# A cephalometric study of children presenting clinical signs of malnutrition*

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Malnutrition per se is customarily included among the etiological factors of human malocclusion.[1,2,3] The experimental evidence in support of this contention rests primarily on observations made during the feeding of restricted diets to growing laboratory animals. In 1924 Howe[4] stated that jaws of monkeys fed on deficient diets became narrow, plastic, and flattened, or extensively decalcified. In a subsequent study in 1927, Howe[5] showed that the deletion of vitamins C and D from the diets of young monkeys resulted in the development of narrow arches and protruding anterior teeth. The mandibular condyles were thick and shapeless with little depth to the sigmoid notch and little height to the coronoid process. In some instances, the coronoid processes were plastic and osteoporotic. Abnormalities in the arrangement of the teeth which accompanied the changes in the conformation of the dental arches were attributed to a lack of growth or to irregular development of the bones containing the tooth crypts. In this study, Howe observed that the configuration of the nasal passages, palatine arches and upper and lower jaws of monkeys maintained on diets lacking in vitamins C and D resembled in clinical appearance the type of distortion which has been associated with thumb sucking and mouth breathing in children. Recently, Levy[6] reported that mice fed pyridoxine-deficient diets underwent a cessation of growth of the mandibular condyle accompanied by regressive changes in the alveolar bone. The addition of large amounts of protein to these diets caused these changes to occur earlier and to appear more severe. Animals fed riboflavin-deficient diets presented condyles whose growth cartilages were significantly narrowed[7]. The mandibular malformations in the riboflavin deficient mice were alleviated by the feeding of adequate amounts of those essential nutrients.

In view of the inherent differences in growth rate, and the difference between the severity of deficiency states which can be produced in laboratory animals as compared with those which occur in children maintained on substandard home diets, the question arises as to whether findings pertaining to maxillofacial growth derived from animal experimentation can be applied to children without reservations. It was decided, therefore, to ascertain whether children with clinical manifestations of nutritive and growth failure have a characteristic skeletal pattern which can be readily discerned from cephalo-

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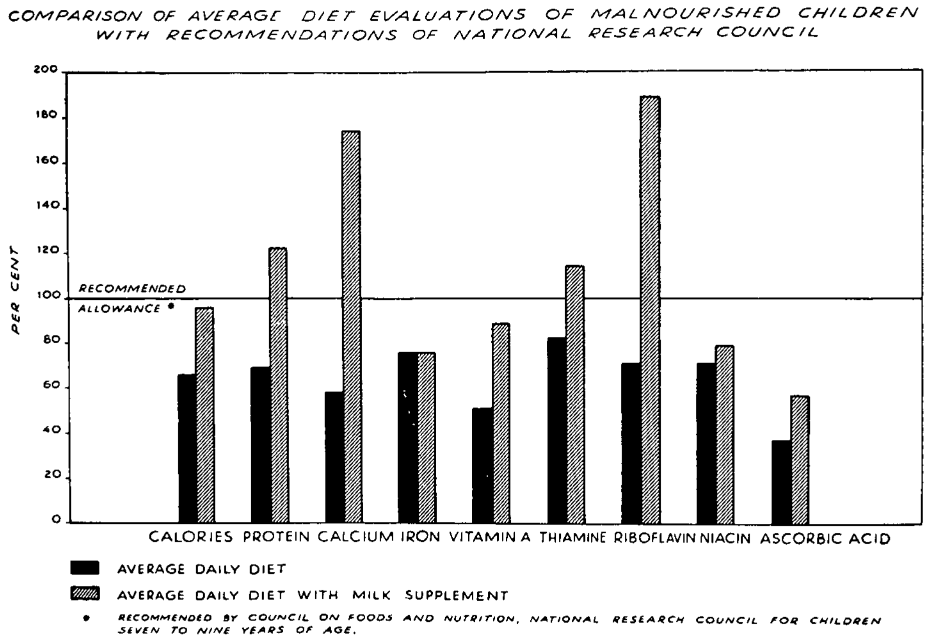


Fig. 1

metric radiographs, and if so, whether it can be changed by a dietary supplement of reliquefied dry milk solids.

## Materials and Methods

The study group consisted of 88 children selected on the basis of history or evidence of nutritive failure in the child, parents or older siblings, freedom from infectious disease and freedom from hypersensitivity to dietary constituents. Clinically these children appeared small for their age, an observation which was supported by Wetzel Grid findings[8]. Each child was of Anglo-Saxon extraction, born in north-central Alabama, and a member of a low income family whose chief source of support was relief funds.

