

Ascorbic Acid Requirements of Adults: 30 mg or 75 mg?

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IN WESTERN Europe and North America it is possible to appraise an ordinary mixed diet if we know only the daily allowances of calories, protein, vitamins A and D, thiamine, riboflavin, niacin, ascorbic acid, as well as calcium, phosphorus, and iron, and it is for these nutrients that we need standards of requirement.

We have three main types of standards for daily requirements of nutrients:

(1). *Minimum requirement* indicating the quantity of a nutrient the daily allowance of which is sufficient to prevent the appearance of symptoms of disease.

(2). *Optimum requirement* indicating the quantity of a nutrient the daily allowance of which ensures for the individual the best possible state of health, functional efficiency, and resistance, e.g., to infections.

(3). *U. S. Recommended Dietary Allowances* do not quite correspond to the optimum requirements mentioned under point 2, but are stated to have been calculated so amply that they will under all circumstances cover the requirements of all healthy individuals, as well as cases where these are especially great, for instance, during temporary stress.

We know the *minimum requirements* best. Our first recognition of the importance of the qualitative and quantitative composition of the food is, indeed, due to the practical experience which shows that the lack of certain types of nutrient in the diet will cause diseases, and that allowance of the food and nutrient in question will make the disease disappear.

In Western Europe and North America, however, the minimum requirements have mainly

theoretic interest. What we wish to know and compare with our dietary surveys are optimum requirements.

The reason why I have chosen to discuss optimum requirements of adults for ascorbic acid is that considerable disagreement exists about this very requirement. The fact is that whereas there is agreement on recommending a daily allowance of 30 mg ascorbic acid for infants, *The British Medical Research Council*¹ and a number of scientists in Northern Europe are of the opinion that about the same quantity is also the optimum requirement of healthy adults (apart from pregnant and nursing women), while *National Research Council* (of the U. S. A.)² recommends a daily allowance of 75 mg ascorbic acid for healthy adults.

The National Research Council has based and maintained the recommended dietary allowance of ascorbic acid at 75 mg for adults with reference to the comprehensive literature, which shows:

(1) There is evidence that minimum requirement may not be satisfactory for the preservation of optimum health through long periods of time, or when the body is subjected to common forms of stress.

(2) Reference is made to analyses of the contents of ascorbic acid in mother's milk, where the diet of the mother is "good."

(3) Tests with humans and animals of the quantity of ascorbic acid that will produce satisfactory healing of wounds, enzyme action, and cell proliferation.

(4) The variation of concentrations of ascorbic acid in various organs at different allowances of ascorbic acid.

(5) The recommended dietary allowances are about three to seven times greater than the quantities that will protect children and adults

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against macroscopic manifestations of scurvy, *i.e.*, minimum requirement.

(6) It is pointed out that the recommended dietary allowance of ascorbic acid is not "saturation" value since greater intake will produce higher concentrations in the tissues.

Another view is presented by the *British Medical Research Council's* investigations in 1944-46, which form the basis of the insistence of the British on the requirement of the *League of Nations*,³ namely, an allowance of 30 mg vitamin C a day for adults. The tests were conducted on 18 young men and one young woman with application of a thorough and varied research technic, *i.e.*, analyses of the ascorbic acid content of plasma, leucocytes, and urine, investigation of healing of wounds, and observations of physical and mental efficiency.

The results may be summarized as follows:

(1) In order to attain a uniform nutritional state for all 19 subjects, they were given a test diet without supplements for six weeks. The test diet was ample in respect to calories and content of other nutrients, but contained only 1 mg ascorbic acid. After the six-week test period the subjects were divided into the following groups: (a) Ten persons continued on the test diet without supplements. After 26 weeks six of these ten developed hemorrhages of the skin and mucosa; moreover, after 35 weeks nine of the ten had pronounced changes in the gums, and artificially inflicted wounds showed slower and poorer healing.

(2) After six weeks on the basic diet, seven subjects received a daily allowance of 10 mg ascorbic acid. Examination showed no abnormal changes in any of them within a period of 160 days. The latter group was then divided into two subgroups, (a) Three of the seven subjects continued with a supplement of 10 mg ascorbic acid for another 92 and 264 days. All the methods of examination used showed continued normal conditions. (b) Three of the seven subjects received no supplement any more after the 160 days. After 71 days (10 weeks) light skin changes (keratoses) appeared, which disappeared when a daily allowance of 10 mg was again given.

(3) After the six-week period, three persons

received a daily supplement of 70 mg ascorbic acid. Examination disclosed nothing abnormal in these subjects.

From these investigations the British Medical Research Council draws the following conclusions:

(1) 10 mg ascorbic acid a day for healthy adult persons on a diet containing no ascorbic acid but being otherwise optimal will cure scurvy and prevent the appearance of symptoms of scurvy over a period of observation of 12 months.

(2) The minimum requirement for vitamin C in adults must consequently be somewhat below 10 mg a day, and some test results seem to indicate that it is about 5 mg a day.

