NUTRITIONAL STATUS OF PRESCHOOL CHILDREN
WITH EMPHASIS ON ZINC STATUS
AND FIBER INTAKE

By

ANDREA BENDER ARQUITT

Bachelor of Science in Home Economics

University of Tennessee

Knoxville, Tennessee

1966

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1982

NUTRITIONAL STATUS OF PRESCHOOL CHILDREN

WITH EMPHASIS ON ZINC STATUS

AND FIBER INTAKE

Thesis Approved:

Esther Winterfeldt
Thesis Adviser

Mary Alice Kenney

Don Holbert

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

Sincere appreciation is expressed to Dr. Esther Winterfeldt for her guidance and encouragement during my graduate studies. Her enthusiasm and encouragement were especially helpful during planning and conducting this study.

Sincere thanks are also expressed to the members of my committee, Dr. Mary Alice Kenney and Dr. Don Holbert for their help in conducting and evaluating this study. In addition, thanks are expressed to Miss Leone List, Mrs. Jean Bolton, and Mrs. Edna Jungers for their permission to conduct this study in the preschools. I appreciate the interest and cooperation given by all the preschool teachers without whose help this study would not have been possible. Appreciation is also expressed to Dr. Lester Reed, professor of Agronomy at OSU for his guidance and help in completing the atomic absorption analysis of the hair samples.

The help of friends in data preparation during many late nights is gratefully acknowledged. Thanks are given to these friends, Wendy Sandoval and Denise Graven.

Finally, my deepest thanks go to my family without whose support and love all these things would have been impossible: my husband, Ed who kept home and his own job running smoothly; our children, George and Karen, who are looking forward to having a "regular Mom" again. I am truly grateful for their love and patience.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The nutritional status of children received considerable attention in the 1960's and early 1970's. The majority of studies were concentrated around the economically deprived child and were not representative of the United States population. Two national studies sought to identify pockets of malnutrition in the United States: the Ten State Nutrition Survey identified the poor, the very young, women of child-bearing age, and the elderly as being of nutritional risk (U.S. Department of Health, Education and Welfare, 1972); the Hanes study, designed to be representative of the population, identified these same groups as having low nutrient intakes (National Center for Health Statistics, 1979).

During these same years, two broad based nutrition studies were conducted on preschool children. Both of these studies attempted to select representative samples of the population. The North Central Study, comprising 12 states, showed a correlation of nutrition status to family income (Fryer et al., 1972). The Preschool Nutrition Survey, conducted during a two year period in the early 1970's, was national in scope and representative of the United States preschool age population. The researchers found that the age of the child and socioeconomic status were important determining factors of nutritional status; the improved nutritional status with higher economic status could partly be related to the increased consumption of nutrient supplements in the higher socioeconomic groups. However, when considering nutrient intake on the basis of nutrients per unit of energy, there was little basis for differentiation among socioeconomic groups (Owen et al., 1974).

A feature of these studies was the lack of data on newer trace elements in the nutritional status of children. This lack was partially explained by the lack of data on the nutrient composition of foods at the time the studies were done and the lack of accepted biochemical methods of trace element analysis. However, recent publications of nutrient data weakened the argument for omitting these components of nutritional status (Murphy, Willis, and Watt, 1975; Freeland and Cousins, 1976).

Zinc was known to be an essential mineral for humans. Its primary biological importance was established as being a component of enzyme systems presently thought to be over 40 in number. Zinc was related to nucleic acid synthesis and to protein formation, and thus was important in normal growth (Committee on Nutrition, American Academy of Pediatrics, 1978). Zinc deficiency was related to growth retardation and delayed sexual maturation in young males in Iran and Egypt (Halstead et al., 1972). Zinc deficiency was also found in several disease conditions (Sandstead, Vo-Khactu, and Solomons, 1976).

Limited data, however, have been collected on preschool children. Marginal zinc deficiency associated with poor growth performance, low hair zinc levels, and hypogeusia was found in Denver children from middle and upper socioeconomic families (Hambidge et al., 1972). A further study of Denver Head Start children showed significant numbers of children with low hair zinc and poor growth performance (Hambidge, et al., 1976).

Research findings concerning the role of fiber in zinc absorption were conflicting which left many questions and problems for study. Animal studies showed zinc absorption to be decreased in the presence of phytic acid and showed that the presence of high calcium intakes enhanced the inhibitory effect of phytic acid (Oberleas and Harland, 1977). Cummings (1978) stated,

> At the present time, one would be unwise to study the nutritional consequences of any group of substances in the diet without including some reference to their interaction with dietary fiber (p. 521).

Thus, both fiber and zinc status were considered to be significant considerations in the study of nutritional status of preschool children. It was felt that further study in this area would serve as part of an information base for future work. The present study was undertaken to expand the knowledge of nutritional status of preschool children and the knowledge of the relationship between fiber intake and zinc status.

Purpose and Objectives

The purpose of the present study was to assess the nutritional status of preschool children, giving emphasis to the intake of dietary fiber and zinc. Socioeconomic status was used for stratifying the sample for analysis.

The following research objectives were developed for this project:

1. To determine the nutritional status of preschool children relative to socioeconomic status group;
2. To assess zinc status relative to zinc intake as measured

by growth, hair zinc, and taste acuity;

3. To determine zinc status of preschool children relative to fiber intake; and
4. To further the knowledge of factors affecting the nutritional status of preschool children and to make recommendations for further research.

Hypotheses

The following hypotheses were formulated for this study:

1. There will be no significant differences in the nutritional status of preschool children of different socioeconomic status background;
2. There will be no relationship between zinc intake and zinc status as measured by growth achievement, hair zinc, and taste acuity; and
3. There will be no significant differences in the zinc status of preschool children based on fiber intake.

Assumptions and Limitations

The researcher assumed that methodology available for various parts of the study would be applicable to subjects of this age group. The researcher acknowledged the following limitations for this study:

1. The data accumulated will not be generalized to the entire population of preschool children since the sample was not representative of the population;
2. There were a limited number of subjects included;
3. The accuracy of the food intake data was limited by the

ability of the mother or caregiver to recall food consumed and to estimate quantities; and

4. The validity of measurement of zinc in hair as a zinc status indicator was still questionable. The results, however, could be related to the findings of other researchers.

Definitions

The following terms were defined for the purpose of this study.

Nutritional status--

> The condition of an individual's health as influenced by intake and utilization of nutrients, determined from the correlation of information obtained from physical, biochemical, and dietary studies (Owen et al., 1974, p. 597).

Preschool child--any child who was at least three years of age but had not entered kindergarten before September 1, 1981.

Inadequate nutrient intake--the consumption of less than three-fourths of the 1980 Recommended Dietary Allowances for any nutrient.

Low hair zinc--". . . levels more than three standard deviations below the mean for normal young adults" (Hambidge et al., 1976, p. 736).

Hypogeusia--clinical term for diminished ability to taste.

Decreased taste acuity--inability to distinguish differences in a test solution and distilled water at median concentration thresholds for normal adults.

Detection threshold--"The lowest concentration of test solution that can be consistently distinguished from distilled water" (Henkin, Gill, and Bartter, 1963, p. 727).

Fiber--

> . . . the remnants of plant cells resistant to hydrolysis by the alimentary enzymes of man . . . storage polysaccharides

(often water soluble), pectic substances, plant gums, and mucilages should be included as undigested polysaccharides . . . (Trowell, 1978, pp. 7-8).

CHAPTER II

REVIEW OF LITERATURE

In order to plan and evaluate this study, it was necessary to examine the literature for present knowledge of nutritional status of children. Nutritional status of preschool children, the role of zinc in human nutrition, and factors affecting zinc status were reviewed.

Determination of Nutritional Status

Nutritional status has been defined as the state of nutritional achievement of individuals or groups of individuals. To thoroughly define or to explain the status of the individual or group involved assessing the community for its impact on the group or individuals. In compiling community data, one should include dietary records of individuals singly or in groups for comparison against a standard, clinical examinations for overt signs of malnutrition, and laboratory studies to verify or negate other observations. This level of study was considered to be the ideal; it may be limited, however, by levels of funding and personnel to complete the task (Christakis, 1973).

Dietary studies have been used to determine current nutrient intakes; they were not considered true indicators of nutritional status when used alone, but provide some evidence of adequacy or inadequacy of the diet. Various researchers have studied the merits of several methods of obtaining this dietary data.

Dietary Study Methods

Young et al. (1952) found that for estimated intakes, the 24 hour recall did not give the same estimate of intake as the research type dietary history nor was it an unbiased estimate of intake when compared with the seven day record. However, for the children studied (school age), the relationship between the 24 hour recall and the seven day record was a more stable indicator than the relationship between the dietary history and the seven day record. These researchers also found that when group comparisons were being made (using groups of roughly 50 subjects) both the 24 hour recall and the seven day record gave essentially the same result.

Eppright et al. (1952) studied dietary information collection methods in school children. They found that one day records gave fewer indications of unsatisfactory diets than three day records and that three day records gave fewer indications of unsatisfactory intake than did seven day records. In studying these groups of children, the authors also found that both shorter length of food records and parental estimates of portion size (versus weighed diets) resulted in overestimations of nutrient intake. However, analysis of weekend days, particularly Sundays, resulted in lowered nutrient intakes. There was no difference in any combination of any three days in a week in predicting week day consumption. Thus, eliminating weekend days and estimating portion sizes may give falsely elevated dietary scores.

Marr (1971) reported from studies conducted by both Heady and Fidanza and Fidanza-Alberti that information taken from three days of a dietary study correlated closely with the entire seven day record. However, Marr cautioned that individual variation between days should be considered.

The information regarding validity of types of dietary studies was conflicting. Thus, Christakis (1973) stated that researchers have based decisions on the length of a dietary analysis on the number of subjects to be studied, available personnel, and the ability of those being studied to cooperate in recordkeeping, and the use of the data in connection with clinical and biochemical findings.

Establishing Nutritional Standards for Children

The Food and Nutrition Board of the National Research Council defined the Recommended Dietary Allowances (RDA) (National Academy of Sciences, RDA, 1980) as

> . . . the levels of intake of essential nutrients considered in the judgement of the Committee on Dietary Allowances of the Food and Nutrition Board on the basis of available scientific knowledge, to be adequate to meet the known nutritional needs of practically all healthy persons (p. 1).

The RDA's were not designed to estimate an individual's requirement but rather, were designed as recommendations of average needs of population groups. These needs should be met by a varied diet and not through supplementation (National Academy of Sciences, RDA, 1980, p. 1). The requirement for a nutrient is not synonymous with the RDA. The requirement is the minimum amount of a nutrient that maintains health. In children, the requirement is the minimum amount that promotes growth. The RDA then was designed to cover this variable minimum amount plus an added amount to cover population variability and absorption and utilization variability for practically all members of the population group. However, energy recommendations were based on the average need with no margin of safety. For children, these allowances of average intakes were developed from longitudinal studies of children in Boston, Denver, and Iowa City (National Academy of Sciences, RDA, 1980, p. 28).

Little data have accumulated on the nutrient requirements for children. For many nutrients, values have been interpolated from levels known to be in breast milk and known needs of adolescents or adults. The known functions of the nutrients were considered in these estimates with added amounts as "margins of safety" to include estimated needs for most individuals in the population group. Those nutrients whose estimated needs were based on growth rates include protein, vitamin C, vitamin D, calcium, magnesium, and iron. Those interpolated from levels in breast milk included B_{12} and niacin. Vitamin A and riboflavin recommendations were based on adult studies. The thiamin and zinc allowances were based on research with children while folacin was interpolated from data from infants and adolescents. The B_6 recommendation was based on food consumption data (National Academy of Sciences, RDA, 1980). Thus, standards of adequacy used in dietary studies should not be considered requirements for satisfactory growth and development; rather these standards were goals thought to be desirable for group attainment.

Nutrition Status Studies

In the past, interest was centered on the determination of nutrient needs of healthy persons. Many of the data for young children were derived by extrapolation from balance studies conducted on young adults. However, widespread studies on nutritional status of Americans were not undertaken until the 1960's. During those years, several broad based nutrition surveys were conducted.

Ten State Nutrition Survey

The Ten State Nutrition Survey was conducted from 1968 to 1970 during which time 1741 children six months to three years were studied for dietary intake. Biochemical and clinical measures were obtained on part of this number. The goal of the survey was to determine the extent of malnutrition in certain segments of the population. Using 1960 census data, ten states were selected for geographical location. Within these states, census enumeration districts were selected which had the highest percent of families with income below the Orshansky Poverty Index. Many districts had population shifts since the 1960 census; thus, data were collected for persons whose incomes exceeded the index (U.S. Department of Health, Education and Welfare, 1972). Since the goal was to study primarily the poor, the survey results were not representative of the total United States population. However, the survey gave a rather complete picture of nutritional status of one segment of this population.

The survey revealed that determinants of dietary intake were geographical region, economic status, and race or ethnicity. Generally, biochemical data agreed with the dietary intake data. Mexican-Americans in the Southern states had the lowest total intakes of energy and all nutrients studied. However, nutrient density of the diet, or the nutrient consumption per 1000 kilocalories, was the same regardless of economic status or race except for Vitamin A.

The restriction in total food intake of children from low income families was reflected in lower growth performance. Differences in height, weight, and subcutaneous fatfolds for children from low and higher income families were noted during the first year of life and continued throughout childhood. Twice the expected number of Black children and three times the expected number of white children living in poverty were below the fifteenth percentile for height. Thus, income, or the ability to purchase food, was thought to be an important determinant of growth. As the money spent for food increased, growth percentiles achieved by the child also increased.

Significant numbers of children were found to be malnourished when retarded growth and the presence of anemia were considered acceptable indicators of malnutrition. The mean intake of dietary iron was below recommended intakes for all ages regardless of race, economic level, or geographic location (American Academy of Pediatrics, 1973).

Health and Nutrition Examination Survey

The First Health and Nutrition Examination Survey (HANES I) undertaken by the National Center for Health Statistics, measured the nutritional status of the United States population. The sample was representative of the noninstitutionalized American population. The data collection years were 1971-1974.

The dietary standards used in HANES report were not based on one set of dietary standards. The authors stated that the 1974 RDA standards were not used because they had not been released for publication before data processing and analysis of the study began. Vitamin A and calcium standards were similar to the FAO/WHO standards but were slightly less than both the 1968 and 1974 RDA levels. Vitamin C was similar to the 1968 RDA (40 mg/day) but higher than the FAO/WHO levels. Iron, thiamin, and riboflavin were the same as the 1968 RDA's. Thiamin and riboflavin were slightly lower than present standards, but the iron level was considerably higher (15 mg/ day). Both kilocalories per kilogram body weight and grams of protein per kilogram body weight were approximately the same as the 1968 and 1974 RDA's.

The dietary intake data were collected by twenty-four hour recall and three month frequency recall. Mean caloric, protein, and calcium intakes for children were close to the standard. However, even though mean intakes were adequate, 13 percent of white females and 33 percent of Black females aged one through five years had inadequate calcium intakes. Twenty-seven percent of Black males and 12 percent of white males also failed to meet the calcium intake standard (450 mg/day).

Mean iron intakes were below standards by 30 percent or more for all income levels in children one through three years. The mean iron intakes for males and females four and five years were below standards by ten to twenty percent. About 95 percent of all children one through three years failed to meet standards for adequate iron intake (National Center for Health Statistics, 1979).

The results indicated that persons with low income, Blacks, and females had greater nutritional risk from dietary inadequacy than did individuals in higher income groups, whites, and males. These same groups were identified in the Ten State Nutrition Survey.

North Central Study

A regional preschool survey was conducted in the North Central states in the Fall of 1965 (Fryer et al., 1972) to assess the nutritional status in that area and to compare results with other surveys. Dietary intake information was collected by means of a three-day food record. The results of the anthropometric measurements were related to the nutrient intakes and to family income. Males were slightly longer and heavier than females at birth; and mean weights and heights of males remained greater than females through age six years. When the data were superimposed on Iowa growth charts, the results were similar to the historic Iowa growth data.

The mean intakes of calories and all nutrients studied except iron were adequate when compared with the 1968 Recommended Dietary Allowances. A significant linear correlation was found between height, weight, weight:height ratio, and age and intake of nutrients, except for the intake of Vitamin A and ascorbic acid. Vitamin A and ascorbic acid intakes were not significantly related to any body measurements although mean intakes were above the standard.

Body measurements and family income were significantly related although the correlations were smaller than those for body measurements and nutrient intakes. When income was divided into three levels and compared to body measurements, a relationship was found: height was affected more than weight when family income was considered; and children in the lowest income group were heavier than those children in the middle and upper income groups.

In the North Central study, intakes of nutrients were significantly related to caloric intake for all children over one year of age. Approximately two-thirds of the children received the recommended allowances for energy and nearly all received the recommended allowance for protein. Absolute intake of nutrients was related more to body size than to sex.

While the intakes of carbohydrate, protein, and fat were greater than those reported in Owen and Kram's (1969) study, no relationship was found between family income and intakes of energy yielding nutrients. However, when specific nutrients were studied, as money spent for food increased (not family income) intakes of calcium and iron also increased.

Seventy-five percent of the diets did not meet the 1968 recommended allowances for iron. When iron intakes were expressed as units per unit of body weight, a regular decline in intake was noted throughout the preschool period. Absolute iron intakes were similar to those found in Beal's study of Denver children, but the percentage of children meeting the standard was lower since the 1968 RDA's were higher than those used in the Denver study (Fox et al., 1971).

Preschool Nutrition Survey

Owen and associates (1974) proposed a national preschool nutrition survey which was designed to be representative of the U.S. population of preschool age children. As part of this proposal, a pilot study was conducted in Mississippi from 1967 to 1968. Children were grouped for comparison into four per capita income strata. Those children in the lowest income group ($500 per year or less) had mean heights and weights at or near the twenty-fifth percentile ranking on the Harvard growth charts while children in the other income groups had mean heights and weights near the fiftieth percentile ranking.

