# Use of Specific Micronutrients Intervention for Treatment of Malnutrition

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This report presents data obtained from a field study of the effects on the nutritional status of kindergarten children by providing either breakfast and lunch (BL Groups) or specific micronutrients in a fruit-flavored drink (NC Groups) and two corresponding control groups. Some change in the nutritional status was observed in all four groups. In the BL Groups there was a change in the distribution of values, which resulted in a larger percentage of the children being moved into the acceptable ranges for hemoglobin, hematocrits, and serum iron at the conclusion of the experiment. The BL Control Group showed significant changes over the BL Group in several measures. The providing of micronutrients to the NC Group caused significant improvement over its control for the distribution of serum folacin, serum iron, and transferrin saturation. There was an increase noted in all groups for Vitamin A, with no significant difference between treatment and control groups. Paradoxically the serum nonessential to essential amino acid ratio increased in both the BL and NC Groups without a concomitant change in either of the control groups.

For the past several years our laboratory has been studying the nutritional status of children and methods of improving this status with various forms of intervention. This report presents data obtained from a field study in which kindergarten children were provided either breakfast and lunch or a Nutricube drink containing specific micronutrients.

In the summer of 1968 a survey of the nutritional status of a group of children enrolled in "Operation Headstart" was undertaken. The Headstart program in this area is conducted during the summer only. The most significant observations made were the relatively high percentage of children with low hemoglobin levels and with low serum Vitamin A levels. A large number of these children were short and light for their age, although they had normal height-weight ratios. The same children, plus some additional ones, were followed during their kindergarten year with clinical, biochemical, and anthropometric measurements to investigate their nutritional status. These studies were carried out in the kindergarten of the New Orleans Public School system, which is conducted on a half-day basis. Normally the kindergarten children do not receive breakfast, lunch, or a snack during their planned program.

During the initial study, one group of kindergarten children was given Kellogg Product 19 and a half-pint of milk per day. Another group was given only the milk and some cookies. After approximately 7 months of intervention, the children were reexamined and it was found that the Vitamin A levels of the children receiving Kellogg Product 19 were greatly increased, with only a small percentage below 20 $\mu$g/100 ml. This finding represented the main difference observed between the treatment groups. Product 19 contains 2500 units of Vitamin A per serving. There was very little change in the hemoglobin levels in these children, even though Product 19 contains 10 mg of reduced iron per serving.

This work was continued the following year, in which a new group of kindergarten children from the same schools was studied. More extensive nutritional intervention was planned to provide one group of children with breakfast and lunch and another group with specific micronutrients including vitamins, minerals, and certain essential amino acids.

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The design of the experiment and initial data are outlined in Table I. The 125 children in the morning session of two schools were given breakfast and lunch and designated the "Breakfast and Lunch Group" (BL Group). A "Breakfast and Lunch Control Group" (BL Control) containing 92 children was drawn from the afternoon sessions from the same two schools. They received a 4-oz glass of orange juice as a snack. The "Nutricube Group" (NC Group) consisted of 88 children in one morning and one afternoon session from two schools. This is the group to which the specific micronutrients were provided. A "Nutricube Control Group" (NC Control) was comprised of 73 children from the same two schools but in the alternate morning or afternoon sessions.

The lunch, when provided, was a "type-A" lunch which contained at least one-third of a Recommended Daily Allowance of vitamins, minerals, proteins, and calories per school week. The breakfast was lighter than a "type-A" breakfast and included milk nearly every day, dry cereal, grits, meat, or cheese-toast several times a week.

The specific nutrients used for supplementation were those which our earlier studies have suggested were limited in the diet of the New Orleans area. The micronutrients were supplied in the form of a Nutricube furnished by Hoffmann–La Roche Inc.

The Nutricube was not intended to provide calories or the three basic macronutrients, but only to add to the diet those micronutrient ingredients which previous investigations suggested to be marginal or low. This permits additions to the diet without changing food habits or providing a substantial amount of food. The uniqueness of this form of intervention is that it can be tailor-made for a particular geographical area with its unique nutritional problems. It may contain essential amino acids to increase the utilization of already-consumed plant proteins, if these are an important aspect of their diet. The particular amino acids used and their quantity can be based upon the diet patterns of the area. The formula for the Nutricube used in this study is given in Table II. This formula was arrived at jointly by a group at Hoffmann–La Roche and members of the Tulane faculty. It provides one-quarter of a Recommended Daily Allowance for a 5-year-old for each of the nutrients included, *i.e.*, Vitamin A, riboflavin, pyridoxine, folic acid, ascorbic acid, calcium, and phosphorus. Iron was added to furnish one R.D.A., namely 10 mg of iron in the form of ferrous fumarate. This is the same amount of iron that was supplied by Product 19, although a different

