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NUTRITIONAL DEFICIENCIES

Josefina Bulatao-Jayme*

Nutritional deficiency is a condition where the amounts of essential nutrients which are provided to the body cells are insufficient for their metabolic functions.

BASIC CAUSES OF NUTRITIONAL DEFICIENCY

Basically the amount of a nutrient presented to the body cell becomes inadequate because of one or more of the following conditions:

1. Inadequacy in ingestion
2. Inadequacy in absorption
3. Inadequacy in utilization
4. Increase in excretion
5. Increase in requirement

The above factors are related to the minimum daily requirement (MDR) of the body for each nutrient. The MDR for a nutrient is the floor level of average daily intake below which health cannot be maintained under definite conditions of age, sex, body size, activity and other physiologic attributes. These requirements normally differ from individual to individual; in order to be able to assure the provision of health for most people (97%), these requirements are expressed with varying additional margins of safety and are then called Recommended Daily Allowances (RDA). This is true for all nutrients, except that for calories the MDR and the RDA are the same.

CLASSIFICATION OF NUTRITIONAL DEFICIENCIES

Nutritional deficiencies may be either primary (dietary) or secondary (conditioned), depending on their origin. Primary deficiency originates from a defective diet – either inadequate in quantity or quality, or providing an imbalance of nutrients. Secondary deficiency is caused by some disease or condition in the body that affects ingestion, absorption, utilization, excretion or requirement of nutrients.

Nutritional deficiencies are further classified as to intensity (mild, moderate, severe), velocity (acute, chronic) and duration (early, late). Mild, acute and early lesions are more easily reversed by treatment than severe, chronic and late ones.

NUTRIENT RESERVES

The presence of nutrient reserves in the body tends to stabilize the supply of the nutrient in the tissues to relatively constant level. The reserves serve as a buffer against temporary inadequacies in the diet by supplying the

*Assistant Director, Food and Nutrition Research Institute, NSDB.

tissues with the nutrient in short supply thus preventing tissue desaturation. Up to a certain level, they also absorb excesses of supply over body needs by storing these in a metabolic pool. Further excesses are excreted except for some nutrients like vitamin A which are accumulated in the body to toxic levels. When reserves are completely emptied by a severe or continuous depletion of supply, the tissues have to be maintained by a day-to-day supply from the diet, otherwise nutritional deficiency disease develops.

The availability of tissue reserves varies from nutrient to nutrient. Thus the estimated duration of tissue reserves on a continuous depletion diet varies considerably, as may be seen in Table 1 which is based on the daily expenditure of a person weighing 70 kg.