Dietary intakes of protein were more than adequate in all income groups with approximately 60 percent of the protein from animal sources. However, in the lowest income group, much of the animal protein was from frankfurters and luncheon meats. For all income groups, the most limiting nutrients were calories, calcium, iron, and ascorbic acid. Forty-four percent of the lowest income group children and 24 percent of the higher income group children had low caloric intakes. There were also noticable differences in the intakes of these lowest income group children for the other limiting nutrients: 75 percent had low iron intakes while

62 percent of the higher income children had low intakes; 38 percent had low dietary calcium as opposed to 15 percent of children from higher income families; and 30 percent had low ascorbic acid intakes while only 13 percent of higher income children were considered to have low intakes. These dietary values were also reflected in low biochemical determinations for these nutrients except calcium which was not done.

From these dietary and biochemical observations, it was concluded that poverty that does indeed affect nutritional status. Children from low income families were smaller than average and appeared to be more "at risk" biochemically (Owen and Kram, 1969).

With the pilot studies completed, a comprehensive national preschool nutrition survey (PNS) was undertaken to describe the nutritional status of a cross-sectional sample American preschool children. A sample of 5000 children was selected, and complete data were obtained on 2200 of them and dietary data on 3400. It was felt that those participating were reasonably representative of the U.S. population. Warner Index Status Characteristics were used rather than per capita income for stratification of the sample to attempt to overcome geographical influences. Socioeconomic status was found to affect nutritional status; money spent on food was a reflection of socioeconomic status. In addition, the percent of children receiving nutrient supplements increased with socioeconomic status and decreased with increasing age.

Socioeconomic status related poorly with the quality of diet except for ascorbic acid. The problem noted for the children from low socioeconomic status families was the lack of sufficient food rather than poor quality food.

Racial differences in nutrient intakes were seen for some nutrients. Blacks consumed less calcium and ascorbic acid and approximately one milligram per 1000 kilocalories more iron than white children in comparable socoioeconomic groups. However, mean iron intakes were low in 49 to 55 percent of all children studied.

Mean hemoglobin levels were lowest for those children in the lowest socioeconomic status group and increased with the increase in socioeconomic status group. These data correlated with anthropometric data which showed an association between stature and hemoglobin level. Mean height, weight, and head circumference increased over the four Warner Rank groupings. This relationship was also found in the Ten State Nutrition Survey.

The conclusion drawn from the PNS was that lower dietary intakes, lower biochemical indices, and smaller size for age were clustered in the lower socioeconomic group. It was the lack of sufficient food which was related to these characteristics rather than the quality of food selected. In this survey, as also found in Mississippi, limiting nutrients for the lowest socioeconomic group were energy, calcium, iron, and ascorbic acid (Owen et al., 1974).

Zinc in Human Nutrition

Newer trace element status was not investigated in the previous studies. In the past, trace elements were thought to be widely available and generally adequately supplied in the diet. Not until 1974 were recommendations for zinc included in the Recommended Dietary Allowances.

Zinc was recognized as essential for life in bacteria a century ago and in higher plants over fifty years ago. Recent experiments with animals also proved it to be essential for animals with deficiencies resulting in growth retardation, testicular atrophy, and hyperkeratosis (Prasad and Oberlas, 1976).

The importance of zinc in humans was established through elucidation of zinc metalloenzymes which participate in carbohydrate, protein, and lipid metabolism as well as nucleic acid synthesis and degradation. The change in nucleic acid metabolism was hypothesized as the causative factor which limited protein biosynthesis, growth, and tissue regeneration in both human and animal subjects.

Zinc Metabolism in Enzyme and Protein Formation

According to Prasad et al. (1969), studies in which dietary zinc depletion was used to study enzyme activity and zinc deficiency, symptoms showed that zinc was probably associated with tissue components either with high turnover or with sites in which zinc was readily exchanged. Pancreatic carboxypeptidase A, alkaline phosphatase, and thymidine kinase were all found to be zinc containing enzymes in which decreased enzyme activity was noted before the appearance of symptoms of reduced growth rate or loss of appetite.

A rapid decrease in thymidine incorporation into DNA has been demonstrated following dietary zinc restriction in several studies. Thus, biosynthesis of DNA decreased early in zinc deficiency. The activity of thymidine kinase, which is necessary for DNA synthesis, was reduced within six days following dietary restriction in rats. Other studies showed a decreased RNA/DNA ratio in cells of rapidly regenerating connective tissue. The change in these ratios may be the result of increased catabolism and decreased biosynthesis of these polynucleotides.

The increased rates of activity of ribonuclease in the depleted tissues was indicative of the lower RNA levels and RNA/DNA ratios.

Zinc Balance Studies

For over 40 years human subjects have been involved in zinc balance studies. In 1939 Scoular conducted zinc balance studies on preschool children and found intakes of four to six milligrams per day resulted in a negative balance. In 1942 Macy reported a high retention of zinc (4.9 mg/day) in preadolescent children on intakes of 14 to 18 milligrams per day indicating a high requirement during the growing years. In 1970 Price and associates reported a two to four fold increase in zinc retention when measured comparing a high protein diet to a low protein diet; the zinc content of both diets was approximately the same. Thus protein content of the diet seemed to be an important factor in zinc absorption and retention.

Zinc and Taste Acuity

Henkin and associates (1971) reported the incidence of idiopathic hypogeusia with associated symptoms of dysgeusia, hyposmia, and dysomia (all taste and smell disorders) in 35 patients. Detection and recognition thresholds for the four taste modalities were found to be elevated well above the median thresholds for adults. In an effort to determine causative factors, supplemental oral zinc was given which appeared to correct many of the symptoms in the subjects. Zinc was selected because metals of the transition series had previously been associated with taste, and zinc was one of the least toxic and best tolerated of these metals.

Since that time Henkin and others have studied the role of zinc in saliva and taste. Henkin found that the salivary protein, gustin, was present in subjects with normal taste acuity. This protein is composed of eight percent histidine and contained two moles of zinc per mole of protein. In addition he found that gustin is reversibly bound to isolated bovine taste bud membranes. He believed that this finding was consistent with the hypothesis that the function of gustin was to nourish taste buds.

Other factors believed to relate zinc and taste included the fact that alkaline phosphatase, a zinc dependent enzyme, was the most highly purified enzyme in bovine taste buds. In addition gustin and nerve growth factor (NGF) had been closely associated in molecular weight and in the percentage of neutral, basic, and acidic amino acids in the taste buds. In addition, hormonal changes associated with taste dysfunction have been shown to change the levels of gustin and NGF in some species (Henkin, 1976).

While measures of zinc status have not been clearly defined, the generally accepted definition of zinc deficiency has been the response of the subjects when given supplemental zinc. Many study subjects have shown improved taste acuity when supplemental zinc was given, thus enhancing the probability of an underlying zinc deficiency as the causative factor (Gregor and Geissler, 1978; Hambidge et al., 1972; Hambidge et al., 1976; Bunzia et al., 1980). However, others have found that not all patients regain taste acuity when treated with supplemental zinc and have concluded that there are many causes of taste dysfunction, among which one may be an underlying zinc deficiency (Catalanotto, 1978).

Zinc Deficiency in Humans

Early in the 1960's human zinc deficiency was reported in Iran and Egypt. A controlled study in Iran in 1972 proved that zinc deficiency was responsible for nutritional dwarfism and hypogonadism in fifteen growth retarded subjects. A key factor in the diets of the subjects was the consumption of large quantities of unleavened bread along with little animal protein. In studies with men and women rapid growth and sexual maturation resulted when the diets were supplemented with zinc (Halsted et al., 1972). Since this first study, nutritional dwarfism was reported in many countries including Turkey, Portugal, and Morrocco (Prasad, 1978).

Zinc Deficiency in Children

While it was considered unlikely that substantial segments of the United States population suffered from marginal zinc deficiency, Sandstead (1973) identified several population groups at risk. These at-risk individuals were in periods of rapid growth when requirements were high as well as those consuming diets typical of low income groups.

In 1972 Hambidge and associates investigated the use of human hair as an indicator of trace mineral status and found substantial numbers of infants and children in Denver with low hair zinc. These children from middle and upper socioeconomic families were further studied for growth percentiles and some for taste acuity. The group (338 children) was not selected by height and weight, and sex distribution was approximately equal. In neonates the mean values for zinc in hair were near the normal values for young adults; these fell throughout infancy and preschool years up to age four. In some children hair zinc levels reached values as low as those found in Egyptian adolescents with observed zinc deficiency. A relationship was found between low hair zinc, poor growth performance, and poor appetite. Ten of the subjects with low hair zinc were tested for taste acuity; five of these had demonstrable hypogeusia. Both increased hair zinc levels and improved taste acuity followed zinc supplementation (Hambidge et al., 1972).

In a later study of hair and plasma zinc in Head Start children both the mean plasma and hair zinc levels were found to be significantly lower than those of a middle income control group. The Head Start group was selected on the basis of retarded growth performance. The results suggested that high incidence of inadequate zinc nutrition was common in these children (Hambidge et al., 1976).

Results similar to Hambidge et al. (1976) were found in school age children in Yugoslavia. Highly significant ($p < .001$) correlations were found between hair zinc, plasma zinc, and stature and between hair and plasma zinc and weight for age. Those children with lowered taste acuity had significantly lower hair zinc values than those with normal taste acuity; 48 percent of the children with impaired taste acuity had hair zinc of less than 70 parts per million. None of the children with normal taste acuity had hair zinc below this level (Buzina et al., 1980).

Determination of the causative factors involved in impaired zinc status has been further investigated. Decreased dietary intake, excessive blood loss, parasitic infestation, and excessive sweating as well as poor absorption were all reported as conditions involved in impaired zinc status (Prasad and Oberleas, 1976). Dietary fiber and phytate were also identified as factors related to reduced absorption of zinc.

Since bread was the principal part of the diets of the Iranian nutritional dwarfs, the bread was analyzed further for possible factors related to the zinc deficiency. Reinhold and associates (1976) found the addition of a leavening agent to the village bread increased the solubility of labeled zinc and increased the zinc uptake in rat jejunum to a greater degree than could be explained by a decreased level of phytate. In further studies they determined that fiber, starch, and protein of wholemeal breads all bind zinc firmly. However, the starch-zinc and the protein-zinc bonds were released during digestion while the fiber-zinc bond was not. Thus fiber consumption was considered an important factor in the development of zinc deficiency in Iran.

Fiber and Zinc Status

In the past fiber was defined as crude fiber which was known to be an incomplete estimate of the true fiber content of plants. Dietary fiber was defined by Trowell (1978) as

> . . . the remnants of plant cells resistant to hydrolysis by the alimentary enzymes of man . . . storage polysaccharides (often water soluble), pectic substances, plant gums and mucilages should be included as undigested polysaccharides . . . (pp. 7-8).

Fiber content of food can be increased by the preparation method; for instance, the nonenzymatic browning reaction from baking or frying resulted in the Maillard polymer wtih physical properties similar to lignin. Van Soest (1978) stated the browning resulted in unavailability of a large portion of the protein in cereal products.

Freeland-Graves, Ebanget and Hendrikson (1980) determined the effect of consumption of a lacto-ovo-vegetarian diet on zinc status of non-vegetarians. The uptake of zinc by plasma after an oral zinc load was significantly higher after 22 days on the lacto-ovo-vegetarian diet. They believed this change was due to the high levels of phytate and fiber common in vegetarian meals. The dietary fiber was calculated as crude fiber; therefore, the total fiber content of the diet was considerably higher than calculated. However, in the experimental diet, crude fiber content was designed to be eight grams per day as this approximated the average fiber content of vegetarian diets. The conclusions the authors drew were that the lacto-ovo-vegetarian diet adversely affected zinc status and that the presumed causative factors were large quantities of fiber and other zinc-binding ligands.

Another study was conducted in Sweden to determine the effect of phytic acid, calcium, and protein from natural foodstuffs on zinc absorption. Two levels of wheat flour were used--100 percent and 72 percent extraction--as well as various combinations of milk, cheese, beef, and egg. Labeled zinc was contained in the test meals by extrensic tag in dinner rolls. Results on absorption were obtained by whole body counting two weeks after the test meal.

Comparing results from different test meals with the same zinc content showed that zinc was less well absorbed from wholemeal breads than from breads made with refined flour. However, when absorption was expressed in absolute amounts rather than percentages, absorption from wholemeal bread was equal to or greater than from the refined flour. Enriching both breads with zinc resulted in a much greater absolute absorption from white flour but only slight changes in the absorption from wholemeal flour.

While calcium has been implicated in increasing the effect of phytic acid in reducing zinc absorption, the Swedish study showed that the addition of calcium by means of cheese and milk increased the absorption of zinc. This was true even in the meal with a high content of phytic acid and fiber from wholemeal bread.

To study the effect of animal protein on zinc absorption, sodium caseinate was added to the diet without increasing the zinc content. The results were as expected--zinc absorption increased from wholemeal bread. The authors hypothesized that in countries in which the diets were typically high in animal protein, wholemeal flour would have little effect on decreasing zinc status. Likewise, they concluded that simply refining flour alone would not appreciably increase zinc absorption in people whose diets consisted primarily of bread (Sandstrom, Arvidsson, Cederblad, and Bjorn-Rasmussen, 1980).

Little information concerning fiber intake in preschool children was reported in the literature. However, Endres, Gulley and Fisher (1981) studied fiber intake in preschool children to differentiate characteristics of diets with high and low fiber intakes. Their sample was divided into quartiles on the basis of quantity of fiber in the diet. The mean crude fiber intake was 2.0 grams with a range of 0.33 to 5.86 grams. They found those with higher fiber intakes consumed more varied diets than those with lower fiber intakes. They also tended to meet two-thirds of the RDA for all nutrients studied except iron. Consumption of Vitamins A and C were higher in the high fiber group than in the low fiber group. Levels of riboflavin and calcium, however, were higher in the low fiber group.

CHAPTER III

RESEARCH PROCEDURES

The type of study conducted and the selection of the sample were described in this chapter. The type of data which were collected and the methods of analysis were also discussed. Before beginning the collection of data an outline of the project was submitted to and approved by the committee responsible for protecting the rights of human subjects.

Research Design

The study was descriptive research of the current nutritional status of preschool children in Stillwater, Oklahoma. Since the purpose was to assess the nutritional status and to determine what relationships, if any, existed between food intake and certain objective measures, causal comparative descriptors were used. Data from this study added to the information base on zinc status of preschool children in the United States.

Sample and Population

The sample was randomly selected from three preschool institutions in Stillwater, Oklahoma. While the sample was not representative of the entire population of preschool children in Stillwater, it was representative of most of the economic strata of the community due to the schools selected.

The sample originally was designed to consisted of 45 children three to five years old attending the Stillwater Head Start Center, Oklahoma State University Laboratory Schools, and the Will Roger Elementary School four-year-old program. The names of the children in all classes at each school were compiled into alphabetical lists for each school from which names for subjects were randomly selected. The schools were oversampled to provide replacements for any subjects unable to participate. After sampling, letters explaining the study and consent forms requesting permission for the child to participate were sent to the parents of each child (Appendix A). (Forty-six children were included through oversampling.) Approximately 15 children from each school were in the final sample. However, only 43 were included in the final analysis; three were eliminated due to incomplete data. Children with known medical disorders were not used in the study. Random selection of subjects also provided for random sex distribution and age categorization. The sample size was limited to that manageable within the time lines for data collection, for access to families with children, and by time restrictions of the types of data collection.

Procedures

Dietary Intake Measurements

Dietary records consisted of a 24 hour recall and a two-day food record. Examples of these forms were included in Appendix B. The 24 hour dietary recall information was obtained by the researcher in a personal interview. On the two days following the recall the interviewed person (mother or primary caregiver) kept food intake records for the child. To increase the accuracy of estimates of food intake, food models constructed by the researcher according to published procedures, were used during the interviews (Moore, Judlin, and Kennemur, 1967). The collection of food intake information was designed to include only the week days; therefore, if an interview took place on a Thursday or Friday, the mother skipped the weekend days and continued the food record on Monday. The mother was responsible for requesting babysitters to record food intakes when she was not present. When completed, the mother mailed the dietary records to the researcher. Since children attending the Head Start Center consumed approximately two-thirds of their total food intake at the center, all teachers were instructed in the methods of keeping the food records. At the end of the three day period, the researcher picked up the records from the teachers. A questionnaire relative to appetite, health history, and eating habits provided additional background information for each child. These forms were included in Appendix B.

Socioeconomic Status Measure

Socioeconomic status was found to be more indicative than income in determining food selection practices by Owen et al. (1974). Thus determination of socioeconomic status was relevant to the present study. Duncan's Socioeconomic Index was used for socioeconomic status classification. The index reflected the occupational status scores from the 1970 census (Nam et al., 1975).

Clinical Measures

Each subject was measured for height and weight. Triceps and subscapular skinfolds and mid-arm circumference were recorded at the same time. All anthropometric measures were completed for each child at one time. All children in the same school were measured on the same day; however, children absent on that day were measured later.

The skinfold thicknesses were measured using the Lange caliper according to procedures given by Foman (1976). Heights and weights were measured using a calibrated scale and a standard height measure constructed for this study. All children were weighed and measured barefoot with only jeans or a light dress on. No belts or other heavy items were worn during the measurements. These values were plotted on growth charts for percentile standing of each subject (Hamill et al., 1978).

Hair Zinc Measurement

Hair samples, weighing approximately 100 mg., obtained at the same time as anthropometric measurements, were cut from the suboccipital area of the head using forged stainless steel barber's scissors. The proximal two centimeters of hair were cut directly into labeled plastic bags and sealed until analysis. The distal sections were discarded. Hair zinc was measured by atomic absorption spectrophotometry using a procedure modified from that of Freeland-Graves et al. (1980). Specific directions for the hair zinc determination were included in Appendix C.

