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Ascorbic Acid and Glucose: Their Relation to Rheumatic Fever in Utah, and Their Relation to Incidence of Dental Caries in Idaho

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ASCORBIC ACID AND GLUCOSE: THEIR RELATION TO RHEUMATIC FEVER IN UTAH, AND THEIR RELATION TO INCIDENCE OF DENTAL CARIES IN IDAHO

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INTRODUCTION

Diseases which in the sixteenth century were found to be related to a deficiency of some substance in the natural foods consumed in the diet were later known as deficiency diseases. As early as 1881, Lunin found that rats could not live on a purified diet of carbohydrate, fat, protein and minerals, but could exist on a diet supplemented with certain natural foods. These findings were found to be in agreement with records of early descriptions of deficiency diseases. Scurvy was recognized very early in voyages made across oceans where ships had no means of being reprovisioned. Progress was very slow in determining the cause of this dread sickness.

In 1535, Jacques Cartier's seamen had an epidemic of scurvy. The Indians of the surrounding country gave him a drink made of evergreen leaves and bark. The rapid recovery of the seamen was considered miraculous. It has been stated (Beeuwkes 1948) that scurvy did not occur until the advent of sailing ships and subsequent long voyages. Prevalence of scurvy was found to be in direct proportion to the length of time the vessel was on the ocean. When it was recognized that lack of fresh fruits and vegetables caused the disease, various countries made regulations requiring the sailing vessels to carry a supply of them. Holst and Frolick confirmed experimentally the dietary origin of the disease in 1907 (Hawk, et al. 1949).

Ascorbic acid was not isolated until 1932 when King and Waugh announced the isolation of hexuronic acid from lemons (Wohl 1945) which were active in preventing or curing scurvy. The name "ascorbic acid"

was given by Szent-Gyorgyi and Hayworth.

Since the time of its isolation, ascorbic acid has been studied a great deal. In recent years it has been found to be related to resistance to disease. The requirement has been reported to be higher in Hodgkin's disease, protracted fevers, active rheumatic heart disease, and tuberculosis.

The purpose of this study was to find what relationship may exist between serum ascorbic acid and blood glucose to the rheumatic fever state in Utah and to the incidence of dental caries in three areas of Idaho, each of which has a different fluoride content of water.

A nutritional status study was made on information collected as part of the Western Regional Research Project on the Nutritional Status of Population Groups. Its purpose was to determine the relationships between diet and physical well-being and dental health of normal children and also those having rheumatic fever in the Ogden, Utah, area. The second part of the study included normal children in three areas of Idaho, each of which has a different fluoride content of the water supply. The following tests were made on the blood and urine samples of the five groups of children and the parents of some of the children who had rheumatic fever: urine analyses for albumin and sugar; blood analyses for hemoglobin, hematocrit, white and red cell count, sedimentation rate, blood smears and glucose, and serum analyses for ascorbic acid, riboflavin, cholesterol, vitamin A, carotene, alkaline phosphatase, iron and copper. Also obtained on these groups were seven-day diet records, dietary history, medical history and examination, dental examination, and dental and bone X-rays.

This study included only the ascorbic acid and blood glucose values. Correlations between these findings and the diet records and/or other constituents of the blood will be presented in later papers.

REVIEW OF LITERATURE

Ascorbic Acid

In relation to rheumatic fever. Since 1941 new methods of determining ascorbic acid in blood serum have been developed. The trend in these methods for the most part has been toward micromethods that used progressively smaller samples, thereby enabling an investigator to increase the scope of his experiment without inconveniencing the participant. The method described by Lowry, Lopez, and Bessey (1945) uses as little as 10 c.mm. of serum for a sample; it is used frequently in nutrition studies.

Some investigators have been able to show the relationship of the amount of ascorbic acid in blood to tissue saturation of ascorbic acid. The level of ascorbic acid necessary to maintain tissue saturation in the body has been set at approximately 1 mg. per day per kilogram of body weight. Haines and co-workers (1947) reported that at 70 mg. there was slight depletion of tissue stores. The association between the diet record of ascorbic acid and intake and the blood content of the vitamin was studied by Putnam and co-workers (1949). They reported a significant association between ascorbic acid intake and blood content. Higher blood levels accompanied higher dietary intakes on the average and vice versa. Jolliffe, et al, (1950) reported that if recent intake is liberal, 75 to 100 mg., values obtained will be 1.0 to 1.4 mg. per cent, and if smaller doses of 15 to 25 mg. has been taken, values will be 0.1 to 0.3 mg. per cent.

