The nutrition of Nigerian children, with particular reference to their ascorbic-acid requirements

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A study of the diets eaten by 10 to 12-year-old children of Ibo and Yoruba salaried officials living in Kaduna, Northern Nigeria, was undertaken in 1954, and has been described in a previous paper (Nicol, 1956). The results confirmed an impression that the customary diet of these children supplies only small amounts of ascorbic acid during 10 months of the year owing to a shortage of fresh fruit and vegetables, and that large quantities of vitamin C are obtained from mangoes during the 2 months beginning about mid-April.

The investigation reported in this paper was designed to record the heights and weights of such children throughout 1 year, and to study the effect on growth of supplementing their diet with ascorbic acid.

EXPERIMENTAL

Subjects

The subjects were children attending the Government School, Kaduna, where the curriculum is similar to that of an English day school. They attended the Health Clinic run by the Ministry of Health in the school compound, where the physical examinations were carried out.

In July 1954, during the rains, boys and girls from 9 to 15 years of age were paired by sex, age to within 6 months, and height to within $\frac{1}{2}$ in. All but a few of the children from this class of family now have birth certificates, but when these were not available the age was determined by careful questioning. Initially fifty pairs were examined, but several pupils left school during the year, which reduced the number of pairs that were fully investigated to forty, ten pairs being girls and thirty pairs boys. The data presented in this paper were obtained from these eighty children.

Methods

Clinical examination. The form of the investigation is shown in Fig. 1. The height and weight of each child were recorded at monthly intervals for 1 year from the beginning of July 1954. Heights were measured in the vertical position, and the children were weighed on a spring balance checked monthly against government-inspected weights. At the first and last monthly examinations the following additional measurements were made: cristal height, intercristal diameter, thoracic antero-posterior and transverse diameters, and five skinfold thicknesses. The thoracic and intercristal diameters were measured with a pelvimeter, the former being at the level

of the fourth sterno-chondral articulation. The skinfold thicknesses were measured with Longworth calipers designed by Ancel Keys (1952, unpublished) which had blade 1·2 cm² and an opening pressure of 180 g.

In August 1955 the number of attendances recorded during the year for each child on the school-clinic out-patient cards was noted. Attendances on account of bites (insect, reptilian and human), vaccinations and routine inspections were excluded.