Taste Acuity Determination

Taste acuity was measured as part of the determination of zinc status. Taste thresholds above the median adult threshold were considered to be indicative of low taste sensitivity. Taste acuity was measured using the three drop forced choice technique of Hambidge et al. (1972). The procedures were included in Appendix D. Only detection levels were recorded. Five concentrations of each solution were prepared for each taste (Table I). The solutions were prepared using laboratory grade reagents and distilled water.

TABLE I

CONCENTRATIONS OF SOLUTIONS FOR TASTE ACUITY TESTS

Solution	Concentration, mmole/liter				
Sodium chloride	30	60	90	150	300
Sucrose	15	30	60	150	300
Urea	120	150	300	500	1000
Hydrochloric acid	3	6	15	30	60

Analysis of Data

Dietary Analysis

Food records were coded and sent to Louisiana State University for analysis by the Nutritional Analysis System. Total intake by days of the study and mean intakes for all nutrients included in the 1980 Recommended Dietary Allowances were determined for each subject. Comparisons of nutrient intake with the Recommended Dietary Allowances were made for each subject. Nutrient intake levels were considered on both the basis of food alone and food plus supplements.

Dietary Scoring

Means, ranges, and standard deviations for 13 nutrients were computed to form the basis for a dietary score. Nutrients included in the dietary score were energy, vitamin D, vitamin C, calcium, zinc, protein, vitamin A, folacin, niacin, thiamin, riboflavin, vitamin B_6, and iron. The percent of RDA for each nutrient studied was calculated for each subject. A three day mean consumption of 75 percent or more of the RDA for a given nutrient was scored +1. Fifty to 75 percent of the RDA received a score of 0; 25 to 50 percent of the RDA was scored -1; and consumption of less than 25 percent of a nutrient was scored -2. Individual nutrient scores were totaled for each subject for a composite score. Those subjects whose diets scored +12 or +13 were classified as high. Those scoring +7 through +11 were classified as medium; and those scoring less than seven were classified low. Differences in dietary scores by socioeconomic groups were tested by chi square for significant differences. Analysis of variance of mean dietary scores by socioeconomic group was computed using Duncan's test.

Anthropometric Analysis

Growth achievement and weight for height percentile rankings were calculated for each subject. Frequency distributions of subjects within percentile rankings for growth were calculated by socioeconomic status groupings. Percentile rankings of skinfold thickness were calculated for each subject from tables by Fomon (1976). Frequency distributions of percentile rankings for subjects in each socioeconomic group were also computed.

Zinc Status Analysis

Plots of micrograms of hair zinc, height percentiles and taste acuity scores and dietary zinc, hair zinc and socioeconomic status were used for zinc status analysis. Mean fiber intake from the dietary analysis was compared to other zinc status measures to determine if a relationship existed between fiber intake and zinc status in this sample.

CHAPTER IV

RESULTS AND DISCUSSION

Description of the Sample

The sample consisted of 43 children from three preschools in Stillwater, Oklahoma. The original sample included 46 children; however, three were dropped from the final sample due to lack of complete data.

Socioeconomic Status (SES) Groups

The subjects were divided into two socioeconomic status groups on the basis on occupational scores of the parents (Nam et al., 1975). Originally the division was made to include approximately half of the subjects in each group; a "natural" break (at score = 72) in the socioeconomic status scores resulted in 23 children in the low socioeconomic status (low SES) group and 20 in the higher group (high SES). As the data were examined, it became clear that there were considerable differences between the Head Start subjects, who were classified previously into the lower group on the basis of the SES scores, and the other subjects in the lower group. Thus, the Head Start subjects were classified into a third group. With this separation, one child was removed from the high SES group and 12 from the low SES group. The final division of subjects into socioeconomic groups was shown in Table II. Both of the other schools included subjects in high and low SES groups.

TABLE II

DESCRIPTIVE DATA OF SUBJECTS BY SOCIOECONOMIC STATUS GROUPS

Socioeconomic Status Group	Number of Subjects N	Male Number	Female Number	Age Months	Anthropometric Percentile Rankings: Height Percentile	Weight for Height Percentile	Triceps Skinfold Percentile	Subscapular Skinfold Percentile
Low SES	11	7	4	58.9 (46,67)[a]	26.2 (<5,75)	63.6 (25,75)	47 (<10,75)	40.5 (5,90)
High SES	19	13	6	60.5 (46,69)	33.6 (<5,95)	57.4 (10,95)	40.28 (<10,95)	32.5 (5,95)
Head Start	13	6	7	61.3 (41,74)	47.3 (10,95)	68.5 (10,95)	57.9 (10,90)	36.5 (5,90)
Combined	43	26	17	60.35	35.86	58.3	47.32	38.78

[a] Ranges indicated in parentheses.

Anthropometric Measures

Variation in growth achievement between groups was noted in Table II. Head Start subjects were the tallest for age of the three groups; all these subjects were above the tenth percentile. Many of the children had attended day care previous to beginning Head Start, and several of them had attended Head Start for more than one year. Thus, they had been provided diets more nutritious than those typical of low income families. Four children in the Head Start group (30.8%) were above the 75th percentile while in the high SES group five (21%) were above this percentile and in the low SES group, only one was. (The compiled percentile rankings by socioeconomic group are shown in Table XI, Appendix E.)

Growth achievement less than the tenth percentile was also identified in the low SES group (18.2%) and the high SES group (10.5%) but not in the Head Start group. In only one of these cases was low growth achievement thought to be attributed to parents' height: this one subject was an adopted child for whom information concerning the height of the natural mother was only "very short."

A weight for height ranking was calculated for each subject. The frequency distribution was shown in Table XII Appendix E. Mean weights for heights were similar in all groups; however, the range was narrower in the low SES group. Twenty-seven percent of the subjects in the low SES group were above the 75th percentile in weight for height while 47.4 percent of the high SES group and 61.5 percent of the Head Start group were above this percentile ranking. Since this ranking was based on growth achievement independent of age, the difference may have been related to energy intake.

Mean triceps skinfold thickness was greatest in the Head Start group (Table II) as was the mean weight for height. Frequency distribution of triceps measurements are found in Table XIII Appendix E. When all subjects were considered as a group, there was a high correlation (r = .73) between weight for height percentile rankings and triceps measurement. Mean subscapular skinfold thicknesses did not increase in the Head Start group. However, the distribution was more even throughout the percentile rankings in the Head Start group than in the other two groups (Table XIV Appendix E).

Nutritional Status of Preschool Children

Use of Nutrient Supplements

Among all the subjects, 44.2 percent consumed a vitamin and/or mineral supplement at least once a week. In the low SES group, 72.7 percent consumed a supplement five times per week. The percentage of subjects who took supplements was lower (36.8%) in the high SES group than in the low group and was lowest in the Head Start group (30.8%). Not only was the number of subjects who used supplements lower in Head Start, but the frequency of use was also lower. None of the supplements taken by these subjects contained zinc, however. These findings were in opposition to those of Owen et al. (1974) who found greater use of nutrient supplements in the higher socioeconomic groups than in the lower socioeconomic groups. The nutrients provided by each supplement were shown in Table XV Appendix E.

Dietary Scores

Dietary scores were calculated for 13 nutrients on the basis of the portion of the RDA in the diet. Individual scores were combined for a cumulative score for each subject. A "high" dietary score category resulted from diets containing 75 percent or more of the RDA for 12 of the 13 nutrients. A diet was scored "medium" if it contained an average of 75 percent or more for seven or more nutrients. A diet scored "low" if more than seven nutrients were below 75 percent of the RDA.

The mean dietary scores for subjects by groups are shown in Table III. The difference in mean scores was highly significant (P=.0001) between the low and high SES groups and between the low SES group and Head Start. Chi square scores also indicated a significant difference in the distribution of diet score categories (high, medium, and low) among the three groups.

The range of scores was presented in Figure 1. As can be observed, the lower SES group showed a greater variation in scores than was observed in the high SES group. The scores in the Head Start group had the narrowest range of all groups. None of the children in the lower SES group fell into the "high" diet category; in fact, the mean score for this group was in the "low" category. The high SES group scores were predominantly in the "medium" cateogry although an equal number were in the "high" and "low" diet categories.

None of the children attending Head Start had diet scores in the "low" category. Since food records included only weekdays, the mean intakes of these children attending Head Start, therefore, included two meals and one snack at school which met Head Start requirements for nutrient content.

Dietary scores did change because of the use of nutrient supplements. Because nutrients calculated in the dietary score included some

TABLE III

MEAN DIET SCORES AND DIET SCORE CATEGORIES BY SOCIOECONOMIC STATUS GROUPS WITH AND WITHOUT SUPPLEMENTS

			Diet Score Category Without Supplements*				Diet Score Category With Supplements+		
Group	N	Mean Score	High	Medium	Low	Mean Score	High	Medium	Low
			Number of Children				Number of Children		
Low SES	11	2.36[a]	0	2	9	7.75[a]	2	6	3
High SES	19	8.74[b]	5	9	5	9.78[ab]	10	6	3
Head Start	13	10.77[b]	5	8	0	11.39[b]	7	6	0
Combined	43	7.72	10	19	14	9.34	19	18	6

*Diet Classification χ^2 19.198 P = 0.0007
Results of AOV
F = 15.77
PR > F = .0001

+ χ^2 = 6.48 P = .1659
Results of AOV significant difference at alpha level .05

a,b = means with the same letter are not significantly different.

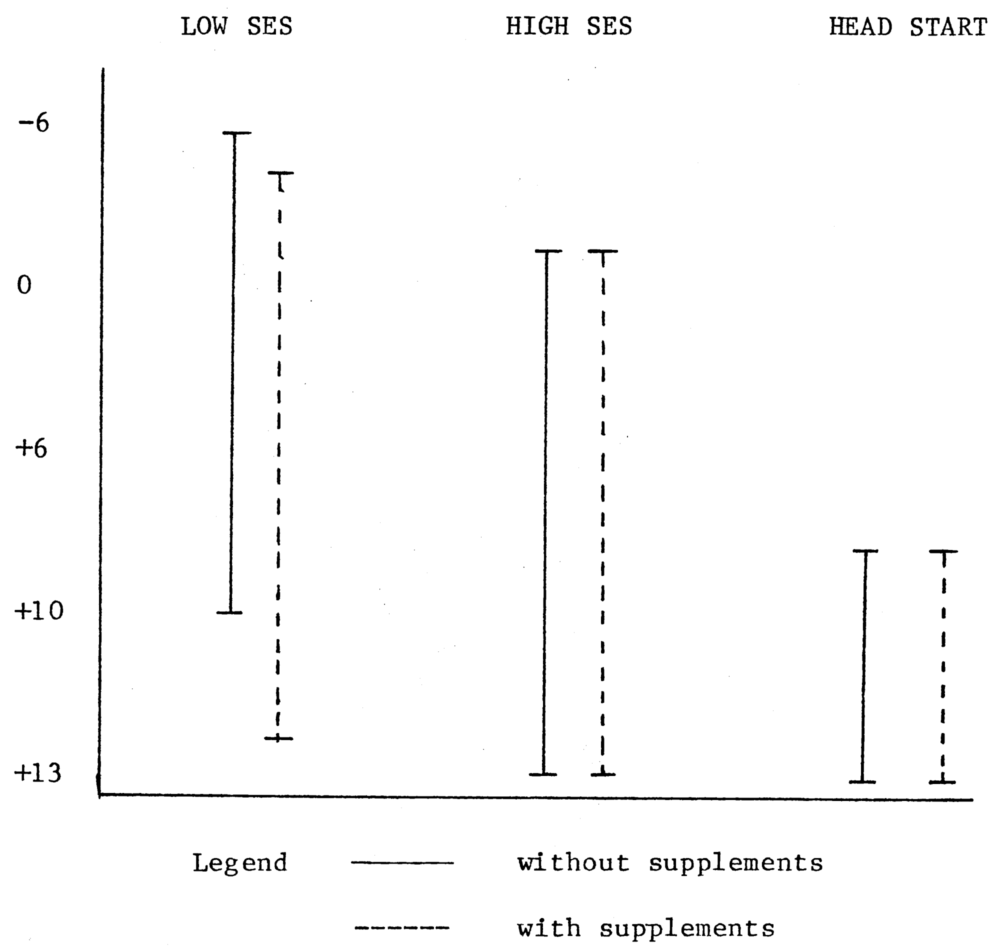


Figure 1. Range of Scores by Socioeconomic Groups With and Without Supplements

which were not usually included in nutrient supplements (energy, protein, zinc, and iron), taking the supplement did not insure a high dietary score. The effect of nutrient supplements on the diet score categories for those children who did take them were shown in Table IV. While none of the scores decreased, not all became "high." In the low SES group, seven of the eight children taking supplements increased their dietary score category; however, one child's diet was still so poor that it was classified "low." In the high SES group, all score categories increased; one increased from the "low" to "high". In the Head Start group, two of the subjects score categories increased, but two did not. Thus, the supplements did not necessarily insure a better overall quality of diet.

Intake of Individual Nutrients

When intakes of individual nutrients were calculated for each group, differences were again obvious (Table V). Children attending Head Start had the highest intake for all nutrients; in fact, no mean intakes were less than 75 percent of the RDA. However, a lesser intake of most nutrients was noted in both the low SES group and the high SES group.

When frequencies of individual intakes were computed, one subject's iron intake was between 25 and 50 percent of the RDA. There were also some subjects whose intakes were 50 to 75 percent of the RDA for Vitamin D, folacin, Vitamin B_6, calcium, zinc, and iron (Table VI) both with and without supplements included.

In the high SES group, mean intakes of both Vitamin D and B_6 were below 75 percent of the RDA. Again frequency of percent intake showed individuals with intakes less than 50 percent of the RDA for some nutrients

TABLE IV

CHANGES IN DIET SCORES IN NUMBER OF SUBJECTS TAKING SUPPLEMENTS

GROUP	N	HIGH DIET SCORE	MEDIUM DIET SCORE	LOW DIET SCORE
Low SES	8			
without supplements		0	1	7
with supplements		2	5	1
High SES	7			
without supplements		1	4	2
with supplements		6	1	0
Head Start	4			
without supplements		0	4	0
with supplements		2	2	0

TABLE V

INTAKES OF INDIVIDUAL NUTRIENTS WITHOUT AND WITH SUPPLEMENTS BY SOCIOECONOMIC STATUS GROUPS

Group	Energy	Protein, g	Animal Protein, g	Total Fat, g	Total CHO, g	Fiber, g	Vitamin A, RE	Vitamin D, IU	Thiamin, mg	Riboflavin mg
RDA (Ages 4-6)	1700	30	-[a]	-	-	-	500	400	0.9	1.0
Low SES										
Without supplement	1355±287	43.3±10.7	29.4±11.8	55.8±15.1	175.2±40.6	1.96±1.2	827.5+416.98	173.2±141[d]	0.86±0.4	1.07±0.5
With supplement[b]							1106.7±449.49	378.4±200	1.42±0.6	1.70±0.7
High SES										
Without supplement	1472±328	54.8±14.7	37.6±12.7	58.5±15.8	187.4±50.5	2.24±0.7	1138.1±694.1	248±101.9[e]	1.06±0.2	1.54±0.5
With supplement[b]							1299.7±734.7	365.3±188.0	1.38±0.5	1.90±0.7
Head Start										
Without supplement	1772±425	66.9±20.2	49.9±18.0	71.0±25.3	221.3±56.7	2.83±0.9	1513.2±999.97	323.8±136.9	1.21±0.3	1.90±0.7
With supplement[b]							1606.6±999.7	399.9±117.6	1.40±0.4	2.10±0.6
Total										
Without supplement	1533±381	55.5±17.8	39.2±16.0	61.6±19.6	194.5±52.4	2.35±0.96	1172.0±775.4	251.8±133.3[e]	1.06±0.4	1.53±0.6
With supplement							1343.1±775.9	379.1±170.0	1.40±0.5	1.92±0.7

Group	Niacin, mg	Vitamin B_6, mg	Vitamin B_{12} µg	Ascorbic Acid, mg	Folacin, ug	Calcium, mg	Iron, mg	Mg, mg	Zn, mg
RDA (Ages 4-6)	11	1.3	2.5	45	200	800	10	200	10
Low SES									
Without supplement	8.1±2[e]	0.64±0.3[d]	2.3±0.1	51.5±31.4	81.7±41.7[d]	640.2±389	7.6±2.3	165.8±65.6	6.4±1.7[e]
With supplement[b]	15.2±6.9	1.19±0.5	4.4±2.4	117.4±69.6	240.1±155.8	657.1±383.4	13.7±6.9	173.6±85.5	c
High SES									
Without supplement	10.8±1.9	0.96±0.2[e]	3.3±1.7	95.7±52.7	168.2±63.2	955.8±461.5	8.6±2.1	203.5±63.8	8.2±2.5
With supplement[b]	14.7±5.2	1.28±0.5	4.6±3.0	116.3±64.2	247.1±157.5	c	11.6±6.3	c	c
Head Start									
Without supplement	14.3±4.8	1.26±0.4	4.7±4.1	117.5±71.7	192.9±71.7	1024.7±398.7	10.7±3.5	251.9±75.6	8.8±2.5
With supplement[b]	16.9±6.2	1.45±0.5	5.5±3.8	135.0±74.4	249.0±128.9	1027.4±397.3	11.8±4.8	c	c
Total									
Without supplement	11.2±3.9	0.97±0.4[e]	3.4±2.7	91.0±58.0	153.5±74.3	895.9±443.5	9.0±2.9	208.5±74.0	7.9±2.5
With supplement	15.5±5.9	1.30±0.5	4.8±3.1	122.2±67.7	245.9±145.5	901.0±439.6	12.2±6.0	210.5±77.6	c

[a] No RDA for animal protein, fat, CHO, or fiber
[b] Changes only are indicated
[c] Not included in any supplement taken by these subjects
[d] Less than 50% RDA
[e] Less than 75% RDA

