Nutritional Status of Selected Adolescent Children

III. ASCORBIC ACID NUTRITURE ASSESSED BY SERUM LEVEL AND SUBCLINICAL SYMPTOMS IN RELATION TO DAILY INTAKE

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ADOLESCENCE is a period of great physiologic stress. Even so, this age has received comparatively little attention from the viewpoint of basic nutritional information. Some adolescent subjects have been included in ascorbic acid studies involving children of various ages.[1-9] A few studies have emphasized the 14-to 16-year-olds.[10-12] The main methods for assessing dietary adequacy and ascorbic acid nutrition have been dietary records and blood level of ascorbic acid.

In the course of a comprehensive study of 248 selected adolescent boys and girls in two areas of Washington State,[13] information was obtained pertaining to ascorbic acid status. Dietary intake, serum ascorbic acid, biomicroscopic examination of the gums and of the epithelium of the upper arm, colored photography of the gums, and physical examination of the gums and of the skin of the upper arm were the indices available for the evaluation of ascorbic acid nutrition. In this report, correlations between food intake, serum ascorbic acid levels, and physical manifestations of ascorbic acid deficiency are discussed as well as the ascorbic acid status of the selected adolescent subjects.

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PROCEDURE

The selection of areas for study and the description of subjects have been reported previously.[13] Yakima County, east of the Cascade Mountains and Snohomish County, west of the Cascades, were the two areas chosen. The subjects were 15- and 16-year-old boys and girls who had been born and reared in either of these counties. About 125 subjects were studied in each of the two areas. There were almost equal numbers of boys and girls in each age group in each area.

Dietary Data

Semiquantitative seven-day dietary records[13] were the source of the information on ascorbic acid intake from food. Vitamin supplements were recorded separately.

Serum Ascorbic Acid

Serum ascorbic acid determinations by the method of Lowry, Lopez, and Bessey[14] were made on fasting blood immediately following collection.

Biomicroscopic Examination

Examination of the gingiva and of the epithelium of the upper arm was made with the Bausch and Lomb Poser Slit Lamp. All biomicroscopic observations were made by the same operator.

The Gingiva: Hyperemia, swelling, infiltration, pitting, recession of the interdental papillae, and recession at the dental margin were noted in the gingiva of the upper and lower gums. A qualitative value of "normal," "slight," "some," "marked," or "very marked" was assigned to each lesion. Each qualitative description was arbitrarily quantified by giving "normal" the value of 1; "slight," 2; "some," 3; "marked," 4; and "very marked," 5. The average value was obtained for the entire gum for each subject because the upper or lower gingiva is not likely to be more affected than the other.[15] The presence of any one of the symptoms was classified as a chronic condition. The value for hyperemia plus swelling was obtained in addition to the above values and was considered to be an acute condition.

The Epithelium of the Upper Arm: The posterolateral aspect of the left upper arm was examined for signs of hyperemia. This lesion was qualitated and quantified in the same manner as the gingiva.

Colored Photography

The gums of each subject were photographed using a Leica camera with 135 mm telephoto lens, 90–100 mm extension tube and ground glass copy attachment for focusing, Kodachrome A film, a 81C Rattan filter and #6 G.E. flash bulb. The distance of camera from subject was 11 inches. Each slide was evaluated as "good," "fair," or "poor" for each of the lesions, hyperemia, swelling, recession of the interdental papillae, and recession of the dental margin. These qualitative values were arbitrarily assigned quantitative values of "good," 1; "fair," 2; and "poor," 3. The lesions of each subject were further evaluated as acute or chronic. The colored-slide evaluation and biomicroscopic examinations were made by the same operator. Viewing distance from the 54 × 40 inch screen was 9 feet.

Physical Examination

The epithelium of the upper arm and the gums were examined during the physical examination of each subject. One physician made the examination in Snohomish County, a second physician in Yakima County. Perifollicular petechiae (hyperemia) of the arm were observed as "mild," "moderate," or "severe." Gingivitis (swelling), recession of the interdental papillae, recession at the dental margin, and hyperemia were noted in the gums. The quantitative values for the qualitative descriptions were "absent," 1; "mild," 2; "moderate," 3; "severe," 4.

Statistical Treatment of Data

Daily mean intakes of ascorbic acid and standard error of the means were obtained for both boys and girls from Snohomish and Yakima Counties. The arithmetic mean intakes were compared with the National Research Council Recommended Allowances.[16] Since skewness was apparent, the geometric means and their logarithms were used in statistical treatments involving daily intake data.