(3) With a daily allowance of 30 mg ascorbic acid it must consequently be assumed that we are on the safe side, and the optimum requirement is covered.

(4) Thus the daily allowance of 75 mg ascorbic acid recommended by the Americans for adults (not including pregnant and nursing women) should be too high.

The foregoing is a summary account of the opinions on the requirements for ascorbic acid.

The most important of the investigations that may form the basis for a determination of the most probable optimum requirements is the investigation of the requirements of ascorbic acid of guinea pigs and humans (Table I).

STUDIES ON GUINEA PIGS

Numerous tests with guinea pigs have shown that *macroscopic* symptoms of scurvy do not occur if the animal is given a daily allowance of 0.5 mg ascorbic acid (Table I). *Microscopic* scorbutic changes to the teeth of the guinea pigs can only be prevented by an allowance three to four times as great, *i.e.*, 1.5 to 2.0 mg a day. If the guinea pigs are to show the greatest possible resistance to outer influences however (a question that has been examined by determination of healing speed of an artificially inflicted wound or bone fracture,⁴ or by the degree of resistance to injection of diphtheritic toxin),⁵ the guinea pigs must have a daily allowance of 5 mg ascorbic acid,

TABLE I
Standards and Requirements of Ascorbic Acid for
Humans and Guinea Pigs

	Guinea pigs mg	In- fants mg	Adults with requirement of 2,400 calo- ries (except pregnant and nursing women) mg
<i>Standards</i>			
League of Nations 1938 ³	—	30	30
Brit. Med. Res. Council 1948 ¹	—	30	30
U. S. Recommended Dietary Allowance, 1953 ²	—	30	75
<i>Minimum requirement</i>			
On the basis of macro- scopic examination for scurvy	0.5	3-6	Below 10
On the basis of micro- scopic examination for scurvy	1.5-2.0	?	?
<i>Optimum requirement</i>			
Determined by resist- ance to infection and intoxication	5	?	?
Determined by heal- ing of wounds and bone fractures	5	—	10

i.e., *ten times the dose that prevents macroscopic manifestations of scurvy.*

The fact that no symptoms of scurvy have been ascertained by means of the methods used, by which the minimum requirements have been fixed, does not prove that the guinea pig has been healthy. Perhaps it only indicates that our general clinical methods of examination are too coarse to disclose slight morbid manifestations of vitamin C deficiency. This assumption is supported in part both by tests with animals, and partly—as we shall see later—by observations on humans.

By tests with guinea pigs we find, as already mentioned, that 0.5 mg ascorbic acid a day will protect against the appearance of macroscopic indications of scurvy (changes in the cartilage of the ribs, visible hemorrhages, loose teeth, etc.) whereas as much as 0.5 to 2.0 mg a day is necessary in order fully to prevent the presence also of microscopic deficiency symptoms in the teeth of the animals. On the basis

of a gross examination we should say that the minimum requirement of the guinea pig for ascorbic acid is 0.5 mg ascorbic acid a day, but after the microscopic examination that it is at least three to four times as great, viz., 0.5 to 2.0 mg. Thus even in the fixing of minimum requirement in guinea pigs a considerable uncertainty manifests itself.

STUDIES ON MAN

Investigations of the ascorbic acid requirement of *humans* are numerous, and only certain main points are mentioned here.

In *infants* nourished on diluted cow's milk, mild symptoms of scurvy are not rare.⁶ Raw cow's milk contains from 0.1 to 2.5 mg ascorbic acid/100 ml, a little less than half when pasteurized. If the consumption of liquid by the infant during the first three months is estimated at 500 to 1,000 ml a day, and if the usual dilutions of the milk are used, a bottle-fed infant will get an average daily allowance of 3 to 6 mg ascorbic acid, and 3 to 6 mg thus will not in all cases be sufficient against the manifestations of scurvy. Consequently *the minimum requirements for infants* would seem to be greater than 3 to 6 mg ascorbic acid.

In this connection I should like, however, to call attention to the imperfection of our clinical examination technic in infants as pointed out by Follis *et al.*⁷ Scurvy was diagnosed by microscopic examination of the bones of 69 dead children, although this ailment had been diagnosed clinically in only six of the 69 children while they were patients in the pediatric ward. It is therefore very possible that the minimum requirement for ascorbic acid if determined by a more elaborate technic is higher than the 3 to 6 mg stated for infants.