Ascorbic acid functions in some way in giving the body increased resistance to disease and infections. This was shown by King and Menten

(1935) in their experiment on the influence of ascorbic acid upon resistance to diphtheria toxin. After injection of the toxin the survival time of guinea pigs was shortened about 50 per cent when the animals were partially depleted of their ascorbic acid reserves before any scorbutic signs appeared externally. This experiment shows that there is a wide zone of ascorbic acid deficiency before scurvy appears when the animal is more sensitive to injury from bacterial toxins.

Since the resistance to infection was indicated, investigators have tried to find a correlation between acute and chronic illnesses and ascorbic acid values of the blood serum. Rinehart and co-workers in a series of articles (1934a, 1934b, 1936, 1937, 1938, and 1943) have reported evidence that would indicate a relationship between ascorbic acid deficiency and rheumatic fever. Wilson and Lubschev (1946) studied the relation of ascorbic acid intake to blood levels in normal children and those with acute and chronic illnesses. They found that the blood levels of the rheumatic fever subjects did not differ from those of non-rheumatic fever subjects on the same intakes. Another study (Nutrition Reviews, 1944) found that patients with rheumatic fever had low plasma ascorbic acid values and convalescents of that disease had subnormal values. A later report gave the opinion (Note in Jour. Amer. Med. Assoc., 1948) that adequate doses of ascorbic acid are as important in the diet of rheumatic fever patients as with any other acute or chronic disease. However, they also stated that massive doses above the normal requirements have no specific effect. A preliminary report by Massell and co-workers (1950) stated that previous therapeutic failures of ascorbic acid were due to the fact that the investigators were thinking of vitamin C deficiency and therefore used small doses. Massell used as much as 4 grams per day with good results. Coburn

(1951) also reported good results were obtained from large doses (1 to 4 grams) of ascorbic acid in treating children with rheumatic fever. Other factors such as medications given for treatment of rheumatic fever enter in and may vary the amount of ascorbic acid which should or can safely be administered. These possibilities merit further investigation.

Diet seems to exert an important influence on health and disease as is indicated by the studies of Jackson and associates (1949) who found that deficiencies of ascorbic acid occur in combination with other nutritional deficiencies, namely, lack of protein, calcium, phosphorus, iron, and vitamin A, and that these deficiencies seem to be a predisposing factor of rheumatic fever. Peete (1944) suggested that poor dietary habits, skin coloring, variation of diet due to seasons, and altitude all have some effect on the incidence of rheumatic fever.

The state of Utah has been found to have a high incidence of rheumatic fever. Young and Viko (1950) studied a group of fifth grade students and found that although Utah is high in incidence of rheumatic fever, it is not as high as had been feared. However, the incidence is high in relation to other parts of the United States. They also found that about 50 per cent of the students examined had functional or non-pathological heart murmurs.

In relation to teeth. One of the pathological changes that occur in scurvy is that affecting the teeth and gums. The gingival tissues swell and loosen from the teeth (Jolliffe, et al. 1950) allowing infection to enter. These changes have led many investigators to study the relationship between gingivitis and peridontal disturbances and ascorbic acid deficiencies. Burrill (1942) found that ascorbic acid values in the plasma tended to be lower in patients with gingivitis than in those free from this disorder.

Patients with peridontal disease also showed lower ascorbic acid values. However, Burrill suggests that a patient who neglects his mouth may also neglect his diet and that the poor conditions result from the same cause rather than one from the other.

Since ascorbic acid was found to aid in repair of gingival tissue, it has been thought that an excess of the vitamin would cause damage to the enamel of the teeth. Hess and Smith (1949) studied the ascorbic acid content of the saliva in carious and non-carious subjects. They found a slight difference which showed no statistical significance. Miller (1950) found that acid fruits gave a slight enamel erosive effect but that the juices from them had marked erosive properties. This was also found to be true by Spencer and Ellis (1950) in an experiment with male rats with the sole beverage being commercially canned grapefruit juice. With the addition of 50 ppm. of fluoride to the juice, however, 60 per cent protection was afforded the enamel. In contrast to these findings Ruskin, et al. (1948) found that the normal drinking of orange juice would not injure the enamel except where the decay had already begun. They also found that if the ascorbic acid were replaced with a neutral salt such as sodium or calcium ascorbate, little involvement of the dental enamel was apparent.