The diets consumed by these children were deficient in all of the nutrients for which standards have been accepted (Figure 1). Forty-five of the 88 children were given a dietary supplement of either whole or non-fat cow's milk three times per week for a period of 31 months between April 1948 and October 1950. This supplement was reconstituted from dried milk powder and given to the children at school or at home by fulltime workers on the staff of the Nutrition Clinic. Each supplement was equivalent in protein value to one quart of raw milk. The increase in the nutritive value of the diet by the addition of the supplement is shown in Figure 1. The forty-three children who did not receive the milk supplement constituted the control group. Milk supplements were given to 22 boys and 23 girls ranging in age from 2 years 5 months to 10 years 9 months. The control group consisted of 21 boys and 22 girls girls ranging in age from 2 years 7 months to 10 years 1 month. The age distribution is shown in Table 1.

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* Dietary evaluations were made by Miss Cleo Arnett.

| *Age* | *Number of Cases* | | | |
|---|---|---|---|---|
| | *Boys* | | *Girls* | |
| | *Test* | *Control* | *Test* | *Control* |
| 2 | 1 | 2 | 2 | — |
| 3 | 4 | 3 | 1 | 2 |
| 4 | — | 2 | 4 | 3 |
| 5 | 5 | 2 | 5 | 4 |
| 6 | 2 | 2 | 2 | 4 |
| 7 | 4 | 3 | 3 | 3 |
| 8 | 2 | 3 | 3 | 4 |
| 9 | 2 | 3 | 3 | 2 |
| 10 | 2 | 1 | | |
| Total | 22 | 21 | 23 | 22 |

Each child was brought to the Nutrition Clinic every four months for examination and radiographing throughout the 31-month test period. Postero-anterior and lateral roentgenograms of the skull were taken by means of a Broadbent cephalostat.[9] The radiographs were placed on a shadow box and tracings made, care being exercised to pick up certain anthropometric landmarks. The anthropometric landmarks used in the evaluation of maxillofacial growth are shown in Figure 2. Measurement of the following angles was made by placing a protractor directly on the tracing:

1) N-A-P
2) NP-AB
3) Difference of S-N-a and S-N-b
4) N-S-Gn
5) NS-GoGn
6) FH-N-P
7) ManPL-FH
8) Difference of S-N-1 and S-N-Gn
9) U1-NS
10) U1-L1
11) L1-Go-Gn
12) ab-FH
13) L1-NP (mm)
14) S-Gn-FH

The Northwestern University Orthodontic Clinic means* for each of these angles served as a standard of reference (Table 2). The mean values for the control group were compared with those constituting the standard of reference. Evaluations were made every four months during the 31-month test period.

## Observations

*The Growth pattern of the skull in children with chronic nutritive failure*: A comparison of the mean values of the fourteen angles of the children with nutritive failure who did not receive milk supplements with those of the Northwestern University Orthodontic Clinic standards is shown in Figures 3 and 4. It will be noted that there is a notable tendency in the former group toward a forward divergent face. With the exception of angle S-Gn-FH, all readings fell with plus/minus one standard deviation from the reference value. The mean value for angle S-Gn-FH exceeded minus one standard deviation at each evaluation in the boys and in all but three of the evaluations in the girls. The means of angles ManPL-FH, NS-GN (boys) and U1-NS, and the difference of angles S-N-L1 and S-N-Gn all presented angular increments of a magnitude less than that of the standard, but within minus one standard deviation of the reference

* This is a composite table of means and standard deviations taken from works done by Mayne[10] and Riedel.[11]