**Table I. Description of Groups and Initial Data for Nutritional Supplementation Study, 1969–1970**

| | BL[a] | BL Control | NC[a] | NC Control |
|---|---|---|---|---|
| Number of children | 125 | 92 | 88 | 79 |
| Boys | 58 | 40 | 52 | 34 |
| Girls | 67 | 52 | 36 | 45 |
| Age, years approx | 5 | 5 | 5 | 5 |
| Number of schools | 2 | 2 | 2 | 2 |
| Sessions | Morn | Aft | 1 Morn<br>1 Aft | 1 Morn<br>1 Aft |
| | Mean of values | | | |
| Vitamin A, μg/100 ml | 32.8 | 34.1 | 29.0 | 30.0 |
| Hemoglobin, g/100 ml | 11.5 | 11.2 | 11.5 | 11.5 |
| Hematocrit, % | 37.6 | 36.4 | 37.3 | 37.0 |
| Serum iron | | | | |
| High Hb subgroup | 118.0 | 82.6 | 97.3 | 106.0 |
| Low Hb subgroup | 88.4 | 84.6 | 83.5 | 85.0 |
| Transferrin saturation, % | | | | |
| High Hb subgroup | 28.3 | 20.0 | 26.6 | 27.5 |
| Low Hb subgroup | 23.5 | 21.4 | 25.0 | 20.8 |
| Serum folacin, μg/ml | | | | |
| High Hb subgroup | 8.1 | 4.5 | 5.4 | 7.2 |
| Low Hb subgroup | 6.8 | 5.2 | 5.0 | 5.6 |
| Serum protein, g/100 ml | 7.46 | 7.60 | 7.33 | 7.45 |
| Amino acid ratio | 1.80 | 1.88 | 1.52 | 1.55 |
| Height, mm Boys | 1109.1 | 1087.2 | 1096.3 | 1098.6 |
| Height, mm Girls | 1098.3 | 1092.7 | 1082.1 | 1082.0 |
| Weight, lb Boys | 42.1 | 39.4 | 41.0 | 39.5 |
| Weight, lb Girls | 40.2 | 38.2 | 38.5 | 37.5 |
| Subscapular skinfold, mm Boys | 4.7 | 4.7 | 4.8 | 4.2 |
| Subscapular skinfold, mm Girls | 5.2 | 5.2 | 5.2 | 5.1 |

[a] BL, Breakfast and Lunch Group; NC, Nutricube Group.

form. The essential amino acids, L-lysine and L-tryptophan, added were at a level sufficient to improve rice and corn protein in the diet, assuming that these children would receive approximately one-half of a R.D.A. per day of protein from these cereals.

This formulation was originally designed to be added to boiling water in the process of cooking such foods as grits, oatmeal, or rice. However, because of limitations, we were unable to use it in this way. Instead, the cubes were dissolved in boiling water. Then chilled water and flavored syrup were added to make a fruit-flavored drink. This method of administering the supplement was far from ideal, since a precipitate did result, although it contained little of the micronutrients. Nevertheless, the drink was given to the children in a paper cup with a straw, so that the precipitate was also consumed. This was done approximately 1 hr before or after lunch.

## METHODS

The examination procedures used are similar to those used in the National Nutrition Survey and are outlined in the ICNND Manual for Nutrition (1963). The biochemical methods used are as follows: serum Vitamin A (Neeld and Pearson, 1963), hemoglobin, cyanmethemoglobin method, microhematocrit, serum and total iron binding capacity (Caraway, 1963), serum folacin leichmannii method, serum protein, microbiuret (ICNND, 1963), serum nonessential to essential amino acid ratio by the paper method (Whitehead, 1964). Anthropometric measurements are by techniques standardized in this laboratory during the National Nutrition Survey.

## RESULTS

The results to be presented in this preliminary report include those in which effects have been observed and present only a portion of the total experimental data collected.

