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Bone Densities and Dietary Intakes of Preschool Children in Knox County, Tennessee

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To the Graduate Council:

I am submitting herewith a thesis written by Sarah May Tucker entitled "Bone Densities and Dietary Intakes of Preschool Children in Knox County, Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Nutrition.

Roy E. Beauchene, Major Professor

We have read this thesis and recommend its acceptance:

Bernadine Meyer, Jane R. Savage, Rossie L. Mason

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

August 8, 1969

To the Graduate Council:

I am submitting herewith a thesis written by Sarah May Tucker entitled "Bone Densities and Dietary Intakes of Preschool Children in Knox County, Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Nutrition.

Roy E Beauchene
Major Professor

We have read this thesis and recommend its acceptance:

Bernadine Meyer

Jane R. Savage

Rossie L. Mason

Accepted for the Council:

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Vice Chancellor for
Graduate Studies and Research

BONE DENSITIES AND DIETARY INTAKES OF PRESCHOOL CHILDREN IN KNOX COUNTY, TENNESSEE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Sarah May Tucker

August 1969

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ABSTRACT

The purposes of this study were to evaluate the diets of preschool children in selected kindergartens of Knox County, Tennessee; to determine the bone densities and other parameters of growth of these children; and to study the relationships that exist between diet and these measurements.

The subjects for the study were 142 children enrolled in four Head Start centers and two private preschools in the Knoxville area. Height, weight, and bone density measurements of the phalanx 5-2 were determined for the children, and seven-day dietary records were obtained for them. The bone density measurements were done by the direct scan technique using x-rays. Food records were kept in terms of common household measures and were later converted to grams. Individual nutrients including calories, protein, calcium, iron, vitamin A, thiamine, riboflavin, niacin, and ascorbic acid were calculated by computer.

Results of the study showed that the Head Start lunches provided more than the required 1/3 of the Recommended Dietary Allowances for preschool children, but the lunches of a private preschool made much smaller contributions to the total day's intake. Of all the children in the study, 35.3% had daily intakes of less than 2/3 of the Recommended Dietary Allowances of one or more nutrients. Other children might have fallen into this category had they not been taking vitamin or iron supplements. Iron was the nutrient most often deficient in the diets of

these children and calcium and niacin ranked second and third, respectively.

Bone density values ranged from 0.50 to 0.96 gram equivalents per cubic centimeter of bone with a mean value of 0.69. There was no difference between the mean bone density of the boys and that of the girls and no significant difference between the mean bone densities of Head Start and private preschool children. Correlations between bone density values and levels of calcium and ascorbic acid intake were not significant. A significant correlation existed between weight and bone density for boys, but not for girls.

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CHAPTER I

INTRODUCTION

The preschool age group has been the subject of few nutritional studies. However, the increased concern of international organizations over the poor nutritional status and high mortality rate of children in the one- to six-year age group in the developing countries is beginning to have an effect even in the United States where severe nutritional deficiencies are rare. The mushrooming growth of kindergartens--both Head Start and private--makes nutritional studies easier to perform than previously since subjects are now more readily available.

Bone density has not been extensively studied, and the wide range of methods used makes a uniform expression of density and pooling of data for the establishment of bone density norms impossible. Of the studies which have been reported, only a few have been concerned with the bone density of young children.

The purposes of this study were to evaluate the diets of preschool children in selected kindergartens of Knox County, Tennessee; to determine the bone densities and other parameters of growth of these children; and to study the relationships that exist between diet and these physical measurements.

CHAPTER II

REVIEW OF LITERATURE

Dietary Study Methods

It is recognized that the most accurate method for evaluating a diet involves the weighing of food portions and subsequent chemical analysis of aliquots of the foods used. However, this method is not always practical or even possible. Therefore the use of diet histories, dietary records, and calculations from food composition tables definitely has a place in evaluating nutritional intake. In fact, Eppright and coworkers (1) found that the standard deviations for nutrients were as large when food was weighed as when it was recorded in estimated servings and common household measures. Nevertheless, they warned that values obtained by the latter method are likely to be somewhat higher than those for weighed food portions. Carroll and coworkers (2) reported similar results for protein, thiamine, and riboflavin whether they were calculated from food composition tables or obtained by chemical analysis.

Hunscher and Macy (3) pointed out some considerations which should be kept in mind when using food composition tables and estimated weight of food to calculate nutrient intake. One of the most important of these is the wide variation among individual observers as to the meaning of such descriptive terms as "small," "medium," and "large." Another is the fact that food composition tables themselves are subject to errors in analysis and, at best, are values only for a small sample of the food and do not take into account variations which may occur within, for example, different varieties of green beans.

Young et al. (4) studied the relationship between values obtained from dietary histories taken by interviewer and seven-day food records. These studies carried out in Massachusetts, New Jersey, New York, Rhode Island, and West Virginia showed that the two methods gave different results. The trend was to overestimate intake in the histories and was most pronounced among younger children.

Burke (5) pointed out that while balance studies and weighing and analyzing food may be more accurate than other methods, they are artificial situations in which subjects probably will not eat normally. She recommended the use of dietary histories which give a complete meal-by-meal record of eating habits as a more practical method of getting average dietary intake for a considerable period of time.

The general conclusion seems to be that each method has its advantages but also its limitations. Therefore, the experimenter should consider carefully the problem he wishes to investigate and the resources available to him and then choose the method most appropriate for his study.

Dietary Studies with Young Children

Some of the earliest work in child nutrition was done in the late 1930's. Mack and coworkers (6) conducted one of these studies using children in the intermediate grades in school. Diet and nutritional status of children in a college community were compared to those of children of lower economic status in an industrial city. The children of parents with higher incomes and educational status generally exhibited better nutritional status according to the following measurements: healthy appearance, as judged by a pediatrician; body build and weight status; skeletal status; dental status; slump, standing and sitting; plantar contact; hemoglobin values; and response to the biophotometer and capillary wall strength tests. According to these criteria, even some of the children in the college community were not in optimal nutritional status.

Hardy and coworkers (7) carried out a study among 7,363 children from different socioeconomic groups in the Chicago area during the period of January, 1939 through August, 1941. Their evaluation of nutritional status was based on amount of fat padding, muscle tone, pallor, posture, bone formation, skin condition, and occurrence of dental caries. Even when dental abnormalities were excluded, only 14% of the children were free from physical deviations, and 5% were subnormal in most of the above-mentioned categories. There were more deficiencies among Negro than among white or Mexican children, and there was a definite relationship between nutrition and socioeconomic groups of white children. Dietary patterns were evaluated according to the number of servings per week of milk, fruits and vegetables, and protein foods. Using five and a half quarts of milk, twenty-four servings of fruits and vegetables, and seven servings of protein-rich foods as the standard, only 28% of the diets were judged adequate, and the foods most often lacking were those in the vegetable and fruit group. Children in the five- to nine-year age group had the highest percentage (32%) of adequate diets. Although family income was found to greatly influence diet adequacy, at least 1/3 of the children of financially able families had poor diets.

Much of our best information on nutrient intake of children has been collected in longitudinal studies of child growth and development carried out in Denver by the Child Research Council since the early 1940's and reported in a series of articles by Beal (8,9,10,11,12,13). Dietary histories of the children were taken at regular intervals by skilled interviewers and were used for calculating nutrient intakes from food composition tables. By this method, intakes of carbohydrate, fat, protein, calcium, phosphorus, iron, thiamine, riboflavin, and niacin were studied and mean intakes were reported for each age group. Concern in these studies was for the establishment of optimal and maximal levels of nutrient intake compatible with good health since the intakes of American children are rarely such that clinical deficiency symptoms result. Only iron and niacin intakes have been consistently low in these subjects. The 1965 report (13) emphasized the need for a reevaluation of the use of height: weight ratios for an over-all index of over- or under-nutrition now that there are better means for determining body composition.