Blood Glucose

Glucose is the sugar that is normally present in the blood. Best and Taylor (1950) give the approximate normal levels of blood sugar at 0.08 to 0.11 per cent, or 80 to 110 mg. per cent. The normal level is maintained by a balance between the rate at which glucose enters the blood stream and the rate at which it leaves. The liver maintains a normal blood sugar level by converting excess glucose absorbed into the blood from the intestines into glycogen. When the blood level falls the glycogen

in the liver is reconverted into glucose to maintain the normal blood level. Abnormal amounts of sugar in the blood may appear when various disorders of carbohydrate metabolism occur. These disorders will not be discussed in this paper.

EXPERIMENTAL PROCEDURE

The children which comprised the rheumatic fever group were from the Ogden, Utah, rheumatic fever clinic and were paired as to age, sex, and economic status with normal children from the same area. The study included 131 children having rheumatic fever and their normal controls and 46 parents of the children having rheumatic fever. All of the children were born and reared in Utah except 7.6 per cent of the children having rheumatic fever and 10 per cent of the normal children. For some comparisons the rheumatic fever group was divided into those with a heart murmur and those without a heart murmur. The children ranged in age from 5 to 19 years; approximately five-sixths of the subjects of both sexes were in the age group 8 to 16, inclusive. The study was conducted through the period July to December, 1950.

Children from three areas of Idaho which represented differences in dental caries incidence as shown in a previous study (Porter and Woods 1951) were chosen. Boise, Nampa, and Coeur d'Alene were the places selected due to the differences in fluoride content of the water supplies. The water which supplies Boise contains 0.3, Nampa 1.5, and Coeur d'Alene 0.0 ppm. of fluorine. Ninety-four children from Boise, 92 from Nampa and 94 from Coeur d'Alene participated in the study. The groups were compared as to age, sex, and area, and were 15 and 16 years of age. Only children who were born and reared in each area were studied. This phase of the study covered the period January to June, 1951.

Participants from both studies were required to come to the clinic without breakfast where they had a physical examination and X-ray. The

blood and urine samples were taken here for analyses.

Twenty milliliters of blood were taken from a vein in the arm. A small portion of it was oxalated and the rest allowed to clot in a centrifuge tube. Oxalated blood was used for blood glucose determination within about 5 minutes from the time it was drawn. The blood in the centrifuge tube was allowed to stand 10 minutes and was loosened with a long wooden applicator stick so that the serum would come off clear after centrifuging. It was centrifuged for 10 minutes and the clear serum was removed from the packed cells with a medicine dropper. This serum was then used for the ascorbic acid and other determinations.

A modification of the Lowry, Lopez and Bessey method (1945) was used to determine the ascorbic acid. The protein was precipitated directly with trichloracetic acid without the addition of norit. Triplicate aliquots of 20 lambdas of serum were analyzed for each subject. The samples of serum in trichloracetic acid were stored in a refrigerator until the next day before completing the analyses, or, if the analyses could not be completed until later, the supernatant liquid was removed from the protein after centrifuging and was frozen.

The glucose was determined by a modification of the Miller and Van Slyke method (1936). The blood was deproteinized by the Somogyi copper sulfate method and the resulting filtrate used for the determination.

A statistical analysis was run on the paired values of the normal children versus those having rheumatic fever of all ages and sex, and on each age group (Snedecor 1950). The remainder of the analyses was run on groups, comparing each age group within the normal and rheumatic fever groups. An analysis of variance was used to compute the variance in the data from the Idaho study.