Blood serum ascorbic acid and the quantified values for the biomicroscopic observations, the colored photography evaluations and the physical examinations were expressed in terms of mean values for Snohomish County boys and girls and Yakima County boys and girls.

Analysis of variance was used for comparisons between groups.[17]

Correlations[17] were calculated for the four groups: Snohomish boys, Snohomish girls, Yakima boys, and Yakima girls. Ascorbic acid intake including vitamin C supplementation was correlated with serum ascorbic acid levels and with the various quantified physical and biomicroscopic values. Similarly, the quantified values were correlated with each other and with the serum levels.

RESULTS AND DISCUSSION

Ascorbic Acid Intake

Ascorbic acid intakes from food were low for all groups except the Snohomish girls (Table I). Thirty-two per cent of the girls were getting less than 50 mg per day, while 34 per cent of the boys had less than 60 mg daily.[13] The girls in Yakima County consumed significantly less ascorbic acid (at the 1 per cent level) than the Snohomish girls. No significant difference was found between the intakes of 15- and 16-year-olds, either boys or girls.

When the daily mean intakes were compared with the National Research Council Recommended Allowances,[16] the Snohomish girls and boys consumed 99 and 87 per cent, respectively, of the recommended ascorbic acid allowances and the Yakima girls and boys, 74 and 88 per cent, respectively. Other dietary studies[18–22] have indicated that ascorbic acid may be low in the diets of adolescent children.

Fourteen of the 248 subjects reported the intake of vitamin C supplements. For 6 of the 14, supplementation considerably increased (by 17 to 1666 per cent) the intakes from diets alone.

Blood Serum Ascorbic Acid

The serum ascorbic acid levels (Table I) rate "good" for the girls and "fair to good" for the boys as compared with the serum ascorbic acid classification reported by Bessey and Lowry.[23] No significant differences were found between 15- and 16-year-olds or between areas. A significant difference (at the 5 per cent level) existed between sexes. Sex differences have been noted also by Bring, Warnick, and Woods[11] in Idaho, and by Clayton *et al.*[24] in the Northeast.

One-fourth of the girls and over one-third of the boys had serum levels of 0.4 mg per 100 ml or less. Twenty-seven per cent of the girls also had serum ascorbic acid levels of 1.1 mg per 100 ml or over while only 15 per cent of the boys reached this value. A similar distribution has been reported by Roderuck *et al.*[7] Clayton *et al.*[24] found a lower percentage of males than females in the 1.0 mg per 100 ml groups, as did Wilcox *et al.*[1] in the Utah 13- to 19-year-old nonrheumatic subjects. Storvick, Hathaway, and Nitchals[10] on the other hand, found about one-third of both Oregon girls and boys in the "excellent" range. Montana adolescents[12] had higher serum ascorbic acid levels; 73 per cent of the girls and 58 per cent of the boys could be classified as "excellent."

That the serum ascorbic acid levels of adolescent subjects are directly related to the food intake is illustrated in Figures 1 and 2. The correlation coefficient (r) was 0.616 for all subjects (significant at the 1 per cent level), 0.683 for boys, and 0.543 for girls. It has been reported[7] that ascorbic acid intake per kilogram of body weight is a more accurate indicator of serum concentration than is daily ascorbic acid intake. A relationship between intake per kilogram and serum concentration did exist in both adolescent boys and girls. However, the correlations between intake per kilogram and serum concentration were less ($r = +0.674$ for the boys and $r = +0.470$ for the girls) than the correlations with daily ascorbic acid intake.

There appears to be a difference in ascorbic acid metabolism in girls compared to boys. Although the daily ascorbic acid intake tended to be lower for the girls than for the boys (Table I), the serum blood levels of the girls were significantly higher than those of the boys. It is difficult to draw definite conclusions on the basis of a week's intake and of one blood sample, but the blood levels for the girls do seem higher than might be expected. This has been reported also by Wilcox *et al.*[1] and by Roderuck

TABLE I

Mean Daily Intake of Ascorbic Acid and Mean Serum Levels of Ascorbic Acid by Area and Sex

	Snohomish County		Yakima County	
	Boys (63)	Girls (62)	Boys (61)	Girls (61)
	Daily intake			
Arithmetical mean (mg) and S. E. of mean	82 ± 5.73	79 ± 5.33	83 ± 5.00	59 ± 3.97
Geometric mean (mg)	72	69	74	52
Log. of geom. mean and its S. E.	1.8550 ± 0.0287	1.8372 ± 0.0308	1.8710 ± 0.0271	1.7186 ± 0.0285
	Serum levels			
Mean (mg/100 ml) and S. E.	0.64 ± 0.04	0.86 ± 0.06	0.70 ± 0.06	0.72 ± 0.06