Macy and Hunscher (14) studied the effect of caloric intake on the growth of children and found that different children have different optimum intakes which allow them to feel well and be mentally and physically alert. However, they also discovered that a difference of as little as ten calories per kilogram of body weight could mean the difference between good and poor weight gains even when protein intake was being maintained at three grams per kilogram of body weight. Calories in double the amounts needed for basal metabolism seemed to be adequate for growth and proper utilization of other nutrients. Appetite did not prove to be a reliable guide for selecting sufficient quantities of food to support growth.

A study of diets and nutritional status of Iowa school children was conducted by Eppright and coworkers (15,16,17) between 1948 and 1952. The sample included 1,188 children ages six through eighteen from rural, town, and city schools. Dietary information was obtained using the seven-day dietary record. Mothers kept records for the younger children, but the older ones assisted in keeping their own. It was found that the intakes of girls were approximately 10% less than those of boys in the six- to twelve-year age group, and increases occurred in spurts for girls rather than regularly as for boys. Forty percent of the girls and 30% of the boys had diets with one or more nutrients present in amounts less than 67% of the National Research Council's Recommended Dietary Allowances (RDA) with teen-age girls having the most conspicuously poor diets. Milk and vitamin-rich fruits and vegetables were the foods most often omitted from the diet making vitamin A and ascorbic acid the two nutrients most often lacking. Milk consumption was generally between two and three cups daily depending on the age and sex of the child. This resulted in a rather low intake of calcium. Children who met the RDA for all the nutrients tended to be a little taller and heavier than the children with average nutrient intakes below the recommendations. Most biochemical data did not show significant differences although serum concentrations of ascorbic acid and carotenoids did reflect intake.

In a later study of 104 Ohio preschoolers, Matheny and coworkers (18) found that 21% of the children were receiving 100% of the recommendations for all nutrients, but 18% of them were eating diets which provided less than 67% of one or more nutrients. Iron was the least well-supplied nutrient, but 1/2 of the children were also receiving insufficient amounts of calories, thiamine, and calcium. The lowest income group again had the poorest diets. When family eating habits were studied, it was found (19) that only about 1/5 of the families had regular meals. Forty percent classified their meals as semiregular, and 39% were termed irregular in their meal patterns. The major reasons given for skipping meals were lack of time, lack of appetite, and illness.

Dierks and Morse (20) studied children of a group of University of Minnesota students and, even with this biased sample, found a substantial number of dietary deficiencies of vitamin C and niacin in addition to a significantly low iron intake for the group. A survey of food preferences of the children revealed that vegetables were generally the most unpopular food, and meat, fruit, and sweets were among the most liked.

In a 1963 study of children from low-income families in Iowa, Hootman et al. (21) found that the differences between the diets of rich and poor were less pronounced than they had been in the past since poor diets were not restricted to low-income families. Food intakes were obtained from diet histories and were classified into three groups according to level of nutrient intake. Diets which contained 100% or more of the RDA for all nutrients were termed "high." Those which had at least one nutrient below 100% but none below 67% were classified "adequate," and those which had at least one nutrient below 67% were "inadequate." According to this classification, none of the boys and only three of the sixteen girls in the age group of three- to nine-year-olds had inadequate diets. The nutrient lacking in these three cases was ascorbic acid. When heights and weights of the children were compared to the norms, the boys in this age group tended to fall below the means.

In appraising the health of 842 children in the Early School Admissions Project of four Baltimore City Schools, Stine and coworkers (22) found that some real nutritional problems existed. Iron deficiency anemia was found to be quite prevalent and was caused by incomes too low to buy meat, generally poor nutrition knowledge of the mothers, and the overfeeding of milk during infancy and early childhood. White girls tended to be short and heavy with about 10% of them satisfying published criteria for obesity.

Ling (23) conducted a study on the dietary adequacy of preschool children in Kansas during 1964. Children were from two different socio-economic groups, and in this study, the children in the lower income group had the better diet. Iron was the least adequately supplied nutrient followed by calcium and calories. An inverse relationship existed between calcium and iron with diets high in one of these nutrients being low in the other. When caloric intake was high, this situation was counteracted. A positive relationship was shown between dietary adequacy and weight while an inverse relationship existed between dietary adequacy and height.

A second Kansas study (24) showed that preschool children with the least adequate diets were in the lower half of the Jackson and Kelly distribution for both height and weight. Protein, as well as iron, calcium, and calories, was frequently deficient in these diets.

Cloud (25) compared dietary intake and indices of nutritional status of four-year-olds from low-income families cared for at home with those of similar children in day care centers in Alabama. The nutrient intake of the day care children exceeded the RDA for all nutrients except iron and niacin, and these exceeded 2/3 of the recommendations. For the children cared for at home, most of the nutrients exceeded 2/3 of the RDA, but ascorbic acid intake for the group was below 50%.

The nutritional status of 40 Nebraska preschoolers from two socioeconomic groups was assessed by dietary, biochemical, and anthropometric measures and has been reported by Kerrey et al. (26) and Crispin et al. (27). Three-day food records were kept and were inspected daily to check for omissions or inaccuracies. Calories were a little low but the mean for all other nutrients except iron met or exceeded the Recommended Dietary Allowances. Iron, ascorbic acid, and vitamin A were the three nutrients which were most limiting in the largest number of individual diets. Iron and thiamine were more plentiful in the diets of the low-income children whereas the high-income group had diets which provided more ascorbic acid and vitamin A. Urinary excretion of thiamine, riboflavin, niacin, pantothenic acid, nitrogen, and creatinine all tended to be higher for the higher socioeconomic group than for the low, but hemoglobin and hematocrits were similar for the two groups. Heights, weights, body circumferences, skinfold thicknesses and muscularity measurements were done. All of these except skinfold thickness tended to be greater for the high-income group, but the differences were significant only for height and waist circumferences.

In 1965, a study of 3,444 children from birth to six years of age was carried out by the Illinois, Iowa, Kansas, Nebraska, and Ohio Agricultural Experiment Stations and was reported by Eppright et al. (28). Most of the families could afford to give their children adequate diets, and many mothers were inclined to overestimate the needs of their preschool children and thus encourage overeating. Nutrition knowledge of the mothers varied directly with their level of education, but most mothers were concerned with the following eating problems of their preschoolers: the limited variety of food eaten, dawdling over food, eating either too little or too much, overeating of sweets, and reluctance to eat at mealtime.

Newman (29) stated that body size and growth rate are especially important in influencing nutritional needs with activity level also playing an important role in determining energy needs. Growth rate is very rapid during the first two years of life and decreases between two and eighteen except during adolescence. Growth rate averages about three inches and five pounds per year during the preschool period. This decrease in growth rate after age two means that a decrease in food consumption is both common and normal during the preschool years.

Bone Density Measurements

Research in the area of bone density began as early as 1927 at Pennsylvania State University and has involved both in vivo and in vitro methods. The history of the methods employed by various workers has been reviewed in a Master's thesis by Wang (30).