RESULTS AND DISCUSSION

Ascorbic Acid

Utah data. The statistical analysis of the differences of the normal children and those with rheumatic fever as given in table 1 showed that ascorbic acid values were highly significant in favor of the rheumatic fever group. The analyses were based on the paired samples for all ages and both sexes. When the children were divided into the two sexes, the differences between the females were highly significant in favor of the rheumatic fever group while the values for the males did not show a significant difference. Division into two age groups showed that the 5 to 12 year old females having rheumatic fever had significantly higher values than the normal group of the same age, while males of the same age did not. In the age group 13 to 19 differences were not significant for either sex.

The ascorbic acid values for each age group and sex in the normal and rheumatic fever groups are shown in tables 2 and 3. The 5 to 12 year old males of the normal group had significantly more serum ascorbic acid than the age group 13 to 19, while comparisons of the same age groups of the females did not show any significance. Comparison of the 5 to 12 year old females with those of the age group 13 to 18 in the rheumatic fever group in table 3 showed that the values of the younger females were significantly higher than the older group. Significant differences were also found between the 5 to 12 year old males and those of the age group 13 to 19. When all the 5 to 12 year old children from the normal and rheumatic fever groups were compared with all those in the older group differences were not significant.

Table 1. Statiscal analysis: Paired ascorbic acid values of blood serum of normal children and those having rheumatic fever

Age	Sex	No. children	Ascorbic Acid		Pair difference ±S.E.
			Normal Mean± S.E.	Rheumatic fever Mean± S.E.	
			mg. %	mg. %	
5-12	Males	36	1.37± .063	1.40 ± .056	.034 ± .052
13-19	Males	27	1.03 ± .072	1.05 ± .100	.016 ± .073
5-12	Females	33	1.18 ± .068	1.48 ± .061	.30 ± .063**
13-18	Females	35	1.09 ± .066	1.19 ± .065	.104 ± .054
5-19	Males	63	1.22 ± .051	1.25 ± .057	.026 ± .043
5-18	Females	68	1.13 ± .047	1.33 ± .048	.198 ± .041**
5-19	Total	131	1.18 ± .035	1.29 ± .037	.11 ± .027**

*Significant at P = .05
**Highly significant at P = .01

Table 2. Statistical analysis: Comparison of serum ascorbic acid values of different age groups of normal children

Children			Ascorbic acid	Vs.	Children			Ascorbic acid	Mean diff.
Age	Sex	No.	Mean ± S.E.		Age	Sex	No.	Mean ± S.E.	± S.E.
			mg. %					mg. %	
5-12	F	33	1.18± .068	vs.	13-18	F	35	1.09 ±.066	.09 ±.094
5-12	M	36	1.37 ±.063	vs.	13-19	M	27	1.03 ±.072	.34 ±.095**
5-12	F	33	1.18 ±.068	vs.	5-12	M	36	1.37 ±.063	.19 ±.092*
13-18	F	35	1.09 ±.066	vs.	13-19	M	27	1.03 ±.072	.06 ±.097
5-12	F	33	1.18 ±.068	vs.	13-19	M	27	1.03 ±.072	.15 ±.098
13-18	F	35	1.09 ±.066	vs.	5-12	M	36	1.37 ±.063	.28 ±.091**

*Significant at P = .05
**Highly significant at P = .01

Table 3. Statistical analysis: Comparison of serum ascorbic acid values of different age groups of children having rheumatic fever

Children			Ascorbic acid	Vs.	Children			Ascorbic acid	Mean diff.
Age	Sex	No.	Mean± S.E.		Age	Sex	No.	Mean ± S.E.	± S.E.
			mg. %					mg. %	
5-12	F	33	1.48 ± .061	vs.	13-18	F	35	1.19 ± .065	.29 ± .090**
5-12	M	36	1.40 ± .056	vs.	13-19	M	27	1.05 ± .100	.35 ± .114**
5-12	F	33	1.48 ± .061	vs.	5-12	M	36	1.40 ± .056	.08 ± .083
13-18	F	35	1.19 ± .065	vs.	13-19	M	27	1.05 ± .100	.14 ± .120
5-12	F	33	1.48 ± .061	vs.	13-19	M	27	1.05 ± .100	.43 ± .118**
13-18	F	35	1.19 ± .065	vs.	5-12	M	36	1.40 ± .056	.21 ± .087**

*Significant at P = .05
**Highly significant at P = .01

The values of the 5 to 12 year old males were significantly higher than those of the females of the same age in the normal group; however, in the 5 to 12 year old children of the rheumatic fever group differences between the sexes were not significant. Comparison of the ascorbic acid levels of all the 5 to 12 year old males against those of all the females of the same age did not show any significance. Comparison of the levels of the younger males with those of the older females showed differences significantly higher in both the normal and rheumatic fever groups. The younger females of the rheumatic fever group also had values significantly higher than those of the older males.