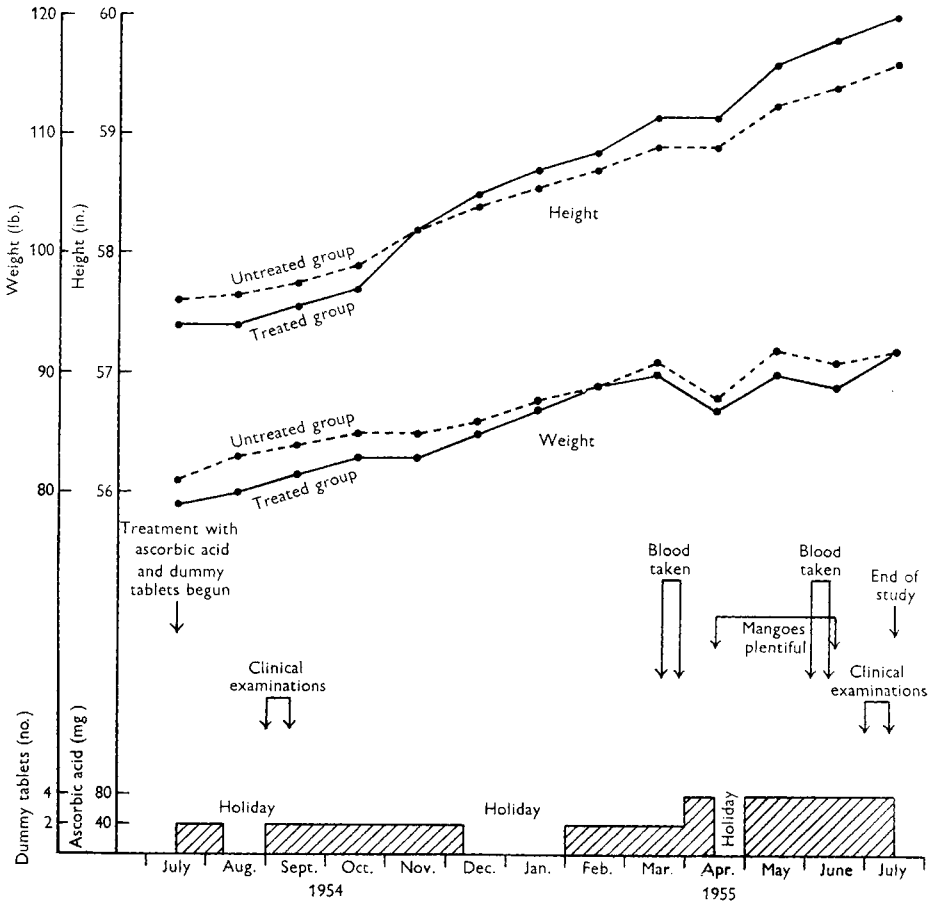

Fig. 1. Amounts of ascorbic acid administered during 1 year to a group of forty Nigerian schoolchildren, sons and daughters of parents of the salaried classes; numbers of placebo tablets administered to a similar group of children paired by sex, age and height; examinations carried out shown in chronological order; mean monthly heights and weights of the children. - - -, untreated group; —, treated group.

A full clinical examination was conducted in September 1954 and again in July 1955, both in the wet season.

Diet and vitamin supplement. It was not possible to record the food eaten by all the pupils included in the experiment. The diet of thirty-nine Kaduna children from the same tribes and social class was measured for three periods of 10 days each in March, June and September 1954, by methods previously reported (Nicol, 1956). Ten of these thirty-nine children took part in the investigation now reported.

At the beginning of July one child from each pair was given a supplement of 40 mg ascorbic acid which was consumed under supervision, and recorded, between 9 and 9.30 a.m. every school-day. The other child of the pair was given two tablets made of lactose, stearic acid, essence of lemon and tartaric acid. The vitamin supplement was given in the form of an extract of blackcurrants. In addition to naturally occurring vitamin C this extract contained anthocyanin pigments, flavonoids, citric and malic acids, glucose, fructose and added sucrose. During the whole experimental period of a year the vitamin supplement contributed a daily average of 90 Cal. and the dummy tablets 50 Cal. These two groups of children are termed the treated and untreated groups. In order to maintain the ascorbic-acid intake of the treated group at a considerably higher level than that of the untreated group during the mango season, the vitamin C supplement was increased from 40 to 80 mg from the beginning of April until the end of the experiment in July 1955, and the number of tablets was increased from 2 to 4 (see Fig. 1). On account of absenteeism and school holidays the mean daily supplement of ascorbic acid for the period July 1954 to March 1955 was 21 ± 3 mg, and for the period April to July 1955 was 50 ± 4 mg. The mean daily supplement of ascorbic acid for the year of the study was 33 ± 4 mg. During the season each child was asked to note how many mangoes he or she ate, and this was recorded daily. The average weight of the edible portion of Kaduna mangoes was determined from 100 fruits. The ascorbic-acid content of the edible portion was estimated by the dichlorophenolindophenol method.

Biochemical measurements. At the end of March and in June 1955, before and at the end of the mango season, between 9 and 9.30 a.m., 8 ml. of venous blood were withdrawn from an antecubital vein into 10 ml. screw-cap bottles oxalated with the residue of one drop of 30% potassium oxalate. The same day, before 2.30 p.m., the plasma ascorbic-acid concentration was determined by the dichlorophenolindophenol method described by E. J. King (1951), and erythrocyte sedimentation rates (E.S.R.) were measured in Westergren tubes.

RESULTS

Diet. The type of diet eaten by children of salaried Ibo and Yoruba officials in Kaduna at three seasons of the year 1954 is set out in Table 1, and the nutrient composition, computed by methods previously described (Nicol, 1956), in Table 2.

The calorie value of the diet was lowest at the end of the dry season in March (2310 Cal.) and highest in September (2890 Cal.), cassava flour being the item that contributed most to the total. The intake of protein was lowest in June (51 g) and highest in September (69 g), being largely dependent upon the amounts of cowpeas, yams, beef and dried fish eaten.