One of the events which has caused increased interest in bone density in the last few years is the effect of space flights on bone mineral loss. Mack and LaChance (31) did a study of the effect of varying levels of calcium intake on subjects during complete bed rest to see whether this situation caused bone mineral losses comparable to those of the astronauts. They reported that mean calcium consumption showed a negative correlation to bone density losses in their subjects, but they would not apply this unconditionally to the astronauts since uncontrolled variables such as stress and dietary factors other than calcium intake come into play during the space flights.

The relationship of bone density to aging is another area which is beginning to receive considerable attention. Mainland (32,33) reported a study of the x-ray density of the human calcaneus and of five bones in the hand and wrist of 62 subjects ranging in age from 19 to 84 years. He found no significant correlations between the density of the calcaneus and stature, body weight, sex, or age after soft tissue corrections were made. However, there was a highly significant negative correlation of the density of the phalanx of the right hand of males with age. If the regression he found was accepted as being linear, it would mean that mean bone density would decrease about 5% for each 20 years of life. No such age-density correlation was found for females.

Morgan et al. (34) studied the bone densities of men and women over 49 years of age living in Colorado, Utah, and California. California women showed significant correlations between density of the phalanx 5-2 and both serum vitamin A and serum cholesterol. Ascorbic acid intake also had a positive, though not a significant, correlation with bone density. Geographical location of the subjects was associated with marked differences in densities.

Baker and Angel (35) determined the densities of bone segments of human cadavers with a mean age of around 70 using a specific gravity technique. They found no consistent differences between the densities of white and Negro females, but Negro males had denser bone segments than white males.

Baker and Little (36) did a similar study on Peruvian cadavers. They found a negative correlation between age and bone density, but the correlation was not always significant. When comparing their results to those of the United States study (35), they found that the Peruvians had densities similar to U. S. whites. They reported a high degree of variability in the densities of different bone segments so that

> the density of any one bone segment was a poor predictor of the density of another bone segment in the same individual, and the fact that a given segment density was apparently affected by the age or sex or race of an individual did not necessarily mean that another bone segment would show the same relationship.

Some animal studies have been done in relation to bone density. Schraer and Schraer (37) compared the density of the midpoint of the femurs of 30 rats fed low-calcium diets with those of animals fed diets adequate in calcium. The densities of the rat femurs were measured for the first group after 36 days with measurements being done on succeeding groups at seven-day intervals. As the animals matured, bone density increased more rapidly for rats receiving diets adequate in calcium than for those with low calcium intakes. When, after 64 days, a calcium supplement was given to the deficient rats, a marked increase in bone density values occurred in less than one week's time. Williams and coworkers (38) found that mature rats showed an increase in calcium content but not in bone density when fed diets high in calcium, but young, growing rats did show significant increases in both these measurements with increased calcium intake.

Williams et al. (38) found in working with college students that while calcium balance was a good indication of present calcium intake, bone density appears to be an indication of past nutritional status and does not change readily with temporary changes in intake.

Nicholls et al. (39) studied adaptation to low calcium intake by using four men who had been accustomed to high calcium intake for most of their lives and three men who had been accustomed to low calcium intakes. They found a positive correlation between bone density and calcium intake, but with such a small number of subjects, the authors thought it could have been due to chance.

In 1958, Fisher and Dodds (40) used a similar approach to the problem of adaptation by selecting subjects who, according to records and interviews, had average daily calcium intakes greater than 1.5

grams, between 1.05 and 0.95 grams, and below 0.5 grams and had maintained these over a considerable period of time. The subjects were all college students and included 56 women and 61 men. A significant correlation was found between calcium intake and os calcis density for the group as a whole, but there was no significance when the data was divided according to sex. The authors concluded that

> the two bone positions now being used for the measure of bone density, the os calcis and the phalanx (end), are not sensitive enough to detect quantitative changes that might occur within the normal range of human nutritive intake of calcium.

In the same year, Mack et al. (41) reported a study of the effect of orange juice on the nutritional status of preschool and elementary school children. They found that an increase in skeletal density could be seen in subjects whose diets had been supplemented with orange juice with greater increases for longer periods of supplementation. This is consistent with Morgan's findings (34) of a positive correlation between ascorbic acid intake and bone density in California women.

Vavich and coworkers (42) investigated the nutritional status of 11- through 16-year-old Papago Indian children in Arizona. Part of the children attended the Indian service school where an ample, well-balanced lunch was provided, and part attended private schools where this was not true. The home diets of the children were very poor. A favorable bone density status was reported for Indian service school girls but not for the boys. Values were low for both boys and girls attending the private schools.

In 1958, the Montana Agricultural Experiment Station (43) published a report of bone density determinations and dietary evaluations of 1,888 subjects ranging in age from five to more than eighty years. There was little, if any, indication of a relationship between diet and bone density in the group as a whole even though an association was found for the Papago Indians (42) who were included in the study. Dietary information for the study had been obtained from seven-day dietary records, and it was felt that these did not give the type of long-range information necessary to give the cumulative nutrient intake of which bone density seems to be an indication. A 1959 interregional nutrition status report (44) summarized work done in the Western region, Pennsylvania, and Tennessee including some of the studies previously cited in this thesis (38,42,43) and indicated a need for the establishment of bone density norms for both sexes throughout the life cycle.

Schraer (45) has studied the roentgenographic density of both the os calcis and the phalanx for subjects of both sexes and a wide range of ages from childhood to young adulthood. The mean density of both of these bones was found to increase significantly with age in both sexes except for a few exceptions which included the os calcis path for females ages 13-20 and the phalanx center path for males between ages seven and twelve. Females had higher phalanx density coefficients than the males, but the reverse was true for os calcis densities except in the seven- through nine-years age group.

Williams and Samson (46) compared the bone density of East Indian and American students and found that for subjects of average height and weight a highly significant positive correlation existed between density coefficients and weight. When the subjects who were above or below average size were included, the significance was destroyed. It was postulated that the short, light people who had very high bone densities had probably had growth stunted by some nutrient other than calcium. Therefore, a normal intake of calcium could build denser-than-average bones. Lower-than-average bone densities can result when dietary calcium drops too low after full growth has been attained.

Hard and coworkers (47) examined the nutritional status of adolescent subjects by use of seven-day dietary records and biochemical tests and related these results to bone density. The results which correlated most consistently with bone density were the values for serum vitamin A, serum alkaline phosphatase, and hematocrit. However, it was felt that there may have been no cause-and-effect relationship since all the criteria were merely indications of good nutritional condition.

A bone density and dietary survey was recently made in Cumberland County, Tennessee (48) using 223 subjects ranging in age from three to ninety years. Three-day dietary records, dietary histories, bone density scans, and results of physical examinations were obtained for each subject. Age-density correlations showed that bone density increases up to age 20 for males while slow increases continue until about age 50 for females before dropping off. Calcium consumption showed a somewhat similar curve except for a sharp decrease in calcium intake about age 15 which did not reverse until about age 30.

CHAPTER III

EXPERIMENTAL PROCEDURE

Selection of Subjects

The subjects for this study were children enrolled in four Head Start centers and two private preschools in the Knoxville area. The study was conducted during April and May, 1969 after most of the children had been in kindergarten since the previous September. Eighty-one Head Start children and 61 children from the private preschools were included giving a total of 142 subjects. The sample included 63 boys and 79 girls. Complete dietary information was obtained for 102 of the children. The distribution of the subjects among the various schools is shown in Table 1. In order to simplify identification of the groups, the Head Start centers are labeled H-1, H-2, H-3, and H-4, and the private preschools, P-1, and P-2.