Table 1. Estimated Duration of Nutrient Reserves in a 70 Kg.-Weight Person

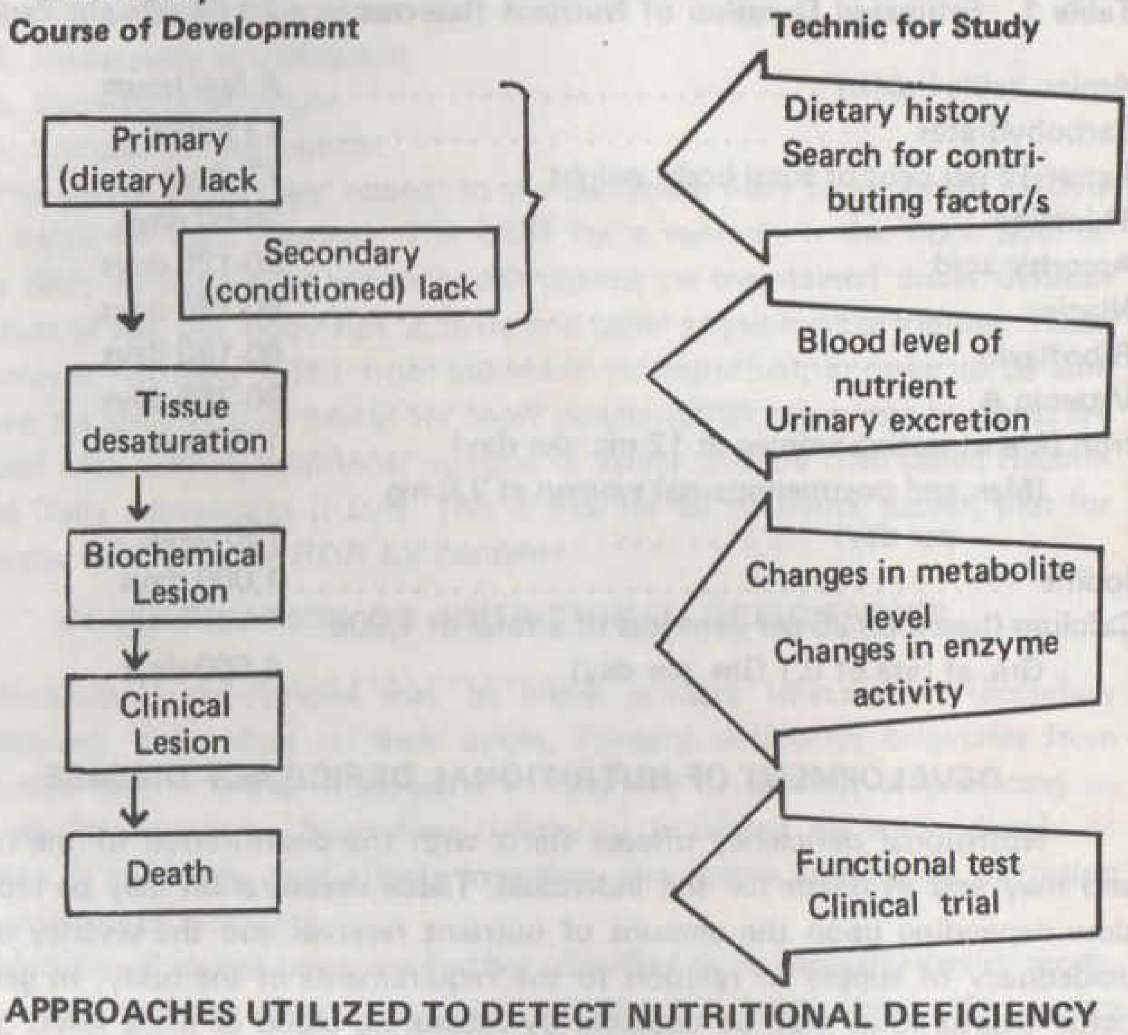
Amino acids (labile)	A few hours
Carbohydrates	13 hours
Fat at 12 per cent of total body weight	27 days
Thiamine	30-60 days
Ascorbic acid	60-120 days
Niacin	60-180 days
Riboflavin	60-180 days
Vitamin A	90-365 days
Iron (Menstruating woman at 12 mg. per day)	125 days
(Man and postmenopausal woman at 2.0 mg. per day)	750 days
Iodine	1,000 days
Calcium (based on 25 per cent loss of a total of 1,000 Gm. at rate of 0.1 Gm. per day)	2,500 days

DEVELOPMENT OF NUTRITIONAL DEFICIENCY DISEASE

Nutritional deficiency disease starts with the desaturation of the tissues and may end in death for the individual. Tissue desaturation may be rapid or slow depending upon the amount of nutrient reserves and the severity of the inadequacy of supply in relation to the requirements of the body. In general, tissue desaturation may be detected by measuring blood or urine levels of the nutrients. When a load test is made in connection with these analyses, measurement of the urinary excretion after a defined period of time will show a lower level of nutrient in a deficient person because priority in the body is given to refilling the empty tissue reserves before eliminating the excess dose through excretory points.

Further progress of the nutritional deficiency leads to biochemical lesions which can be detected in terms of a change from the normal enzyme activity or as changes in the level of the metabolites. If continued, functional changes follow sooner or later. For example, in vitamin A deficiency, decreasing levels of serum vitamin A are detected for several months followed by defective night vision called night blindness. The severity of night blindness can be measured by the dark adaptation test. If depletion continues, anatomical lesions then follow which at first can only be detected microscopically but later become gross in size. Death can occur suddenly in some nutritional deficiency diseases as when the heart is affected by the wet type of beriberi or, more often, death takes a longer time to occur (as is the case in protein-energy malnutrition, or was the case of the sailors at sea before the cause of scurvy was discovered). The development of nutrition deficiency disease is shown graphically in Figure 1.

