TASTE SENSITIVITY, EATING BEHAVIOR, AND BODY FATNESS OF PRESCHOOL CHILDREN

by

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CHAPTER I

INTRODUCTION

Obesity is presently considered to be one of the most prevalent nutritional disorders in the Western world; leading to and aggrevating debilitating disease conditions. It is a disorder which affects people of all ages; particularly disturbing is the increase in obesity in young children. The British Agricultural Research Council and Medical Research Council stated that "Virtually nothing is known about obesity in preschool children." (Agricultural Research Council, 1974)

Poor eating habits have been shown to be a contributing factor in the etiology of certain disease conditions, including that of obesity (Latham, 1972). Because there is a commonly held belief that eating habits of preschool children tend to persist throughout life, it is of crucial importance to study some of the factors related to eating behavior of preschool children. Taste sensitivity may be one factor related to eating behavior in preschool children; however, little work has been done in this area. The assumption is often made that children are probably more sensitive to taste than are adults (Smart and Smart, 1977). Surprisingly few researchers have studied the taste behavior of preschool children (Korslund, 1962; Gauger, 1929; and Gustafson, 1952).

On the other hand, taste sensitivity has been studied with relative frequency in the adult. Some researchers have found a relationship between the degree of taste sensitivity and food likes and dislikes (Korslund, 1972; Fischer and Griffin, 1963; Glanville and Kaplan, 1965). Others have studied obesity and have found that obesity may well be associated with the "absence of satiety aversion for sucrose" (Cabanac and Duclaux, 1970). Still others have studied the role of the hypothalamus in the regulation of food intake and the incidence of obesity; they have suggested that the biological "set-point" (point where body fat stores are maintained at a base-line level) is related to taste responsiveness (Nisbett, 1972; Jacobs and Sharma, 1969). Fischer, et al. (1956) observed that highly sensitive tasters of both 6-n propylthiouracil (PROP) and quinine tended to be ectomorphic. Thus, these observations tempt one to believe that there may be a distinct relationship between obesity and taste sensitivity; body fatness may be in part a function of taste sensitivity.

The relationship of taste sensitivity to body size has not been studied in preschool children. In studying body size as a function of taste sensitivity, it is necessary to control all possible environmental factors conducive to the presence of obsesity. For this reason, socio-economic data must be collected as well as anthropometric and taste sensitivity data. If a relationship can be discerned between sensitivity to various taste modalities and the presence or absence of obesity, then it may be possible to conduct screenings for potential obesity, just as screenings are currently carried out for other public health problems. Taste sensitivity tests can indicate abnormal metabolic states, as in the case of cystic fibrosis, where all four taste modalities are affected (Henkin, 1967). Therefore, it may be that taste tests may have a potential role in the early detection of potential obesity or the lack of it.

The objectives of this study were as follows:

1. To determine if there was a correlation between an accepted standard index for body fatness and taste sensitivity to quinine sulfate and sucrose.
2. To determine if there was a relationship between birthweight, breastfeeding or bottlefeeding, age first fed solids, and present body weight and taste sensitivity to quinine sulfate and sucrose.
3. To determine if there was a correlation between food likes and dislikes, caloric intake, and sensitivity to quinine sulfate and sucrose; and whether these factors were related to body fatness.

These objectives are based on the following hypothesis: Body fatness is a function of taste sensitivity in that taste sensitivity plays a role in determining the types and amounts of foods eaten.

CHAPTER II

REVIEW OF THE LITERATURE

Obesity Research

Hypothalamic Theories

At the present time, perhaps the most widely accepted explanation of obesity from a physiological point of view is that of the hypothalamic regulation of food intake. Briefly, the theory suggests that the obese individual behaves in a manner very similar to that of the hungry or food deprived organism in terms of eating behavior, emotional responses, activity levels, and sexual behavior. This type of behavior takes place when the individual is below his/her biological set-point or that base-line for both fat stores set by both genetic and environmental conditions (Nisbitt, 1972).

Research in this area suggests that the eating behavior of the obese is similar to that of a food deprived organism in that obese subjects will eat more of a good tasting food than will lean subjects (Price and Grinker, 1973; Nisbett, 1968). Thompson, *et al*. (1976) stated that a hedonic monitor influenced by both body weight and caloric intake may exist. It appears that some degree of food deprivation, as in the case of the obese or overweight person trying to lose weight, will cause the individual to behave as a hungry organism because he/she is below his/her biological set point.

Most of the studies done on the hypothalamic theory have their roots in the studies done by Kennedy (1957). Kennedy first suggested that animals with lesions in the ventromedial hypothalamus had an impairment in the food intake regulatory mechanism. He postulated that the intact ventromedial hypothalamus had the effect of maintaining the animal at weight equilibrium. The eating behavior of rats with lesions in the ventromedial hypothalamus has been described in several classical studies; one of the most interesting results of hypothalamic lesions lies in the fact that lesioned animals are more taste responsive (Corbitt and Stellar, 1964; Teitelbaum, 1955).