Letters of explanation about the study were sent to the parents of the children in the six centers. Forms to be signed stating whether or not parental permission was being granted for use of the children as subjects in the study were included in the letters with instructions to return these to the schools. Visits were made to many of the homes; the project was explained at parents' meetings of three of the schools; and some of the parents were contacted by telephone.

TABLE 1

DISTRIBUTION OF SUBJECTS

School	Total Subjects Included	Complete Dietary Data	Physical Measurements[1]
H-1			
Boys	12	8	12
Girls	12	8	12
H-2			
Boys	13	10	11
Girls	10	6	10
H-3			
Boys	8	6	8
Girls	9	8	8
H-4			
Boys	7	6	7
Girls	10	8	7
P-1			
Boys	11	8	11
Girls	20	15	19
P-2			
Boys	12	7	12
Girls	18	12	18
Total Head Start	81	60	75
Total Private	61	42	60
Total	142	102	135

[1]Includes bone density, height, and weight.

Collection of Dietary Information

Dietary information was obtained from short, modified dietary histories and from seven-day dietary records. (See the Appendix for these forms.) The dietary histories for the Head Start children were filled out during personal interviews with the mothers, but these sheets were sent home by the children in P-1 and P-2 with the request that they be completed and returned to The University of Tennessee. Food intakes were recorded in terms of common household measures and were later converted to grams by use of weights listed in Food Values of Portions Commonly Used by Bowes and Church (49).

Food portions eaten by the children at school were recorded by the research team with the help of the teachers. Estimations of the food portions served were then recorded. Snacks were served at all six centers and the Head Start centers also served lunches. School P-2 provided a noon meal for part of the children, but P-1 had no lunch program. The feeding program of each of the six centers will be briefly described.

Center H-1 was housed in an elementary school, and the children were fed in the school cafeteria in the building. Serving sizes were adjusted to suit the ages of the children, and seconds were allowed only after all the original meal had been eaten. Snacks were served in the rooms and were always some type of juice, usually orange juice.

Children of H-2 were housed in a church, but they walked to a nearby elementary school for lunch. Serving sizes were appropriate for the age group, but the children were allowed to trade foods with each other meaning that a rather unbalanced meal could result. Snacks were served in the church and consisted of juice or milk, and crackers served on alternate weeks. Our records are from a "milk" week.

School H-3 was in a separate building with its own cafeteria. Servings were an appropriate size during the week of the study. The children were allowed unlimited quantities of all items except desserts. These were restricted to one per child. Snacks were prepared by the aides and consisted of anything from juice and crackers to left-over cake and peanut butter-stuffed celery with milk.

School H-4 had its own building, but the children were transported by bus to an elementary school for lunch. Servings were very large; seconds were allowed only on approval by a teacher. Snacks were served early at school and were usually milk with peanut butter and crackers.

School P-1 served snacks which usually consisted of juice or some other type of fruit drink, with crackers or cookies. Snacks at P-2 were of a similar type. "Hot" lunches were provided for the children who wanted them. Some of the children brought their lunches and others went home for lunch. Seconds were allowed but were never requested during the period of the study.

The mothers of the children in all schools were requested to record food intakes at home. Instructions for this procedure were given either in person or over the telephone to all except part of the parents of the private preschool group. Letters of explanation and examples of food records were sent to these parents. A standard measuring cup, measuring spoons, and a ruler were given along with the instructions for measuring portion sizes.

Food items recorded on the home dietary sheets and at school were summarized, coded, and the amounts converted to grams by the research team. These were then transferred to data cards, and the intakes were calculated by computer using the values in USDA Handbook No. 8 (50). Nutrients obtained from vitamin and mineral supplements were added manually. Intakes obtained in this manner were then compared to the 1968 revisions of the National Research Council's Recommended Dietary Allowances (51).

Bone Density Measurement Technique

The bone density measurements were made by the x-ray bone densitometer method described by Mason and Ruthven (52). The bone densitometer was developed at The University of Tennessee. Wang (30) found that results obtained by this method were consistent with those obtained by the film method but were more reproducible. Reproducibility of bone densitometer estimations was found to be within 2.5% for a phantom bone and within 3-6% for human subjects as compared to the reproducibility of 12-15% generally reported for the film method.

In doing the bone density measurements in this study, a pathway was marked at the midpoint of the subject's left phalanx 5-2. The hand was positioned in the finger stand of the instrument, and a low-intensity x-ray beam passed through the little finger at the marked pathway. Both anterior-posterior and lateral views were traced for each subject so that the elliptical shape of the bone could be taken into consideration in calculating the bone density value. The automatic recorder on the instrument drew the absorption curve on graph paper as the finger was passed through the x-ray beam. The aluminum alloy wedge described by Williams and Mason (53) was used as the standard, and the absorption curve for it was traced. After the necessary measurements had been made on the tracings, the bone density value expressed as x-ray equivalent grams of alloy per cubic centimeter of bone was calculated by computer.

Procedure for Weighing and Measuring

Heights and weights of the children were taken at school. The children were measured to the nearest 1/8 inch with subtractions being made for shoes. They were weighed wearing light indoor clothing including shoes. Weights were recorded to the nearest 1/4 pound.

Statistics

Significant differences of means were tested using Student's "t" test, and correlations were run between selected factors using the statistical procedures outlined by Steel and Torrie (54).

CHAPTER IV

RESULTS AND DISCUSSION

The nutrients available from the food provided in lunches and snacks at each school were calculated and daily averages compared to the RDA for four- to six-year-olds. The results of these calculations expressed in absolute amounts are shown in Table 2 and as percentages of the RDA in Table 3.

The Head Start programs are required to provide food which contains at least 1/3 of the RDA for the children. It was found that all nutrients were being provided in excess of these amounts in lunches and snacks at all four Head Start centers. Iron and niacin were generally provided in the lowest percentages, but even these ranged from 36% to 57% of the RDA. It should be pointed out that throughout this thesis only values for preformed niacin are reported as niacin with no attempt being made to include niacin equivalents from tryptophan. More than 100% of the RDA for protein was provided at each school. Therefore, the niacin equivalents, if calculated, would raise the niacin level considerably.

All the Head Start centers served milk at lunch, and H-2 and H-4 also served it at snack time. This resulted in provision of a high percentage of the RDA for calcium, especially for the latter two schools. In H-1, where orange juice was served at snack time each day, 259% of the RDA for ascorbic acid was provided. H-3 served fruit juices several

TABLE 2

MEAN DAILY NUTRIENTS PROVIDED AT SCHOOL COMPARED TO AMOUNTS ACTUALLY EATEN

School	kcal	Protein	Calcium	Iron	Vitamin A	Thia-mine	Ribo-flavin	Niacin	Ascorbic Acid
		g	mg	mg	IU	mg	mg	mg	mg
RDA	1600	30	800	10.0	2500	0.80	0.90	11.00	40
H-1									
Provided	830	34	497	4.1	1991	0.42	0.80	5.16	104
Boys' intake	756	30	448	3.7	1573	0.42	0.75	4.72	106
Girls' intake	730	31	454	3.6	1594	0.43	0.81	5.23	104
H-2									
Provided	936	38	676	3.6	1695	0.36	1.11	4.16	17
Boys' intake	747	31	629	2.3	1191	0.30	1.00	3.20	13
Girls' intake	727	29	600	2.2	1128	0.29	0.95	2.80	11
H-3									
Provided	942	32	510	3.6	1856	0.40	0.88	4.87	56
Boys' intake	736	28	420	3.4	1393	0.37	0.70	4.70	64
Girls' intake	807	31	470	3.4	1379	0.41	0.81	4.99	62
H-4									
Provided	1060	44	760	4.9	2728	0.41	1.20	6.27	24
Boys' intake	830	38	733	3.2	1552	0.39	1.11	4.65	18
Girls' intake	682	31	650	2.5	1486	0.37	0.98	3.57	16
P-1[1]									
Provided	118	1	17	0.3	73	0.05	0.02	0.29	13
Boys' intake	116	1	15	0.3	69	0.04	0.02	0.30	11
Girls' intake	115	1	17	0.3	78	0.04	0.02	0.32	14
P-2									
Provided	509	17	228	2.8	1030	0.22	0.38	2.34	32
Boys' intake	394	12	193	1.8	606	0.16	0.31	1.68	22
Girls' intake	438	12	157	2.8	664	0.18	0.25	2.16	19

[1]This school did not have a lunch program. Only snacks were provided.

