

NUTRITIONAL NEED VERSUS OPTIMAL INTAKE

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ABSTRACT

The lack of biochemical basis for "nutritional need" is discussed. The current use of "nutritional need" as the basis in nutritional recommendations suggests that the general approach of such recommendations should be re-evaluated. "Optimal intake" -approach is suggested as an alternative.

INTRODUCTION

There has been much disagreement about the use of nutrients in preventive and clinical medicine. The controversy about the effect of vitamin C on the common cold is a good example. Conflicting results are clearly one reason for many controversies, but in this article it is proposed that another important reason for controversies is the use of the obscure concept "nutritional need." Much of the discussion as well as the official recommendations on nutrition are based on this concept. In this article the lack of biochemical basis for the "need" is discussed and an optimum approach is proposed as an alternative to the traditional approach towards nutrition.

Recommendations for nutrient intake have a great deal of influence since they are used in evaluating the nutritional status of people. Also many practical measures or the lack of them are based on such recommendations. It is important to understand the basis for such recommendations, since only then is it possible to judge their restrictions. Probably the most influential recommendations are the Recommended Dietary Allowances (RDA) that are used in the USA. In this article RDA is used as an example of the traditional approach towards nutrition.

THE GENERAL APPROACH USED IN RDA

The recommendations are defined as follows (ref. 8, p.1):

"Recommended Dietary Allowances (RDA) are the levels of intake of essential nutrients considered ... to be adequate to meet the known nutritional needs of practically all healthy people."

The concept "nutritional need" has the implication that there is a precise amount which is required in order to prevent a deficiency disease. Also the word "need" has the implication that the amount of nutrient intake is of no significance when it is larger than the "need", except in cases of toxicity. However, the rates of chemical reactions are smoothly dependent on concentrations and thus the concept of "need" does not seem to have any reasonable interpretation at the biochemical level.

Many nutrients function as cofactors of enzymes. These enzymes are catalytically active only when they have bound a cofactor (Fig. 1).

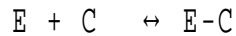


Fig. 1: When inactive form of an enzyme (E) binds a cofactor (C), active form of the enzyme (E-C) is formed. Proportion of the active form depends on the amount of cofactor.

The proportion of enzyme molecules which are in the active form depends on the concentration of the cofactor, as the principle of chemical equilibrium states. The more cofactor there is the more the enzyme is in the active form. In addition, the total concentration of the enzyme (i.e. active plus inactive) sometimes depends on the cofactor. The effect of the amount of nutrient on the degree of saturation and the total amount of an enzyme may be seen from a study by Ellis et al. (3). Three patients were treated with pyridoxine (100 mg/day) for 11 weeks. The proportion of the active form of glutamic oxaloacetic transaminase of erythrocytes increased from $71 \pm 8 \%$ to about 100% and the total concentration of the enzyme increased by $109 \pm 76 \%$ as calculated from their data. Accordingly, the amount of nutrient may determine the activity of an enzyme by changing both the degree of saturation and the total concentration of an enzyme. In these kinds of cases it is clearly arbitrary to call an amount of nutrient "need."

Some of the reactions of nutrients are non-enzymatic, such as the reaction of ascorbate with histamine (2). The rates of enzymatic reactions are always limited by the total amount of enzyme. On the other hand non-enzymatic reactions are not limited, instead the rates of reactions increase either linearly or non-linearly. In these kinds of cases there is even less basis for "need" as there is no upper limit for reaction rates. However, the lack of interpretation of "need" at the biochemical level and the smoothness of the concentration dependency of reactions are not discussed in the recommendations (8).

RDA FOR VITAMIN C AS AN EXAMPLE

It is useful to become familiar with the arguments by which the RDA for vitamin C has been chosen. The purpose of the recommendations is to guarantee adequate reserves against scurvy. Clinical symptoms of scurvy appear when the body pool falls below 300 mg. However, psychological changes can be observed when the body pool has been depleted to 600 mg. 1500 mg is considered to be an acceptable reserve against scurvy, as a pool of that size protects the body against scurvy for about one month. 60 mg/day has been chosen for the RDA

because it maintains the body pool at about 1500 mg (8, p.72-82).

There are, however, no medical experiments described in the recommendations, which would suggest that 60 mg/day is the optimal dose. Nor is this the intention of RDA. The aim is only to protect the body from scurvy. Also the RDA is not intended to saturate the reserves (8, p.75): "... efforts to attain such pool sizes (2500 mg by 200 mg/day) are unnecessary in view of the decreased efficiency of absorption and increased rate of excretion of unmetabolized ascorbic acid at these higher levels."

This reasoning clearly demonstrates the lack of a biochemical approach. The physiological function of vitamin C is not to be in "reserves against scurvy", but to participate in the chemical reactions of the body. The rates of these reactions depend on the concentration of vitamin C and therefore the magnitude of the "body pool" and the daily intake are very important. Scurvy is only a systemic expression of the exceedingly slow reaction rates of vitamin C -dependent reactions.

The recommendations claim that (8, p.78): "... ascorbic acid in large doses may have some pharmacological or drug-like effects that are not related to the normal functioning of the vitamin."

However, the reactions are the same at all concentrations of vitamin C. It is only the reaction rates which are dependent on concentrations. Of course, the concentration dependency varies with different reactions (e.g. enzymatic vs. non-enzymatic as noted above). Thus some reactions proceed much faster at higher concentrations while some have only a small dependency on concentration. Thus the crude division between pharmacological and normal amounts is clearly arbitrary and misleading.