In general, it appeared that the children with rheumatic fever were higher in ascorbic acid than the normal children and also that the younger children were higher than the older groups. This is also shown by the comparison of the ascorbic acid values of some of the parents who participated with normal and rheumatic fever groups (table 4). The ascorbic acid values of the 46 parents cooperating with the study ranged from 0.22 to 1.93 mg. per cent. The values of the children ranged from 0.26 to 2.31 mg. per cent. In all cases the children of the 5 to 12 age group were significantly higher than the parents. The older males of both groups of children did not show any differences in serum ascorbic acid from the parents while the older females of the normal group of children were approaching significance, and those of the rheumatic fever group were significant. The total normal children compared with the parents were highly significant in favor of the normal children. The total rheumatic fever group were also significantly higher than the parents.

The serum ascorbic acid values for the Utah study ranged from 0.26 to 2.31 mg. per cent. Nine of the children were below 0.4 mg. per cent and

Table 4. Statistical analysis: Comparison of serum ascorbic acid values of normal children and those having rheumatic fever with the values obtained for the parents

Normal children			Ascorbic acid	Parents	Ascorbic acid	Mean diff.
Age	Sex	No.	Mean ± S.E.	No.	Mean ± S.E.	± S.E.
			mg. %		mg. %	
5-12	Male	36	1.37 ± .063	46	.96 ± .065	.41 ± .090**
13-19	Male	27	1.03 ± .072	46	.96 ± .065	.07 ± .096
5-12	Female	33	1.18 ± .068	46	.96 ± .065	.22 ± .093*
13-18	Female	35	1.09 ± .066	46	.96 ± .065	.13 ± .093
5-19	Total	131	1.18 ± .035	46	.96 ± .065	.22 ± .073**
Rheumatic fever				Parents		
5-12	Male	36	1.40 ± .056	46	.96 ± .065	.44 ± .085**
13-19	Male	27	1.05 ± .100	46	.96 ± .065	.09 ± .119
5-12	Female	33	1.48 ± .061	46	.96 ± .065	.52 ± .089**
13-18	Female	35	1.19 ± .065	46	.96 ± .065	.23 ± .092**
5-19	Total	131	1.29 ± .037	46	.96 ± .065	.33 ± .075**

*Significant at P = .05
**Highly significant at P = .01

36 above 1.6 mg. per cent. A study by Moyer, et al. (1948) gave values ranging from 0.2 to 2.4 mg. per cent for 2 to 18 year old children. Storvick and co-workers (1951) gave ascorbic acid values ranging from 0.0 to 2.2 mg. per cent in a nutritional status study of 14 to 16 year old children conducted in Oregon.

The range in mean ascorbic acid values for the Utah study was 1.03 to 1.37 mg. per cent for the normal group and 1.05 to 1.48 for the rheumatic fever group. Putnam, et al. (1949) gave mean values of plasma ascorbic acid ranging from 0.31 to 1.04 mg. per cent. Storvick and co-workers (1951) gave mean values ranging from 0.6 to 1.2 mg. per cent while Moyer, et al. (1948) gave mean values of from 0.68 to 1.19 mg. per cent.

After rheumatic fever has been diagnosed in a patient, improved dietary habits are recommended as a part of the treatment. Such improvement in the diet would tend to bring about higher serum ascorbic acid in these patients. Another fact which might affect this value is supplements to the diet in the form of vitamin pills or capsules. Grouping the children who took vitamin pills into normal and rheumatic fever groups showed differences in serum ascorbic acid in favor of the rheumatic fever group. These differences, however, were not significant. Comparisons of these two groups with those who did not take vitamin pills were not significant. The rheumatic fever group did approach significance, however.

The ascorbic acid values for the rheumatic fever subjects with a heart murmur were approaching significance compared with those without a murmur. Normal children were also compared with the subjects having rheumatic fever with murmurs and without murmurs, and the difference was found to be significant in favor of the children with rheumatic fever.