It has been found that the soaking, pounding and boiling by which fresh root vegetables are prepared for eating in Nigeria destroyed about 80% of their ascorbic-acid content. Cassava flour does not contain any vitamin C. Two-thirds of the ascorbic acid in leaves, peppers and other vegetables are destroyed by boiling in water and oil to make soup. These allowances for destruction of the vitamin in cooking having been made, the amount of ascorbic acid supplied by the diet was found to be

Table 1. *Diet (g/day) of thirty-nine Ibo and Yoruba (Nigerian) schoolchildren, sons and daughters of parents of the salaried classes living in Kaduna in* 1954

Foodstuff	March	June	September
Yam (*Dioscorea* spp.)	360	242	487
Coco yam (*Colocasia* Schott)	50	0	52
Cassava flour (*Manihot utilissima*)	212	320	335
Rice, milled (*Oryza sativa*)	58	50	57
Maize, yellow: mature (*Zea mays*)	26	0	25
immature	0	14	0
Plantain (*Musa sapientum* var. *paradisiaca*)	1	23	0
Banana (*M. sapientum*)	10	10	10
Sweet potato (*Ipomoea Batatas*)	8	5	4
Groundnut (*Arachis hypogaea*)	17	8	16
Locust bean cake (*Parkia filicoidea*)	2	2	2
Pumpkin and melon seeds (*Cucurbita* and *Citrullus* spp.)	3	3	3
Wild mango kernel (*Irvingia gabonensis*)	2	0	1
Kola nut (*Cola acuminata*)	1	3	2
Red palm oil (*Elaeis guineensis*)	16	20	18
Groundnut oil (*Arachis hypogaea*)	6	6	6
Cowpeas (*Vigna sinensis*)	74	72	97
Fruit (citrus, guava, pawpaw and others)	4	6	5
Fresh leaves (Amaranth, *Talinum*, *Vernonia* and others)	5	10	5
Okra, fresh (*Hibiscus esculentus*)	4	4	8
Onions (*Allium cepa*)	2	2	2
Tomato (*Lycopersicum esculentum*)	10	6	8
Mango (*Mangifera indica*)	0	327	0
Beef, lean	44	30	43
Pork, lean	9	5	7
Liver	2	2	0
Fish: fresh	2	10	0
dried	9	5	10
Milk: sweetened condensed	10	6	5
Cow's butter	4	2	0
Cocoa powder	3	5	4
Cube sugar	6	10	8
Salt	4	4	4
Pepper, red dried	3	3	3

Table 2. *Mean daily amounts of calories and nutrients obtained from their food by thirty-nine Ibo and Yoruba (Nigerian) schoolchildren, sons and daughters of parents of the salaried classes living in Kaduna in* 1954

	March	June	September
Calories (Cal.)	2,310	2,540	2,890
Protein: animal (g)	16	11	15
vegetable (g)	44	40	54
total (g)	60	51	69
Fat (g)	51	47	49
Carbohydrate (g)	409	490	550
Calcium (g)	0·45	0·43	0·51
Iron (mg)	15	15	18
Vitamin A (i.u.)	12,000	20,000	12,000
Thiamine (mg)	1·5	1·3	1·7
Riboflavin (mg)	0·6	0·7	0·6
Nicotinic acid (mg)	13	13	15
Ascorbic acid: (*a*)* (mg)	58	208	70
(*b*)† (mg)	14	175	18

* Not allowing for losses in cooking.

† Allowing 80 % for cooking loss in preparing root vegetables, and 67 % for loss from leaves, okra and peppers in making soup.

highest in June during the mango season (175 mg), lowest in March (14 mg), and low also in September (18 mg). The other nutrients were present in the diet in remarkably constant amounts at the different seasons.