From this example it can be seen that RDA does not represent optimal amounts. Thus RDA should not be used as a basis for the argument that higher intakes do not have beneficial effects.

AN ALTERNATIVE: AIMING AT OPTIMAL INTAKE

The purpose of RDA is to protect against deficiency diseases, however, the goal could be to aim at optimal amounts of nutrients, and RDA is not concerned with this. The usefulness of the concept optimum may be seen in Yew's experiment (9), in which guinea pigs were given different amounts of vitamin C. The growth rate depended on vitamin C as shown in Fig. 2. The recovery time from anesthesia was also studied. Recovery was a little faster with 500 mg/kg (bodyweight) per day than with 50 mg/kg/day. Both 0.5 and 5 mg/kg/day were clearly suboptimal by this criterion. From the experiment it may be concluded that the optimal intake was about 50 mg/kg/day under experimental conditions. Large individual differences between guinea pigs may also be seen in the experiment. The individual optima may be quite different for different guinea pigs.

Similarly with humans, functions are influenced by the amount of nutrient. Sometimes, as with vitamin C, even the order of magnitude of the optimum is unknown. While 10 mg/day is sufficient to prevent

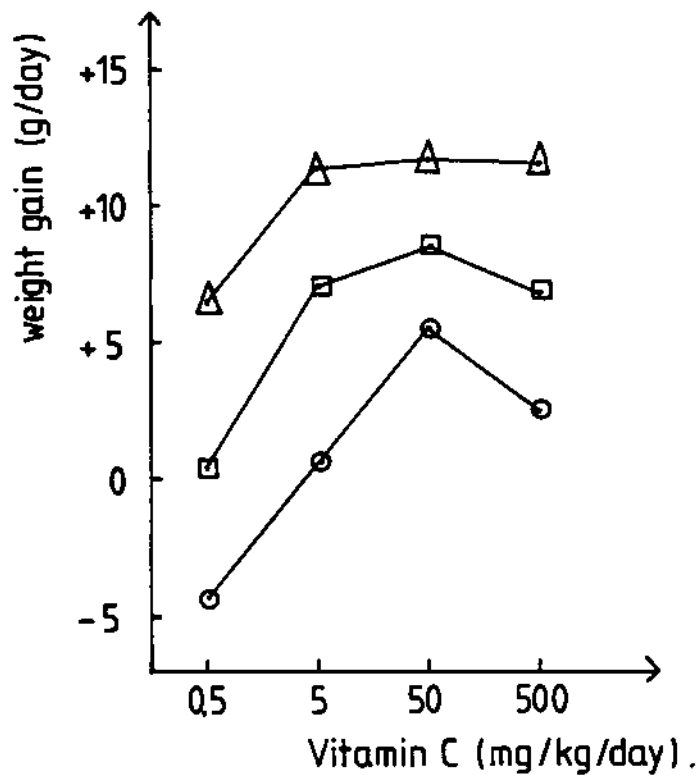


Fig. 2: The dependency of the weight gain on daily vitamin C amount in guinea pigs. □ : average weight gain for the group (10 animals per group), ○ : weight gain for the slowest growing animal in the group and △ : weight gain for the fastest growing animal in the group. Drawn from table 1 in reference 9.

scurvy, many grams per day have sometimes been recommended for maintaining good health and treating diseases (1, 5, 7). Scorbatic symptoms appear when the plasma ascorbate level is less than 0.2 mg/dl (8, p.73), With 60 mg/day the plasma ascorbate is about 0.7 mg/dl (8, p.73) and with 3 grams per day it increases to about 3 mg/dl (4). Thus the reactions of vitamin C may proceed at very different rates depending on the amount ingested per day.

The optimum concept is in agreement with the biochemical viewpoint. If the amount of nutrient is too small, some reactions are too slow, and this is expressed as a deficiency disease on the systemic level. Over-large amounts have the result that some reactions are too fast, which is expressed as slight or severe toxicity. In the biochemical level the change from deficiency to toxicity corresponds to a smooth increase in concentrations. Optimal intakes correspond to optimal concentrations, with which the body functions best.

Optimal amounts of nutrients cannot, however, be determined from the biochemical level, at least not yet. Instead the results from epidemiological, clinical, and intervention studies can be used to estimate approximate optimal amounts. There are obviously large individual difference between humans and therefore it is clear that the optimum varies. Yet such an optimum should be aimed at. Individual differences prevent us from over-generalizing and encourage experimentation on the individual level. We should not ask whether 45 or 60 mg per day of vitamin C is adequate, but whether 10, 100, 1000 or 10 000 mg per day is the best approximation of the optimum.

The optimum approach was first formulated by Pauling, who suggested it for treating mental illness (6):

"Orthomolecular psychiatric therapy is the treatment of mental disease by provision of the optimum molecular environment for the mind, especially the optimum concentrations of substances normally present in the body."

CONCLUSION

The traditional approach to nutrition aims at preventing deficiency diseases and therefore the recommended allowances are not optimal. Acceptance of the "optimal intake" -approach would have a great effect on the nutrition of healthy and sick people as there is no reason to suppose that everyday food is optimal. Thus the "optimal intake" -approach leads to the need for greater investigation into the subject of vitamin and mineral supplementation.

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