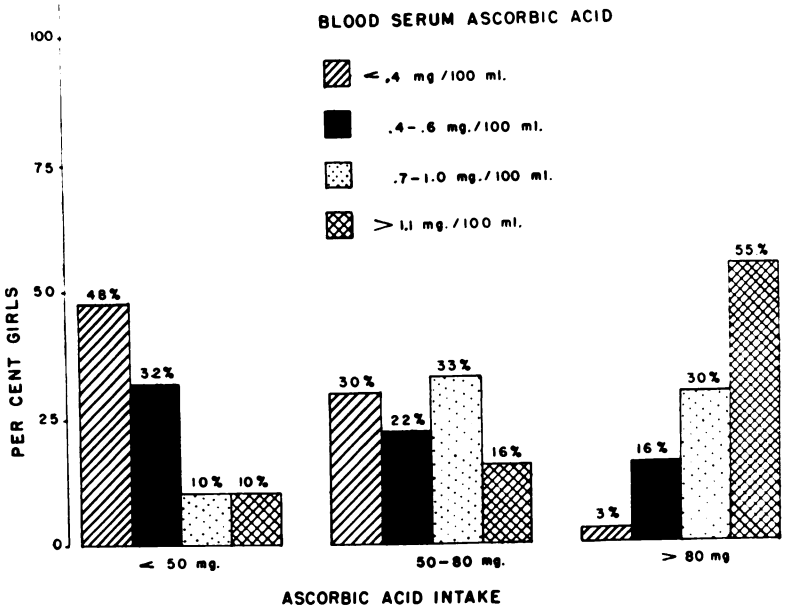

Fig. 1. Distribution of serum ascorbic acid levels of adolescent girls having daily ascorbic acid intakes of <50 mg, 50–80 mg, and >80 mg.

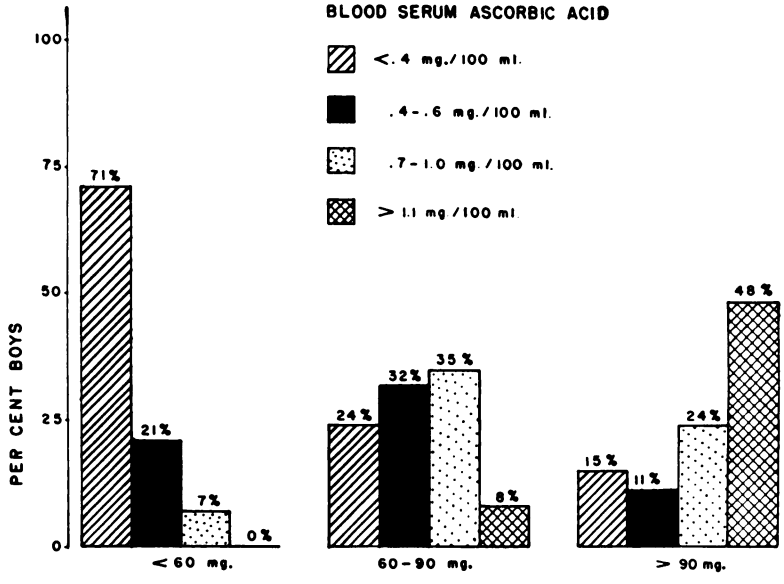

Fig. 2. Distribution of serum ascorbic acid levels of adolescent boys having daily ascorbic acid intakes of <60 mg, 60–90 mg, and >90 mg.

et al.[7] On the hypothesis that the sex difference might be due in part to hormonal influence, a correlation was made between basal metabolic rate and serum ascorbic acid. Only one group, the Yakima boys, showed significant relationship (at the 5 per cent level). Tisdall and Jolliffe[25] have suggested an association of ascorbic acid deficiency with increased respiratory rate.

Subclinical Symptoms of Ascorbic Acid Deficiency

Biomicroscopic Examination: Biomicroscopic observations of subclinical symptoms often

associated with ascorbic acid deficiency are summarized in Table II. The average quantified scores for the arm and gingival lesions indicate a "slight" deficiency of vitamin C. Gingival recession is somewhat more pronounced than the other manifestations. The scores for chronic lesions (column 8) were somewhat higher for all subjects than were those for acute lesions (column 7). This suggests a greater incidence of chronic than of acute gum lesions. Except for hyperemia of the arm and infiltration of the gingiva, a greater percentage of the girls than of the boys were "normal."