TABLE VI

FREQUENCY OF NUTRIENT INTAKES WITHOUT AND WITH NUTRIENT SUPPLEMENTS AS A PERCENT OF THE RDA BY SOCIOECONOMIC STATUS GROUPS

GROUP	Vitamin D	Ascorbic Acid	Calcium	Zinc	Protein	Vitamin A	Folacin	Niacin	Riboflavin	Thiamin	Vitamin B_6	Iron	Energy
Low SES													
<25% RDA													
without supplement	4	1	0	0	0	0	3	0	0	0	1	0	0
with supplement	2	0	0	0	0	0	2	0	0	0	1	0	0
25-49% RDA													
without supplement	3	1	5	3	0	0	3	2	0	2	5	1	0
with supplement	1	0	5	3	0	0	0	0	0	1	0	0	0
50-74% RDA													
without supplement	2	3	1	6	0	0	3	3	3	5	3	6	5
with supplement	0	1	0	6	0	0	2	2	2	1	3	3	5
75+% RDA													
without supplement	2	6	5	2	11	11	2	6	8	4	2	4	6
with supplement	8	10	6	2	11	11	7	9	9	9	7	8	6
High SES													
<25% RDA													
without supplement	0	0	1	0	0	0	0	0	0	0	0	0	0
with supplement	0	0	1	0	0	0	0	0	0	0	0	0	0
25-49% RDA													
without supplement	6	1	0	1	0	0	1	0	0	0	1	1	0
with supplement	3	1	0	1	0	0	1	0	0	0	1	1	0
50-74% RDA													
without supplement	9	0	2	7	0	1	8	1	1	6	11	4	5
with supplement	7	0	2	7	0	1	5	0	1	4	7	2	5
75+% RDA													
without supplement	4	18	16	11	19	18	10	18	18	13	7	14	14
with supplement	9	18	16	11	19	18	13	19	18	15	11	16	14
HEAD START													
<25% RDA													
without supplement	1	0	0	0	0	0	0	0	0	0	0	0	0
with supplement	1	0	0	0	0	0	0	0	0	0	0	0	0
25-49% RDA													
without supplement	1	0	0	0	0	0	0	0	0	0.	0	1	0
with supplement	0	0	0	0	0	0	0	0	0	0	0	1	0
50-74% RDA													
without supplement	3	0	2	6	0	0	5	0	0	0	4	2	0
with supplement	3	0	2	6	0	0	3	0	0	0	3	2	0
75+% RDA													
without supplement	8	13	11	7	13	13	8	13	13	13	9	10	13
with supplement	10	13	11	7	13	13	10	13	13	13	10	10	13

(Table VI). One subject consumed less than 25 percent of the RDA for calcium. In the low SES group, there was a greater incidence of low nutrient intakes when either means or frequencies were considered. This also occurred when supplements were included in the calculations of nutrient intake. The influence of supplements on total nutrient intake was shown both in mean intakes and the change in frequency of low intake (Tables V and VI). The children in the low SES group had the highest intake of supplements as indicated by the increased levels in their diets. One child took "Dolomite" which increased the mean calcium and magnesium intake of this entire group. While improved diets were noted, it was also apparent that some essential nutrients were not analyzed or reported in this study. In addition, the nutrient zinc, not common in the supplements, was still low in the supplemented diets. Furthermore, when frequencies were examined, there were subjects with intakes less than 25 percent of the RDA for Vitamin D, folacin, and Vitamin B_6 whether or not they took supplements. Intakes of individual nutrients in unsupplemented and supplemented diets were shown in Tables XVI and XVII Appendix E.

Intakes of Energy and Energy Yielding Nutrients

Energy intakes were shown as a progression from the low SES group to the high SES group and finally to the Head Start group. When calculated according to the age of the child, the low SES group had a calorie intake of 82.4 percent of the RDA, the high SES group 87.8 percent, and the Head Start group 110.2 percent. Energy intakes from each of the three energy producing nutrients were similar in each socioeconomic group and were consistent with that found by Endree et al. (1981) and by

Fryer et al. (1971). Table VII showed the comparison for these groups. In the present study, an increase in calories supplied by protein was noted from the low SES group through the high SES group to the Head Start group. This tendency also appeared in the absolute amount of carbohydrate, protein, and fat in the diets (Table V, p. 42).

Mean caloric intakes were adequate to provide sufficient energy for adequate growth, according to the Recommended Dietary Allowances. Ten of the 43 children consumed less than 75 percent of the recommended level; nine of these ten also had a diet score classification of "low."

Growth Achievement and Dietary Intake

When growth achievement was compared with diet scores without supplements, none of the subjects whose growth was at or above the 90th percentile had diets classified as "low" (Table VIII). In addition, none of the subjects whose diets scored "high" were shorter than the tenth percentile for their age. Only 31.4 percent of the subjects scoring "low" on their diets were above the 50th percentile in height. For all children less than the 25th percentile in growth achievement, 41.2 percent had diets classified as "low," 47.1 percent had diets classified as "medium," and 11.8 percent had diets classified as "high."

When dietary scores with supplements were compared to growth achievement, 31.6 percent scoring "high" were less than the 25th percentile while only 11.8 were below the 25th with unsupplemented diets. Thus, some nutrients not commonly found in supplements and not included in this dietary scoring method might have had an effect on growth achievement.

All six of the children scoring "low" on the supplemented diets were between the tenth and 50th percentile for growth. While none of

TABLE VII

COMPARISON OF INTAKES OF ENERGY YIELDING NUTRIENTS WITH OTHER STUDIES

Group	Calories	Carbohydrate % of Calories	Protein % of Calories	Fat % of Calories	Total Intake[c] %
Low SES	1355	51.6	12.7	37.0	101.3
High SES	1472	50.9	14.8	35.8	101.5
Head Start	1772	49.9	15.1	36.1	101.1
Endres et al.[a]	1488	45.9	15.1	39.1	100
Fryer et al.[b]	1736	47.4	15.7	38.6	101.7

[a] Estimate based on figures for upper and lower quartile.

[b] Calculated from figures given for children 48-72 months.

[c] Totals do not equal 100 due to rounding.

TABLE VIII

DISTRIBUTION OF DIET SCORES BY HEIGHT PERCENTILES

	Height Percentiles							
Diet Score Category	<5	5	10	25	50	75	90	95
	Number of Subjects							
High								
Without Supplement	0	0	2	3	1	2	1	1
With Supplement	1	0	5	5	3	2	1	2
Medium								
Without Supplement	2	1	5	3	4	1	0	3
With Supplement	2	1	4	3	3	3	0	2
Low								
Without Supplement	1	0	6	4	1	2	0	0
With Supplement	0	0	4	2	0	0	0	0

the subjects whose supplemented diets scored "low" were less than the tenth percentile for growth, 16.7 percent of those scoring "medium" were less than the tenth percentile.

There was no apparent relationship between the supplemented dietary score and either triceps or subscapular skinfold thicknesses. This was at least partially explained by the fact that the dietary score was a reflection of more than caloric intake and did not actually reflect body fatness.

Summary of Testing H_1

The researcher rejected the null hypothesis that there was no significant difference in nutritional status of children of different socioeconomic status groups. While the nutritional status of these preschool children was not significantly different when socioeconomic status was the single stratifying factor, the difference in nutritional status was significant between the high SES group and the low SES group when Head Start children were separated. In addition, there was a significant difference in the nutritional status of the Head Start children and the low SES group. This is of particular interest because all except one subject attending Head Start was classified in the low SES group. The benefits of the Head Start program can be seen in the higher level of nutrient intake as well as in greater growth achievement of these subjects.

Determination of Zinc Status

Zinc Intake

The zinc status of preschool children was of interest because rapid growth occurs during this period and because of reports of marginal zinc deficiencies in this age group. The mean dietary zinc intake (7.93 mg) represented 79 percent of the RDA for this age child. The mean intake was above the estimated requirement of 6 mg/day for preadolescent children (National Research Council, RDA, 1980).

Protein Intake

The consumption of protein for all children was high (mean intake 190 percent of the RDA), and 70 percent of that protein was from animal sources (Table IX). Further, the recommended intake of protein was more than adequately met by animal sources alone; zinc intake would be expected to be adequate since protein food sources are also good zinc food sources.

Hair Zinc

Hair zinc levels ranged from 23 μg/g to 283 μg/g among subjects in this study. The mean hair zinc level was 113.7 μg/g. There was no significant difference between socioeconomic status groups (Table IX); hair zinc levels were not shown to be related to dietary zinc or to growth achievement. Six of the 43 subjects had hair zinc levels less than 70 μg/g (Table XVIII Appendix E). All of these subjects consumed more than 6 mg zinc, and only one was shown to be less than the tenth percentile for height. They were all between 58 and 74 months old. The mean fiber intake for these subjects was only 2.33 grams. Thus, low hair zinc levels were apparently not related to insufficient dietary zinc, to fiber intakes, or to age.

TABLE IX

MEAN DIETARY AND HAIR ZINC LEVELS AND COMPARISON OF MEASURES INFLUENCING ZINC STATUS

Group	Dietary Zinc, mg	Hair Zinc µg/g	Total Protein, g	Animal Protein, g	Energy Kcal.	Crude Fiber, g	Height Percentile	Age, Months
Low SES	6.37 (3.88,9.36)[a]	127.5 (80,283)	43.3 (29.8,64.6)	29.35 (9.4,52.2)	1355.7 (851,1756)	1.96 (0.8,4.9)	26.2 (5,75)	58.9 (46,67)
High SES	8.24 (4.8,14.5)	108.3 (23,183)	54.8 (35.5,95.3)	37.6 (21.8, 72.5)	1472.7 (1042,2310)	2.24 (1.2,3.6)	33.6 (5,95)	60.5 (46,69)
Head Start	8.81 (5.4, 12.9)	110 (50,183)	66.9 (43.1,121.0)	49.9 (28.9,92.4)	1772 (1141,2857)	2.83 (1.8,4.7)	47.3 (10,95)	61.3 (41,74)
Mean	7.93	113.7	55.5	39.2	1533.0	2.35	35.9	60.3

[a] Range of values in parentheses.

Taste Acuity

Taste thresholds for children have not been established; therefore, other researchers have used median adult thresholds as normal when testing children (Hambidge et al., 1972; Buzia et al., 1980). The taste thresholds for the four substances in this sample are shown in Table X. The median adult thresholds are the same as level 1 and the recognition threshold is the same as level 2. For sodium chloride, however, the recognition threshold is the same as level 1 (Henkin et al., 1971). The taste difference between the lowest level of these test solutions and distilled water (naturally slightly bitter in taste) is very slight and difficult to detect especially by children when attention span and concentration were variable. However, the recognition level (level 2) is much easier to distinguish. When considering levels one and two as normal, a number of subjects had responses considered "abnormal."

Relationships Between Hair Zinc, Growth Achievement and Taste Acuity

When hair zinc, growth, and taste acuity were analyzed in regard to zinc status, no consistent results were found. Hair zinc levels did not increase with increases in growth achievement, neither did abnormal taste acuity scores cluster around the low hair zinc-low growth achievement scores (Figures 2 - 5).

Responses to taste acuity tests were not consistent in that some subjects were able to taste one solution but not another. However, differences were observed in regard to NaCl and HCl. If abnormal taste acuity was considered only to be above median recognition thresholds

TABLE X

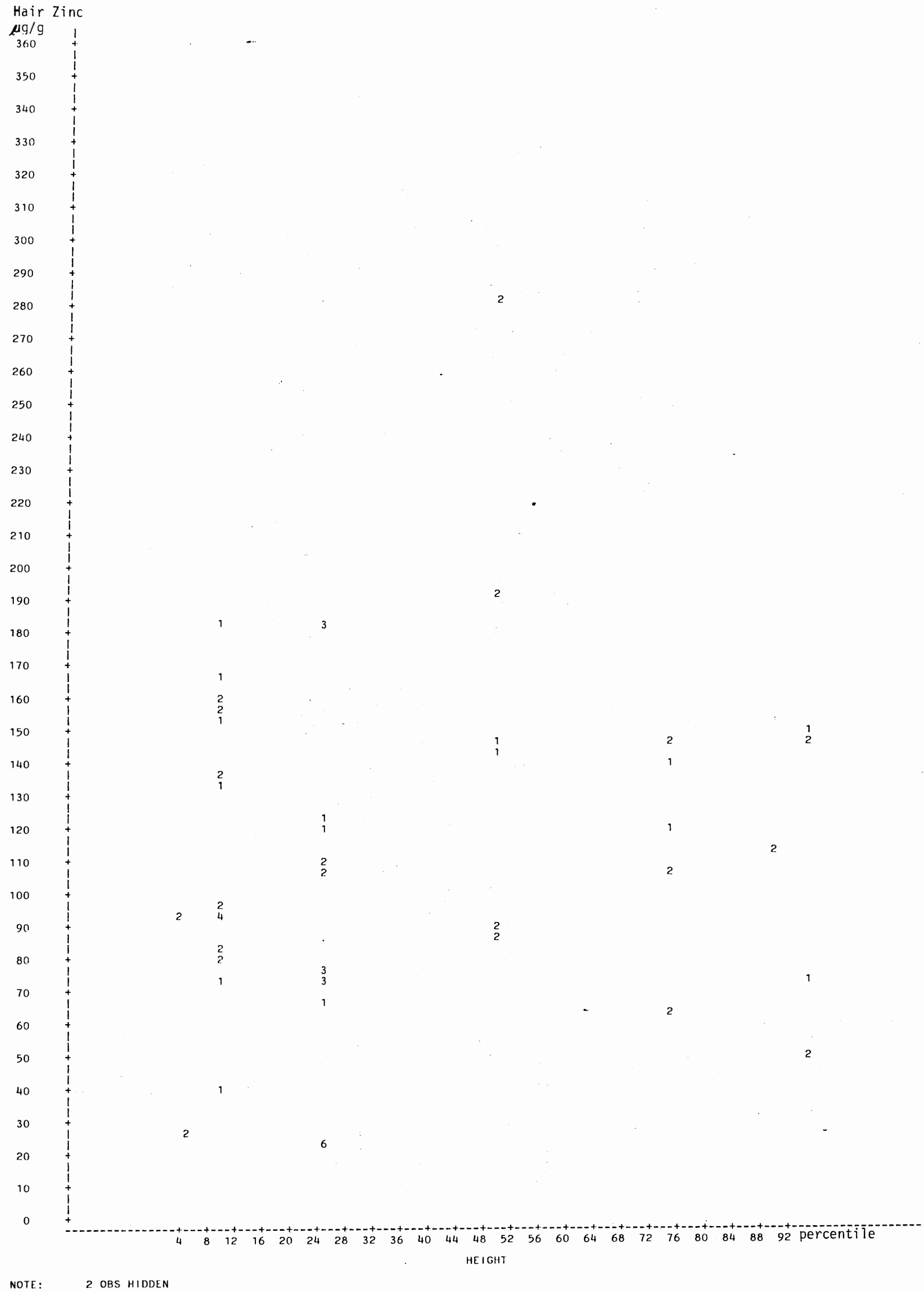
FREQUENCY OF RESPONSE TO TASTE LEVELS IN PRESCHOOL CHILDREN

Solution	N[b]	Test Level Response[a] 1	2	3	4	5	6[c]
Soldium Chloride	41	15	21	3	1	0	1
Sucrose	43	21	13	5	3	0	1
Hydrochloric Acid	43	24	15	2	2	0	0
Urea	39	9	14	7	7	1	1

[a] Response levels are the same concentrations shown in Table I, page 30.

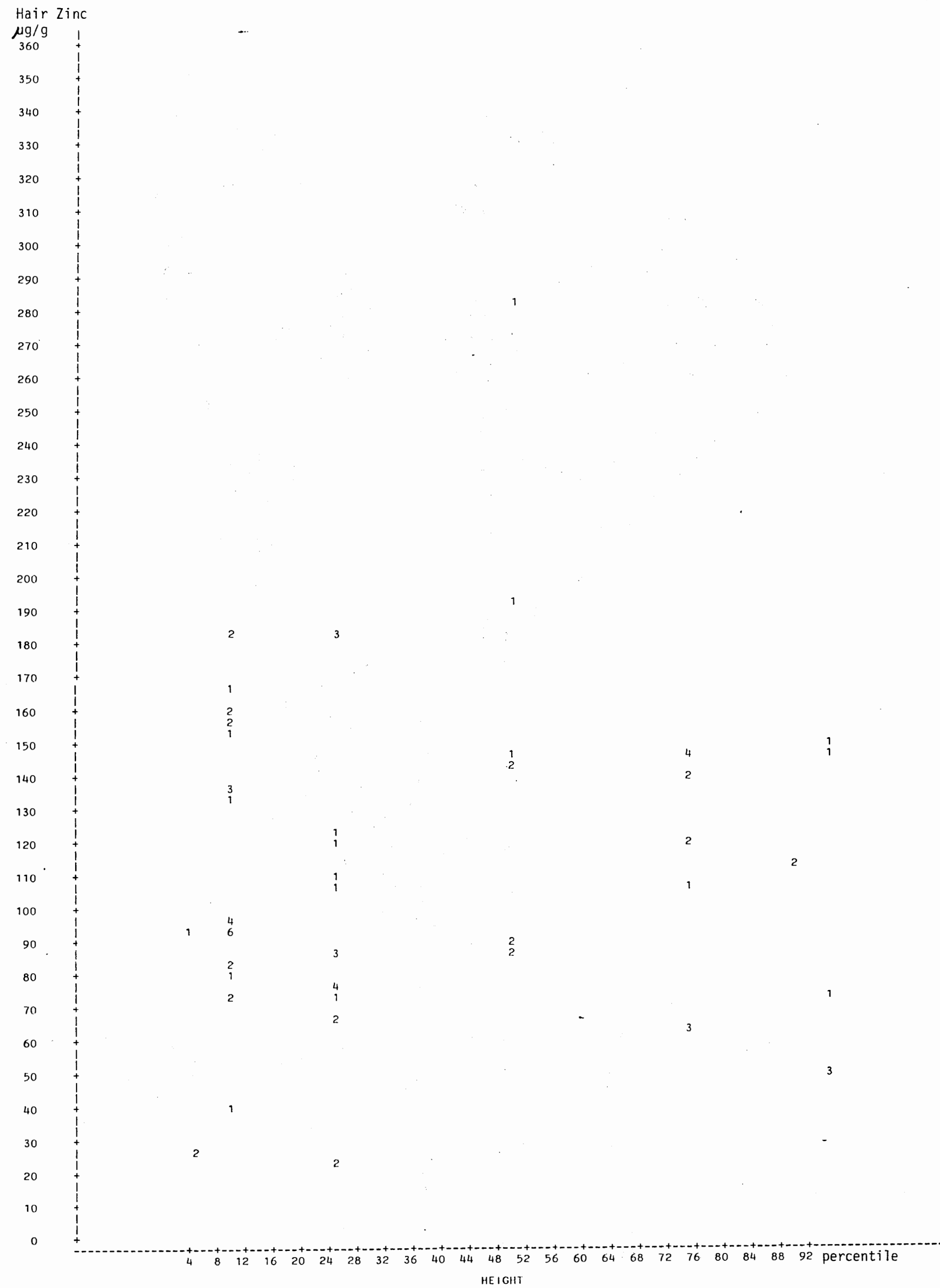
[b] Totals are different as not all subjects participated.