Mother's milk contains about four times as much vitamin C as cow's milk, which moreover is diluted in milk mixtures, in fact, fluctuating according to the diet of the mother from 4 to 8 mg/100 ml breast milk. Breast-fed infants, who never show indications of scurvy, thus get a daily allowance of at least 20 mg, often 40 to 50 mg ascorbic acid. Of course we do not know *the optimum requirement of infants* just because we know the quantities of ascorbic acid that breast-fed infants

receive in mother's milk, but it must be supposed nevertheless that mother's milk from healthy women living on a satisfactory diet is appropriately composed with regard to the nutrients that are essential for the infant, including ascorbic acid. This is supported by Braestrup's⁶ analyses of the plasma ascorbic acid content in the blood and milk of nursing women, and the plasma and urine ascorbic acid in their children. The ascorbic acid content of the blood plasma of the mothers and of the mother's milk showed the usual seasonal variations whereas a corresponding seasonal variation was not demonstrated in the plasma of breast-fed infants, a fact which Braestrup construes as an indication that breast-fed infants are saturated or nearly saturated with ascorbic acid even in the poor season. This is in accord with the fact that a considerable number of the normal infants excreted ascorbic acid in the urine.

It is of interest, that in 50 of 53 healthy breast-fed infants in the first six months of life Braestrup⁶ found plasma ascorbic acid in quantities between 0.5 and 1.5 mg per 100 ml, most often about 1.0 mg per 100 ml. In healthy infants who had been fed solely on diluted cow's milk, the plasma ascorbic acid contents averaged about 0.25 mg per 100 ml.

It is on the question of *the optimum requirement of healthy adults*, that disagreement prevails. The investigations are numerous. I shall only remind the reader of the observations of the British physician, Lind, in 1753 to the effect that scurvy might be prevented by a daily

allowance of 25 to 30 ml lemon juice, which, according to our present knowledge, contains about 14 mg ascorbic acid.

Concerning the optimum requirement I wish to call attention to the results of the investigations of plasma ascorbic acid in test subjects, and to compare them with the previously mentioned investigations of plasma ascorbic acid of infants. These are indicated in Table II.

Whereas plasma ascorbic acid in persons on a freely chosen diet shows considerable variation, including pronounced seasonal variation, the plasma ascorbic acid is relatively constant in test persons living on a diet with a constant content of vitamin C provided that a fasting blood specimen is examined. It is seen that 50 mg ascorbic acid a day for adult test subjects will produce plasma ascorbic acid levels which are only a little above that of the bottle-fed infants (about 0.25 mg per 100 ml). Test persons who received 70 mg ascorbic acid a day had plasma ascorbic acid of 0.55 mg per 100 ml or barely as much as minimum of breast-fed infants.

The following reasons seem to indicate that the daily allowances recommended by Americans of 75 mg ascorbic acid for healthy adults with a daily requirement of 2,400 calories is closer to the optimum requirement than the 30 mg indicated by the League of Nations and by the Medical Research Council in England.

(1) The optimum requirement for ascorbic acid for guinea pigs is about 10 times the minimum requirement as determined by macroscopic examination.

TABLE II
Comparison of Plasma Ascorbic Acid in Adults and Infants

Daily allowance of vitamin C mg	Infants (Braestrup) ⁶		Adults (Brit. Med. Res. Council) ¹		
	Diet	Plasma ascorbic acid mg/100 ml	Number of persons	Test period (days)	Plasma ascorbic acid mg/100 ml
1	—	—	10	205-269	<0.03
6	Bottle-fed infants (about 3-6 mg ascorbic acid a day)	About 0.25	3	125	<0.05
10	—	—	6	101-157	<0.10
20	—	—	5	47-92	<0.10
50	Breast-fed infants (30-50 mg ascorbic acid a day)	About 1.0 (0.5-1.5)	2	61-66	0.31
70	—	—	3	300-336	0.55

(2) Infants' allowance of ascorbic acid in mother's milk is about 10 times the minimum requirement, and the plasma ascorbic acid content is "locked" above 0.50 to 1.5 mg per 100 ml, as a rule about 1.0 mg per 100 ml.

(3) The minimum requirement of adults is not known precisely. It is between 5 to 10 mg ascorbic acid a day. The plasma ascorbic acid content in test persons receiving a daily allowance of 10 mg and 20 mg ascorbic acid was inconsiderable, below 0.10 mg per 100 ml and 50 mg ascorbic acid a day for adults gave only 0.31 mg per 100 ml. Only with 70 mg ascorbic acid a day were values attained that approach those known for breast-fed infants, i.e., more than 0.50 to 0.60 mg per 100 ml. Even at these plasma values the organism is far from being "saturated," i.e., from excreting ascorbic acid in the urine.

The methods of examination that can be applied to humans apparently are so coarse that all that can be established on the existing basis is that adults perhaps have a minimum requirement of 5 to 10 mg ascorbic acid a day when otherwise subsisting on a diet that is adequate in all other respects, and when leading a life without special exertions or harmful influences. If the minimum requirement has been determined with certainty to be about 5 to 10 mg of ascorbic acid a day, the optimum requirement

of adults, on the basis of experience gained by investigations with guinea pigs and infants, should for the present most safely be estimated by multiplying by ten. Hence, the optimum requirement of adults must be estimated at 50 to 100 mg ascorbic acid a day. This leads to the American figure of 75 mg, which brings the plasma ascorbic acid up near that which we find in breast-fed infants without causing "saturation."

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