High sedimentation rate as found in this study did not appear to be

correlated with the blood serum ascorbic acid value. The children with rheumatic fever having sedimentation rates above 15 mm./hr. were compared with those of the same age and sex and the mean serum ascorbic acid value for both was almost the same (1.20 mg. per cent and 1.21 mg. per cent).

A test was run between values for ascorbic acid and weight to see if there was any correlation (Figure 1). A negative correlation coefficient of -.4009 was obtained and this is significant at $P = <.01$. Therefore, it would appear that as the subject gains in weight his blood serum ascorbic acid value would drop. However, many other factors enter in which should be taken into consideration, but they will not be discussed here.

Idaho data. The ascorbic acid values from the three different areas of Idaho showed significant differences between sex, adjusted to age and area, and between areas, adjusted to age and sex. The analysis of variance is reported in table 5 and the adjusted mean values in table 6. The range of values in the Boise area was 0.12 to 1.92 mg. per cent, in Nampa 0.09 to 2.32 mg. per cent, and Coeur d'Alene 0.23 to 2.40 mg. per cent. The females of both ages had higher ascorbic acid values than the males (1.20 and 0.95 mg. per cent, respectively). Of the three areas tested, Coeur d'Alene had the highest ascorbic acid value of 1.18 mg. per cent. This area also shows the highest incidence of dental caries. Fifty-eight of the children were found to be below 0.4 mg. per cent and 16 above 1.6.

The mean values obtained from the Ogden, Utah, study for the children over age 15 were 0.94 and 0.93 mg. per cent ascorbic acid for the males of the normal and rheumatic fever groups, 1.04 and 1.26 mg. per cent for the females of the normal and rheumatic fever groups, respectively. A total of 59 subjects were in this group. The values of the males compared to the Idaho data show very little difference and the values of the females

Table 5. Analyses of variance of serum ascorbic acid values of Idaho school children

Source	df	Sqs	Msqs
Overall effect, adj.	1	52.934	52.934
Age, adj.	1	.0433	.0433
Sex, adj.	1	2.1672	2.1672**
Age, sex, adj.	1	.0241	.0241
Area, adj.	2	2.5369	1.2684**
Remainder	272	66.4965	.2445
Total	278	289.8100	

**Highly significant at P = .01

Table 6. Ascorbic acid content of blood serum of Idaho school children

Source	Number of children	Ascorbic acid	
		Observed mean	Adjusted mean
		mgm.%	mgm.%
Age:			
15	131	0.92	1.09
16	146	0.86	1.06
Sex:			
Male	125	0.75	0.95
Female	152	0.99	1.20
Area:			
Boise	94	0.78	0.98
Nampa	90	0.88	1.07
Coeur d'Alene	93	0.99	1.18

of the rheumatic fever group from Utah and the females from Idaho are similar. The females from the normal group in the Utah study, however, lie midway between the other values. Variations in the values may be due to differences in the season of the year when the samples were taken. The Utah study was completed in the summer and fall and the Idaho study in the winter and spring.

A report from an Oregon nutritional study (Storvick 1951) on children 14 to 16 years of age gave mean values that range from 0.6 to 1.2 mg. per cent. These values would be slightly lower than the mean values for Utah (0.96 to 1.48 mg. per cent) and for Idaho (0.95 to 1.20 mg. per cent).

Blood Glucose

Utah data. The blood glucose values ranged from 69.5 mg. per cent to 118.5 in the normal group and 49.5 to 121.8 in the rheumatic fever group. The normal range is given as 80 to 110 mg. per cent (Best and Taylor 1950). These values, therefore gave a wider range than normal, especially those of the rheumatic fever group. The differences in blood glucose values in the younger and older children and between normal and rheumatic fever groups were not significant when the paired analysis was used (table 7). Some significant differences did appear, however, in comparing the values of the 5 to 12 year old males against the 13 to 19 year old males in the normal group and in comparing the 5 to 12 year old females with the older group of males in the same group (table 8). The older males were higher in both cases. There were no significant differences in any of the rheumatic fever group comparisons (table 9). The blood glucose values of the 45 parents cooperating with the study ranged from 58.2 to 113.0 mg. per cent. Comparisons of the 5 to 12 year old males of the normal group with the parents did approach significance while the rest did not (table 10). Values for