Figure 1. The Stages of Nutritional Deficiency Disease and the Technics for Their Study



APPROACHES UTILIZED TO DETECT NUTRITIONAL DEFICIENCY DISEASE

No single approach can give definitive information regarding the presence of a nutritional deficiency disease. Dietary intake and clinical examinations are less sensitive than biochemical tests, but the latter can often be deceptive in that they may be only reflective of recent intake and not of nutritional state. A correlation of these three types of approaches is the most ideal. As a rule, the usefulness of these techniques are far better when used on a group basis rather than when applied to an individual.

DIETARY EVALUATION

A study of the dietary pattern of an individual or a group of individuals enables one to suspect the type and extent of nutritional deficiency present and to suggest specific steps to be taken for improvement of the diet.

The following are the more common techniques of dietary evaluation:

1. Food recall usually done on a one-day to five-days' intake.
2. Diary listing of everything eaten usually in a week's time.
3. Food inventory usually of a week's family food supplies.
4. Food weighing of either the raw or the cooked food to be eaten.
5. Chemical analysis of duplicate samples of the food eaten.

In this country, regional and nationwide surveys are carried out using the food weighing and the food recall methods. The calculations are based on the proximate, vitamin and mineral values of foods as found in the Food Composition Table Recommended for Use in the Philippines published by the Food and Nutrition Research Institute, NSDB.

BIOCHEMICAL ASSESSMENT

The biochemical evaluation of an individual or a group of individuals is the most precise and objective method of assessment of nutritional status. Usually, but not at all times, it is most useful in cases of suboptimal state or latent nutritional deficiency disease where clinical signs and symptoms have not yet become evident. The biochemical basis for the tests vary from nutrient to nutrient and this must be well understood before a valid judgment of nutritional state can be made. Biochemical tests may be used to evaluate any of the following:

1. Dietary intake: Certain tests do not measure nutritional status *per se* but only reflect levels of intake of the nutrient. Some tests do this for *usual* intake as in the case of urea-nitrogen/creatinine-nitrogen excretion ratio which gives some indication of the adequacy of the usual levels of dietary protein in relation to muscle protein. Other tests may be so strongly influenced by an immediate *recent* intake that the value obtained may lose its meaning in so far as nutritional status of the individual subject is concerned. However, on a group basis, as in population surveys, one can still make meaningful conclusions from their results. Examples of this type of test are those for serum carotene and serum vitamin C.

2. Depletion of body stores: Plasma or serum vitamin A value is an example of a good indicator of nutritional status (for this nutrient), but because of its long-term storage, it does not necessarily reflect any short-term decline in dietary intake to dangerous levels. The liver level is an even better indicator of vitamin A nutritional state, but this test requires more difficult technics. In the case of vitamin C, white cell-

blood platelet ascorbic acid concentration is more closely related to tissue levels than serum vitamin C. The state of depletion of body stores in the case of thiamine, riboflavin and niacin can most conveniently be measured through urinary excretion, especially if done in a timed load test. The results are usually expressed in terms of urinary creatinine excretion. Although low total serum protein and serum albumin reflect low protein nutritional state, these tests have not much practical diagnostic value as both levels become depressed only after clinical signs have already become very evident.

3. Metabolic changes: Changes may be found in enzyme activity, as in the case of red blood cell transketolase activity, which is depressed in thiamine deficiency. Incidentally, this test is more accurate than the measurement of the thiamine urinary level. Other changes may be found by testing the levels of metabolites as in the case of the serum amino acid ratio dispensable amino acids / indispensable amino acids which is high in protein deficiency. The dispensable amino acids measured are glycine + serine + glutamine + taurine; the indispensable ones are leucine + isoleucine + valine + methionine.