[c] Not recognized.



Identifying numbers are threshold levels.

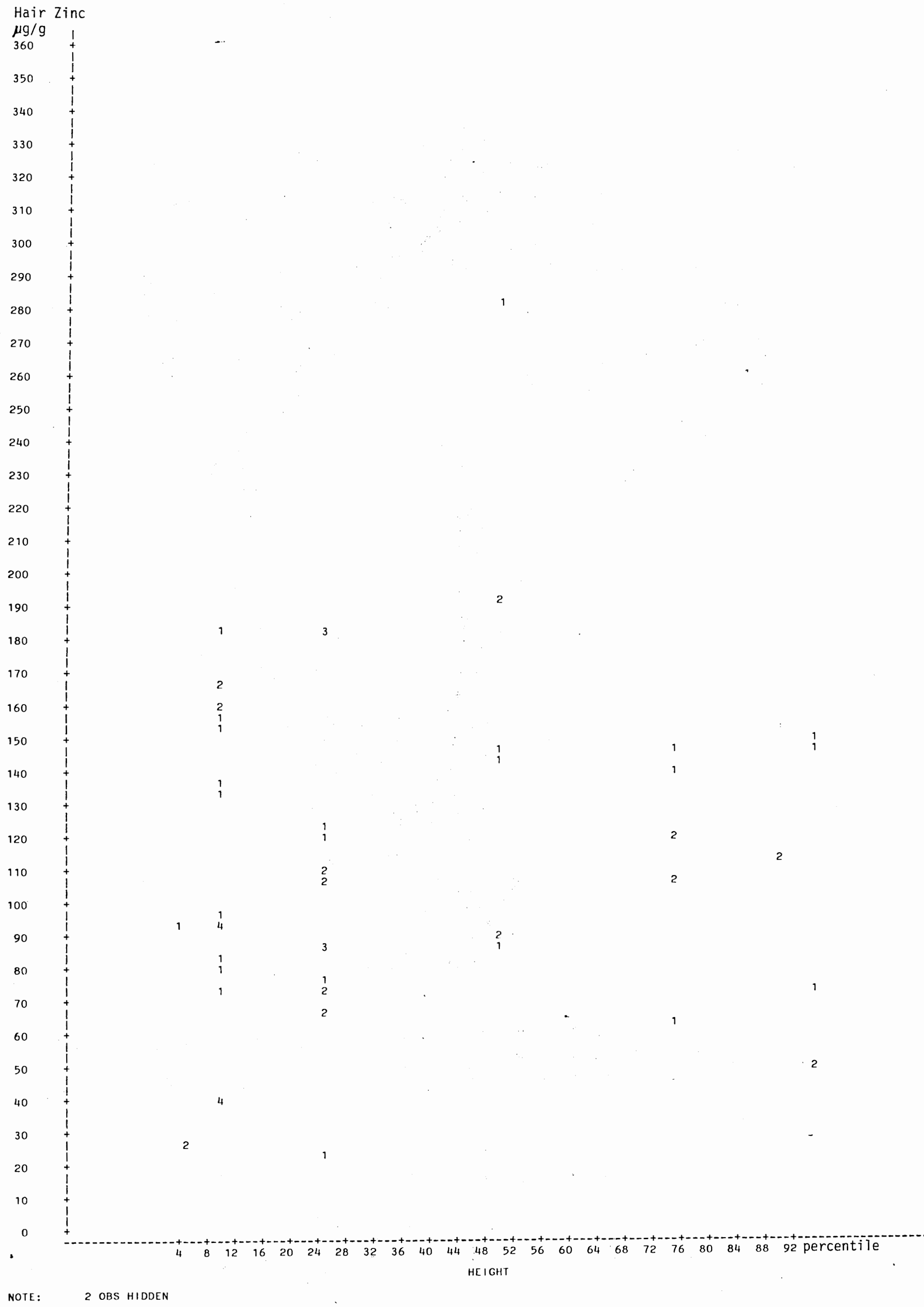
Figure 2. Hair Zinc and Height Relationships Related to NaCl (salt) Taste Acuity



NOTE: 2 OBS HIDDEN

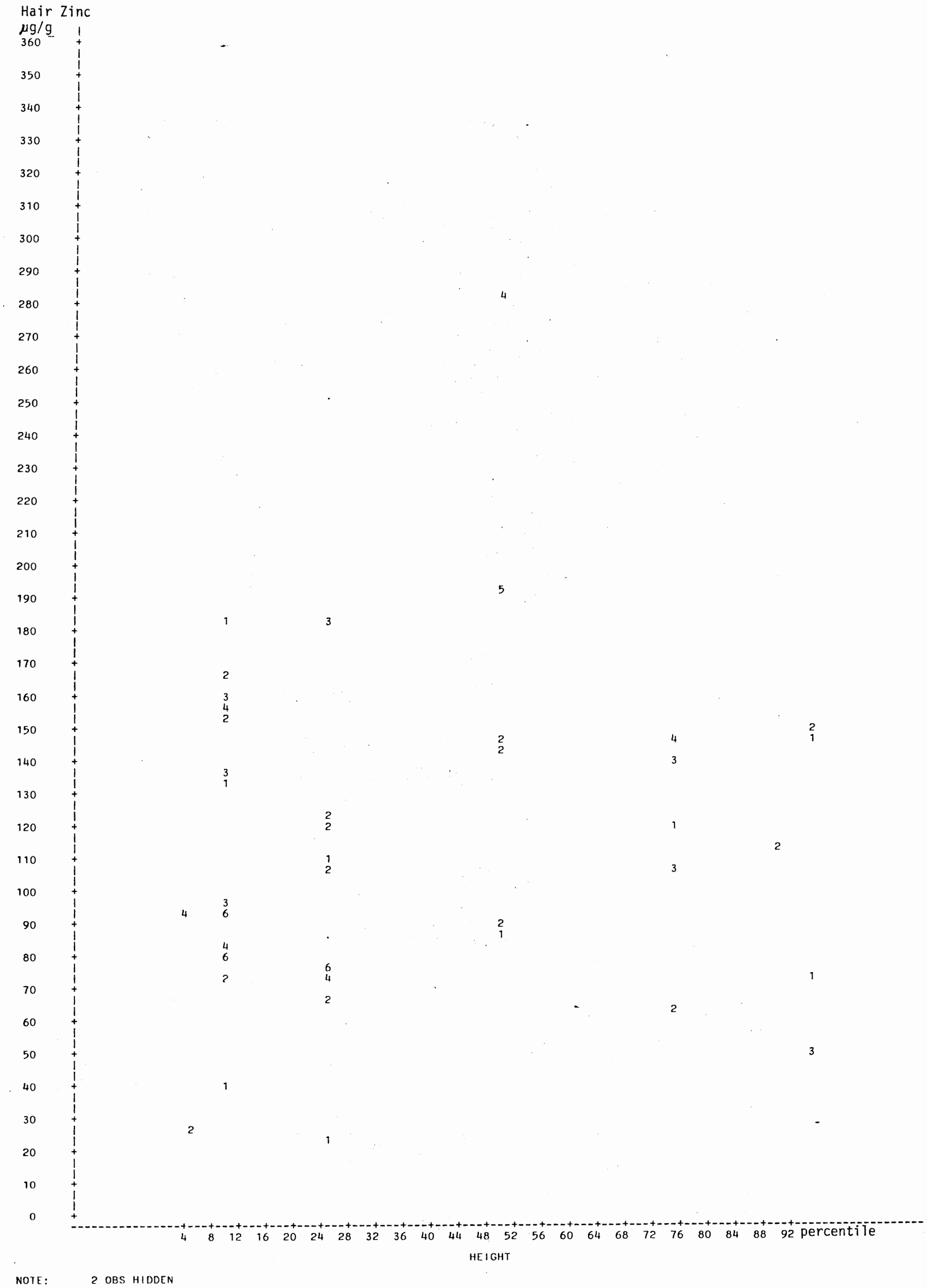
Identifying numbers are taste threshold levels.

Figure 3. Hair Zinc and Height Relationships Related to Sucrose (Sweet) Taste Acuity



Identifying numbers are taste threshold levels.

Figure 4. Hair Zinc and Height Relationships Related to HCl (Sour) Taste Acuity

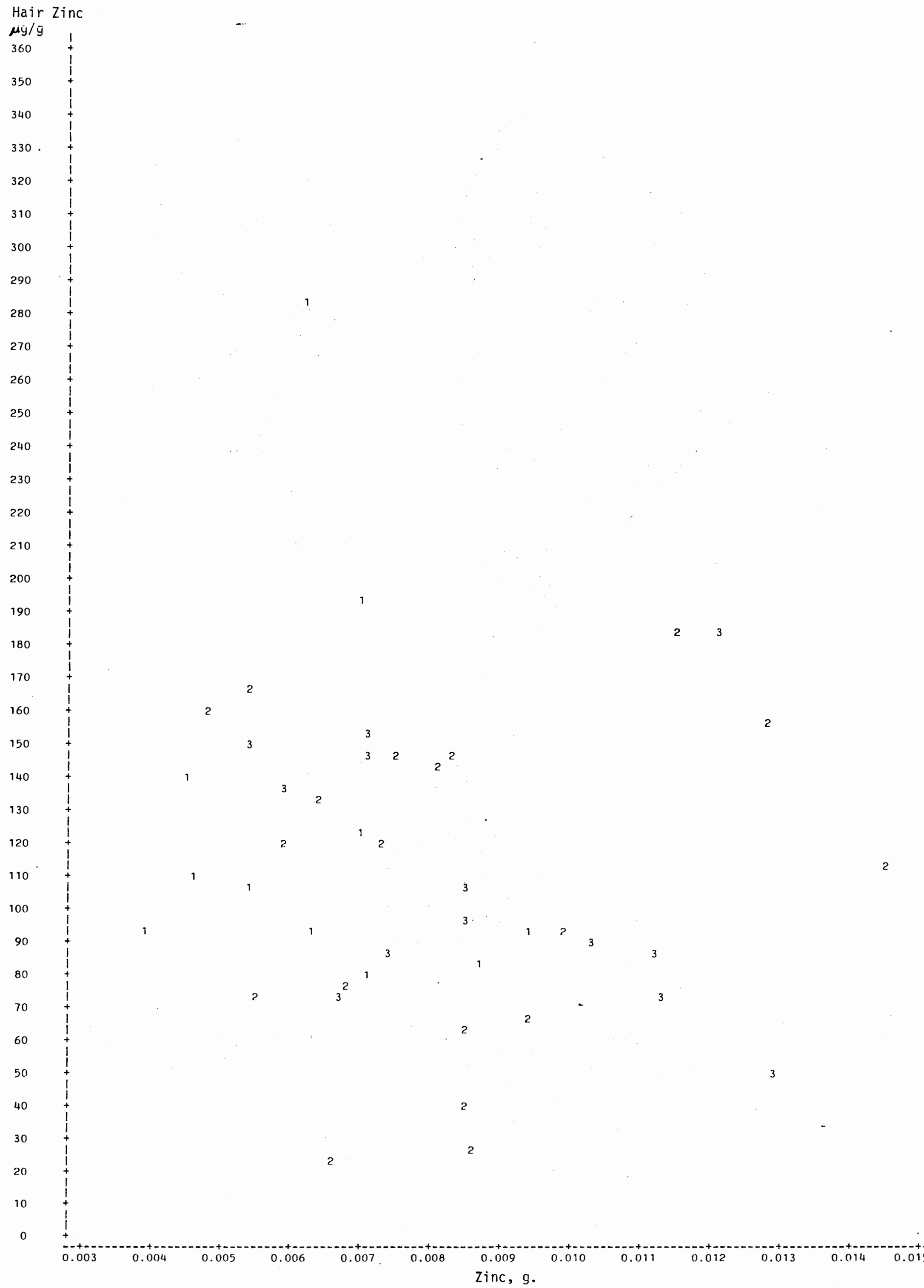


Identifying numbers are taste threshold levels.

Figure 5. Hair Zinc and Height Relationships Related to Urea (Bitter) Taste Acuity

(levels three and above), then subjects with abnormal scores were all below the 25th percentile for height and had hair zinc levels less than 100 µg/g. This hair zinc level is two standard deviations below the normal adult mean. However, "normal" scores also fell into this section of the plot (Figures 2 and 4). There were no such clear distinctions of abnormal values in those plots for sucrose and urea (Figures 3 and 5).

When dietary zinc and hair levels were considered, there was again no relationship (Figure 6). This, however, could be expected since hair zinc may reflect eating habits (zinc intake) up to six months in the past while dietary zinc indicated the subject's recent intake. While Hambidge et al. (1972, 1976) found a correlation between low zinc in hair, low growth achievement, and impaired taste acuity, these factors were not consistently related in the present study. However, in Hambidge's earlier study (1972), only children more than five years old who had low levels of hair zinc were tested for taste acuity; using only older children may have led to more accurate responses than were possible with younger children. In addition, only ten of the subjects from approximately 132 in the age range of four to 17 years were found with all the characteristics of low growth achievement, low hair zinc, and impaired taste acuity. In Hambidge's latter study (1976), preschool children attending Head Start were selected on the basis of low growth achievement. Thirty-seven percent (137 of 350 children) were below the tenth percentile on the Iowa growth grids. While there was a significant difference in mean hair levels in the study group and a control group from the earlier study, not all of the short children had low hair zinc. Thus, the difference in criteria for sample selection and the total number of subjects included in these studies may be the determinants



Identifying number is SES group: 1=Low, 2=High, 3=Head Start.

Figure 6. Hair Zinc and Dietary Zinc Relationship

of the different findings in the present study and the previous ones.

Summary of Testing H_2

The researcher did not reject hypothesis two: there were no significant differences in zinc status as measured by dietary zinc, growth achievement, taste acuity, or hair zinc analysis. While there were children with low dietary zinc intakes, these were not necessarily related to growth, taste acuity, or hair zinc. Likewise, neither high levels of hair zinc nor growth achievement were related to each other or to taste acuity.

Fiber Intake and Zinc Status

Fiber was thought to be one of the factors adversely affecting zinc availability. Mean crude fiber intakes and even the maximum intake (4.9 g) in this sample were low. When estimating the total dietary fiber at two to three times the crude fiber intake, the levels are still well within normal intakes. There is no evidence that these fiber intakes would adversely affect zinc status. Sandstrom et al. (1980) concluded that in diets high in animal protein, zinc absorption was unlikely to be affected by fiber from wholemeal bread. Further, fiber intakes were not related to hair zinc levels, growth, or dietary zinc as seen in Table XVIII Appendix E.

The fiber intakes of this sample were similar to that found by Endres et al. (1981) in a study of 169 preschool children in Illinois. They found mean fiber intakes were 2.0 grams with a range of 0.33 to 5.86 grams. In the present study, the mean fiber intake was 2.35 grams with a range of 0.80 to 4.90 grams. These similarities seem to indicate a degree of consistency in the eating habits of children in this age group.

Summary of Testing H_3

The researcher did not reject hypothesis three: there was no relationship between fiber intake and zinc status. Fiber intakes were low in most subjects and dietary zinc, protein, and animal protein intakes were sufficient for adequate zinc absorption. Therefore, fiber intake was not a determinant of zinc status.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

A nutritional status study of 43 preschool children attending schools in Stillwater, Oklahoma, who were between the ages of 41 and 74 months was conducted during March and April, 1981. Complete dietary data, anthropometric measurements, taste acuity tests, and hair analysis were obtained for each subject. Socioeconomic status was determined by the occupation status scores of the parents.

The dietary data were obtained by 24 hour dietary recalls followed by two day food records. These were coded and then analyzed for nutrient content by the Nutritional Analysis System at Louisiana State University, Baton Rouge. Mean intakes from the three day food records were used in this study. A dietary score was computed for each subject on the basis of 13 nutrients and was then categorized into either a "high," "medium," or "low" diet score category. Dietary intake was compared by socioeconomic status groups for diet category scores and for individual nutrients, both with and without the inclusion of nutrients provided by supplements.

Growth achievement and weight for height rankings were determined from growth charts published by the National Center for Health Statistics (Hamill et al., 1977). Skinfold thickness percentile rankings were determined from charts in Foman (1976). Anthropometric measures were compared by socioeconomic status groups and by relationship to the diet score category.

Taste acuity was measured by the three drop forced choice method. Levels above the median adult detection threshold were considered impaired.

Hair samples, obtained when anthropometric measurements were taken, were cut close to the scalp from the suboccipital region on the head with forged stainless steel barber's shears. Only the proximal two centimeters were used. Mineral analysis of hair for zinc was done by atomic absorption spectrophotometry using a method modified from that of Freeland-Graves et al. (1980).