Estimation of the ascorbic-acid content of ripe Kaduna mangoes gave a value of 45 mg/100 g edible portion, and since a few of the fruits were eaten before they were fully ripe the figure used to compute their contribution of vitamin C to the diet was 50 mg/100 g edible portion. The Food and Agriculture Organization tables (Chatfield, 1954) give 48 mg/100 g, an amount considerably higher than the representative figure of 30 mg given in the Medical Research Council tables (Platt, 1945). The mean daily amount of vitamin C obtained by the children from mangoes was calculated to be 160 ± 91 mg for the treated group and 155 ± 80 mg for the untreated group, figures which agree well with that calculated for the diet of Kaduna children of similar class (Table 2). The treated group's mean daily intake of ascorbic acid during the mango season was, therefore, 160 mg from mangoes, 18 mg from other foods, and 50 mg from the supplement, a total of 228 mg. The untreated group's intake at the same time of year was 155 mg from mangoes and 18 mg from other foods, a total of 173 mg. Throughout the remaining 10 months of the year the treated group's mean daily intake of vitamin C was 21 mg from the supplement and 16 mg from other sources, a total of 37 mg, whereas the untreated group received only 16 mg from their food.

Somatometric data. The mean monthly heights and weights for girls and boys combined are shown in Fig. 1. The mean gain in height of the treated group was 0·61 in. greater than that of the untreated group; the difference is 10·6 times its standard error, and thus of considerable statistical significance. A significant difference between the increase in weight of the two groups was not demonstrated. Girls were heavier than boys of the same age ($P = 0{\cdot}05$). The initial and final mean measurements of cristal height and pelvic intercristal and thoracic diameters are given in Table 3. Although the mean cristal height and pelvic intercristal diameter of both sexes showed a greater increase during the year in the treated than in the untreated group these differences were not found to be significant.

The values obtained from skinfold measurements are presented in Table 4. There was no significant difference between the amount of subcutaneous tissue in the two groups, but the girls were fatter than the boys. Skinfold measurements did not correlate with weight or height in boys up to the age of 15 years or in girls below 13 years, but a very significant correlation was found to exist between weight and skinfold thickness in girls of 13–15 years of age ($r = 0{\cdot}883$; $t = 12{\cdot}784$).

Clinical features. The observations made at the first examination in September 1954 and at the second in July 1955 are given in Table 5. Attendances at the school clinic on account of sickness, including those resulting in admission to hospital, averaged 13 ± 9 for the treated group and 14 ± 12 for the untreated group. The ranges were 0–39 and 0–62, respectively. Sores, scabies, fungal skin infections, conjunctivitis, tonsillitis, malaria and unexplained fevers comprised most of the diagnoses recorded on the cards.

Biochemical findings. The mean concentration of ascorbic acid in the plasma of the treated and untreated groups in March, before the start of the mango season,

Table 3. *Mean cristal height, and pelvic intercristal, thoracic antero-posterior and transverse diameters of forty pairs (ten female and thirty male) of Ibo and Yoruba (Nigerian) schoolchildren, sons and daughters of parents of the salaried classes, showing the increase in each dimension recorded after treatment for a year of one group with a daily dietary supplement of ascorbic acid and of the other with a placebo (for further details see p. 276)*

	Cristal height			Pelvic intercristal diameter			Thoracic antero-posterior diameter			Thoracic transverse diameter			Ratio, total : cristal height	
Group	July 1954 (in.)	July 1955 (in.)	Increase (in.)	July 1954 (in.)	July 1955 (in.)	Increase (in.)	July 1954 (in.)	July 1955 (in.)	Increase (in.)	July 1954 (in.)	July 1955 (in.)	Increase (in.)	July 1954	July 1955
Girls: treated	36·7	37·8	1·1	8·9	9·3	0·4	6·2	6·3	0·1	8·7	8·9	0·2	1·60	1·60
untreated	37·0	37·6	0·6	8·6	8·9	0·3	6·4	6·5	0·1	8·8	9·0	0·2	1·59	1·60
Boys: treated	36·5	38·1	1·6	8·3	8·6	0·3	6·3	6·5	0·2	8·6	8·8	0·2	1·56	1·57
untreated	36·2	37·6	1·4	8·3	8·5	0·2	6·2	6·4	0·2	8·6	8·9	0·3	1·59	1·58

Table 4. *Skinfold measurements* of forty pairs (ten female and thirty male) of Ibo and Yoruba (Nigerian) schoolchildren, sons and daughters of parents of the salaried classes, one group treated for a year with a dietary supplement of ascorbic acid and the other group given a placebo (for further details see p. 276)*