**Table II. Nutricube Formula, 1969–1970**

| | |
|---|---|
| Vitamin A | 825 units |
| Riboflavin | 0.22 mg |
| Pyridoxine HCl | 0.25 mg |
| Folic acid | 0.05 mg |
| Ascorbic acid | 10.0 mg |
| Calcium | 200.0 mg |
| Phosphorus | 200.0 mg |
| Iron | 10.0 mg |
| L-Lysine HCl | 170.0 mg |
| L-Tryptophan | 70.0 mg |

An examination of the school children was carried out in midSeptember prior to beginning the supplementation program. This consisted of a clinical history, a physical examination, anthropometric measurements, and the following biochemical determinations: hemoglobins, hematocrit, level of serum Vitamin A, carotene, ascorbic acid, cholesterol, and protein, as well as nonessential to essential amino acid ratio, and serum protein electrophoresis. The urinary excretion of riboflavin and thiamine was measured. On a subsample of children, namely the ones with the highest 10% hemoglobin (High HB subsample) and lowest 10% hemoglobin (Low HB subsample), additional determinations were made for serum folic acid, serum iron, and iron binding capacities. Data for serum carotene and ascorbic acid, thiamine, and riboflavin excretion will not be included, since all findings were within normal ranges in the pretreatment period.

The effects of both types of intervention on the various biochemical and anthropometric measurements are shown in the following two ways. The first is to determine the percent change of each individual, calculated by dividing the value obtained prior to intervention into the value at the end of the intervention period, multiplying by 100, and determining the mean for each school. The mean percent change for

**Table III. The Mean Percent Change and Distribution of Serum Vitamin A, Hemoglobin, and Hematocrit Levels in New Orleans Kindergarten Children before and after Nutrition Supplementation, 1969–1970**

| Group | No. of children | 100 + mean % change ± S.D. | | % Distribution[a] Deficient | Low | Acceptable |
|---|---|---|---|---|---|---|
| | | | Serum Vitamin A | | | |
| | | | | <20[b] | 20.0–29.9[b] | ≥30[b] |
| BL | 99 | 100.7 ± 35.68 | Before | 6.1 | 30.3 | 63.3 |
| | | | After | 7.1 | 31.3 | 61.6 |
| BL | 90 | 104.9 ± 35.89 | Before | 5.6 | 33.3 | 61.1 |
| Control | | | After | 2.2 | 32.2 | 65.6 |
| NC | 75 | 123.1 ± 43.65[c] | Before | 13.3 | 41.3 | 45.4 |
| | | | After | 4.0 | 36.0 | 60.0 |
| NC | 73 | 122.5 ± 61.40[c] | Before | 8.2 | 46.6 | 45.2 |
| Control | | | After | 1.4 | 19.2 | 79.4 |
| | | | Hemoglobin | | | |
| | | | | <20[d] | 20.0–29.9[d] | ≥30[d] |
| BL | 125 | 103.9 ± 7.37[c] | Before | 8.8 | 14.4 | 76.8 |
| | | | After | 1.6 | 8.8 | 89.6 |
| BL | 91 | 101.7 ± 5.49[c] | Before | 5.5 | 27.5 | 67.0 |
| Control | | | After | 2.2 | 26.4 | 71.4 |
| NC | 88 | 98.9 ± 6.14[e] | Before | 3.4 | 20.5 | 76.1 |
| | | | After | 3.4 | 21.6 | 75.0 |
| NC | 79 | 99.1 ± 5.78 | Before | 5.1 | 17.7 | 77.2 |
| Control | | | After | 1.3 | 26.6 | 72.2 |
| | | | Hematocrit | | | |
| | | | | <29.9[f] | 20.0–39.9[f] | >33.9[f] |
| BL | 125 | 100.7 ± 6.28 | Before | 0.8 | 5.6 | 93.6 |
| | | | After | 0 | 3.2 | 96.8 |
| BL | 92 | 102.8 ± 4.96[c] | Before | 0 | 7.6 | 92.4 |
| Control | | | After | 0 | 4.3 | 95.7 |
| NC | 88 | 99.1 ± 5.77[e] | Before | 0 | 3.4 | 96.6 |
| | | | After | 0 | 2.3 | 97.7 |
| NC | 79 | 99.9 ± 5.27 | Before | 0 | 8.9 | 91.1 |
| Control | | | After | 0 | 3.8 | 96.2 |

[a] O'Neal *et al.* (1970). [b] μg/100 ml. [c] $p < 0.01$. [d] g/100 ml. [e] $p < 0.05$. [f] Percent.

each group is determined by first calculating the mean percent change for each school then averaging the schools. One-hundred was not subtracted from these means.