The results of dietary analysis both with and without supplements showed a significant difference in the quality of the diet between those children attending Head Start and the low socioeconomic group. There was a significant difference in the diets without supplements in the high socioeconomic group and the low socioeconomic group; there were no significant differences in the diets of these two groups when supplements were included, however. The Head Start children were taller for age and heavier for height than the other two groups. For all children, skinfold thickness measurements were positively related to weight for height.

Energy needs were met for most children in this sample. The distribution of energy yielding nutrients was similar to other studies, but energy supplied by protein increased from the low SES group through the high SES group to Head Start (12.7% to 15.1%). Mean nutrient intakes were above 75 percent of the RDA for all nutrients studied in the Head Start group.

In the high SES group mean intakes of Vitamins D and B_6 were below 75 percent of the RDA but were above 50 percent. In the low SES group, mean intakes of Vitamin D and zinc were less than the 75 percent of the RDA, and Vitamins D, B_6 and folacin were less than the 50 percent. However, when supplements were included, the high SES group received 75 percent or more of the RDA for all nutrients on the basis of mean scores while mean intakes in the low SES group were still low in zinc.

Nutrient supplements were used in 44.2 percent of the subject with the low SES group having the highest usage. In the low SES group 72.7 percent of the children took a supplement on the average frequency of five times per week. Head Start children used fewer supplements and took them less often.

Zinc intakes were not related to hair zinc, growth achievement, or to taste acuity. While there were children with low zinc intakes, they were not necessarily also low in percentile ranking for height, low in hair zinc (< 70 μg/g), or impaired in taste acuity. Mean zinc intakes were above the estimated need of 6 mg/day. Protein intakes for all children were high, and, for all except one child, animal protein intakes were also high.

Fiber intakes in the sample were low. There was no relationship between fiber intake and measures of zinc status. While the fiber intakes appeared low, they were similar to those found by other researchers.

Conclusions

The researcher made the following conclusions on the basis of this study:

1. There was a difference in nutritional status among different socioeconomic groups when children attending Head Start were considered as a separate group. The lower socioeconomic status children had lower nutrient intakes and were shorter for age than the higher socioeconomic status children. Head Start children had the highest nutrient intakes and were the tallest.
2. There was no relationship between dietary zinc intake and zinc status measures of growth, hair zinc, or taste acuity in this sample.
3. There was no relationship between fiber intake and zinc status in this sample.

Recommendations for Research

Zinc status was considered to be an important research area in preschool children. There were conflicts in findings in this study and other published investigations. The researcher recommended the following areas for further research:

1. Taste thresholds need to be determined in preschool children, and appropriate measuring techniques for determining taste acuity in children need to be investigated.
2. Further studies should be conducted to investigate the use of hair analysis as a measure of zinc status.
3. A larger sample should be included to more adequately reflect the population and to detect variances in socioeconomic groups.

4. Comparisons of children attending Head Start should be made with other children of low socioeconomic status at entry into Head Start to determine if there are basic differences in these segments of the population.
5. Longitudinal studies of preschool children should be conducted to investigate the change in nutritional status with increasing age and to determine the possible effect of school attendance. This would be particularly important in the case of the Head Start children if there were no differences in them and other low socioeconomic status children at entry into school.

SELECTED BIBLIOGRAPHY

American Academy of Pediatrics, Committee on Nutrition: Zinc. Pediatrics 62: 408, 1978.

Buzina, R., Jisoc, M., Sapunar, J., and Milanovic, N.: Zinc nutrition and taste acuity in school children with impaired growth. Am. J. Clin. Nutr. 33: 2262, 1980.

Cantalanotto, F. A.: The trace mineral zince and taste. Am. J. Clin. Nutr. 31: 1098, 1978.

✓ Christakis, G.: Nutritional Assessment in Health Programs. Washington, D.C.: The American Public Health Assoc., Inc., 1973.

Cummings, J. H.: Nutritional implications of dietary fiber. Am. J. Clin. Nutr. 31: S21, 1978.

Endres, J., Gulley B., and Fisher, C. E.: Crude fiber and nutrients in the diets of preschoolers, H.E. Res. J. 9: 319, 1981.

✓ Eppright, E. S., Patton, M. B., Marlatt, A. L., and Hathaway, M. L.: Dietary study methods V. Some problems in collecting dietary information about groups of children. J. Am. Dietet. A. 28: 43, 1952.

Foman, S. J.: Nutritional Disorders of Children. Prevention, Screening, and Follow-up. DHEW Publ. No. (HSA) 76-5612. Public Health Service. Washington, D.C.: Government Printing Office, 1976.

Fox, H. M., Fryer, B. A., Lamkin, G. H., Vivian, V. M., and Eppright, E. S.: Diets of preschool children in the North Central Region. J. Am. Dietet. A.: 59: 223, 1971.

Freeland, J. H. and Cousins, R. J.: Zinc content of selected foods. J. Am. Dietet. A. 68: 526, 1976.

Freeland-Graves, J. H., Ebangit, M. L., and Hendrickson, P. J.: Alterations in zinc absorption and salivary sediment zinc after a lacto-ovo-vegetarian diet. Am. J. Clin. Nutr. 33: 1757, 1980.

Fryer, B. A., Lamkin, G. H., Vivian, V. M., Eppright, E. S., and Fox, H. M.: Growth of preschool children in the North Central Region. J. Am. Dietet. A. 60: 30, 1972.

Greger, J. H. and Geissler, A. H.: Effect of zinc supplementation on taste acuity of the aged. Am. J. Clin. Nutr. 31: 633, 1978.

Gurney, J. M., and Jelliffe, D. B.: Arm anthropometry in nutritional assessment: nomogram for rapid calculation of muscle circumference and cross-sectional muscle and fat areas. Am. J. Clin. Nutr. 26: 912, 1973.

Halsted, J. A., Ronachy, H. A., Abadi, P., Haghshenass, M., Amirhakemi, G. H., Baraket, R. M., and Reinhold, J. G.: Zinc deficiency in man: The Shiraz experiment. Am. J. Med. 53: 277, 1972.

Hambidge, K. M., Hambidge, C., Jacobs, M., and Baum, J. D.: Low levels of zinc in hair, anorexia, poor growth and hypogeusia. Pediat. Res. 6: 868, 1972.

Hambidge, K. M., Walravens, P. A., Brown, R. M., Webster, J., White, S., Anthony, M., and Roth, M. L.: Zinc nutrition of preschool children in the Denver Head Start program. Am. J. Clin. Nutr. 29: 734, 1976.

Hamill, P. V. V., Drizd, T. A., Johnson, C. L., Reed, R. B., and Roche, A. F.: NCHS Growth Curves for Children Birth - 18 years. (Vital and Health Statistics: Series 11, Data from the National Health Survey; no. 165) (DHEW publication (PHS) 78-1650). Washington, D.C.: Government Printing Office, 1977.

Henkin, R. I.: Zinc, Saliva, and Taste: Interrelationships of Gustin, Nerve Growth Factor, Saliva and Zinc. In Zinc and Copper in Clinical Medicine. Eds. K. M. Hambidge and B. L. Nichols. New York: SP Medical and Scientific Books, 1976, pp. 35-48.

Henkin, R. I., Gill, J. R., and Bartter, F. C.: Studies on taste thresholds in normal man and in patients with adrenal cortical insufficiency: the role of adrenal and cortical steroids and of serum sodium concentration. J. Clin. Invest. 42: 727, 1963.

Macy, I. G.: Nutrition and chemical growth in childhood. In: Evaluation, Vol. I. Chas. C. Thomas, Springfield, Ill, 1942.

Marr, J. W.: Individual dietary surveys: Purposes and methods. World Rev. Nutr. Diet. 13: 105, 1971.

Moore, M. C., Judlin, B. C., and Kennemyr, P. M.: Using graduated food models in taking dietary histories. J. Am. Dietet. A. 51: 447, 1967.

Murphy, E. W., Willis, B. W., and Watt, B. K.: Provisional tables of the zinc content of foods. J. Am. Dietet. A. 66: 345, 1975.

Nam, C. B., LaRocque, J., Powers, M. G., Holmberg, J.: Occupational status scores: Stability and change. Proceedings of the Am. Stat. Assoc. pp. 570-575, 1975.

National Academy of Sciences: Recommended Dietary Allowances. Ninth Revised Edition. Washington, D.C.: Food and Nutrition Board, National Research Council, 1980.

National Center for Health Statistics: Caloric and selected nutrient values for persons 1-74 years of age: First Health and Nutrition Examination Survey. United States 1971-1974. Washington, D.C.: Government Printing Office, 1979. Vital Health Statistics (1) Series 11 (209), 1979.

Oberleas, D. and Harland, B. F.: Nutritional agents which affect metabolic zinc status. In Zinc Metabolism: Current Aspects in Health and Disease. Eds. George J. Brewer and Ananda S. Prasad. New York: Alan R. Liss, Inc., 1977.

Owen, G. M., and Kram, K. M.: Nutritional status of preschool children in Mississippi. J. Am. Dietet. A. 54: 490, 1969.

Owen, G. M., Kram, K. M., Garry, P. J., Lowe, J. E., and Lubin, A. H.: A study of nutritional status of preschool children in the United States, 1968-1970. Pediatrics 53: 597, 1974.

Prasad, A. S.: Trace Elements and Iron in Human Metabolism. New York: Plenum Medical Book Co., 1978.

Prasad, A. S., and Oberleas, D.: Trace Elements in Human Health and Disease. Vol. I. Zinc and Copper. New York: Academic Press, 1976.

Prasad, A. S., Oberleas, D., Wolf, P., Horwitz, J. P., Miller, E. R., and Luecke, R. W.: Changes in trace elements and enzyme activities in tissues of zinc-deficient pigs. Am. J. Clin. Nutr. 22: 628, 1969.

Price, N. O., Bunce, G. E., and Engel, R. W.: Copper, manganese, and zinc balance in preadolescent girls. Am. J. Clin. Nutr. 23: 258, 1970.

Reinhold, J. G., Faradji, B., Abadi, P., and Ismail-Beigi, F.: Binding of zinc to fiber and other solids of wholemeal bread. In Trace Elements in Human Health and Disease. Vol. I. Zinc and Copper. Ed. A. S. Prasad. New York: Academic Press, 1976.

Sandstead, H. H., Munoz, J. M., Jacob, R. A., Kelvay, L. M., Reck, S. J., Logan, R. A., Dintzis, F. R.: Influence of dietary fiber on trace element balance. Am. J. Clin. Nutr. 31: S 180, 1978.

Sandstead, H. H., Vo-Khactu, K. P., and Solomons, N.: Conditioned zinc deficiencies. In Trace Elements in Human Health and Disease. Eds. A. S. Prasad and D. Oberleas. New York: Academic Press, 1976.

Sandstrom, B., Arvidsson, B., Cederblad, A., Bjorn-Rasmussen, E.: Zinc absorption from composite meals. I. The significance of wheat extraction rate, zinc, calcium, and protein content in meals based on bread. Am. J. Clin. Nutr. 33: 739, 1980.

Scoular, F. L.: A quantitative study, by means of spectrographic analysis, of zinc in nutrition. J. Nutr. 17: 103, 1939.

Trowell, H.: The development of the concept of dietary fiber in human nutrition. Am. J. Clin. Nutr. 31 (10 Supp.): S 3, 1978.

U. S. Dept. of Health, Education, and Welfare, Health Services and Mental Health Administration: The Ten State Nutrition Survey 1968-1970 Vol. I - V. Department of HEW Publication No. (HSM) 72 - 8130. Atlanta: Center for Disease Control, 1972.

Van Soest, P.: Dietary fibers: their definition and nutritional properties. Am. J. Clin. Nutr. 31: S 12, 1978.

Young, C. M., Hagan, G. C., Tucker, R. E., and Foster, W. D.: A comparison of dietary study methods. II. Dietary history vs. 24-hr. recall. J. Am. Dietet. A. 28: 218, 1952.

APPENDIXES

APPENDIX A

LETTER AND CONSENT FORM

Oklahoma State University

Department of Food, Nutrition and Institution Administration

STILLWATER, OKLAHOMA 74078
(405) 624-5039

February 25, 1981

To the parents of

Dear Parents:

Interest in nutrition and nutrient needs of preschool children is a current and important concern. Oklahoma State University nutritionists are currently assessing the nutritional status of individuals from preschool age through the elderly to determine what foods are being eaten at various ages in the life cycle. A particular interest is the role of fiber in the diet as it affects nutritional status and other nutrients. My particular interest is the zinc status of preschool children related to fiber and dietary intake, since the trace mineral zinc is known to be essential for adequate growth.

Your child has been randomly chosen to participate with your consent in this nutrition study. Participation will involve a personal interview with you to determine the food eaten and general food and health habits of your child. This interview will take no longer than one hour. You will also be asked to record the food your child eats for two days.

In the school, I will be doing several things with each child. One will be height, weight, and skinfold thicknesses to determine growth achievement. A very small sample of hair will be carefully cut at the nape of the neck for hair zinc determinations. The hair sample will be so small it will not be noticeable. Taste sensitivity tests to detect a child's ability to taste differences and recognize the basic tastes of sweet, sour, salty, and bitter will also be done. Your child will be asked to taste samples of each of these to tell me if the test liquid tastes the same or different than water. All of these tests have been used by other researchers and pose no known risk to your child.

This study has been approved by the OSU Human Rights Committee. This committee examines all research which involves human beings for safety and for the protection of individual rights. The study has also been approved by the administration of your child's school.

Please sign the enclosed consent form and return it to your child's teacher by March 6, 1981, if you are willing to have your child participate. I will call you shortly thereafter for an appointment to meet with you.

I will be happy to answer any questions you may have concerning this project. A summary of the results will be sent to all participants when the study is complete if you wish to have them.

Sincerely,

Andrea B. Arquitt
Master's Degree Student
Telephone: office 624-5039
home 372-8048

Esther Winterfeldt
Esther Winterfeldt, PhD
Advisor
Professor and Head, Dept. of Food, Nutrition, and Institution Administration

Consent to Participate in an
Oklahoma State University
Preschool Nutrition Survey

I give permission for my child to participate in this Preschool Nutrition Study. I understand that I will be expected to cooperate in the following ways:

A. One interview of approximately one hour concerning general food habits, health history, and a dietary recall.

B. Keeping a record of my child's total food and beverage for two days.

I understand my child is at no risk in this study. He/she will participate in the following parts of the study.

A. Height, weight, and skinfold thickness measurements.

B. Provide a small hair sample from the nape of the neck.

C. Participate in two taste tests for sensitivity to sweet, sour, salty, and bitter tastes.

I have been assured that only properly trained persons will be collecting the information, and that the results of the study will not be used in any way that will identify me. I retain the right to withdraw my child from the study at any time if I change my mind.

__________________________ ______________
Parent/Guardian Date

____
Participant's name

APPENDIX B

FORMS FOR DATA COLLECTION

24-HOUR DIETARY RECALL

Subject _______ Time __________

Date _______ Location ___________

Interviewee _____ Mother = 1 Father =2 Grandmother = 3 Grandfather = 4
Other = 5 Specify _________________

Day of the Week S M Tu W Th F S

" Iwould like you to tell me everything your child ate and drank from the time he got up yesterday until he got up today. This includes everything we commonly think of as 'food' as well as other items. I will show you food models to help determine the amount eaten. The easiest way for up to do this is to think through what the child did during the day and who he ate with. Let's start."

	Time	Food	Amount Serv.	Amount Left	With whom	Where
	6:00 to 9:00					
	9:00 to 11:00					
	11:00 to 1:00					
	1:00 to 4:00					
	4:00 to 6:00					
	6:00 to Bedtime					

INSTRUCTIONS FOR THE FOOD INTAKE RECORD

PLEASE PREPARE AND SERVE MEALS AS YOU NORMALLY WOULD. THERE SHOULD BE NO SPECIAL PREPARATION FOR THIS RECORD. THANK YOU.

1. All foods or berverages comsumed are important. For these two days please keep this record in a convenient place so that foods can be written down as they are eaten. Foods eaten or beverages consumed at times other than "scheduled meals" need to be included.

2. Food preparation methods are important.
   For example: Meat — indicate if it is baked, fried, stewed, etc.
   Poultry
   Fish

   Eggs — indicate if they are boiled, scrambled or fried

   Fruit — indicate if it is fresh or canned

   Vegetables — indicate if fresh, canned, frozen or raw

   Milk — indicate if it is whole, 2%, 1%, or skim or if it is reconstituted dry or evaporated

   Cereals — brand names would be helpful

   Cookies and desserts — if purchased, please give brand name
   if "homemade" please so state

   Beverages — soft drinks indicate if sweetened (regular) or diet

   Snack foods — please estimate quantities or check the wrapper

3. Estimate the quantities in household units. That is: teaspoons, tablespoons $\frac{1}{4}$ cup, $\frac{1}{2}$ cup, 1 cup, etc.
   Ounces may be used for meats or you may estimate by measurement.
   For example: sliced turkey 1" x 2" x $\frac{1}{4}$".

4. Sauces or condiments served with foods should also be listed as well as the amount.
   Examples:

Hamburger pattie	$1\frac{1}{2}$ oz.	Puffed wheat	$\frac{1}{2}$ cup
Catsup	1 Tablespoon	Sugar	1 teaspoon
Lettuce	$\frac{1}{4}$ cup	Cauliflower	3 Tablespoons
French dressing	1 Tablespoon	Cheese sauce	1 Tablespoon

5. Combination dishes such as stews may be hard to estimate. Please list all the foods included and indicate the quantity.
   Examples: Beef Stew

Beef	2 ounces (or in tablespoons if it is easier to estimate)
Potatoes	2 tablespoons
Carrots	2 tablespoons
Celery	2 tablespoons
Gravy	2 tablespoons

6. Keep in mind that the quantities listed in the examples are only examples. The units are not necessarily the "correct" or "desirable" portions for a child.