	Treated group				Untreated group			
	Girls		Boys		Girls		Boys	
	July 1954	July 1955	July 1954	July 1955	July 1954	July 1955	July 1954	July 1955
Value* (mm)	49	56	28	31	52	59	28	30
Standard deviation (mm)	±21	±20	±5	±4	±19	±22	±4	±3
Range (mm)	38–102	30–101	21–40	25–39	30–91	38–102	20–39	22–38

* Mean value for the sum of five measurements: abdomen, just below and to the right of the umbilicus; just below the right costal margin in mid-clavicular line; back, just below angle of right scapula; right arm, midway between shoulder and elbow, posteriorly over triceps; right arm, midway between shoulder and elbow, anteriorly over triceps.

Table 5. *Mean percentage* incidence of the clinical features observed in forty pairs (ten female and thirty male) of Ibo and Yoruba (Nigerian) schoolchildren, sons and daughters of parents of the salaried classes, before and after treatment with a daily dietary supplement of ascorbic acid or with a placebo* (*for further details see p.* 276)

	Treated			Untreated		
Clinical feature	Sept. 1954	July 1955	1954 and 1955	Sept. 1954	July 1955	1954 and 1955
General appearance: good	63	68	65	55	55	55
fair	35	30	33	40	43	41
poor	2	2	2	5	2	4
Skin: staring hair	3	0	1	3	3	3
generalized xerosis, mild degree	15	15	15	13	18	15
elephant skin, knees and elbows only	8	13	10	5	10	8
follicular hyperkeratosis	0	0	0	0	3	1
folliculosis	50	63	56	70	68	69
nasolabial seborrhoea	40	40	40	28	38	33
permanent gooseflesh	13	18	15	13	13	13
skin of shins atrophic	90	80	85	78	73	75
Lips and tongue: angular stomatitis	23	20	21	33	38	35
epithelium atrophic:						
marginal only	23	25	24	23	40	31
patchy atrophy	3	8	5	7	0	4
bald, smooth	0	0	0	0	0	0
'pebbling'	53	60	56	50	70	60
Eyes: pigmentation of sclera	50	53	51	55	57	56
thickened conjunctiva	38	48	43	43	43	43
conjunctiva thickened over sclera	8	3	5	3	10	6
xerophthalmia	0	0	0	0	0	0
superficial corneal opacities	3	3	3	0	0	0
photophobia	3	0	1	0	0	0
conjunctivitis	28	15	21	30	20	25
blepharitis	10	3	6	3	5	4
blue spots	55	43	49	45	35	40
Thyroid: generalized minor enlargement	20	10	15	10	3	6
nodular goitre	0	0	0	0	0	0
thyrotoxicosis	0	0	0	0	0	0
Rachitic signs: bossed skull	8	8	8	10	10	10
beaded ribs	0	0	0	3	3	3
bow knees	15	15	15	18	18	18
knock knees	5	5	5	0	0	0
Teeth and gums: gingivitis	20	10	15	38	20	29
pyorrhoea or abscess	3	15	9	3	20	11
caries	13	10	11	23	30	26
teeth filled	3	5	4	0	8	4
teeth missing	0	0	0	3	3	3
Hepatomegaly, 1½ in. below costal margin	5	13	9	5	8	6
Splenomegaly, spleen palpable	28	20	24	25	18	21
Hepatomegaly and splenomegaly (included in above figures)	5	8	6	5	8	6
Skin diseases: tinea	8	6	7	10	10	10
scabies	5	4	4	4	4	4
urticaria, onchocercal	3	0	1	0	0	0
chronic staphylococcal infection	3	0	1	0	0	0

* Given to the nearest whole number.