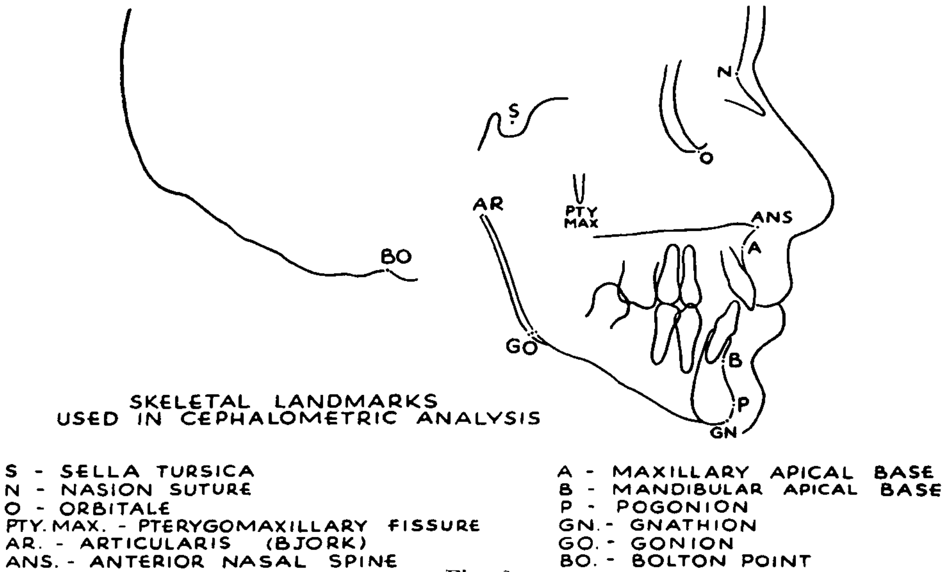



Fig. 2

values. The mean values for angles FH-NP and ab-FH exceed those of the standard to a degree, which at some points was greater than plus one standard deviation. No significant difference was observed between the means of the group of children with nutritive failure and the standard of reference for angle N-A-P and the difference of angles S-N-a and S-N-b, two angles frequently used as an aid in orthodontic diagnosis.

The findings pertaining to the denture pattern of the children with nutritive failure are shown in Figure 4. These curves are more irregular than those depicting the skeletal pattern. The denture pattern was characterized by a substandard degree of labial in-

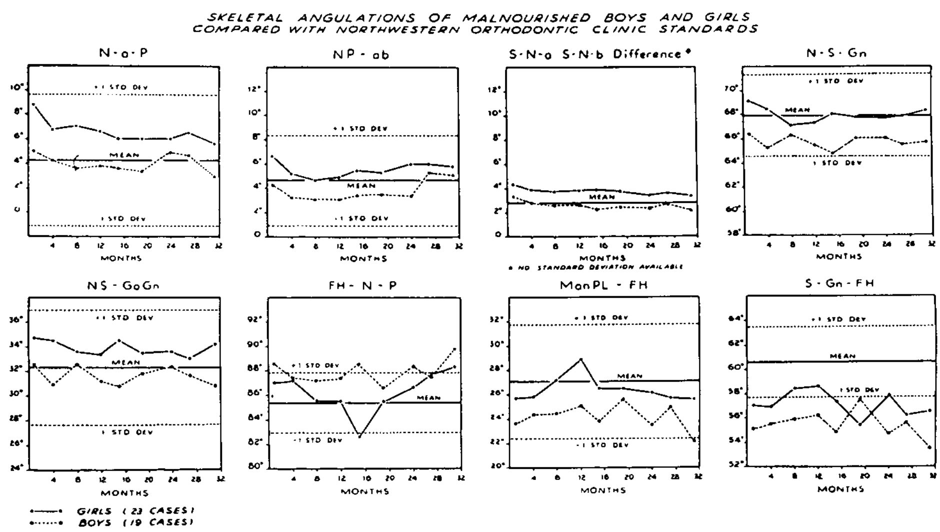



Fig. 3

Table 2: Comparison of mean values and standard deviation of angular measurements in test and control groups for April 1948 and July 1950, together with values used in Northwestern University Orthodontic Clinic

| Angle | Mean Values* | | | | | Standard Deviation* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Northwestern Univ. Clinic | Nutrition Clinic | | | | Northwestern Univ. Clinic | Nutrition Clinic | | | |
| | | Boys | | Girls | | | Boys | | Girls | |
| | | Test | Control | Test | Control | | Test | Control | Test | Control |
| **April, 1948** | | | | | | | | | | |
| N-a-p | 4.22 | 9 | 4.4 | 5.11 | 8.3 | 5.38 | 5.18 | 6.40 | 5.11 | 3.96 |
| NP-ab | —4.6 | —5.5 | —2.85 | —5.26 | —4.47 | 3.67 | 3.156 | 4.147 | 2.683 | 1.893 |
| Diff. S-N-a— S-N-b | 2.77 | 3.8 | 3.36 | 3.5 | 4.16 | | 2.674 | 2.258 | 2.086 | 2.355 |
| N-S-Gn | 67.69 | 68.28 | 66.12 | 67.85 | 68.31 | 3.34 | 2.007 | 3.48 | 4.319 | 3.775 |
| NS-GoGn | 32.27 | 35.3 | 32.0 | 34.9 | 35.1 | 4.67 | 5.238 | 5.172 | 4.58 | 3.541 |
| FH-N-P | 85.33 | 86.1 | 88.32 | 85.44 | 85.6 | 2.42 | 4.949 | 3.766 | 4.937 | 5.894 |
| ManPl-FH | 27.06 | 27.6 | 23.4 | 26.6 | 28.2 | 4.67 | 6.799 | 4.320 | 5.126 | 7.852 |
| S-Gn-FH | 60.58 | 57.53 | 55.03 | 57.4 | 57.33 | 2.89 | 4.236 | 4.197 | 5.114 | 3.711 |
| ab-FH | 80.58 | 80.8 | 84.4 | 80.7 | 81.0 | 4.25 | 5.662 | 5.762 | 4.636 | 4.183 |
| **July, 1950** | | | | | | | | | | |
| N-a-P | 4.22 | 8.02 | 2.6 | 5.97 | 7.1 | 5.38 | 6.36 | 6.9 | 4.87 | 3.06 |
| NP-ab | —4.6 | —6.43 | —4.36 | —5.29 | —6.03 | 3.67 | 2.779 | 2.630 | 1.944 | 1.946 |
| Diff. S-N-a— S-N-b | 2.77 | 4.27 | 2.53 | 3.06 | 3.43 | | 2.605 | 3.442 | 1.956 | 1.693 |
| N-S-Gn | 67.69 | 68.05 | 65.63 | 67.61 | 67.23 | 3.34 | 3.391 | 3.743 | 3.207 | 3.596 |
| NS-GoGn | 32.27 | 35.18 | 31.8 | 35.8 | 33.3 | 4.67 | 6.157 | 5.961 | 5.728 | 5.264 |
| FH-N-P | 85.33 | 85.9 | 87.1 | 86.2 | 86.4 | 2.42 | 3.635 | 3.766 | 5.041 | 5.860 |
| ManPl-FH | 27.06 | 27.4 | 25.89 | 26.9 | 25.86 | 4.67 | 5.842 | 4.640 | 5.045 | 5.214 |
| S-Gn-FH | 60.58 | 58.21 | 56.7 | 57.5 | 57.0 | 2.89 | 4.999 | 4.123 | 4.716 | 3.575 |
| ab-FH | 80.58 | 79.4 | 83.3 | 81.65 | 81.9 | 4.25 | 4.629 | 4.744 | 4.128 | 2.334 |