Thank you for your cooperation and help.

FOOD RECORD FOR PRESCHOOL CHILDREN

Subject No. ______

Date ___________ Day: M Tu W Th F

	Time	Food & Preparation Method	Amount Serv.	Left	With whom	Where
	6:00 to 9:00					
	9:00 to 11:00					
	11:00 to 1:00					
	1:00 to 4:00					
	4:00 to 6:00					
	6:00 to Bedtime					

FOOD RECORD FOR PRESCHOOL CHILDREN

Subject No. ______

Date ____________ Day: M Tu W Th F

	Time	Food & Preparation Method	Amount Serv.	Left	With whom	Where
	6:00 to 9:00					
	9:00 to 11:00					
	11:00 to 1:00					
	1:00 to 4:00					
	4:00 to 6:00					
	6:00 to Bedtime					

PERSONAL INTERVIEW

	Columns	Code
Subject Number ________	1 - 3	____
Sex M = 1 F = 2	4	____
Race White = 1 Black = 2 Other = 3	5	____
Birthdate________________ (age in months)	6 - 7	____
Birth length _________ (in. convert to cm ________)	8 - 9	____
Birth weight ___________(lbs./oz. convert to kg., one dec.)	10 - 11	____
Does the child have a past history of serious illness no = 0 yes = 1 ____________________________	12	____
Does the child presently have any allergies or illnesses no = 0 yes = 1 What? ________________________	13	____
Does the child presently take any medication? no = 0 yes = 1 What? ________________________	14	____
Does the child take a vitamin or mineral supplement? no = 0 yes = 1 Brand? ________________________	15	____
How often does he/she take the supplement? (0-7x/wk)	16	____
Breast fed? no = 00 yes = _______(no. of months)	17 - 18	____
Formula fed? no = 00 yes = _______(no. of months) Brand?______________	19 - 20	____
When were solid foods first introduced? ____________(mo.)	21 - 22	____
What food was added first? _______________ Meat =1 Fruit =2 Vegetable = 3 Cereal = 4 Other =5	23	____
When was the child fed exclusively "family foods"? _______________(months)	23 - 25	____
What is your impression or memory of your child's appetite as an infant (less than 1 yr.)? Excellent =1 Good = 2 Fair = 3 Poor = 4	26	____
Has your child ever been treated for anemia? When? _____ no = 00 yes = age in months ________	27 - 28	____
For how long? ________(months)	29 - 30	____
Was the blood retested after treatment? no = 0 yes = 1	31	____
Was the treatment considered successful? no = 0 yes = 1	32	____

Does your child eat substances not considered typically as food? no = 0 mud pies = 1 ice = 2 bones = 3 other = 4 ________ 33 ____

Does your child have a favorite breakfast cereal?________ 34 ____
no = 0 natural = 1 regular fortified = 2
sweetened fortified = 3 "vitamin supplement" type = 4
high fiber = 5

How many times a week does he/she eat it?______(o - 7) 35 ____

Does your child attend a sitter or day care center in addition to school? ____________ 36 ____
no = 0 yes = times per week

When did he/she begin preschool?_________(age in months __) 37 - 38 ____

What shampoo is used for the child?___________ 39 ____
Is this the only one used? no = 0 yes = 1 40 ____

Is a conditioner or other hair care product used?______ 41 ____
no = 0 yes = 1

Has he/she ever had a permanent wave?____________ 42 - 43 ____
no = 0 yes = ________wks. in past

Mother's barefoot height?_______ft/in _________cm. 44 - 47 ____
Father's barefoot height?_______ft/in _________cm. 48 - 51 ____

Mother's occupation ___________ code_______ 52 ____
Father's occupation ___________ code _______ 53 ____
Number of person's in family _________ 54 - 55 ____

CHILD

Present height _________cm. (one decimal) 56 - 59 ____
Present weight ________kg. (one decimal) 60 - 62 ____
Percentile ranking__________ 63 - 64 ____
Left triceps _________mm 65 - 66 ____
Left midar circumference_________cm 67 - 69 ____
Left subscapular skinfold ________mm 70 - 71 ____
Taste sensitivity:conc 1 =1 conc 2 = 2 conc 3 = 3
conc 4 = 4 conc 5 = 5 unable to taste = 6
NaCl _______ 72 ____
Sucrose_______ 73 ____
HCl _______ 74 ____
Urea ______ 75 ____
Hair zinc _________μg/g 76 ____

Subject #________________ Date________________

Height________________

Weight________________

L. Triceps________ ________ ________

L. Midarm Circumference__________

Subscapular Skinfold________ ________ ________

TASTE SENSITIVITY Date____________

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5
NaCl					
Sucrose					
HCl					
Urea					

APPENDIX C

PROCEDURE FOR HAIR ZINC DETERMINATION

All glassware, plastic bottles, crucibles, and stirring rods were washed, rinsed, and acid washed in 50 percent hydrochloric acid before use. Volumetric and plastic ware were soaked overnight in the acid and then rinsed three times with distilled water. Beakers, stirring rods, crucibles, and funnels were simmered for 15 minutes in the acid and rinsed three times with distilled water. All materials were air dried inverted on low ash filter paper in a closed cabinet. In addition, crucibles were dried at 100°C for 24 hours, cooled in a desiccator, and weighed prior to use. The desiccator had previously been washed and lined with filter paper to minimize dust contamination. Only teflon or teflon coated instruments were used in washing the glassware or in sample handling.

Hair samples were stored in labeled, sealed plastic bags until analysis. The samples were washed with hexane in 50 milliliter beakers for 15 minutes. The hexane was decanted and the samples were then washed for 15 minutes with 95 percent ethanol. The ethanol was decanted and the samples were rinsed three times with 15 milliliters of distilled water. The washed samples were transferred to crucibles and dried for 24 hours at 105°C. The samples were cooled overnight in a desiccator and then weighed to the nearest one tenth milligram on a Mettler H18 analytical balance.

The hair samples were ashed in a muffle furnace at 500°C for 24 hours. The temperature was increased gradually to the desired temperature to prevent klinking of the sample. The time count was begun when the oven temperature reached 500°C. At the end of the 24 hours, the oven was turned off and allowed to cool before removing the samples for dilution. The hair samples of the younger children contained a dark orange bead while the ash from the older children was only tinged with orange. All of this material dissolved with the nitric acid.

The ashed samples were dissolved in 7 N nitric acid and diluted to volume with distilled water. Those samples initially weighing approximately 70 milligrams or less were dissolved in one-half a milliliter of nitric acid and diluted to a final volume of five milliliters. Those samples weighing over 70 milligrams were dissolved with one milliliter of nitric acid and were diluted to a final volume of ten milliliters. Each crucible was rinsed three times with a portion of the dilution water to remove all ash for analysis. The samples were stored in tightly-capped, acid-washed plastic bottles until readings were taken.

Standards were prepared to include the ranges of expected values. The standards were prepared using the same proportion of nitric acid and distilled water as were used in the sample dilution to compensate for any contamination in the nitric acid.

Zinc concentrations in the samples were read on a Perkins Elmer 403 atomic absorption spectrophotometer at a wavelength of 214.15 Å using a zinc lamp. Two readings were obtained from each sample.

APPENDIX D

PROCEDURE FOR TASTE ACUITY DETERMINATION

Solutions of sodium chloride, sucrose, hydrochloric acid, and urea were prepared each week before the tests were done. Only two solutions were tested at a time: hydrochloric acid and sucrose, and sodium chloride and urea. All children were tested for sensitivity to sucrose and hydrochloric acid first.

The children were tested one hour after the last time food or drink was consumed. The children rinsed their mouths with distilled water before the tests.

Two drops of distilled water and one of the test solution were placed on the anterior third of the tongue. The lowest concentration of the test solution was used first. The children were asked to state if the three drops tasted the same or different. When differences were noted, that level of concentration of solution was considered the detection level. To reduce the chance of children stating differences they could not detect, the child was asked to point to the place on the tongue with the different taste. Subjects were tested for each taste only one time.

APPENDIX E

TABLES XI THROUGH XVIII

TABLE XI

FREQUENCY DISTRIBUTION OF GROWTH ACHIEVEMENT BY SOCIOECONOMIC STATUS GROUPS

GROUP	N	MEAN % ranking	Percentile Ranking[a]							
			<5	5	10	25	50	75	90	95
Low SES	11	26.2	2	0	3	3	2	1	0	0
High SES	19	33.6	1	1	7	4	1	3	1	1
Head Start	13	47.3	0	0	3	3	3	1	0	3

[a] Rankings indicate growth achievement was at least at this percentile ranking but not as great as the next level.

TABLE XII

FREQUENCY OF WEIGHT FOR HEIGHT PERCENTILE RANKINGS
BY SOCIOECONOMIC STATUS GROUPS

GROUP	N	MEAN % ranking	Percentile Ranking[a] 10	25	50	75	90	95
Low SES	11	63.6	0	4	4	3	0	0
High SES	19	57.4	1	6	3	3	3	3
Head Start	13	68.5	1	3	1	5	0	3
Total	43	58.3	2	13	8	11	3	6

[a] Rankings indicate weight for height was at least at this percentile ranking but not as great as the next level.

TABLE XIII

FREQUENCY OF PERCENTILE RANKING OF TRICEPS SKINFOLD THICKNESS BY SOCIOECONOMIC STATUS GROUPS[a]

			Percentile Ranking						
GROUP	N	MEAN	<10	10	25	50	75	90	95
Low SES	10	47	0	2	2	2	4	0	0
High SES	18	40.28	0	5	6	2	2	2	1
Head Start	13	57.9	2	0	3	0	4	4	0

[a]Contingency coefficient = .557

TABLE XIV

FREQUENCY OF PERCENTILE RANKING OF SUBSCAPULAR SKINFOLD THICKNESS BY SOCIOECONOMIC STATUS GROUPS

			Percentile Ranking						
GROUP	N	MEAN	<10	10	25	50	75	90	95
Low SES	10	40.5	1	1	2	5	0	1	0
High SES	18	32.5	5	4	1	5	2	0	1
Head Start	13	36.5	3	2	2	3	2	1	0

TABLE XV

NUTRIENT CONTENT OF SUPPLEMENTS TAKEN BY PRESCHOOL SUBJECTS

Supplement	Vit A I.U.	Vit D I.U.	Vit E I.U.	Thiamin mg	Ribo-flavin mg	Niacin mg	Vit B_6 mg	Vit B_{12} μg	Vit C mg	Folic Acid mg	Fe mg	Ca mg	Mg mg	Pantothenic Acid mg
V-Supp														
#1														
Bugs Bunny	2500	400	15	1.05	1.2	13.5	1.05	4.5	60	0.3				
Flintstones														
Rexall MinuteMan														
#2														
Chocks with Fe	2500	400	15	1.05	1.2	13.5	1.05	4.5	60	0.3	15			
Flinstones with Fe														
Spiderman with Fe														
Revco with Fe														
#3														
Polyvisol with Fe	2500	400	15	1.05	1.2	13.5	1.05	4.5	60	0.3	12			
Good Value with Fe														
#5														
Flinstones with C	2500	400	15	1.05	1.2	13.5	1.05	4.5	250	0.3				
Bugs Bunny with C														
#6														
New Life Young Vites	5000	400	10	1.2	1.2	10	1.2	5.0	40					
#7														
Nutrolite	2500	200	10	0.7	0.8	9	0.7	0.3	40	0.2	10			5
#8														
Dolomite												250	120	
#9														
OsCal		125										250		
C-Supp														
#1									150					
#2									250					

TABLE XVI

DIET SCORES OF SUBJECTS AND INTAKE OF NUTRIENTS AS A PORTION OF THE RDA

Obs. No.	Subject	SES Grp.[a]	Diet Score Category	Diet Score	Vit. D	Ascorbic Acid	Calcium	Zinc	Protein	Vit. A	Folacin	Niacin	Ribo-flavin	Thiamin	B_6	Iron	Energy
1	9	1	LO	5	0.3675	0.68889	0.88750	0.544	1.29667	2.77804	0.3840	0.95455	1.0000	1.00000	0.45385	0.99000	1.03294
2	11	1	MD	9	1.1150	1.64444	1.74250	0.936	2.15333	1.65264	0.5055	0.63636	1.9600	0.75833	0.55385	0.71000	0.99529
3	13	1	LO	4	0.5550	1.82222	0.92000	0.633	1.58667	1.72721	0.7215	0.74545	1.2600	0.52500	0.38462	0.58000	0.59941
4	14	1	MD	10	0.9475	1.31111	1.49000	0.703	2.46957	4.42051	0.8710	0.93333	2.3125	0.94444	0.91111	0.42667	1.26154
5	33	1	LO	-1	0.2000	0.66667	0.42250	0.388	1.31000	1.13341	0.2395	0.88182	0.7100	0.55833	0.56923	0.76000	0.78000
6	34	1	LO	5	0.1250	0.93333	0.54500	0.715	1.21000	1.07755	0.5465	0.91818	0.7900	1.66667	0.69231	1.26000	0.74941
7	37	1	LO	-5	0.3450	2.26667	0.39625	0.463	0.99333	1.87561	0.1325	0.51818	0.6100	0.43333	0.23077	0.57000	0.72706
8	39	1	LO	6	0.0425	2.00000	0.36125	0.866	1.20000	1.34177	0.7665	0.98182	0.8000	0.59167	0.90000	1.00000	0.50059
9	41	1	LO	-1	0.2500	0.44444	0.47750	0.698	1.42000	0.81135	0.2305	0.78182	0.8500	0.53333	0.36923	0.67000	0.87588
10	45	1	LO	0	0.6825	0.20000	1.17500	0.623	1.70667	0.86606	0.2505	0.49091	1.3500	0.73333	0.34615	0.53000	0.87706
11	46	1	LO	-6	0.1350	0.62222	0.38500	0.447	1.10667	1.40527	0.2790	0.41818	0.6100	0.40833	0.25385	0.63000	0.67000
12	1	2	MD	11	0.5375	0.77778	0.73250	0.986	1.80000	2.51267	1.7050	1.41111	1.8250	1.31111	1.36667	0.81333	0.98923
13	2	2	HI	12	0.7350	3.40000	1.40000	0.943	2.28667	2.67564	1.1090	1.32727	1.7900	0.97500	0.95385	0.98000	1.05235
14	3	2	MD	9	0.6175	0.77778	1.22125	0.864	1.86667	1.79008	0.4445	0.77273	1.4400	0.85000	0.71538	0.80000	0.90765
15	4	2	MD	10	0.5000	3.31111	1.52375	0.809	2.07667	1.79446	1.2030	0.81818	1.4600	0.80000	0.70000	[illegible]	0.90412
16	5	2	LO	-1	0.4075	1.51111	0.22625	0.548	1.18333	0.70181	0.5235	1.07273	0.6500	0.66667	0.38462	0.63000	0.61294
17	6	2	MD	8	0.5650	1.51111	1.37125	0.540	1.63667	2.18781	0.5420	1.24545	1.5000	0.74167	0.72308	0.78000	0.82882
18	7	2	HI	13	1.4000	3.55556	2.27375	1.284	2.61333	4.35819	0.8385	1.07273	2.8000	1.23333	0.94615	1.02000	0.93000
19	8	2	LO	4	0.6750	1.46667	1.20250	0.483	1.70667	2.38954	0.6365	0.90000	1.4200	0.60000	0.69231	0.48000	0.66059
20	12	2	LO	5	0.6600	0.44444	0.97625	0.683	1.36000	1.54029	0.5335	0.86364	1.4700	0.65833	0.72308	0.78000	0.66941
21	15	2	LO	6	0.4625	2.31111	0.56125	0.848	1.47333	1.16365	0.6130	0.80000	0.9400	0.60833	0.50769	0.75000	0.74529
22	31	2	MD	9	0.4775	2.51111	1.06000	0.728	1.78333	2.71307	0.9715	0.98182	1.4200	0.81667	0.59231	0.81000	0.82588
23	32	2	MD	10	0.5750	2.02222	1.08125	0.830	1.72333	5.70027	0.8355	0.97273	1.5400	0.81667	0.70000	0.76000	0.72294
24	35	2	HI	13	0.8875	2.88889	1.21500	0.755	1.67333	2.75516	1.4735	1.06364	1.9200	1.14167	1.03077	1.08000	0.82941
25	36	2	MD	9	0.3275	3.17778	0.87875	0.660	1.39333	1.42894	1.0545	0.90909	1.2000	0.79167	0.73846	0.87000	0.87706
26	38	2	MD	7	0.3100	1.77778	0.78125	0.595	1.50333	1.35192	0.7180	0.80000	1.0700	0.80000	0.52308	0.70000	0.80941
27	40	2	HI	13	0.9025	4.86667	2.79750	1.449	3.17667	5.10387	1.5460	0.85455	2.5500	1.31667	0.85385	1.19000	1.35882
28	42	2	LO	5	0.4025	2.02222	0.80500	0.645	1.56000	1.10588	0.7345	0.74545	1.1400	0.70833	0.54615	0.68000	0.75412
29	43	2	HI	12	0.5275	0.88889	1.28250	1.147	2.23667	0.97609	0.7740	1.17273	1.7700	1.36667	0.76154	1.24000	1.27706
30	44	2	MD	11	0.8100	1.17778	1.31000	0.848	2.05000	1.50049	0.5755	1.12727	1.9000	0.99167	1.03846	0.74000	0.93588
31	16	3	MD	10	0.5375	1.42222	0.85375	0.741	2.03043	3.09246	1.3670	1.00000	1.6500	0.87778	0.85556	0.60667	0.87769
32	18	3	MD	8	0.5550	1.60000	0.74250	0.711	2.16000	1.09346	0.6100	1.31818	1.1300	0.76667	0.70769	0.79000	1.13706
33	19	3	HI	13	0.8175	6.51111	1.65000	0.852	2.26333	4.57449	1.3395	1.69091	2.0500	1.05833	0.88462	1.24000	1.19529
34	20	3	MD	11	0.8550	0.82222	1.63375	1.133	2.61000	1.67433	0.5905	0.97273	2.1500	1.30833	0.66154	0.92000	1.20412
35	21	3	HI	13	1.0050	4.08889	1.63125	1.035	4.03333	2.13304	1.2610	2.10909	2.3500	1.53333	1.64615	1.19000	1.68059
36	22	3	MD	11	0.8225	2.20000	1.36750	0.540	1.69667	1.89894	0.7345	1.26364	2.0700	1.06667	0.97692	1.18000	0.88412
37	23	3	MD	9	0.6675	1.73333	1.01750	0.713	1.87667	1.56646	0.6805	1.00000	1.4900	0.80833	0.67692	0.80000	0.91765
38	24	3	MD	11	1.3850	2.20000	2.26625	1.119	3.20435	4.39086	2.5360	1.28889	3.5250	1.35556	1.77778	0.49333	1.19692
39	25	3	HI	13	1.2725	3.93333	1.65500	1.209	2.29000	8.72684	1.6830	1.50909	2.7900	1.16667	1.05385	1.99000	1.16235
40	26	3	MD	8	0.2025	2.88889	0.50125	0.855	2.72609	2.39601	2.4930	1.56667	1.4625	1.13333	1.47778	0.70000	1.24077
41	27	3	MD	8	0.3750	2.46667	0.78625	0.593	1.43667	3.74143	0.6315	0.91818	1.1800	0.80000	0.62308	0.79000	0.86647
42	29	3	HI	13	0.9125	1.53333	1.47875	1.286	2.75333	3.74143	0.7825	2.10000	2.8000	1.30833	1.43077	1.45000	1.10824
43	30	3	HI	12	1.1150	2.55556	1.06750	0.673	1.75667	2.28810	1.0300	0.91818	1.4800	0.80000	1.11538	0.83000	0.85941