TABLE 3

PERCENTAGES OF RDA PROVIDED BY THE SCHOOLS COMPARED TO PERCENTAGES ACTUALLY EATEN

School	kcal	Protein	Calcium	Iron	Vitamin A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
H-1									
Provided	51.9	112.3	62.1	41.0	79.6	52.5	88.9	46.9	259.0
Boys' intake	47.2	100.0	56.0	37.2	62.9	52.5	83.3	42.9	265.0
Girls' intake	45.6	102.7	56.8	35.8	63.8	53.8	90.0	47.5	259.0
H-2									
Provided	58.5	126.7	84.5	36.0	67.8	45.0	123.3	37.8	41.5
Boys' intake	46.7	102.3	78.7	23.4	47.6	37.5	111.1	29.1	32.6
Girls' intake	45.4	96.6	75.0	22.0	45.1	36.2	105.6	25.4	28.5
H-3									
Provided	58.9	105.0	63.8	36.0	74.3	50.6	98.3	44.3	141.2
Boys' intake	46.0	92.5	52.4	34.0	55.7	46.2	77.7	42.7	159.4
Girls' intake	50.4	102.9	58.7	33.9	55.2	51.2	90.0	45.4	154.7
H-4									
Provided	66.2	146.7	95.0	49.0	109.1	57.5	133.3	57.0	60.0
Boys' intake	51.9	126.7	91.6	32.0	62.1	43.8	123.3	42.3	45.0
Girls' intake	42.6	103.3	81.2	25.0	59.4	36.2	108.9	32.4	39.2
P-1[1]									
Provided	7.3	4.0	2.1	3.0	2.9	6.2	2.2	2.6	32.5
Boys' intake	7.2	4.3	1.9	3.0	2.8	5.0	2.2	2.7	27.5
Girls' intake	7.2	4.3	2.1	3.0	3.1	5.0	2.2	2.9	35.0
P-2									
Provided	31.8	56.7	28.5	28.0	41.2	27.5	42.2	21.3	80.0
Boys' intake	24.6	40.0	24.1	18.0	24.2	20.0	34.4	15.3	55.0
Girls' intake	27.4	40.0	19.6	28.0	26.6	22.5	27.8	19.6	47.5

[1] This school did not have a lunch program. Only snacks were provided.

times during the week making the available ascorbic acid 141.2% of the RDA. Only 41.5% and 60.0% of the RDA for ascorbic acid was provided by H-2 and H-4 respectively where the milk snacks were served. However, as was pointed out in the original description of the feeding program, H-2 served milk for snacks one week and orange juice the next. If dietary information could have been obtained for a "juice" week as well as a "milk" week, a truer picture might have been presented. It seems that since the primary nutritional contribution of orange juice is ascorbic acid, which cannot be stored by the body, it might have been better to alternate snacks on a daily rather than a weekly basis. Also, the teachers indicated that the children seemed to get tired of the milk snacks before the end of a "milk" week.

When the percentages of nutrients actually eaten are considered, it can be seen that more than 1/3 of the RDA for all nutrients except iron in H-2 and H-4 and ascorbic acid in H-2 was being consumed. Since seconds were allowed in all schools, more was eaten in some cases than was provided in the original servings. The most waste (difference between provided and eaten) occurred for the protein foods and the provitamin A-rich vegetables. School H-1 had the smallest amount of waste with about 90% of the food provided being consumed. High percentages of all the available nutrients except calories and vitamin A were consumed by the children at H-3. In contrast, the H-2 children and the boys at H-4 ate only about 80% of the available calories, and the girls at H-4 ate only about 65%. The servings at H-4 were much larger than at the other schools resulting in an actual intake by these children not too different from those at the other centers. The servings at H-4 were not adjusted to the age group being served. That is, they were the same for preschooler through teenager. The boys at H-4 were generally "better eaters" than the girls. The reverse was true for H-3, and there was little difference between intakes of boys and girls at H-1.

Since school P-1 did not serve lunch, most nutrients were provided in only minute amounts. However, almost 1/3 of the daily requirement of ascorbic acid was available in the fruit juices which were served at snack time. Almost all the food that was provided was eaten.

In contrast to the high percentages of the RDA provided by the Head Start food, less than 1/3 of the daily requirements of calories, calcium, iron, thiamine, and niacin was available from the lunches and snacks at P-2. About 85% of the available calories were consumed, but only about 70% of the protein, calcium, vitamin A, and ascorbic acid was actually eaten. Calcium, riboflavin, and ascorbic acid intakes were higher for boys than for girls, but calories, iron, vitamin A, thiamine, and niacin intakes were lower.

The mean daily nutrient intakes of the children are summarized in Table 4. These were obtained by adding the nutrients eaten at home to those consumed at school. According to these data, five groups were receiving less than 100% of the RDA for calories. These included both boys and girls in schools P-2 and H-3 and girls from H-1. Calcium intake was below the recommended amount for girls at H-1 and for boys at H-3 and P-2. Iron intake was a little below the RDA for boys in H-2, H-3, and P-2 and girls in P-1. None of the groups were consuming less

TABLE 4

MEAN DAILY NUTRIENT INTAKES OF PERESCHOOL CHILDREN

School	kcal	Protein	Calcium	Iron	Vitamin A	Thia-mine	Ribo-flavin	Niacin	Ascorbic Acid
		g	mg	mg	IU	mg	mg	mg	mg
RDA	1600	30	800	10.0	2500	0.80	0.90	11.00	40
H-1									
Boys	1859	73	904	20.4	4385	1.76	2.30	17.57	130
Girls	1559	59	773	17.5	5080	1.54	2.25	16.61	123
H-2									
Boys	1484	59	936	6.8	5247	1.72	2.72	17.53	61
Girls	1657	64	1125	17.9	4824	2.37	2.91	22.75	77
H-3									
Boys	1496	55	771	7.3	4028	1.12	1.82	12.34	72
Girls	1560	61	934	16.4	7712	1.88	2.83	18.32	96
H-4									
Boys	1889	71	1136	22.2	5355	1.60	2.79	16.98	55
Girls	1794	72	1201	19.0	6843	2.07	3.27	20.07	71
P-1									
Boys	1969	68	980	10.2	6761	2.07	3.00	22.51	179
Girls	1749	59	869	8.8	7632	2.12	3.04	25.56	160
P-2									
Boys	1546	56	776	8.7	6940	1.95	2.87	21.72	122
Girls	1610	64	1007	13.6	5216	1.36	2.32	15.83	93

than 67% of the RDA for any nutrient. These findings were similar to those reported for Nebraska preschoolers (26). Means for the vitamins in all groups and for iron in most groups is deceptively high because many of the children were receiving supplements of these nutrients.