Table 7. Statistical analysis: Paired analyses of blood glucose values of normal children and those having rheumatic fever

Age	Sex	No. children	Blood Glucose		Pair difference ± S.E.
			Normal Mean ± S.E.	Rheumatic fever Mean ± S.E.	
			mg. %	mg. %	
5-12	Males	35	84.1 ± 1.36	86.1 ± 2.04	0.48 ± 1.53
13-19	Males	27	90.4 ± 1.97	89.1 ± 1.50	0.13 ± 1.37
5-12	Females	34	84.8 ± 1.66	85.3 ± 1.32	0.06 ± 1.28
13-18	Females	34	86.2 ± 1.33	85.3 ± 1.89	0.10 ± 1.76
5-19	Males	62	86.9 ± 1.20	87.4 ± 1.34	0.50 ± 1.04
5-18	Females	68	85.5 ± 1.06	85.3 ± 1.37	0.20 ± 1.09
5-19	Total	130	86.2 ± 0.80	86.3 ± 0.87	0.13 ± 0.24

Table 8. Statistical analysis: Comparison of blood glucose values of different age groups of normal children

Children			Blood glucose Mean ± S.E.	Vs.	Children			Blood glucose Mean ± S.E.	Mean diff. ± S.E.
Age	Sex	No.			Age	Sex	No.		
			mg. %					mg. %	
5-12	F	34	84.8 ± 1.66	vs.	13-18	F	34	86.2 ± 1.33	1.4 ± 2.13
5-12	M	35	84.1 ± 1.36	vs.	13-19	M	27	90.4 ± 1.97	6.3 ± 2.39*
5-12	F	34	84.8 ± 1.66	vs.	5-12	M	35	84.1 ± 1.36	0.7 ± 2.14
13-18	F	34	86.2 ± 1.33	vs.	13-19	M	27	90.4 ± 1.97	4.2 ± 2.38
5-12	F	34	84.8 ± 1.66	vs.	13-19	M	27	90.4 ± 1.97	5.6 ± 2.57*
13-18	F	34	86.2 ± 1.33	vs.	5-12	M	35	84.1 ± 1.36	2.1 ± 1.90

*Significant at P = .05

Table 9. Statistical analysis: Comparison of blood glucose values of different age groups of children having rheumatic fever

Children			Blood glucose	Vs.	Children			Blood glucose	Mean diff.
Age	Sex	No.	Mean± S.E.		Age	Sex	No.	Mean± S.E.	± S.E.
			mg. %					mg. %	
5-12	F	34	85.3+ 1.32	vs.	13-18	F	34	85.3 +1.89	0.0 + 2.31
5-12	M	35	86.1± 2.04	vs.	13-19	M	27	89.1 ±1.50	3.0 ± 2.54
5-12	F	34	85.3± 1.32	vs.	5-12	M	35	86.1 ±2.04	0.8 ± 2.43
13-18	F	34	85.3± 1.89	vs.	13-19	M	27	89.1 ±1.50	3.8 ± 2.42
5-12	F	34	85.3± 1.32	vs.	13-19	M	27	89.1 ±1.50	3.8 ± 2.00
13-18	F	34	85.3± 1.89	vs.	5-12	M	35	86.1 ±2.04	0.8 ± 2.78

Table 10. Statistical analysis: Comparison of blood glucose values of normal children and those having rheumatic fever with values obtained for the parents

Normal children			Blood glucose	Parents	Blood glucose	Mean diff.
Age	Sex	No.	Mean± S.E.	no.	Mean± S.E.	± S.E.
			mg. %		mg. %	
5-12	Males	35	84.1± 1.36	45	88.2± 1.61	4.1± 2.10
13-19	Males	27	90.4± 1.97	45	88.2± 1.61	2.2± 2.54
5-12	Females	34	84.8± 1.66	45	88.2± 1.61	3.4± 2.30
13-18	Females	34	86.2± 1.35	45	88.2± 1.61	2.0± 2.09
5-19	Total	130	86.2± 0.80	45	88.2± 1.61	2.0± 1.79
Rheumatic fever				Parents		
5-12	Males	35	86.1± 2.04	45	88.2± 1.61	2.1± 2.60
13-19	Males	27	89.1± 1.50	45	88.2± 1.61	0.88±2.20
5-12	Females	34	85.3± 1.32	45	88.2± 1.61	2.9± 2.08
13-18	Females	34	85.3± 1.89	45	88.2± 1.61	2.9± 2.48
5-19	Total	130	86.3± 0.87	45	88.2± 1.61	1.9± 1.83

the children in the rheumatic fever group compared with the parents did not show any significant differences.