*Values given in terms of degrees.

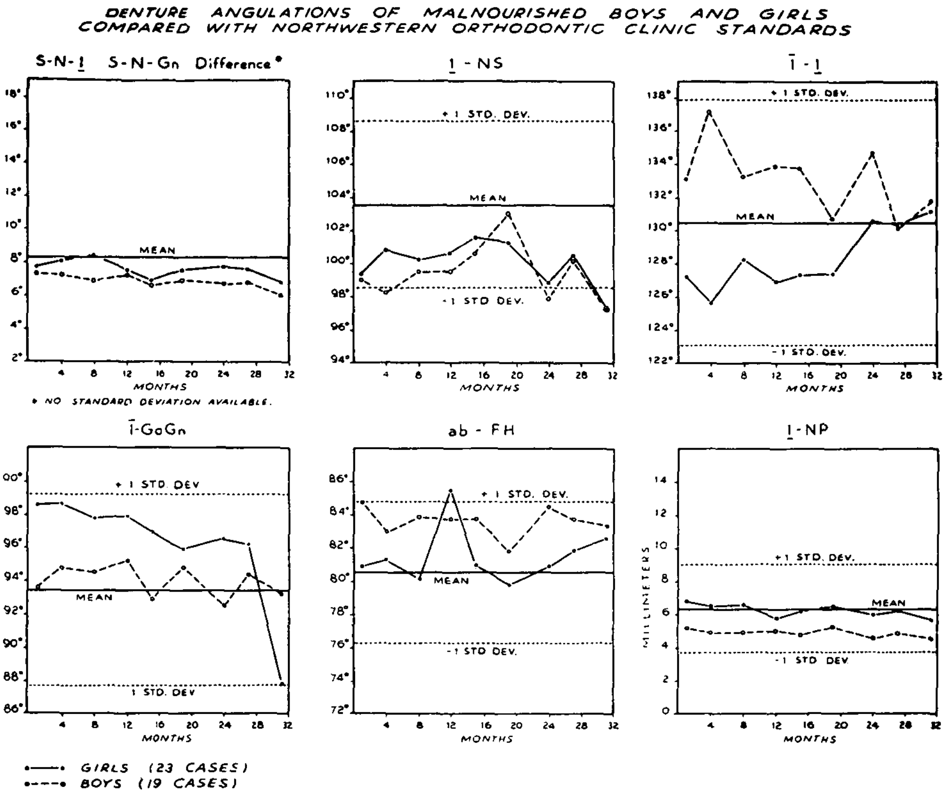



Fig. 4

clination of the maxillary incisors as manifested by a low U1-NS angle. The axial inclination of the mandibular incisors to the Go-Gn plane were within the range of normal, resulting in a high U1-L1 angle. For the girls this finding was not as prominent in the beginning of the experiment due to the high L1-GoGn angle. The distance from the tip of the maxillary incisor to the NP plane in millimeters, while within one standard deviation of the reference value, was consistently below the mean.