The percentages of children from each center who were taking supplements are summarized in Table 5. Of all the children, 53.9% were receiving vitamin supplements; 16.7% were receiving iron; and 8.8%, both vitamins and iron. Most of the vitamin supplements used provided 100% or more of the adult RDA for each nutrient. The usual iron supplement was 36 mg. per day. However, some children were receiving only 10 mg., and one child was taking a 60 mg. supplement. More children in the private preschool group (76.2%) than in the Head Start group (38.3%) were receiving vitamin supplements. However, 21.7% of the Head Start children were taking iron supplements compared to only 9.5% of the private preschool group. All the children from P-1 and P-2 who were taking iron were also taking vitamins but this was not true for those in Head Start. Several of the Head Start children had been diagnosed as having anemia at the time of their physical examinations before entering kindergarten, and the iron supplements were prescribed for them at that time.

In the following discussion, diets will be described as high, adequate, and inadequate according to the following criteria:

High--level of all nutrients is equal to or above 100% of the RDA.

Adequate--level of at least one nutrient is below 100% of the RDA but none is below 67%.

TABLE 5

PERCENTAGES OF CHILDREN TAKING SUPPLEMENTS

School	Vitamins	Iron	Both
H-1			
Boys	25.0	25.0	12.5
Girls	37.5	25.0	12.5
H-2			
Boys	50.0	0.0	0.0
Girls	50.0	16.7	16.7
H-3			
Boys	16.5	0.0	0.0
Girls	50.0	25.0	0.0
H-4			
Boys	33.3	50.0	16.7
Girls	37.5	37.5	12.5
P-1			
Boys	87.5	12.5	12.5
Girls	93.3	6.7	6.7
P-2			
Boys	85.7	14.2	14.2
Girls	41.7	8.3	8.3
Head Start, All	38.3	21.7	8.5
Private, All	76.2	9.5	9.5
Head Start and Private, Combined	53.9	16.7	8.8

Inadequate--level of at least one nutrient is below 67%.

According to these criteria, 13.7% of the children had a high dietary level, and 51.0% had adequate diets. However, 35.3% would be classified as inadequate. Percentages for boys and for girls having high, adequate, and inadequate levels of intake are given by schools in Table 6. There was little difference between the percentage of children with high nutrient intakes in the Head Start group and that of children in the private preschool group. However, there was a higher percentage of Head Start children than of private preschool children with inadequate diets even though most of the Head Start children had been receiving considerably more than 1/3 of the RDA for each nutrient from the food eaten at school. There was no difference between the percentage of boys and that of girls in each dietary classification for the Head Start group and little difference between boys and girls for the private preschool group. School H-2 had the highest percentage of inadequate diets, and P-1, the group which had no school lunch program, had the lowest percentage. This may have been due, at least in part, to the high percentage of children at P-1 taking vitamin supplements.

Twenty-two of the 36 children who were eating inadequate diets were inadequate in only one nutrient while 14 of them were inadequate in more than one. The poorest diet was that of a girl in P-2 who was eating inadequate levels of six nutrients. One girl in H-1 was receiving inadequate amounts of five nutrients, and a boy from H-2 and one from P-2 were deficient in four.

TABLE 6

PERCENTAGES OF CHILDREN HAVING HIGH, ADEQUATE, AND INADEQUATE LEVELS OF NUTRIENT INTAKE

School	High[1]	Adequate[2]	Inadequate[3]
H-1			
Boys	25.0	50.0	25.0
Girls	12.5	50.0	37.5
H-2			
Boys	0.0	40.0	60.0
Girls	16.7	33.3	50.0
H-3			
Boys	0.0	50.0	50.0
Girls	0.0	62.5	37.5
H-4			
Boys	33.3	50.0	16.7
Girls	25.0	37.5	37.5
P-1			
Boys	25.0	62.5	12.5
Girls	13.3	60.0	26.7
P-2			
Boys	0.0	57.1	42.9
Girls	16.7	50.0	33.3
Head Start, All	13.3	46.7	40.0
Private, All	14.3	57.1	28.6
Head Start and Private, Combined	13.7	51.0	35.3

[1]Level of all nutrients is equal to or above 100% of RDA.

[2]Level of at least one nutrient is below 100% of RDA, but none is below 67%.

[3]Level of at least one nutrient is below 67% of RDA.

Table 7 gives the percentages of children having a high level of intake of each individual nutrient. All of the children consumed high levels of protein and more than 80% had high levels of all the vitamins except niacin. Only 31.4% of all the children were high in iron, and almost half of these were taking iron supplements. Of the total group, 55.9% and 64.7% were high in calories and calcium, respectively. A larger percentage of the Head Start children were high in calcium and iron while the private preschool children tended to have higher intakes of the vitamins. Table 8 shows the percentages of children having an adequate level of intake of each individual nutrient, and Table 9 shows those for inadequate levels. There were no inadequate levels of protein or riboflavin. In contrast to this, one Kansas study (24) showed a high percentage of protein deficiencies. Of all the children in the present study, 23.5% had inadequate iron intakes with almost equal percentages coming from the Head Start and private preschool groups. This agrees with the high percentages of iron deficiency, observed by many other investigators (10,18,20,22,24,26). Calcium was the second most often lacking nutrient with 10.8% of the children being deficient in it. This also agrees with previous observations (18,23,24). While 16.7% of the private preschool children had inadequate intakes of calcium, only 6.7% of the Head Start children were deficient in this nutrient. The percentages of children deficient in the intakes of the other nutrients ranged from 8.8% for niacin to 1.9% for thiamine.

The vitamin and iron supplements kept many of the children from having inadequate intakes of one or more of these nutrients. Of the 63

TABLE 7

PERCENTAGES OF CHILDREN HAVING HIGH[1] INTAKES OF INDIVIDUAL NUTRIENTS

School	kcal	Protein	Calcium	Iron	Vitamin A	Thia- mine	Ribo- flavin	Niacin	Ascorbic Acid
H-1									
Boys	62.5	100.0	62.5	75.0	75.0	87.5	100.0	75.0	100.0
Girls	50.0	100.0	50.0	37.5	75.0	75.0	87.5	87.5	100.0
H-2									
Boys	30.0	100.0	80.0	0.0	70.0	100.0	60.0	60.0	50.0
Girls	50.0	100.0	83.3	16.7	83.3	100.0	100.0	66.7	100.0
H-3									
Boys	50.0	100.0	33.3	0.0	83.3	66.7	83.3	50.0	100.0
Girls	50.0	100.0	75.0	25.0	75.0	83.5	100.0	63.0	87.5
H-4									
Boys	83.5	100.0	83.5	50.0	100.0	100.0	100.0	83.3	50.0
Girls	62.5	100.0	100.0	75.0	75.0	75.0	100.0	50.0	50.0
P-1									
Boys	87.5	100.0	87.5	37.5	100.0	87.5	100.0	75.0	87.5
Girls	60.0	100.0	59.9	19.9	100.0	100.0	100.0	93.3	100.0
P-2									
Boys	57.1	100.0	43.9	14.4	85.7	85.8	85.7	85.7	100.0
Girls	41.7	100.0	33.3	41.7	66.5	66.7	91.7	66.5	94.6
Head Start, All	53.3	100.0	70.6	33.3	78.4	80.0	96.7	68.4	78.4
Private, All	59.5	100.0	54.7	28.3	88.0	85.3	95.1	80.9	92.7
Head Start and Private, Combined	55.9	100.0	64.7	31.4	82.2	82.3	96.1	73.6	84.3

[1] 100% or more of RDA.