It is not possible to make comparisons among the studies which have used biomicroscopic observations to assess nutritional status because many different methods of describing the lesions and quantifying the results have been employed.

Simple correlation coefficients for acute and chronic gingival lesions and hyperemia of the arm with serum ascorbic acid and with ascorbic acid intake with supplements are given in Table III. All were nonsignificant except for chronic gingival lesions and serum ascorbic acid in Yakima girls. This correlation ($r = -0.263$) significant at the 5 per cent level, may be attributable to chance.

The lack of correlation between dietary intake, blood values, and biomicroscopic observations is in agreement with the theory proposed by Kruse.[26] Serum ascorbic acid values fluctuate with current intake whereas the state of body tissues probably reflects the nutritional status of an individual over a period of *years*. Biomicroscopic observations of the tissues made by an experienced operator should contribute information to the over-all assessment of nutritional status.

Kodachrome Observations: The average scores of the gingival lesions (Table IV) as observed from kodachrome slides generally agree with the biomicroscopic results. The evaluation of the slides is not as precise a measure of subclinical symptoms as is the biomicroscopic examination. This is reflected in the quantifying scale—the biomicroscopic observations were quantified from 1 to 4, but the kodachrome scale was 1 to 3. On this basis, the kodachrome observations suggest a "fair" state of ascorbic acid nutrition in these subjects.

Table III reveals a highly significant correlation between the kodachrome and biomicroscopic observations for acute and chronic gingival lesions. This suggests, that under

TABLE II

Mean Quantified Scores* for Biomicroscopic Observations of the Gingiva and of the Epithelium of the Upper Arm

Tissue	Gingiva																Arm	
Lesions	Hyperemia (1)†		Swelling (2)		Infiltration (3)		Pitting (4)		Recession of I.D.P.‡ (5)		Recession at D.M.‡ (6)		Acute Lesions (1 & 2) (7)		Chronic Lesions (1–6) (8)		Hyperemia (9)	
	Score	"Normal"	Score	"Normal"	Score	"Normal"	Score	"Normal"	Score	"Normal"	Score	"Normal"	Score	"Normal"	Score	"Normal"	Score	"Normal"
		%		%		%		%		%		%		%		%		%
Snohomish boys (63)	1.6	56	2.0	18	2.4	4	2.2	8	2.8	4	2.3	19	1.8	37	2.2	18	1.2	86
Snohomish girls (62)	1.4	62	1.9	28	2.4	4	2.1	12	2.6	5	1.8	34	1.6	45	2.0	24	1.2	76
Yakima boys (61)	1.4	64	1.8	34	2.4	14	2.1	5	2.8	5	2.7	12	1.6	49	2.2	22	1.0	98
Yakima girls (62)	1.4	62	1.7	36	2.3	14	2.2	2	2.5	9	2.1	25	1.6	49	2.0	25	1.1	90
All boys	1.5	60	1.9	26	2.4	9	2.2	6	2.8	4	2.5	16	1.7	43	2.2	20	1.1	92
All girls	1.4	62	1.8	33	2.4	9	2.2	7	2.6	7	2.0	30	1.6	47	2.0	24	1.2	83

* 1, "normal"; 2, "slight"; 3, "some"; 4, "marked"; 5, "very marked."

† Column number.

‡ I.D.P., Interdental papillae; D.M., Dental margin.

TABLE III

Simple Correlation Coefficients for Biomicroscopic Observations

Biomicroscopic observations	County	Sex	Ascorbic Acid		Gingiva lesions			Arm
					Acute	Chronic		Hyperemia
			Intake	Serum	Kodachrome	Kodachrome	Physical	Biomicroscopic
Acute gingiva	Snohomish	Boys	−0.154	−0.100	+0.488†	+0.523†	+0.333†	−0.032
		Girls	+0.081	+0.064	+0.287†	+0.378†	—	+0.021
	Yakima	Boys	−0.101	−0.044	+0.663†	+0.742†	+0.737†	+0.100
		Girls	−0.206	−0.165	+0.747†	+0.786†	+0.533†	+0.113
Chronic gingiva	Snohomish	Boys	−0.053	+0.007	+0.530†	+0.611†	+0.457†	+0.196
		Girls	+0.012	+0.144	+0.219	+0.368†	—	−0.159
	Yakima	Boys	−0.152	−0.048	+0.392†	+0.569†	+0.588†	+0.122
		Girls	−0.219	−0.263*	+0.461†	+0.573†	+0.482†	−0.133
Hyperemia of arm	Snohomish	Boys	−0.206	−0.086	−0.073	+0.010	+0.133	—
		Girls	−0.012	−0.160	−0.054	−0.008	—	—
	Yakima	Boys	−0.004	+0.045	+0.142	+0.179	+0.184	—
		Girls	+0.013	+0.206	—	−0.014	+0.001	—