*The Effect of milk supplements on cranial and maxillofacial growth in children with nutritive failure*: Table 3 contains a comparison of beginning and after-supplementation readings of the mean values of the fourteen angles in the two groups of children with nutritive failure. No significant difference was observed between any of the measurements in the children who did and did not receive milk supplements when the data were subjected to statistical analysis. In no instance did the actual difference of means exceed three standard errors. A difference greater than three standard errors is generally regarded as being statistically significant as such an occurrence is unlikely to be due solely to chance.

*The effect of increasing age on the growth pattern of the skull in children with nutritive failure*: In Figures 5, 6, 7, and 8 the mean values of the angles under consideration have been grouped according to chronological age. Evalu-

TABLE 3: STATISTICAL EVALUATION OF MEAN OF ANGULAR MEASUREMENTS IN TEST AND CONTROL GROUPS FOR APRIL 1948 AND JULY 1950

| Angle | Diff. in Test and Control Means* | | Standard Error of Diff. of Means* | | Diff. of Means in terms of Standard Error | | Probability in 100 instances of Diff. in Means due to chance | |
|---|---|---|---|---|---|---|---|---|
| | Boys | Girls | Boys | Girls | Boys | Girls | Boys | Girls |
| **April, 1948** | | | | | | | | |
| N-a-P | 4.6 | 3.2 | 2.167 | 1.695 | 2.1(s.e.) | 1.9(s.e.) | 4 | 6 |
| NP-ab | 1.353 | 0.79 | 1.393 | 0.533 | 0.9 | 1.4 | 37 | 16 |
| Diff. S-N-a— S-N-b | 0.44 | 0.66 | 0.956 | 0.528 | 0.4 | 1.2 | > 50 | 23 |
| N-S-Gn | 2.16 | 0.46 | 1.0881 | 1.409 | 1.9 | 0.32 | 6 | > 50 |
| NS-GoGn | 3.3 | 0.2 | 2.004 | 1.44 | 1.6 | 0.1 | 11 | > 50 |
| FH-N-P | 2.2 | 0.16 | 1.6929 | 1.936 | 1.9 | 0.1 | 6 | > 50 |
| ManPl-FH | 4.2 | 2.56 | 2.153 | 2.378 | 1.9 | 1.1 | 6 | 27 |
| S-Gn-FH | 2.5 | 0.07 | 1.594 | 1.567 | 1.6 | 0.04 | 11 | > 50 |
| ab-FH | 3.6 | 0.3 | 2.158 | 1.559 | 1.6 | 0.2 | 11 | > 50 |
| **July, 1950** | | | | | | | | |
| N-a-P | 5.4 | 1.2 | 5.32 | 1.31 | 0.9 | 0.9 | 37 | 37 |
| NP-ab | 2.07 | 0.74 | 1.023 | 0.494 | 2.02 | 1.5 | 4.5 | 13.3 |
| Diff. S-N-a— S-N-b | 1.84 | 0.37 | 1.169 | 0.645 | 1.6 | 0.57 | 11 | > 50 |
| N-S-Gn | 2.41 | 0.38 | 1.173 | 1.051 | 2.1 | 0.36 | 4 | > 50 |
| NS-GoGn | 3.38 | 2.5 | 2.33 | 1.944 | 1.4 | 1.3 | 16 | 19 |
| FH-N-P | 1.2 | 0.2 | 1.028 | 1.945 | 1.2 | 0.1 | 23 | > 50 |
| ManPl-FH | 1.51 | 1.04 | 1.994 | 1.801 | 0.7 | 0.5 | 48 | > 50 |
| S-Gn-FH | 1.51 | 0.5 | 1.732 | 1.469 | 0.9 | 0.3 | 37 | > 50 |
| ab-FH | 3.9 | 0.25 | 1.771 | 1.169 | 0.2 | 0.2 | 50 | > 50 |

*Values given in terms of degrees.