TABLE 8

PERCENTAGES OF CHILDREN HAVING ADEQUATE[1] INTAKES OF INDIVIDUAL NUTRIENTS

School	kcal	Protein	Calcium	Iron	Vitamin A	Thia-mine	Ribo-flavin	Niacin	Ascorbic Acid
H-1									
Boys	25.0	0.0	25.0	25.0	12.5	12.5	0.0	25.0	0.0
Girls	37.5	0.0	37.5	37.5	0.0	25.0	12.5	12.5	0.0
H-2									
Boys	60.0	0.0	10.0	60.0	20.0	40.0	0.0	10.0	20.0
Girls	50.0	0.0	16.7	33.3	0.0	0.0	0.0	33.3	0.0
H-3									
Boys	50.0	0.0	50.0	66.7	16.7	33.3	16.7	16.7	0.0
Girls	37.5	0.0	25.0	50.0	25.0	12.5	0.0	37.0	0.0
H-4									
Boys	16.5	0.0	16.5	50.0	0.0	0.0	0.0	16.7	50.0
Girls	37.5	0.0	0.0	25.0	25.0	25.0	0.0	37.5	25.0
P-1									
Boys	12.5	0.0	0.0	62.5	0.0	12.5	0.0	25.0	12.5
Girls	33.3	0.0	26.7	53.3	0.0	0.0	0.0	6.7	0.0
P-2									
Boys	28.6	0.0	42.8	42.8	14.3	0.0	14.3	14.3	0.0
Girls	58.3	0.0	41.7	33.3	25.0	25.0	8.3	25.0	0.0
Head Start, All	40.0	0.0	21.7	43.3	13.3	20.0	3.3	18.3	11.6
Private, All	35.7	0.0	28.6	47.9	9.6	9.6	4.8	16.7	4.8
Head Start and Private, Combined	38.2	0.0	24.5	45.1	11.8	15.7	3.9	17.6	8.8

[1]Between 67% and 100% of RDA.

TABLE 9

PERCENTAGES OF CHILDREN HAVING INADEQUATE[1] INTAKES OF INDIVIDUAL NUTRIENTS

School	kcal	Protein	Calcium	Iron	Vitamin A	Thia-mine	Ribo-flavin	Niacin	Ascorbic Acid
H-1									
Boys	12.5	0.0	12.5	12.5	12.5	0.0	0.0	0.0	0.0
Girls	12.5	0.0	12.5	25.0	25.0	0.0	0.0	0.0	0.0
H-2									
Boys	10.0	0.0	10.0	40.0	10.0	0.0	0.0	30.0	30.0
Girls	0.0	0.0	0.0	50.0	16.7	0.0	0.0	0.0	0.0
H-3									
Boys	0.0	0.0	16.7	33.3	0.0	0.0	0.0	33.3	0.0
Girls	12.5	0.0	0.0	25.0	0.0	0.0	0.0	0.0	12.5
H-4									
Boys	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Girls	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	25.0
P-1									
Boys	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0
Girls	6.7	0.0	13.4	26.8	0.0	0.0	0.0	0.0	0.0
P-2									
Boys	14.3	0.0	14.3	42.8	0.0	14.3	0.0	0.0	0.0
Girls	0.0	0.0	25.0	25.0	8.5	8.5	0.0	8.5	5.3
Head Start, All	6.7	0.0	6.7	23.3	8.3	0.0	0.0	13.0	10.0
Private, All	4.8	0.0	16.7	23.8	2.4	4.8	0.0	2.4	2.4
Head Start and Private, Combined	5.9	0.0	10.8	23.5	5.9	1.9	0.0	8.8	6.9

[1]Below 67% of RDA.

children taking some form of supplement, 27% were elevated from inadequate to high levels of one or more nutrients, and 44.4% were raised from adequate to high levels. However, 28.6% of the children taking vitamin and/or iron preparations were already consuming high levels of all the nutrients being supplemented.

The percentage of Knoxville children having inadequate diets was higher than that found for Ohio (18) or Iowa (21) children whose diets were judged by the same criteria.

The mean ages, heights, weights, bone densities, and calcium and ascorbic acid intakes for the boys and girls in each school are shown in Table 10. Mean ages, heights, and calcium and ascorbic acid intakes were similar for boys and girls but the difference in weights was significant at the 0.02 level. The mean bone density for both boys and girls was 0.69 ± 0.01 gram equivalents per cubic centimeter of bone showing that no sex difference existed. Neither was there a significant difference between the mean bone density values of the two socioeconomic groups (Head Start, 0.68 ± 0.01; private, 0.70 ± 0.01).

Table 11 summarizes the bone densities, calcium intakes, and ascorbic acid intakes by schools. The children at H-4 had a mean bone density value which was significantly higher ($P < 0.01$) than those of children at all the other Head Start centers. However, it was not significantly higher than the values obtained for the children in the private preschools. Calcium intakes of the children at H-4 were significantly higher than those of children at H-1, H-3, and P-1. Ascorbic acid intake at P-1 was significantly higher than those at all Head Start centers,

TABLE 10

A SUMMARY OF GROWTH PARAMETERS AND CALCIUM AND ASCORBIC ACID INTAKES OF PRESCHOOL CHILDREN

School	Age	Height	Weight	Bone Density Index	Calcium Intake	Ascorbic Acid Intake
	months	inches	pounds	gm/cc	mg	mg
H-1						
Boys	69 ± 2[1]	44.5 ± 0.7	46.4 ± 1.7	0.68 ± 0.01	905 ± 82	130 ± 18
Girls	67 ± 2	43.7 ± 0.7	41.8 ± 1.8	0.67 ± 0.01	773 ± 79	123 ± 17
H-2						
Boys	68 ± 1	45.0 ± 0.5	45.7 ± 1.1[2]	0.66 ± 0.02	936 ± 76	61 ± 13
Girls	69 ± 1	43.7 ± 0.4	41.0 ± 1.0	0.65 ± 0.01	1125 ± 163	77 ± 14
H-3						
Boys	70 ± 2	44.0 ± 0.4	43.7 ± 1.1	0.67 ± 0.02	771 ± 90	72 ± 12
Girls	72 ± 2	44.9 ± 0.8	44.6 ± 2.8	0.64 ± 0.03	934 ± 75	96 ± 21
H-4						
Boys	76 ± 1	45.6 ± 0.8	46.4 ± 1.8	0.75 ± 0.04	1136 ± 137	55 ± 11
Girls	72 ± 3	45.1 ± 0.4	44.8 ± 1.1	0.75 ± 0.01	1201 ± 137	71 ± 17
P-1						
Boys	73 ± 1	45.9 ± 0.4	47.0 ± 1.1	0.67 ± 0.01	979 ± 53	179 ± 69
Girls	73 ± 1	45.7 ± 0.4	45.2 ± 1.6	0.71 ± 0.02	869 ± 78	160 ± 40
P-2						
Boys	70 ± 2	45.0 ± 0.6	46.2 ± 1.5	0.70 ± 0.02	776 ± 94	122 ± 20
Girls	68 ± 1	44.4 ± 0.4	44.0 ± 1.6	0.71 ± 0.02	1007 ± 210	93 ± 13
All Boys	70 ± 1	45.0 ± 0.2	46.0 ± 0.6[3]	0.69 ± 0.01	918 ± 38	105 ± 14
All Girls	70 ± 1	44.7 ± 0.2	43.7 ± 0.7	0.69 ± 0.01	967 ± 57	111 ± 12

[1] Mean ± SE. [2] $P < 0.02$. [3] $P < 0.01$.

