Due to the low protein concentration in such diets, however, the large quantity of food necessary to provide this amount of protein cannot be consumed by children of this age.

In the case of a diet of corn and beans, the optimal combination is one in which 50 per cent. of the proteins are provided by corn and 50 per cent. by the beans (Bressani and Scrimshaw, 1961). Even if such a combination were used, the biological value of its proteins, calculated on the basis of its protein score, would still be only 68 per cent. On this diet, a child of two years would have to consume 250 gm. of corn and 90 gm. of beans daily. If these foods are prepared in the usual way, the child would have to eat 300 gm. of cooked beans and 500 gm. of *tortillas* per day. No child of this age could consume such large quantities.

It is evident, therefore, that trying to increase the intake of the foods now consumed in these areas will not solve the problem. Increased consumption of beans will help a little, but the primary requirement is the introduction of protein-rich foods of higher biological value or an adequate supplementation to foods now being consumed. The latter may be achieved with proteins, not in themselves of high biological value, but which, when combined with those in the regular diet, will increase significantly its total biological value.

Greatly increased consumption of conventional foods of animal origin is, at present, not practical in most tropical and subtropical areas because of problems involving production, transportation, preservation, cost, food habits and other cultural factors. Among the alternatives are maximum use of protein concentrates, such as fish flour, skim milk or yeasts, to enrich the staple food and the development of vegetable mixtures of relatively high protein content and quality, using local resources, such as cereal grains, supplemented with oil seed cakes, nuts, palm kernels or leaf proteins (Scrimshaw and Bressani, 1961). Such mixtures should be adapted to local food habits and produced at a cost within the purchasing power of the populations for which they are designed.

In Central America, efforts in this latter direction have resulted in the development of vegetable mixtures based on corn, sorghum or rice, supplemented with cottonseed flour and a small amount of yeast. These products are now in commercial production under the generic name of Incaparina and have in general been well accepted. These vegetable mixtures have been developed by INCAP specifically to meet the socio-economic situation outlined above. After more than eight years of research, laboratory, clinical and field trials, have clearly shown that its protein value closely approaches that of milk (Scrimshaw and Bressani, 1961).

"Incaparina" can be easily prepared in the home as an *atole* (a hot beverage to which the people of Guatemala are accustomed and enjoy). The cooking of the mixture in the home is in keeping with the cultural pattern of the ultimate consumers and assures the purity of the water which is added to the product. "Incaparina" has also been found to be well suited for incorporation into other foods such as soups, baked dishes, etc. Sufficiently flexible, the formula is being modified by producers in other countries to conform to local dietary patterns.

While direct nutritional measures will contribute significantly toward solving the problem of protein malnutrition in tropical and subtropical areas, they must be combined with improvements in sanitation, education and general living standards.

Summary

The available data on protein requirements for small children are discussed in the light of existing conditions found in tropical and sub-tropical areas. Principally mentioned are: the Josiah Macy, Jr., Conference recommendations, the most recent FAO Expert Committee estimation, and Hegsted's theoretical calculations. It is emphasized that it becomes impossible, in these areas, to satisfy the protein requirements for small children after the weaning period, if there is no adequate supplementation to the foods now being consumed. Requirements are not fulfilled because of the low biological value and low concentration of proteins found in the staple foods native to these areas. Reduction on food intake, the poor utilization of food and increased requirements due to frequent infections, also are important contributing factors. Because a greater consumption of foods of animal origin is not feasible at present, it is suggested that protein concentrates such as fish flour, skim milk or yeast be used to a maximum in order to enrich the staple foods. Vegetable mixtures of high protein content and quality can also be used when adapted to the local economic and cultural conditions of an area.

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