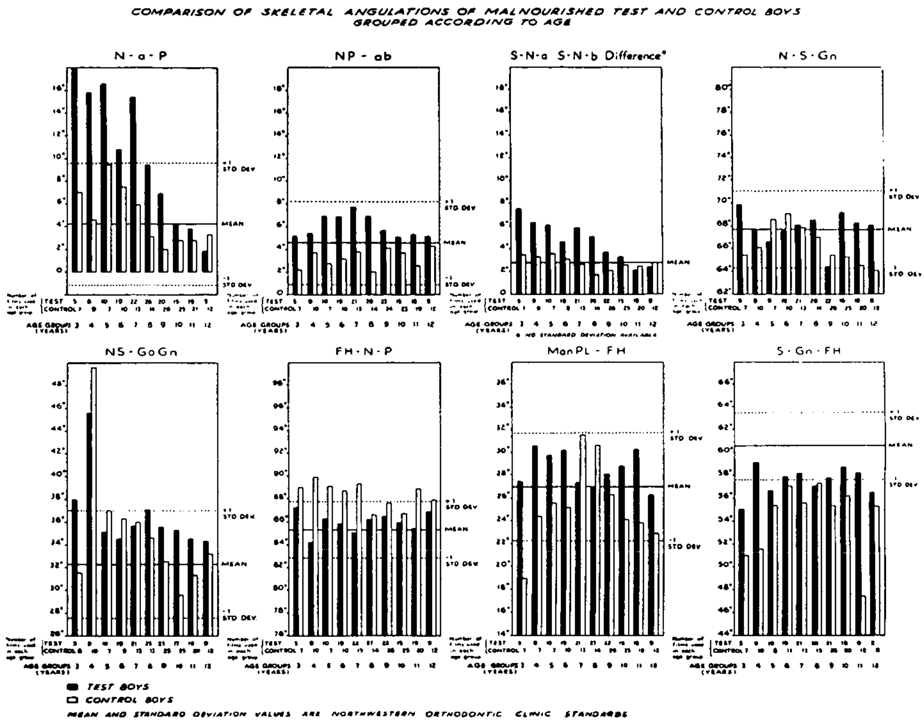



Fig. 5

ations were made for each year between ages three and twelve. A noticeable discrepancy in jaw relationship was observed at ages prior to 7 years. This discrepancy was less marked at 8, 9, and 10 years of age. Angle N-A-P decreased with increasing age. The magnitude of the decrease declined at 9 years of age in the boys and at 8 years of age in the girls. A similar change was noted for the difference between angles S-N-A and S-N-B. The degree of decrease in these angles was greater in the children who received the milk supplements than in the control group. No significant changes were observed in angles FH-NP, NP-AB, and ab-FH. Angles N-S-Gn, S-Gn-FH, and ManPL-FH and NS-GoGn followed an irregular course. The general trend of these angles was an increase of increment at ages 2 to 5 years, a lesser increase at ages 5 to 10 years, and a slight decrease of increment at 10 years of age and over.

The denture patterns underwent a characteristic change. The maxillary incisors inclined labially with age, increasing the U1-NS angle. There was a corresponding decrease in angle U1-L1 and a slight increase in the relation of the mandibular incisor to the Go-Gn plane. The distance from the tip of the maxillary incisors to the NP plane increased slightly. The relation of the most labial portion of the maxillary incisor to the Gn point remained unchanged. The labial inclination of the maxillary incisors together with the forward positioning of the anterior portion of the maxilla kept pace with the forward positioning of the Gn point due to growth of the mandible.