Recent studies with humans have tried to show that obese humans tend to follow the same behavior as that of ventromedially lesioned animals. Price and Grinker (1973) found that prior to a meal, obese subjects would consume more of a preload of snack sandwiches and that they subsequently ate more of a postload (post-meal) snack of crackers than did normal weight subjects. Grinker, et al. (1972) did not find any difference between normal and overweight subjects in terms of taste sensitivity to sucrose. The obese subjects gave lower pleasantness ratings for increasingly high concentrations of sucrose. Rodin (1975) studied the behavior of obese subjects in relation to their ratings of sweet milkshakes. She found that overweight subjects did not differ greatly from normal weight subjects in their ratings for the pleasantness of sweet taste; however, the overweight subjects were willing to work harder at some simple work procedure in order to get a milkshake as a reward. This was in accordance with observations on ventromedially lesioned animals. Moderately overweight subjects were significantly influenced by positive and negative tastes; their preferences for foods were influenced more by taste than were those of normal weight subjects.

The taste preferences of 53 obese and mildly obese women were studied by Rodin, et al. (1976). Obese subjects found sweeter concentrations more pleasant than did normal weight subjects. In the same experiment, 11 obese females who had undergone intestinal bypass surgery were studied. Ratings for pleasantness of sucrose following surgery indicated that the response curve was similar to that for normal weight subjects. These data were interpreted to mean that response to taste can be monitored by internal changes. This is in contrast to the ideas of Schacter (1971) and Nisbett (1968, 1972), who believe that taste is really an "external" cue.

Cabanac (1971) suggested that the hungry organism experiences internal physiological changes which relay messages to the brain that changes in nutritional state have occurred, but these messages are ignored because the organism remains highly susceptible to sweet taste. Four subjects who were fed ad lib for 3 weeks on a bland diet were studied by Cabanac and Rabe (1976). The subjects lost weight and palatability of sucrose solutions, following gastric glucose loads, was not affected by the loss of body weight. The weight loss was attributed to the bland and insipid diet. The authors concluded that body energy balance is mediated by the palatability of the diet; the controlling mechanism is dubbed a ponderostat. Body weight under the influence of normal food intake reflects the set-point of the ponderostat. Rodin, et al. (1977) studied the responsiveness to sensory and external cues as affected by the extent of obesity, age of onset, and weight loss. They found that weight loss did not affect responsiveness to sensory or external stimuli. The authors concluded that the responsiveness to taste was more closely related to changes in the energy status of the individual and that responsiveness to visual cues is not affected by such changes in energy state.

Obese subjects have been found to have an aversion to highly concentrated sweet solutions. Grinker (1977) used sucrose solutions varying in concentration from 1.95% to 19.5% to test the taste preferences of obese and lean subjects. The obese subjects rated the higher concentrations as less pleasant. Bray (1976), as well as others (Cabanac, et al., 1970; Moskowitz, et al., 1976), have found that an aversion to very sweet solutions is characteristic of obese subjects. In contrast, Cabanac and Duclaux (1970) found that obese subjects rated sucrose solutions (5 g in 25 ml water) as pleasant even when the solutions were ingested every three minutes after a gastric glucose load of 50 g. It was concluded that in obesity there is an absence of satiety aversion to sucrose. Normal subjects had been found to rate the sucrose solutions as less pleasant after the gastric glucose load.

The role of taste in hypothalamic obesity, according to the research discussed above, indicates that it is somehow related to food intake in the hungry organism. A study by Jacobs and Sharma (1969) suggested that animals eat for taste when caloric needs must be satisfied; when caloric needs are satisfied, eating is done for the sake of eating, with taste playing no major role. They based this observation on the fact that hypothalamic hyperphagic rats are finicky and ignore caloric density; in doing so they overreact to taste. The rats in Jacobs and Sharma's experiment were fed cellulose-based diets after a regular calorically dense meal pattern. They lowered their food intake when the meal was made unpalatable with quinine adulteration, thereby showing that it was taste and not caloric density for which they were eating. This has also been shown to be the case by several other investigators (Keesey, et al., 1973; Mook and Blass, 1968; Ferguson, et al., 1975; Scafani and Berner, 1976).

To summarize, taste is, in general, currently believed to play a role in food intake; food intake will be stimulated when body weight is below a certain set-point. The pleasantness of food to a deprived organism is suggested to be a biological advantage to encourage the intake of food to return body weight to the desired set-point (Thompson, et al., 1976). To be sure, some of the investigators have not found an increased pleasure rating for sucrose after weight reduction (Underwood, et al., 1973). However, this latter explanation may not be the only explanation. Nisbett (1972) suggested that varying degrees of deprivation may cause the organism to be discriminating in taste, a factor which may have survival overtones. The ingestion of bad-tasting, poisonous or other harmful foods would thus be avoided regardless of the degree of hunger experienced by the organism.