The second method is to show the percent distribution of the levels before and after the period of intervention. The guidelines for the percent distribution for the biochemical measurements are based on those of O'Neal *et al.* (1970) and are considered by them to indicate the deficient, low, and acceptable categories for each measurement, except for serum nonessential to essential amino acid ratios.

BIOCHEMICAL MEASUREMENTS

The mean percent change and distributions of Vitamin A levels for the two treatment groups and two control groups are given in Table III. In the BL Group and in the BL Control Group, there was little change in either the mean percent change or the distribution of Vitamin A values as a result of the dietary supplementation.

There was an improvement in the mean percent change of about 23% in serum Vitamin A level after 7 months of supplementation in both the NC and NC Control Groups significant at the 1% level. There was no significant difference between these groups. Similar changes were observed in the distribution of the values in both the NC Group and the NC Control Group.

The mean percent change and distribution of hemoglobin concentrations are shown in Table III. In the BL Group and BL Control Group the mean percent changes were 3.9 and 1.7%, respectively. Both were significant at the 1% level and there were no significant differences between the two groups. An effect of providing breakfast and lunch for 7 months was noted in the distribution of values. However, the percentage of children whose values were above 11 gm/100 ml changed from 77% before intervention to 90% after intervention in the BL Group. There was no change in the percent distribution in the BL Control Group.

The mean percent change was −1% for the NC Group, a significant decrease at the 5% level, and −1% in the NC Control, which was not a significant change. There was no significant difference in mean percent change between the treatment and control NC Group. There was not an appreciable change in the percentage of children whose hemoglobin values were above 11 gm/100 ml.

The mean percent change and distribution of the hematocrit values are shown in Table III. There was no change in the hematocrit levels for the BL Group. The mean percent change in the BL Control was 2.8%, which was significant at the 5% level and a difference between the BL Group and BL Control Groups was significant at the 1% level.

The mean percent change in hematocrit for both the NC Group and the NC Control Group decreased the similarity by 1%. The decrease in the NC Group was significant at the 5% level. All groups had a higher percentage of children whose hematocrit values were greater than 34% at the end of the experiment.

Based on the preintervention hemoglobin data, a subsample was derived to include the subjects whose level of hemoglobin was in the lowest 10% (Low Hb subgroup) and the highest 10% (High Hb subgroup) of the values obtained. Serum iron, total serum iron binding capacity (from which transferrin saturation was calculated), and serum folic acid levels were determined on the subjects in the subsamples.

**Table IV. Mean Percent Change in Distribution of Serum Iron Levels, Transferrin Saturation, and Folacin Levels in the Low and High Hemoglobin Subgroups in New Orleans Kindergarten Children before and after Nutrition Supplementation, 1969–1970**