TABLE 11

MEAN BONE DENSITIES AND CALCIUM AND ASCORBIC ACID INTAKES SUMMARIZED BY SCHOOLS

School	Bone Density	Calcium Intake	Ascorbic Acid Intake
	g/cc	mg	mg
H-1	0.67 ± 0.01[1]	839 ± 58	127 ± 12
H-2	0.66 ± 0.01	1007 ± 78	67 ± 9
H-3	0.65 ± 0.02	864 ± 60	86 ± 13
H-4	0.75 ± 0.02[2]	1173 ± 94[3]	64 ± 11
P-1	0.70 ± 0.01	908 ± 54	168 ± 35[4]
P-2	0.71 ± 0.02	922 ± 137	104 ± 11[5]

[1]Mean ± SE.

[2]Significantly higher ($P < 0.01$) than H-1, H-2, and H-3.

[3]Significantly higher ($P < 0.01$) than H-1, H-3, and P-1.

[4]Significantly higher ($P < 0.01$) than H-1, H-2, H-3, and H-4.

[5]Significantly higher ($P < 0.01$) than H-2 and H-4.

and the intake at P-2 was significantly higher than those at H-2 and H-4. However, all mean ascorbic acid levels were much higher than the RDA.

The bone density values within each of the Head Start centers was relatively consistent, but there was a tendency for more variation for the children in the private preschools. This indicates that there might be some relationship between diet and bone density since the children in each Head Start center ate lunch and snacks together, and most of the private preschool children ate all their meals except a light snack at home. However, when correlations were run between bone density and calcium and ascorbic acid intakes, no significant relationships were found. Attempts were made to correlate bone density with those particular nutrients because earlier workers (34,37,38,39,40,41,48) had indicated that such relationships might exist. These results and those of correlations with age, height, and weight are shown in Table 12. The only significant correlation was between weight and bone density for boys. That of height and bone density for girls approached significance. Apparently the age range of the subjects was too small to allow a significant correlation to be obtained between bone density and age, and the subjects were probably too young for a sex difference to show up in the mean bone densities. Weight and height variations were slight making correlations unlikely although trends are apparent here. The failure to correlate bone density with nutrient intake may have been due to the fact that the diets of the children had changed since entering school, and the present diets had not had time to cause a bone density change. Another possibility is

TABLE 12

CORRELATION OF SELECTED FACTORS WITH BONE DENSITY

Factor	Number	r value
Age		
Boys	60	0.21
Girls	72	0.16
Height		
Boys	61	0.20
Girls	74	0.22
Weight		
Boys	61	0.27[1]
Girls	74	0.17
Calcium intake		
Boys	44	0.23
Girls	53	0.07
Ascorbic acid intake		
Boys	44	-0.09
Girls	53	-0.04

[1] $P < 0.05$.

that nutrient intake in excess of body needs does not increase bone density much above that which occurs when intake is only at the recommended level.

CHAPTER V

SUMMARY

Food intake of preschool children from four Head Start centers and two private preschools in Knox County, Tennessee were obtained from seven-day dietary records. Nutrient intake coming from food provided at school was calculated separately.

It was found that the Head Start food programs provided well over the required 1/3 of the Recommended Dietary Allowances of each nutrient for preschool children. Each school provided more than 100% of the RDA for protein and two schools provided more than 100% of the RDA for ascorbic acid. The quantity of food eaten was similar regardless of serving size meaning that large servings resulted in more wasted food.

The private preschool which served lunch made much smaller contributions to the daily nutrient intake than did the Head Start centers. This was due both to small servings and to poor eating habits of the children.

When total food intake was considered and the means calculated for each nutrient, neither the boys nor the girls of any school were found to be consuming less than 67% of the RDA for any nutrient. However, calories, calcium, and iron were slightly below the recommended level for some groups. When diets were considered individually, 35.3% of the children had diets which had one or more nutrients present in less than 2/3 of the recommended level, and only 13.7% of them had diets which met or exceeded the RDA for all nutrients. The percentage of boys consuming diets which fell into each of three levels of dietary adequacy was the same as that of girls in each socioeconomic group, but a higher percentage of the Head Start than of the private preschool children had diets which were classified as inadequate. Most of these children were inadequate in only one nutrient, but some children were deficient in as many as five or six.

Vitamin and iron supplements contributed substantially to the intake of these nutrients for the children since 53.9% of them were taking some form of supplement. More of the private preschool children took vitamin supplements while more of the Head Start group took iron. The supplements made worthwhile contributions in some cases, but 28.6% of the children were already consuming high levels of all nutrients being supplemented.

Bone density values were determined for the phalanx 5-2 by the direct scan technique using x-rays. The values ranged from 0.50 to 0.96 gram equivalents per cubic centimeter of bone with a mean value of 0.69. No sex difference or difference between socioeconomic groups was found in bone density values. Correlations between ascorbic acid and calcium intakes and bone density were not significant nor were those between age and bone density. However, a significant correlation did exist between weight and bone density for boys, and the correlation between height and bone density of girls approached significance.

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APPENDIX

I am ____ willing / ____ unwilling to have my child take part in the bone density research.

I understand that a bone density measurement will be made and that 7 day records are to be kept of food eaten by my child.

Signed: ______________________________

Date: ________________________________

UNIVERSITY OF TENNESSEE
Department of Nutrition

Expt. No._____
Date__________

Name of Child:______________________________

Place of birth:_____________________________

Birth Date:___________________________Height___________Weight____________

Name of Parents:_________________________Occupation_____________________

Address:____Telephone:____________

Meals per day: Breakfast______ Lunch______ Dinner ______Other__________

Explanation:

Have special therapeutic diets ever been followed? Yes______No_________

If yes, for what? ____

How long ago? ____

Was participant breast fed__________ or bottle fed_________or both______
as an infant?

Has the child had any broken bones? __________How many?_________________

Foods especially liked:

Foods disliked and avoided:

Supplements used: Fish liver oils_____Vitamins_____Minerals____________

Amounts:_________________________Brand:___________________________

Milk and milk products used: average cups milk per day (drinking

and cooking) _____

Cheese used per week_______________Ice cream per week___________

Green vegetables___________________Green leafy__________________

Energy Expenditure Estimate

Time in bed at night_______________Daytime sleep or rest_________

Day's activities: ____

____

Energy Expenditure: Very light____Light____Moderate____Severe____

Very Severe____

NAME____ NO.________

ADDRESS____

DATE___________________________________ DAY OF WEEK_______________________

	FOOD	KIND STATE	AMOUNT
BREAKFAST			
BETWEEN MEAL			
NOON MEAL			
BETWEEN MEAL			
EVENING MEAL			
AFTER EVENING MEAL			

VITA

Sarah May Tucker was born in Livingston, Tennessee, on May 2, 1947. She attended elementary school there and was graduated from Livingston Academy in 1964. The following September she entered Carson-Newman College, and in May, 1968, she was graduated Magna Cum Laude with the degree of Bachelor of Science in Home Economics. She began graduate work at The University of Tennessee in the summer of that year and served as a graduate teaching assistant in the Department of Nutrition during the academic year 1968-1969 while continuing study toward a Master's degree. She received the degree of Master of Science with a major in Nutrition in August, 1969. She accepted a position as Instructor in the Division of Home Economics at Georgia Southern College in Statesboro, Georgia, for the academic year 1969-1970.