Table 5 (*continued*)

Clinical feature	Treated			Untreated		
	Sept. 1954	July 1955	1954 and 1955	Sept. 1954	July 1955	1954 and 1955
Skin diseases (*cont.*) leprosy	0	0	0	3	3	3
keloid scars	3	3	3	3	3	3
herpes zoster	3	3	3	3	3	3
unhealed tropical ulcers	3	3	3	5	3	4
impetigo	5	3	4	5	5	5
Chronic hypertrophic tonsillitis	10	5	8	15	18	14
Chronic suppurative otitis media	3	0	1	5	3	4
Old osteomyelitis	0	0	0	3	3	3
Coryza and upper respiratory infection	13	8	11	13	10	11
Bronchitis, acute and chronic	3	0	1	3	0	1
'Fever' at examination	5	3	4	8	5	6
Nystagmus, coarse and unexplained	0	0	0	3	3	3
Cardiac lesions†: mitral stenosis	3	3	3	0	0	0
patent ductus	3	3	3	0	0	0
Gynaecomastia	5	5	5	5	5	5
Minor wounds and abrasions	13	15	14	10	10	10

† Diagnosed from clinical features alone.

was 0·49 ± 0·12 mg and 0·25 ± 0·08 mg respectively (Table 6). Towards the end of the mango season the mean plasma ascorbic-acid concentrations were 0·97 ± 0·25 and 0·73 ± 0·17 mg. In June a significant correlation between the intake of ascorbic acid and the plasma concentration of the vitamin was found for individuals of the untreated group ($r = 0{\cdot}912$; $t = 11{\cdot}95$), but this correlation was not statistically significant in the treated group ($r = 0{\cdot}255$; $t = 1{\cdot}602$).

Table 6. *Mean plasma ascorbic-acid concentration, dietary ascorbic acid from mangoes, and erythrocyte sedimentation rate of forty pairs (ten female and thirty male) of Ibo and Yoruba (Nigerian) schoolchildren, sons and daughters of parents of the salaried classes, before and after the mango season in* 1955, *one group treated with a daily dietary supplement of ascorbic acid and the other group given a placebo* (*for further details see p.* 276)

	Treated group		Untreated group	
	March	June	March	June
Plasma ascorbic-acid concentration (mg/100 ml.)	0·49	0·97	0·25	0·73
Standard deviation (mg/100 ml.)	±0·12	±0·25	±0·08	±0·17
Range (mg/100 ml.)	0·32–0·96	0·49–1·60	0·11–0·51	0·31–1·09
Dietary ascorbic acid from mangoes (mg)	0	160	0	155
Standard deviation (mg)	—	±91	—	±80
Erythrocyte sedimentation rate* (mm/h)	27	24	40	35
Standard deviation (mm/h)	±12·5	±10·0	±17·5	±16·0
Range (mm/h)	5–64	3–50	7–105	6–106

* Figures for the 1 h reading on oxalated blood in Westergren tubes.

The mean values obtained for the E.S.R.'s are given in Table 6. The rates recorded for the treated group were 27 mm/h in March and 24 mm/h in June, significantly slower than those of the untreated group which were 40 mm/h and 35 mm/h ($P < 0.01$).

DISCUSSION

Height and weight. The group of children treated with ascorbic-acid supplements showed a gain in height during the year significantly greater than that of the untreated group. The rate of gain in both groups increased in October and November and again in April and May, the increase being greater for the treated than for the untreated group. Growth ceased in March, and the cessation was accompanied by a loss in weight. If, as is believed, the diet described in Table 1 is representative of that of the children in this experiment, the loss of weight in March could be explained by the low calorie value of the diet at that time of year. In March, also, the sick rate was higher than in any other month, owing mainly to upper respiratory infections and unexplained fevers. At other times of the year there was no simple relationship between the calorie value and protein content of the diet on the one hand and the increase in height and weight on the other. The observations are interpreted as suggesting that additional ascorbic acid stimulated growth in height in the conditions of the experiment.

Concentration of ascorbic acid in plasma. The records obtained in March confirmed the relationship between the dietary intake of ascorbic acid and its concentration in the plasma which has been described by others (Goldsmith, 1949; Putnam, Milam, Anderson, Darby & Mead, 1949). In June, when the mean daily intake of the treated and untreated groups had been 228 and 173 mg of vitamin C for 2 months, the plasma concentrations were 0·97 and 0·73 mg/100 ml. respectively. A significant correlation was found between the plasma concentration and ascorbic-acid intake of individuals in the untreated group ($r = 0.912$), but not in the treated group ($r = 0.255$). This may indicate that a state of saturation had been reached by the latter, but not by the former, group. Plasma saturation level is stated by C. G. King (1951) to be between 1 and 2 mg/100 ml. Roberts & Roberts (1942) found that in schoolchildren aged 8–13 years, living in temperate climates, 105–125 mg of ascorbic acid a day were required to produce saturation, but that plasma levels over 0·7 mg/100 ml. could be maintained on a daily intake of 65–75 mg. Goldsmith (1953) states that when diets contain 75–100 mg vitamin C plasma concentrations of 1·0–1·4 mg/100 ml. are observed.