| Group | No. of children | 100 + mean % change ± S.D. | | % Distribution[a] Low | % Distribution[a] acceptable | % Distribution[a] High |
|---|---|---|---|---|---|---|
| | | Serum iron levels | | | | |
| | | High hemoglobin subgroup | | | | |
| | | | | <40[b] | | >200[b] |
| BL | 10 | 85.04 ± 62.39 | Before | 0 | 90.0 | 10.0 |
| | | | After | 0 | 100.0 | 0 |
| BL Control | 11 | 149.41 ± 83.07[c] | Before | 0 | 100.0 | 0 |
| | | | After | 0 | 100.0 | 0 |
| NC | 16 | 103.74 ± 32.92 | Before | 0 | 100.0 | 0 |
| | | | After | 0 | 100.0 | 0 |
| NC Control | 14 | 116.63 ± 39.27 | Before | 0 | 100.0 | 0 |
| | | | After | 0 | 100.0 | 0 |
| | | Low hemoglobin subgroup | | | | |
| BL | 8 | 215.10 ± 192.02 | Before | 37.5 | 62.5 | 0 |
| | | | After | 25.0 | 75.0 | 0 |
| BL Control | 16 | 128.18 ± 71.75 | Before | 0 | 100.0 | 0 |
| | | | After | 6.2 | 93.8 | 0 |
| NC | 14 | 152.50 ± 112.46 | Before | 14.3 | 85.7 | 0 |
| | | | After | 0 | 100.0 | 0 |
| NC Control | 9 | 129.97 ± 60.56 | Before | 0 | 100.0 | 0 |
| | | | After | 0 | 100.0 | 0 |
| | | Serum transferrin saturation | | | | |
| | | High hemoglobin subgroup | | | | |
| | | | | <20[d] | 20–502 | >50[d] |
| BL | 10 | 85.36 ± 53.55 | Before | 20.0 | 80.0 | 0 |
| | | | After | 40.0 | 60.0 | 0 |
| BL Control | 11 | 185.94 ± 113.19[c] | Before | 54.5 | 45.5 | 0 |
| | | | After | 9.1 | 90.9 | 0 |
| NC | 16 | 115.56 ± 45.94 | Before | 18.8 | 81.3 | 0 |
| | | | After | 6.3 | 93.8 | 0 |
| NC Control | 14 | 121.22 ± 33.83[c] | Before | 14.3 | 85.8 | 0 |
| | | | After | 14.3 | 85.8 | 0 |
| | | Low hemoglobin subgroup | | | | |
| BL | 8 | 198.28 ± 168.55 | Before | 37.5 | 62.5 | 0 |
| | | | After | 50.0 | 50.0 | 0 |
| BL Control | 16 | 128.09 ± 75.52 | Before | 56.3 | 43.8 | 0 |
| | | | After | 31.3 | 68.8 | 0 |
| NC | 13 | 141.45 ± 130.01 | Before | 46.2 | 46.2 | 7.69 |
| | | | After | 23.1 | 76.9 | 0 |
| NC Control | 10 | 150.33 ± 71.16[c] | Before | 60.0 | 40.0 | 0 |
| | | | After | 30.0 | 70.0 | 0 |
| | | Serum folacin | | | | |
| | | High hemoglobin subgroup | | | | |
| | | | | ≤30[e] | 30–52 | >5[e] |
| BL | 9 | 103.36 ± 29.1 | Before | 0 | 11.1 | 88.9 |
| | | | After | 0 | 11.1 | 88.9 |
| BL Control | 10 | 137.19 ± 35.51[f] | Before | 10.0 | 50.0 | 40.0 |
| | | | After | 0 | 40.0 | 60.0 |
| NC | 15 | 145.88 ± 56.8[f] | Before | 6.7 | 40.0 | 53.3 |
| | | | After | 0 | 13.3 | 86.7 |
| NC Control | 10 | 80.97 ± 30.71[c] | Before | 0 | 20.0 | 80.0 |
| | | | After | 0 | 60.0 | 40.0 |
| | | Low hemoglobin subgroup | | | | |
| BL | 8 | 153.62 ± 40.68[f] | Before | 0 | 12.5 | 87.5 |
| | | | After | 0 | 0 | 100.0 |
| BL Control | 15 | 138.90 ± 36.24[f] | Before | 0 | 33.3 | 66.6 |
| | | | After | 0 | 13.3 | 86.6 |
| NC | 10 | 158.71 ± 29.4[f] | Before | 0 | 70.0 | 30.0 |
| | | | After | 0 | 0 | 100.0 |
| NC Control | 11 | 114.57 ± 32.10 | Before | 0 | 36.4 | 63.6 |
| | | | After | 0 | 36.4 | 63.6 |

[a] O'Neal *et al.* (1970). [b] mμg/100 ml. [c] $p < 0.05$. [d] Percent. [e] mμg/ml. [f] $p < 0.01$.

The mean percent change and distribution for serum iron levels are shown in Table IV. The mean percent change in High Hb Subgroup of both treatment groups was less than both control groups. The mean percent change in the BL Control Group was significant at the 5% level. The serum iron concentrations in the High Hb subgroup of all treatment and control groups were within normal range except for one individual whose serum iron was high.

In the Low Hb subgroup the mean percent change for the BL Group was 115%, compared to 28% for the BL Control Group and 52% in the NC Group, compared to 29% in the NC Control Group. None of these changes were significant.

Table V. The Mean Percent Change and Distribution of Serum Protein Levels in New Orleans Kindergarten Children before and after Nutritional Supplementation, 1969–1970

| Group | No. of children | 100 + mean % change ± S.D. | | % Distribution[a] Deficient ≤5.6[b] | Low 5.7–6.0[b] | Acceptable 6.0[c] |
|---|---|---|---|---|---|---|
| BL | 93 | 95.1 ± 8.51[c] | Before | 0 | 0 | 100.0 |
| | | | After | 0 | 0 | 100.0 |
| BL Control | 84 | 92.3 ± 7.72[c] | Before | 0 | 0 | 100.0 |
| | | | After | 0 | 0 | 100.0 |
| NC | 69 | 93.8 ± 7.83[c] | Before | 1.4 | 0 | 98.6 |
| | | | After | 1.4 | 0 | 98.6 |
| NC Control | 53 | 91.1 ± 15.4[c] | Before | 1.9 | 0 | 98.1 |
| | | | After | 5.7 | 3.8 | 90.6 |

[a] O'Neal *et al.* (1970). [b] g/100 ml. [c] $p < 0.01$.