* Significant at 5% level.
† Significant at 1% level.

conditions of very good photography and in studies where precise results are not required, the evaluation of kodachrome slides for subclinical symptoms of ascorbic acid deficiency may be substituted for biomicroscopic examination. They have the advantage of providing a more objective evaluation of subclinical symptoms than does a physical examination and they also give a clinical record of the tissue for future reference. Merrow *et al.*[27] have made similar observations. As may be expected no correlation was found between kodachrome observations of chronic gingival lesions and ascorbic acid intake ($r = -0.226$) or serum ascorbic acid ($r = -0.157$).

Physical Examination: A higher incidence of gingival involvement was noted among the Yakima than among the Snohomish subjects. This may be due to differences in evaluating symptoms by the two examining physicians. No abnormalities were recorded for the Snohomish girls. "Mild" recession of the interdental papillae was reported for 10 per cent of the Snohomish boys. In Yakima County, a highly significant correlation was noted between the physical and biomicroscopic scores for acute and chronic gingival lesions (Table III). Similarly, the correlation between physical and kodachrome observations in Yakima County were significant at the 1 per cent level

TABLE IV

Mean Quantified Scores* for Kodachrome Observations of the Gingiva

	Hyperemia (1)†	Swelling (2)	Recession of I.D.P.‡ (3)	Recession at D.M.‡ (4)	Acute lesions (1 & 2) (5)	Chronic lesions (1–4) (6)
Snohomish boys (61)	1.7	2.2	1.6	1.6	2.0	1.8
Snohomish girls (62)	1.9	2.0	1.6	1.5	2.0	1.8
Yakima boys (61)	1.9	2.1	1.9	1.9	2.0	2.0
Yakima girls (62)	1.8	2.2	1.7	1.7	2.0	1.8
All boys	1.8	2.1	1.8	1.8	2.0	1.9
All girls	1.9	2.1	1.7	1.6	2.0	1.8

* 1, "good"; 2, "fair"; 3, "poor."
† Column number.
‡ I.D.P., Interdental papillae; D.M., Dental margin.

($r = +0.640$ for the boys, $r = +0.626$ for the girls). The average scores for acute lesions as observed by the physician were 1.3 and 1.4 for Yakima girls and boys, respectively, and 1.3 and 1.3 for the chronic lesions. About one-fourth of the Yakima subjects were noted to have "mild" to "moderate" manifestations of swelling, recession of the interdental papillae and recession at the dental margin.

The various methods used in this study to assess ascorbic acid nutrition agree fairly well. From the standpoint of present recommendations, the daily food intake is considered to be low. The serum ascorbic acid levels can be classified as "fair" to "good." The subclinical symptoms of deficiency were observed to be "slight." Taking all these criteria into consideration, the ascorbic acid nutriture of the selected Washington adolescent subjects can be described as fairly good.

SUMMARY

The ascorbic acid nutrition of 248 adolescent boys and girls born and reared in two areas of Washington (Snohomish and Yakima Counties) was assessed by five methods—dietary intake including supplementation, serum blood levels, biomicroscopic and kodachrome evaluation of subclinical deficiency manifestations, and physical examination.

By the present standards the ascorbic acid food intake of all boys and of the Yakima girls was low. Mean daily intakes were 82 mg for the boys and 69 mg for the girls. Few (14) subjects took vitamin C supplements.

The mean serum ascorbic acid values were rated "fair" to "good." The values for Snohomish boys and girls were 0.64 ± 0.04 and 0.86 ± 0.06 mg per cent, respectively, and for the Yakima boys and girls, 0.70 ± 0.06 and 0.72 ± 0.06 mg per cent, respectively. A significant difference existed between the sexes.

The average scores for the biomicroscopic observations of the upper arm and gingival epithelial lesions indicated a "slight" deficiency of ascorbic acid. The evaluation of the kodachrome slides suggested a "fair" status of ascorbic acid nutrition. The physical examination revealed few subclinical manifestations.

On the basis of the several criteria used, selected Washington adolescent subjects may be described as being in a fairly good state of ascorbic acid nutrition.

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