Children who had heart murmurs and those who did not have murmurs had similar glucose values.

Idaho data. The blood glucose values from the Boise children ranged from 82.5 to 143.5 mg. per cent, those from Nampa 85.5 to 120.0, and the Coeur d'Alene values were 74.0 to 150.0. The glucose values from the three different areas of Idaho showed significant differences between the two sexes, adjusted to age and area, and between the three areas, adjusted to sex and age (table 11). The males had the highest glucose of the two sexes (table 12) and the children from the Coeur d'Alene area had the highest glucose values of the three areas. It is interesting to note here that the results of the dental phase of this study (Porter 1952) showed a high incidence of dental caries in the Coeur d'Alene area. Might there be a relationship between these two findings?

The glucose values from the Idaho study were higher than the Utah values. The children from the Ogden, Utah, area had mean values ranging from 85.1 to 89.0 mg. per cent as compared to the range for Idaho children of 102.7 to 106.2.

Table 11. Analyses of variance of blood glucose values of Idaho school children

Source	df	Sqs	Msqs
Overall effect, adj.	1	500081.6	500081.6
Age, adj.	1	78.504	78.504
Sex, adj.	1	424.893	424.893*
Age, sex, adj.	1	17.576	17.576
Area, adj.	2	621.345	310.673*
Remainder	272	24966.46	91.788
Total	278	2991248.2	

*Statistically significant at P = .05

Table 12. Blood glucose values of Idaho school children

Source	Number of children	Blood glucose	
		Observed mean	Adjusted mean
		mgm. %	mgm. %
Age:			
15	134	102.5	103.67
16	144	104.0	105.13
Sex:			
Male	124	104.9	106.13
Female	154	102.0	102.67
Area:			
Boise	94	102.4	103.54
Nampa	91	102.7	103.50
Coeur d'Alene	93	104.8	106.16

SUMMARY

The serum ascorbic acid and blood glucose values have been determined on children with and without rheumatic fever in Utah and on children in three areas of Idaho, each of which has a different fluoride content of water.

The Utah study included 131 children having rheumatic fever and their normal controls and 46 parents of the children having rheumatic fever.

Three areas of Idaho were represented: Boise with 94 children of the 15 and 16 age group, Nampa 92, and Coeur d'Alene with 94.

The statistical analysis of ascorbic acid values of the normal children and those with rheumatic fever showed highly significant differences in favor of the rheumatic fever group. The range in mean ascorbic acid values for the Utah study was 1.03 to 1.37 mg. per cent for the normal group, and 1.05 to 1.48 for the rheumatic fever group. The females had significantly higher values than the males and the younger children of the 5 to 12 age group, higher values than the older ones, in most cases. When the values for all normal children were compared with that of the parents, differences were highly significant in favor of the normal children. The total rheumatic fever group were also significantly higher than the parents.

A negative correlation of -.4009 was found to exist between ascorbic acid values and weight.

The ascorbic acid values from the three different areas of Idaho showed significant differences between sex, adjusted to age and area, and between areas, adjusted to age and sex. Coeur d'Alene had the highest ascorbic

acid values. The females were highest of the two sexes. The mean values ranged from 0.95 to 1.20 mg. per cent.

The blood glucose values did not show any significant differences in the paired analyses of the Utah study. In the normal group, however, the younger group of males and females were significantly lower than the older males.

The blood glucose values from the three different areas of Idaho showed significant differences between the two sexes, adjusted to age and area, and between the three areas adjusted to sex and age. The males had the highest glucose values of the two sexes, and the children from the Coeur d'Alene area, the highest glucose value of the three areas.

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