Hypercellular Obesity

While research is emerging which suggests that obesity may be due to physiological reasons beyond the control of the organism, another school of thought suggests that obesity may be due to both heredity and environmental factors which cause an increase in the numbers of fat cells in early life.

Gurr, et al. (1977) supported the theory that fat cell number is stable in older organisms. Using the pig as a subject, it was suggested that empty fat cells are difficult to count and this may account for some of the discrepency between the number of fat cells in normal and obese subjects. However, the fat cells that are seen reflect the amount of fatty tissue inside of them. It may be that subjects which are obese for hyperplastic reasons may not have more fat cells than do so-called normocellular subjects. The authors also stated that adipose tissue from different parts of the body may follow different developmental patterns; researchers should be cautioned against using sample measurements from a restricted number of body sites.

Adipose tissue, according to Brook (1972), is essentially a body organ and appears in fetal life at approximately the 30th week of gestation. The most rapid growth in body fat occurs during the period 9-12 months after birth. Brook studied five groups of children: 64 controls, 52 obese children, 19 light-for-date children, 21 children with growth hormone deficiency, and 13 craniopharyngioma children. He found that the children deficient in growth hormone had a definitely different adipose tissue pattern and suggested that growth hormone may be an essential component for adipose tissue growth. The first year of life appeared to be the "sensitive" period for adipose tissue growth, because children who became obese at an early age also showed a different adipose tissue pattern. Children with growth hormone deficiency did not show changes in adipose tissue patterns, suggesting strongly that growth hormone is necessary for adipose tissue cell multiplication.

Early Food Intake and Obesity

Dwyer and Mayer (1973) stated that obesity in childhood is likely to be of an inheritable type, as opposed to obesity developed in later life. Fat cell hyperplasia and hypertrophy can be in fact inherited. However, the authors suggested that changes in infant feeding patterns, such as early feeding of solids, will contribute greatly to the increase in infantile obesity. The switch from breastfeeding to bottle feeding changes the caloric density and accustoms the infant to an increased intake of calories.

According to Jelliffe (1973), the increase in childhood obesity is due in part to the early feeding of solids and the use of cow milk formulas. In order to investigate this relationship, Wortmann (1976) studied suckling rats fed synthetic rat milk or baby foods (which made up 10% of the total caloric intake). Controls were fed only natural rat milk, while the other groups were fed supplements of synthetic rat milk or baby foods. On day 17 of the study, the body lipids of the rats fed solid foods were significantly higher than the levels found in the controls. Body fat stores were higher at 21 days of life in the experimental groups than in the controls. However, at 60 days of life, there was no difference in body weights between formula fed pups and controls. The group supplemented with baby food, on the other hand, showed an increase in body fat that persisted through 60 days of life. The author suggested that animals fed supplemental solid foods prior to weaning will eat more after weaning and will have higher weights than animals fed only formula or mother's milk.

Meal Taking Behavior

Fabry and Tipperman (1970) force fed rats three times a day, although rats are normally nibblers. The authors found an increased ability of the body to form adipose tissue from carbohydrate precursors. They called this phenomenon "adaptive hyperlipogenesis." Rats were fed at least the amounts that they would eat while nibbling; there was some evidence, however, that the rats ate more since eating time was limited to three times a day. The conclusion drawn from this study was that eating patterns can indeed increase the fat-forming ability of the body.

Blundell (1977) suggested that serotonin (5-hydroxytryptamine or 5-HT) may play a role in radical changes in feeding behavior. If 5-HT is increased at the synaptic cleft, 5-HT receptors which are activated cause a reduction in food consumption. The role of serotonin thereby inhibits feeding by possibly bringing about satiety. Noradrenalinand serotonin might act synergistically to bring about cessation of eating. A defect in brain tryptophan metabolism could increase the tendency to eat larger meals, as in the case of rats who are normally nibblers, due to a decrease in the synthesis of serotonin and to the relaxation of inhibitory control of excessive food intake.

Eating rates, as well as number of meals eaten, may influence obesity. The eating rates of the obese differ from those of normal weight subjects, according to a study done by Drabman, et al. (1977). One hundred and twenty children were studied in a school cafeteria. Observers counted the number of bites, sips, and chews taken by both obese and normal weight children. Obesity was defined as being visibly obese. The authors found that obese subjects took more bites in half-minute periods and chewed food more rapidly than did non-obese subjects. A similar experiment was done by Marston, et al. (1976) who found that obese children tend to eat more rapidly than do lean children, thereby consuming more food in the same amount of time. These two experiments are in general agreement with the work done by those studying hypothalamic obesity: obese organisms eat more rapidly than do normal weight organisms.