BIOCHEMICAL TESTS ADAPTABLE FOR SURVEY USE

Biochemical surveys for the purpose of nutritional assessment of population groups vary in coverage depending on available resources. The single most indispensable test that should be made is the determination of hemoglobin level. Table II shows the list of biochemical tests that may be made, classified into two categories: the first category are those which have been found to be most useful and simple to undertake, while the second category are the more complicated tests that may provide additional specific and more accurate information.

Table 2. Biochemical Tests Adaptable for Survey Use

Nutritional Deficiency	First Category	Second Category
(1) Protein	Amino acid imbalance test	Serum protein fractions by electrophoresis
	Hydroxyproline excretion test (F)	
	Serum albumin	
	Urinary urea (F) *	
	Urinary creatinine per unit of time (T)	
(2) Vitamin A	Serum vitamin A	
	Serum carotene	
(3) Vitamin D	Serum alkaline phosphatase	Serum inorganic phosphorus

		(in young children)	
(4)	Ascorbic Acid	Serum ascorbic acid	White blood cell ascorbic acid Urinary ascorbic acid Load test
(5)	Thiamine	Urinary thiamine (F) *	Load test Blood pyruvate Blood lactate Red blood cell haemolysate transketolase
(6)	Riboflavin	Urinary riboflavin (F) *	Red blood cell riboflavin Load test
(7)	Niacin	Urinary N-methylnicotinamid (F) *	Load test Urinary pyridone (n-methyl-2-pyridone-5-carbonamide)
(8)	Iron	Haemoglobin Haematocrit Thin blood film	Serum iron Percentage saturation of transferrin
(9)	Folic acid	Haemoglobin	Serum folate (*L. casei*)
	Vitamin B_{12}	Thin blood film	Serum B_{12} (*E. gracilis*)
(10)	Iodine		Urinary iodine (F) Tests for thyroid function

* Expressed per gram of creatinine.

(F) In a single urine specimen, preferably fasting.

(T) In timed urine specimens.

It should be kept in mind that biochemical levels vary normally not only between individuals but also in the same individual during the day, the month or the season. For instance, independent of supply, the body undergoes circadian rhythm in ascorbic acid with a peak of the serum levels in the early hours of the morning. These normal variations should also be taken into consideration particularly in the timing of the collection of samples.

CLINICAL ASSESSMENT

This includes the physical examination and the anthropometric measurements of the subjects. They may also include biophysical tests such as x-rays of the bones, dark adaptation tests for the eyes, or measurements of physical performance which are useful but often difficult or impossible to undertake on a survey basis. In the interpretation of clinical signs of malnutrition, a point to remember is that one rarely sees a pure ease of a single deficiency if a diet is deficient in one nutrient, it is most likely to be also deficient to a lesser or greater extent in other nutrients. This fact complicates the appearance of clinical signs of deficiency. Pathognomonic signs of any deficiency are extremely rare; those generally seen can only be labelled as suggestive of a deficiency.

When a growing subject is chronically malnourished, his growth is stunted and his stature is thus lower than normal. Height therefore is a good reflection of the whole past nutritional history of an individual. On the other hand, weight can reflect a more recent nutritional event. For instance, a recent illness with lack of appetite and a restricted diet, may result in a marked loss of weight.

Protein-energy malnutrition is the most common nutritional deficiency disease in the Philippines. It is the basic cause of high mortality among young children in the country. It is also a disease where clinical signs and symptoms are far more useful for early diagnosis than biochemical tests. Two conditions characterize the two ends of the protein-energy spectrum. Marasmus is evidenced by extreme loss of subcutaneous fat. The facies is that of a wizened old man; edema is absent. On the other hand, kwashiorkor which is found at the protein-deficiency end of the scale, is characterized by edema (including "moon-face"), preservation of subcutaneous fat and marked psychomotor change. In both conditions there is marked muscle wasting and growth failure. In the severe form, kwashiorkor cases show some biochemical lesions, but in marasmus deviations from the normal are minimal; this suggests good adaptation to the deficiency stress.

CONCLUSION

Due to the wide ranges of findings among normal individuals, nutritional biochemists in general are not as yet quite satisfied with the usefulness of many of the laboratory tests for nutritional status as presently known. A great deal of research is still needed to improve the diagnostic precision of these tests for nutritional deficiencies.

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