Table VI. The Mean Percent Change and Distribution of Serum Essential to Nonessential Amino Acid Ratio in New Orleans Kindergarten Children before and after Nutritional Supplementation, 1969–1970

| Group | No. of children | 100 + mean % change ± S.D. | | % Distribution[a] >3.0 | 2.1–2.9 | Acceptable ≤2.0 |
|---|---|---|---|---|---|---|
| BL | 106 | 124.4 ± 40.03[b] | Before | 0.9 | 23.6 | 75.5 |
| | | | After | 1.9 | 43.4 | 54.7 |
| BL Control | 89 | 110.9 ± 43.19[b] | Before | 1.1 | 32.6 | 66.3 |
| | | | After | 2.2 | 34.8 | 62.9 |
| NC | 78 | 128.7 ± 52.82[b] | Before | 0 | 6.4 | 93.6 |
| | | | After | 2.6 | 30.8 | 66.7 |
| NC Control | 78 | 101.6 ± 35.65 | Before | 1.3 | 3.8 | 94.9 |
| | | | After | 0 | 11.5 | 88.5 |

[a] Whitehead (1964). [b] $p < 0.01$.

The distribution of values in the Low Hb subgroup changed very little in the BL and BL Control Groups. In the NC Group 14% of the children tested had low serum iron levels initially and this was reduced to zero at the end of the intervention period. The concentrations of serum iron were within the normal range for all individuals of the NC Control Group.

The mean percent change and percent distribution for transferrin saturation is presented in Table IV. In the High Hb subgroup of the BL Group the mean percent change of transferrin saturation decreased 15% while the BL Control Group increased 86%, which was significant at the 5% level. In the High Hb Subgroup of the BL Group, the percentage of the individuals with low transferrin saturation increased from 20% before intervention to 40% after intervention. In contrast, in the BL Control Group, the percentage with low transferrin saturation decreased from 55% initially to 9% after treatment.

There was no difference in the mean percent change in the High Hb subgroup for the NC Group of the NC Control Group. The percentage of children with low transferrin saturation in the High Hb Subgroup in the NC Group changed from 19% before intervention to 6% after intervention. No change was observed in the NC Control Group.

In the Low Hb Subgroups the mean percent change transferrin saturation for BL Group was 98%, compared to the 28% for the BL Control Group. The percentage of the children in the Low Hb subgroup with low transferrin saturation decreased in all groups, except for the BL Group which increased. A difference in the mean percent change was observed between the NC and NC Control Groups which was 41 and 50%, respectively. Only the change in the NC Control Group was significant.

The changes in serum folacin levels before and after intervention are shown in Table IV. In the High Hb subgroup the mean percentage change was greater for the BL Control Group (37%) (significant at 1% level) than for the BL Group (3%); in contrast the NC Group increased 46% (significant at the 1% level) and NC Control Group decreased 19% (significant decrease at 5% level). There was very little change in the distribution of values for either the BL Group or the BL Control Group. In this High Hb Subgroup of the NC Group, 47% of the children had serum folacin levels less than 5 mμg/ml prior to intervention. In the NC Control Group the percentage of individuals with serum folacin levels less than 5 mμg/ml increased from 20% initially to 60% at the end of the treatment period.

In the Low Hb subgroup for the BL Group the mean percent change was 54% and was 39% for the BL Control Group. There was a decrease after intervention in the percentage of children in the Low Hb Subgroup, in the BL Group, and BL Control Group, with folacin levels less than 5 mμg/ml, 12.5% to zero and 33%, respectively.

In the NC Group the mean percent change for Low Hb subgroup was 59%, compared to 15% for the NC Control Group. In the NC Group initially, 70% of the children in the Low Hb Subgroup had serum folacin levels less than 5 mμg/ml and after 7 months of intervention all of the individuals had serum folacin levels greater than 5 mμg/ml. In the NC Control Group there was no change in the percentage of children whose folacin levels were less than 5 mμg/ml.