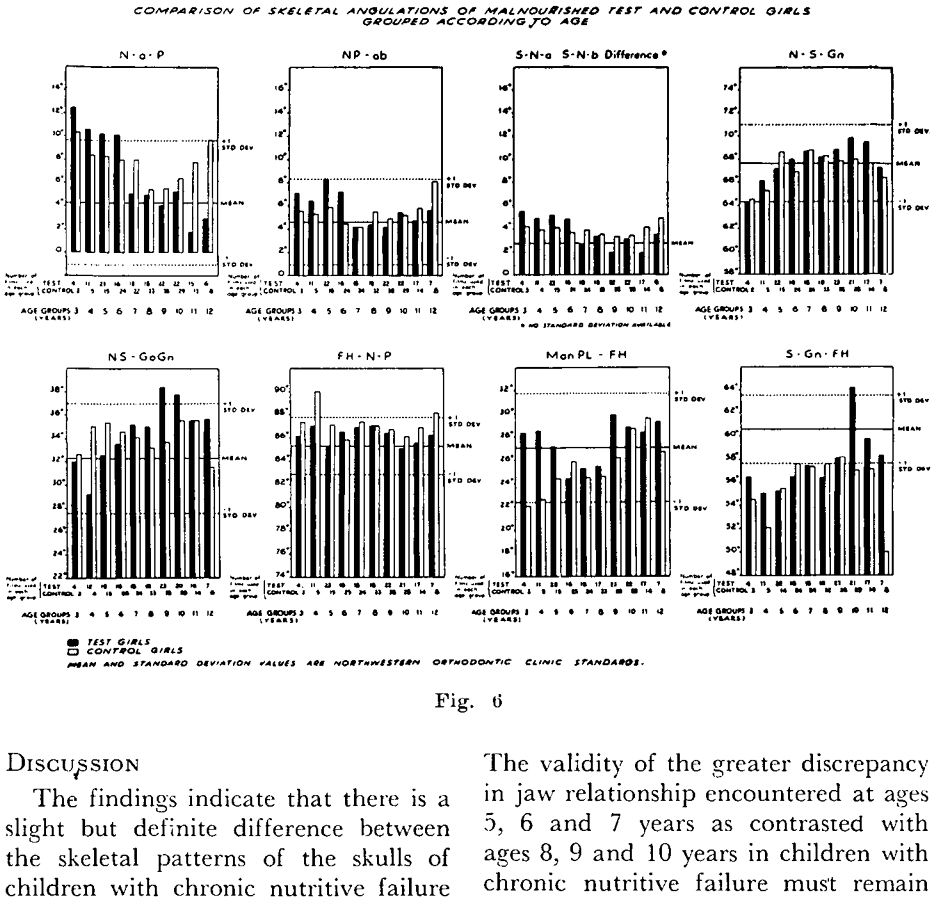



Fig. 6

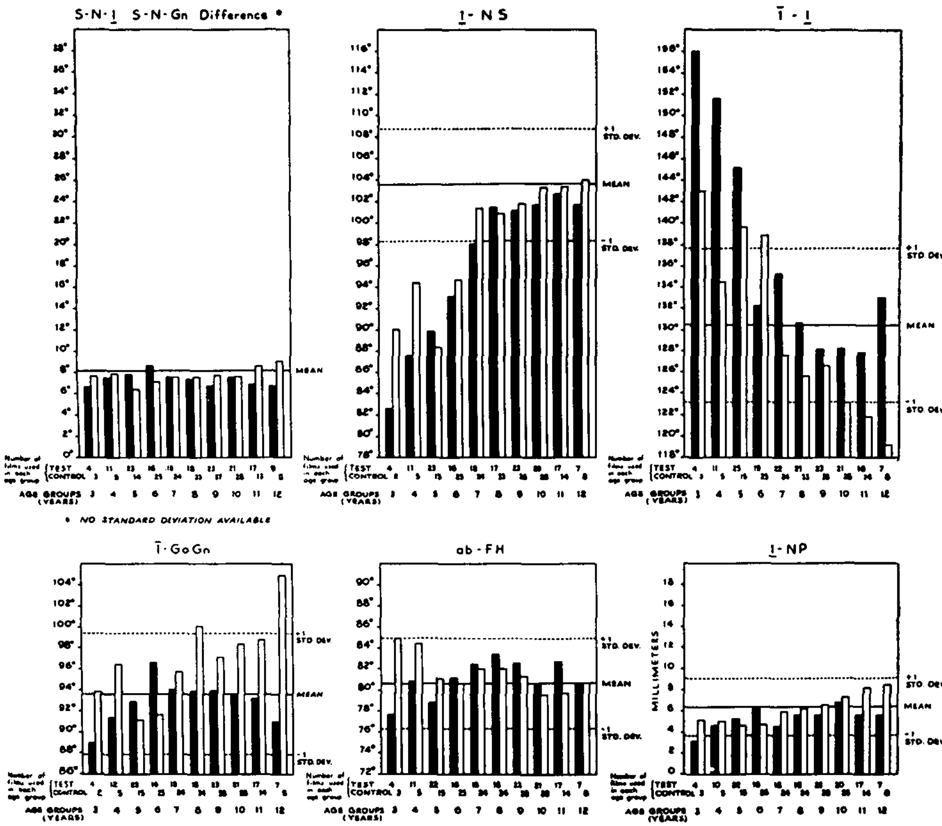
## Discussion

The findings indicate that there is a slight but definite difference between the skeletal patterns of the skulls of children with chronic nutritive failure and those of adequately nourished children which comprised the basis of the standard of reference. A tendency toward a forward divergent face was apparent in the undernourished group regardless of whether or not they received a supplement of three quarts of milk per week for a period of 31 months. Among the factors contributing to the deviation from the standard were a reduced labial prominence of the maxillary incisors and in increased labial prominence of the anterior portion of the mandible.

The standard of reference used in this study was limited in application since the mean values comprising the standard were derived from a sampling which extended over a wide age range. The validity of the greater discrepancy in jaw relationship encountered at ages 5, 6 and 7 years as contrasted with ages 8, 9 and 10 years in children with chronic nutritive failure must remain speculative until a series of means can be established for each angle at each chronological age. Nevertheless, it was of interest to note that the decrease in increments of angle N-A-P and in the magnitude of decrease of the difference between angles S-N-a and S-N-b with increasing age, were greater in the group receiving the milk supplement than in the group not receiving added milk. These changes are indicative of a more favorable jaw relationship. It thus appears that discrepancies in jaw relation in children with nutritive failure may, to some extent, be dietary in causation.