[a] SES Grp. 1 = Low SES; SES Grp. 2 = High SES; SES Grp. 3 = Head Start

TABLE XVII

DIET SCORES OF SUBJECTS AND INTAKE OF NUTRIENTS INCLUDING SUPPLEMENTS AS A PORTION OF THE RDA

Obs. No.	Subject	SES Grp.[a]	Diet Score Category	Diet Score	Vit. D	Ascorbic Acid	Calcium	Zinc	Protein	Vit. A	Folacin	Niacin	Ribo-flavin	Thiamin	B_6	Iron	Energy
1	9	1	HI	12	1.36750	2.02222	0.88750	0.544	1.29667	3.77804	1.88400	2.18182	2.20000	1.87500	1.26154	2.19000	1.03294
2	11	1	MD	9	1.11500	1.64444	1.74250	0.936	2.15333	1.65264	0.50550	0.63636	1.96000	0.75833	0.55385	0.71000	0.99529
3	13	1	MD	11	1.05500	2.71111	0.92000	0.633	1.58667	2.72721	1.72150	1.56364	2.06000	1.10833	0.92308	1.58000	0.59941
4	14	1	HI	12	1.09036	1.50159	1.49000	0.703	2.46957	4.59908	1.29957	1.14762	2.52679	1.11111	1.07778	1.42667	1.26154
5	33	1	LO	-1	0.20000	0.66667	0.42250	0.388	1.31000	1.13341	0.23950	0.88182	0.71000	0.55833	0.56923	0.76000	0.78000
6	34	1	LO	6	0.12500	5.06032	0.77714	0.715	1.21000	1.07755	0.54650	0.91818	0.79000	1.66667	0.69231	1.26000	0.74941
7	37	1	LO	-5	0.34500	2.26667	0.39625	0.463	0.99333	1.87561	0.13250	0.51818	0.61000	0.43333	0.23077	0.57000	0.72706
8	39	1	MD	10	1.04250	3.33333	0.36125	0.866	1.20000	2.34177	2.26650	2.20909	2.00000	1.46667	1.70769	1.00000	0.50059
9	41	1	MD	10	1.25000	1.77778	0.47750	0.698	1.42000	1.81135	1.73050	2.00909	2.05000	1.40833	1.17692	2.17000	0.87588
10	45	1	MD	11	1.68250	5.75556	1.17500	0.623	1.70667	1.86606	1.75050	1.71818	2.55000	1.60833	1.15385	0.53000	0.87706
11	46	1	MD	8	1.13500	1.95556	0.38500	0.447	1.10667	2.40527	1.77900	1.64545	1.81000	1.28333	1.06154	2.13000	0.67000
12.	1	2	HI	12	1.10893	2.80952	0.73250	0.986	1.80000	3.94124	1.70500	2.04603	2.68214	2.07302	2.12857	0.81333	0.98923
13	2	2	HI	12	0.73500	3.40000	1.40000	0.943	2.28667	2.67564	1.10900	1.32727	1.79000	0.97500	0.95385	0.98000	1.05235
14	3	2	MD	9	0.61750	0.77778	1.22125	0.864	1.86667	1.79008	0.44450	0.77273	1.44000	0.85000	0.71538	0.80000	0.90765
15	4	2	HI	13	1.50000	4.64444	1.52375	0.809	2.07667	2.79446	2.70300	2.04545	2.66000	1.67500	1.50769	1.97000	0.90412
16	5	2	LO	-1	0.40750	1.51111	0.22625	0.548	1.18333	0.70181	0.52350	1.07273	0.65000	0.66667	0.38462	0.63000	0.61294
17	6	2	MD	8	0.56500	1.51111	1.37125	0.540	1.63667	2.18781	0.54200	1.24545	1.50000	0.74167	0.72308	0.78000	0.82882
18	7	2	HI	13	1.40000	3.55556	2.27375	1.284	2.61333	4.35819	0.83850	1.07273	2.80000	1.23333	0.94615	1.02000	0.93000
19	8	2	LO	4	0.67500	1.46667	1.20250	0.483	1.70667	2.38954	0.63650	0.90000	1.42000	0.60000	0.69231	0.48000	0.66059
20	12	2	LO	5	0.66000	0.44444	0.97625	0.683	1.36000	1.54029	0.53350	0.86364	1.47000	0.65833	0.72308	0.78000	0.66941
21	15	2	MD	10	0.89107	2.88254	0.56125	0.848	1.47333	1.59222	1.25586	1.32597	1.45429	0.98333	0.85385	0.75000	0.74529
22	31	2	HI	12	1.33464	3.65397	1.06000	0.728	1.78333	3.57021	2.25721	2.03377	2.44857	1.56667	1.28462	0.81000	0.82588
23	32	2	MD	10	0.57500	2.02222	1.08125	0.830	1.72333	5.70027	0.83550	0.97273	1.54000	0.81667	0.70000	0.76000	0.72294
24	35	2	HI	13	0.88750	2.88889	1.21500	0.755	1.67333	2.75516	1.47350	1.06364	1.92000	1.14167	1.03077	1.08000	0.82941
25	36	2	MD	9	0.32750	3.17778	0.87875	0.660	1.39333	1.42894	1.05450	0.90909	1.20000	0.79167	0.73846	0.87000	0.87706
26	38	2	MD	7	0.31000	1.77778	0.78125	0.595	1.50333	1.35192	0.71800	0.80000	1.07000	0.80000	0.52308	0.70000	0.80941
27	40	2	HI	13	1.90250	6.20000	2.79750	1.449	3.17667	6.10387	3.04600	2.08182	3.75000	2.19167	1.66154	2.69000	1.35882
28	42	2	HI	12	1.40250	3.35556	0.80500	0.645	1.56000	2.10588	2.23450	1.97273	2.34000	1.58333	1.35385	2.18000	0.75412
29	43	2	HI	12	0.52750	0.88889	1.28250	1.147	2.23667	0.97609	0.77400	1.17273	1.77000	1.36667	0.76154	1.24000	1.27706
30	44	2	HI	13	1.52429	2.13016	1.31000	0.848	2.05000	2.21478	1.64693	2.00390	2.75714	1.61667	1.61538	2.24000	0.93588
31	16	3	MD	10	0.53750	1.42222	0.85375	0.741	2.03043	3.09246	1.36700	1.00000	1.65000	0.87778	0.85556	0.60667	0.87769
32	18	3	MD	8	0.55500	1.60000	0.74250	0.711	2.16000	1.09346	0.61000	1.31818	1.13000	0.76667	0.70769	0.79000	1.13706
33	19	3	HI	13	0.81750	6.51111	1.65000	0.852	2.26333	4.57449	1.33950	1.69091	2.05000	1.05833	0.88462	1.24000	1.19529
34	20	3	MD	11	0.85500	0.82222	1.63375	1.133	2.61000	1.67433	0.59050	0.97273	2.15000	1.30833	0.66154	0.92000	1.20412
35	21	3	HI	13	1.00500	4.08889	1.63125	1.035	4.03333	2.13304	1.26100	2.10909	2.35000	1.53333	1.64615	1.19000	1.68059
36	22	3	HI	12	1.25107	4.58095	1.36750	0.540	1.69667	2.32752	1.37736	1.78961	2.58429	1.44167	1.32308	1.18000	0.88412
37	23	3	MD	9	0.71214	1.73333	1.06214	0.713	1.87667	1.56646	0.68050	1.00000	1.49000	0.80833	0.67692	0.80000	0.91765
38	24	3	MD	11	1.38500	2.20000	2.26625	1.119	3.20435	4.39086	2.53600	1.28889	3.52500	1.35556	1.77778	0.49333	1.19692
39	25	3	HI	13	1.27250	3.93333	1.65500	1.209	2.29000	0.72684	1.68300	1.50909	2.79000	1.16667	1.05385	1.99000	1.16235
40	26	3	MD	11	1.20250	4.22222	0.50125	0.855	2.72609	3.64601	5.49300	3.06667	2.96250	2.30000	2.64444	0.70000	1.24077
41	27	3	HI	12	1.37500	3.80000	0.70625	0.593	1.43667	4.74143	2.13150	2.14545	2.38000	1.67500	1.43077	2.29000	0.86647
42	29	3	HI	13	0.91250	1.53333	1.47075	1.286	2.75333	3.74143	0.78250	2.10000	2.80000	1.30833	1.43077	1.45000	1.10824
43	30	3	HI	12	1.11500	2.55556	1.06750	0.673	1.75667	2.28810	1.03000	0.91818	1.48000	0.80000	1.11538	0.83000	0.85941

[a] SES Grp. 1 = Low SES; SES Grp. 2 = High SES; SES Grp. 3 = Head Start

TABLE XVIII

DIET SCORES OF ZINC STATUS FOR SUBJECTS BY SOCIOECONOMIC STATUS GROUP

	Subj. No.	Hair Zinc µg/g	Diet Category	Score	Zinc Portion of RDA	Protein Portion of RDA	Energy Portion of RDA	Ani-Pro. g	Fiber g	Height Percent-	Age Mos.	Taste Acuity Threshold Levels: NaCl	Sucrose	HCl	Urea
							Low SES								
1	34	80	LO	5	0.715	1.21000	0.74941	9.4	4.9	10	65	2	1	1	6
2	39	84	LO	6	0.866	1.20000	0.50059	24.8	2.8	10	62	2	2	1	4
3	11	94	MD	9	0.936	2.15333	0.99529	52.2	1.4	4	49	2	1	1	4
4	33	94	LO	-1	0.388	1.31000	0.78000	23.3	2.9	10	67	4	6	4	6
5	13	95	LO	4	0.633	1.58667	0.59941	36.8	0.9	4	59	.	1	2	4
6	9	105	LO	5	0.544	1.29667	1.03294	24.2	1.7	25	60	2	1	2	2
7	37	110	LO	-5	0.463	0.99333	0.72706	18.5	1.4	25	58	2	1	2	1
8	41	123	LO	-1	0.698	1.42000	0.87588	30.2	1.1	25	56	1	1	1	2
9	46	141	LO	-6	0.447	1.10667	0.67000	25.8	1.3	75	64	1	2.	1	3
10	14	193	MD	10	0.703	2.46957	1.26154	41.5	2.4	50	46	2	1	2	5
11	45	283	LO	0	0.623	1.70667	0.87706	36.2	0.8	50	62	2	1	1	4
							High SES								
12	36	23	MD	9	0.660	1.39333	0.87706	25.2	2.7	25	58	6	2	1	1
13	3	27	MD	9	0.864	1.86667	0.90765	42.4	2.2	5	69	2	2	2	2
14	44	41	MD	11	0.848	2.05000	0.93588	45.6	2.6	10	67	1	1	4	1
15	15	64	LO	6	0.848	1.47333	0.74529	30.4	1.7	75	61	2	3	1	2
16	2	67	HI	12	0.943	2.28667	1.05235	43.2	2.7	25	64	1	2	2	2
17	5	73	LO	-1	0.548	1.18333	0.61294	21.8	1.4	10	60	1	2	1	2
18	12	76	LO	5	0.683	1.36000	0.66941	26.7	1.2	25	58	3	4	1	6
19	1	93	MD	11	0.986	1.80000	0.98923	28.6	1.8	4	46	.	1	1	.
20	40	112	HI	13	1.449	3.17667	1.35882	72.5	2.9	90	63	2	2	2	2
21	31	120	MD	9	0.728	1.78333	0.82588	29.7	1.5	25	64	1	1	1	2
22	38	120	MD	7	0.595	1.50333	0.80941	30.0	1.7	75	61	1	2	2	1
23	42	134	LO	5	0.645	1.56000	0.75412	35.9	1.2	10	56	1	1	1	1
24	4	144	MD	10	0.809	2.07667	0.90412	47.8	2.8	50	63	1	2	1	2
25	35	146	HI	13	0.755	1.67333	0.82941	34.7	1.8	75	67	2	4	1	4
26	32	148	MD	10	0.830	1.72333	0.72294	39.2	2.4	95	60	2	1	1	1
27	7	157	HI	13	1.284	2.61333	0.93000	60.8	3.6	10	65	2	2	1	4
28	8	161	LO	4	0.483	1.70667	0.66059	39.2	1.9	10	55	2	2	2	3
29	6	168	MD	8	0.540	1.63667	0.82882	27.7	3.0	10	51	1	1	2	2
30	43	183	HI	12	1.147	2.23667	1.27706	32.3	3.4	10	62	1	2	1	1

TABLE XVIII (Continued)

	Subj. No.	Hair Zinc µg/g	Diet Category	Score	Zinc Portion of RDA	Protein Portion of RDA	Energy Portion of RDA	Ani-Pro. g	Fiber g	Height Percent-	Age Mos.	Taste Acuity Threshold Levels NaCl	Sucrose	HCl	Urea
							Head Start								
31	29	50	HI	13	1.286	2.75333	1.10824	67.7	2.1	95	74	2	3	2	3
32	30	72	HI	12	0.673	1.75667	0.85941	39.7	2.3	25	72	3	1	2	4
33	20	74	MD	11	1.133	2.61000	1.20412	67.1	3.0	95	73	1	1	1	1
34	16	86	MD	10	0.741	2.03043	0.87769	33.8	2.2	50	41	2	2	1	1
35	24	86	MD	11	1.119	3.20435	1.19692	61.7	1.8	25	44	.	3	3	.
36	21	89	HI	13	1.035	4.03333	1.68059	92.4	4.7	50	65	2	2	2	2
37	26	96	MD	8	0.855	2.72609	1.24077	48.6	2.3	10	43	2	4	1	3
38	19	107	HI	13	0.852	2.26333	1.19529	39.7	3.9	75	67	2	1	2	3
39	27	136	MD	8	0.593	1.43667	0.86647	28.9	2.5	10	70	2	3	1	3
40	18	148	MD	8	0.711	2.16000	1.13706	42.9	3.0	50	64	1	1	1	2
41	22	149	MD	11	0.540	1.69667	0.88412	32.9	3.4	95	74	1	1	1	2
42	23	154	MD	9	0.713	1.87667	0.91765	41.1	1.8	10	52	1	1	1	2
43	25	183	HI	13	1.209	2.29000	1.16235	52.1	3.8	25	58	3	3	3	3

VITA

Andrea Bender Arquitt

Candidate for the Degree of

Master of Science

Thesis: NUTRITIONAL STATUS OF PRESCHOOL CHILDREN WITH EMPHASIS ON ZINC STATUS AND FIBER INTAKE

Major Field: Food, Nutrition and Institution Administration

Biographical:

Personal Data: Born in Teaneck, New Jersey, November 1, 1944, the daughter of Dr. & Mrs. C. R. Bender.

Education: Graduated from Sandy Springs High School, Sandy Springs, Georgia, May 1962; attended the University of North Carolina at Greensboro, Greensboro, North Carolina, 1962-63; graduated with High Honors from The University of Tennessee, Knoxville, Tennessee, June 6, 1966; Completed Dietetic Internship at Hines Veterans Administration Hospital, Hines, Illinois, August, 1967; completed the requirements for the Master of Science degree at Oklahoma State University in May, 1982.

Professional Experience: Chief Therapeutic Dietitian, East Tennessee Baptist Hospital, Knoxville, Tennessee, 1967-69; Project Leader, Indian Nutrition Education Program, OSU Cooperative Extension, Stillwater, Oklahoma, 1976; Laboratory Technician, OSU Biochemistry Department, Stillwater, Oklahoma, 1977; Project Director and Curriculum Developer for Nutrition Training Project, Department of Food, Nutrition and Administration, 1978; Instructor, Nutrition Training Project, 1979; Teaching Associate, Department of Food, Nutrition and Institution Administration, Oklahoma State University, Stillwater, 1978-81; Instructor and Assistant Director of Adminstrative Dietetic Internship, Department of Food, Nutrition and Institution Administration, Oklahoma State University, Stillwater, Oklahoma, 1981-present.

Professional Organizations and Honors: Member, American Dietetic Association; member, Oklahoma Dietetic Association; member, Omicron Nu Honor Society.