The mean percent change and distribution for serum protein levels are shown in Table V. Essentially all individuals had serum protein levels greater than 6 g/100 ml initially. In all of the groups there was a 5 to 9% drop in the serum protein levels at the end of the intervention period compared to the beginning. This change was significant at the 1% level in each group and there was no significant difference between treatment and control groups.

Serum nonessential to essential amino acid ratio by the paper chromatographic method of Whitehead (1964) has been used as a possible criterion for protein status. Accord-

Table VII. The Mean Percent Change of Height, Weight, and Subscapular Skinfold in New Orleans Kindergarten Children before and after Nutritional Supplementation, 1969–1970

| | Boys | | Girls | |
|---|---|---|---|---|
| Group | No. of children | 100 + mean % change ± S.D. | No. of children | 100 + mean % change ± S.D. |
| | | Height | | |
| BL | 58 | 103.4 ± 0.85[a] | 64 | 103.8 ± 0.96 |
| BL Control | 36 | 103.9 ± 0.79[a] | 49 | 103.4 ± 1.64 |
| NC | 50 | 103.4 ± 1.45[a] | 36 | 103.6 ± 1.61 |
| NC Control | 35 | 103.4 ± 1.02[a] | 37 | 103.5 ± 0.87 |
| | | Weight | | |
| BL | 58 | 108.0 ± 3.95[a] | 65 | 111.4 ± 8.94[a] |
| BL Control | 36 | 107.2 ± 2.64[a] | 49 | 108.4 ± 3.36[a] |
| NC | 50 | 106.9 ± 4.19[a] | 36 | 108.5 ± 3.85[a] |
| NC Control | 36 | 106.9 ± 4.04[a] | 39 | 109.4 ± 3.52[a] |
| | | Subscapular skinfold | | |
| BL | 57 | 115.0 ± 20.5[a] | 66 | 117.5 ± 24.6[a] |
| BL Control | 36 | 97.8 ± 20.6 | 48 | 107.1 ± 20.3 |
| NC | 50 | 107.8 ± 19.8[a] | 36 | 112.2 ± 21.1[a] |
| NC Control | 36 | 111.9 ± 19.8[a] | 39 | 105.9 ± 24.3 |

[a] $p < 0.01$.

ing to Whitehead, those children with nonessential to essential amino acid ratios of less than 2 are normal. Those with ratios between 2 and 3 have an insufficient quantity or quality of protein in their diet; those with ratios greater than 3 are protein-deficient.

The mean percent change and distribution for the nonessential to essential amino acid ratio is presented in Table VI. The mean percent change in the BL Group was 24%, and 11% for the BL Control Group, both significant at the 1% level. There was not a significant difference between groups.

Similar changes were observed in the NC Group and NC Control Group. The mean percent change was 29% for the NC Group and 2% for the NC Control Group. The change in the NC Group and the variation between treatment and control group was significant at the 1% level.

The changes observed in the two treatment groups were also observed in the distribution of values. Initially the BL Group and BL Control Group had 75 and 66%, respectively, of all ratios below 2. The percentage of initial ratios below 2 for the NC Group and NC Control Group were even higher, 94 and 95%, respectively. Neither control changes appreciably; however, there was marked change in the distribution of both treatment groups. The percentage of children with nonessential to essential amino acid ratios above 2 increased from 24 to 43% in the BL Group and from 6 to 31% in the NC Groups. The direction change in the ratio is opposite to that expected from providing protein of known high quality in breakfast and lunch. However, changes were similar whether intervention consisted of substituting two balanced meals or using specific nutrients which included two essential amino acids. (Plasma lysine and tryptophan are not measured in determining the ratio.)

## ANTHROPOMETRIC MEASUREMENTS

The mean percent change of height for boys and girls is shown in Table VII. The mean percent changes were significant at the 1% level for all treatment and control groups. In boys the mean percent change was significantly greater ($p < 0.05$) in the BL Control Group than in the BL Group.

The mean percent change of weight for boys and girls is shown in Table VII. The change within each of the four groups was significant at the 1% level. In the BL Group Boys, the mean percent change was 8.0% and was 7.2% for the corresponding control group. There was a significant difference (1%) between the mean percent change in girls' weight between BL Group and the BL Control Group. The differences between NC and NC Control Groups for boys or girls were significant.

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