It is possible that the presence of intestinal parasites reduces the absorption of ingested ascorbic acid, and possible also that the prevalence in Africa of chronic infection, ulcers and sepsis makes heavy demands upon the vitamin C present in the plasma and tissues of Nigerian children. The results of the present investigation do not provide any direct evidence on those questions, but they suggest that larger amounts of ascorbic acid are required to produce saturation in Nigerian children than are required to achieve the same effect in children living in a non-tropical environment.

Erythrocyte sedimentation rate. The E.S.R. of the average African is commonly much higher than that found in individuals living in temperate climates, which is customarily attributed to the many acute and chronic bacterial and protozoal infections from which he suffers. In the present experiment the mean E.S.R. of the group of

children receiving daily supplements of ascorbic acid was significantly lower than that of the untreated group, both before and after the mango season ($P < 0{\cdot}01$). A correlation between the E.S.R. and plasma ascorbic-acid concentrations was not found for either group.

Clinical features. Signs of scurvy were not observed in any of the eighty children examined, and none was expected in view of the report of the Vitamin C Subcommittee of the Medical Research Council (Medical Research Council: Accessory Food Factors Committee, 1948, 1953) that a daily amount of 10 mg of ascorbic acid prevents the appearance of the clinical features of the disease. The incidence of gingivitis was high initially in both groups of children, and was considerably reduced by the end of the investigation, but the reduction applied equally to those receiving the vitamin supplement and to the untreated group. The improvement was attributed to the instruction in oral hygiene given at the school clinic and at the dental centre.

The results set out in Table 5 did not reveal any marked or constant improvement in general appearance, or significant reduction in the incidence of disease, that could be attributed to the administration of ascorbic acid.

Conclusions

The results presented suggest that the supplements of ascorbic acid administered to the Nigerian schoolchildren who were the subjects of the experiment had a stimulating effect on growth. If the conclusion is correct it would suggest that their daily intake of ascorbic acid is not sufficient to maintain the maximum growth rate which their customary diet would otherwise support.

The administration of ascorbic acid did not produce any significant reduction in the incidence of disease or in the number of attendances at the school clinic.

The results reported suggest that the plasma of children living in temperate climates can be saturated with ascorbic acid by the ingestion of smaller amounts of the vitamin than are required to produce the same effect in Nigerian children.

SUMMARY

1. Two groups of forty Nigerian children aged 9–15 years, resident in Kaduna, were paired for age, sex and height. Their customary diet, which is described, supplied about 16 mg ascorbic acid daily for 10 months of the year, the amount being increased by the consumption of mangoes to 170 mg during the remaining 2 months. The diet of one group was supplemented throughout the year with ascorbic acid in two different amounts, and a control group received tablets made of lactose, stearic acid, essence of lemon and tartaric acid.

2. During the experimental period of 1 year the average gain in height of the children in the group treated with ascorbic acid was significantly greater than that of the untreated group, but body-weight gain was unaffected by the vitamin C supplement.

3. The cristal height, pelvic intercristal diameter and antero-posterior and transverse thoracic diameters of the children were measured. The gain in cristal height and inter-

cristal diameter during the year was greater, but not significantly so, in the treated than in the untreated group.

4. The clinical features noted at examinations towards the beginning and at the end of the experimental period are described.

5. The concentrations of ascorbic acid in the plasma at different levels of intake were determined. A significant correlation was found between intake and plasma concentration of individuals up to 160 mg and 0·73 mg/100 ml. respectively, but was absent at values of 230 mg and 0·97 mg/100 ml.

6. The erythrocyte sedimentation rate was found to be significantly lower in the treated group than in the untreated group.

7. It is suggested that the children's average daily intake of ascorbic acid was not sufficient to maintain the maximum growth rate which a diet of the pattern described would otherwise support.

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