The mean values derived from measurements of a group of children with comparable genetic and environmental

COMPARISON OF DENTURE ANGULATIONS OF MALNOURISHED TEST AND CONTROL GIRLS GROUPED ACCORDING TO AGE




■ TEST GIRLS
□ CONTROL GIRLS
MEAN AND STANDARD DEVIATION VALUES ARE NORTHWESTERN ORTHODONTIC CLINIC STANDARDS.

Fig. 7

backgrounds are wholly valid only for children similar in all respects to the group from which the standards were developed. The children constituting the undernourished group were all of Anglo-Saxon extraction and lived in the same geographic area under similar environmental conditions. The failure of an increased food intake in the form of milk supplements to change substantially the characteristic skull patterns would appear to suggest that the deviation from the standard may be primarily genetic in origin. This hypothesis is predicated, however, on the basis of a standard which lacks the sensitivity required to establish conclusively its authenticity.

It should be remembered that the investigation of this study concerned itself only with actual angular measurements, a quantitative evaluation. No attempt was made to try to make a qualitative evaluation of the bone structure. The diet supplementation may have had some effect on the quality of the bony structure even though the actual structural pattern was not altered.

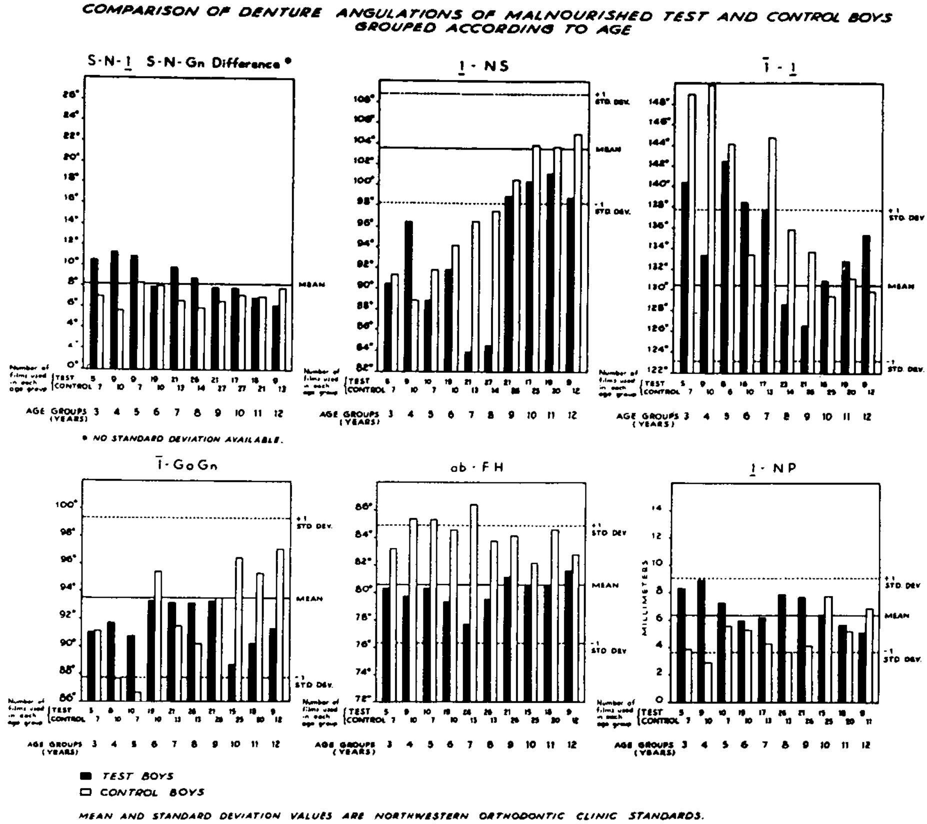



Fig. 8

## Summary and Conclusions

1. The cephalometric patterns of 88 white Alabama children with chronic nutritive failure were compared with that of a standard consisting of the means of measurements obtained from adequately nourished Illinois children. Forty-five of the 88 undernourished children received a dietary supplement of either reliquefied whole or non-fat dry milk solids, equivalent in protein content to three quarts of raw milk per week for a period of 31 months.

2. Except for a more forward divergent face, the cephalometric patterns of the undernourished children were similar to that of the standard. Discrepancies in jaw relationship noticeable in the undernourished children at ages 5, 6 and 7 years declined in magnitude with increasing age. This occurred to a greater degree in the children receiving the milk supplements than in the control group which did not receive the added milk. No other measurable quantitative differences were observed in the growth patterns of the skull in these two groups of children.

3. The findings point to the need for cephalometric standards which provide "norms" for each chronological age level. The lack of sensitivity of the available standards restricts their use to a general rather than to a detailed analysis of growth progress.

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