Environmental Factors Affecting Obesity and Food Intake in Preschool Children

The major socio-economic factors which affect a child's food intake and possible obesity are generally considered to be: income, urbanization, mother's education, numbers of children in the family, occupations of the parents, and food likes and dislikes. Futrell, et al. (1971, 1975) studied the nutritional status of Black preschool children in Mississippi. An analysis of the diets and anthropometric measurements of 247 children resulted in the conclusion that the education of the mother was perhaps the most influential factor in determining nutritional status. If the mother had more than 8 years of schooling, the nutrient intake of the children was considerably higher than if the mother had less than 8 years of schooling. In the two "hunger" counties studied, from 42.7 to 50% of the children were below Stuart-Boston 50th percentiles for weight.

Three hundred and two Ohio school children aged 9-11 years old were studied by Hendel, et al. (1965). The higher the socio-economic status of the family, the more vitamin A and C consumed by the children. They found that children from large families were less likely to consume adequate quantities of these nutrients. Urban children had better diets than did rural children. Hinton, et al. (1962) also studied diets of adolescent girls. Of 140 girls aged 12-14 years old, those coming from a higher socio-economic level had better diets than did those from a lower socio-economic level.

In the culture of poverty, emphasis is placed on the cheapest staple foods, which can lead to a monotonous diet and a restricted nutrient intake (Bender, 1974). Bender found that food intake can be related to the number of children in the family. That income affects the degree of obesity was shown by Stunkard, et al. (1972). Obesity was nine times more prevalent in girls from a lower socio-economic level by the age of 6. Upper class girls who were obese only constituted 3% of the sample, while obese lower class girls made up 29% of the sample.

Fox, et al. (1970) studied 2,000 households in 12 North Central Region states; 3,444 preschool children were involved in the study. Forty-five percent of the subjects came from rural areas or small towns, while 55% of the children lived in urban areas. Subjects came from a wide range of economic levels. The authors concluded that income, education, occupations of the parents, and the size of the family were the most important factors in determining the degree of adequacy of the child's diet.

Food likes and dislikes of children also determine the amount and types of foods consumed. Eppright, et al. (1969) found that vegetables were the most disliked foods, especially spinach, carrots, green beans and peas. There was a tendency for dislikes to be associated with those of the father or an older sibling. It was also found that sweets were often used as rewards for good behavior.

In a longitudinal study, Beyer and Morris (1974) studied 44 children and obtained two 24-hour recalls from them, one at preschool age and one at school age. The foods most disliked were cooked vegetables, liver, and mixed dishes. Meat was the most preferred food (40%), followed by spaghetti and pizza. The authors concluded that school-age children consumed more snacks as preschoolers and that the types of snacks chosen remained constant over the years. This was taken to be an indication that food habits begin early in life.

Dierks and Morse (1965) studied 121 children from the University of Minnesota student housing complex. The subjects ranged in age from 2-6 years. Vegetables were the most disliked foods; 64 subjects would not eat spinach, squash, asparagus, sweet potatoes, or lima beans. Meat was mentioned by 59 subjects as being the most liked food, followed by fruits, sweets, and cereals.

Environmental factors which influence obesity in children were studied by Huenemann (1974a, 1974b). Using the Green Socio-Economic Index, she rated children on environmental factors. Girls were found to have a feminine body conformation even at age 6 months. An obesity index was developed using 21 anthropometric measurements. The scores of the top 10% (obese) and the lower 10% (lean) subjects were compared. More first children were in the obese group, while two times as many boys were in the obese group as were girls. Huenemann did not find any significant difference between the groups in terms of breastfeeding and introduction of solids, which contradicts the theories of Jelliffe. Feeding frequency made no difference in the incidence of obesity. The significant factor was the weight of the mother. If she was obese, she was more likely to be in charge of a less regulated household, to be unsure of herself, and to be divorced, single, or separated. In a follow-up study, Huenemann (1974b) found that at the age of three, 36% of the fat children remained fat, while 50% had become leaner.

Fisch, *et al.* (1975) looked at the birth weights of children and compared these measurements to body size in later childhood. An abnormal gestation period was found to be highly correlated with extremes of fatness and leaness at birth. The authors studied 3,000 subjects and used the ratio index (body mass index) of weight/height to define obesity. The lean neonates stayed lean through ages 4 and 7, although at a decreasing rate. The parents of the obese children tended to be older than those of the more slender children; mothers of obese children tended to gain much more weight during pregnancy. Gestation period was longer in obese children than in slender children. Children obese at age three were found to have higher birth weights, and the author suggested that for some children prenatal life may influence later obesity. Other researchers have also suggested the same theory (Influence, 1977).

Taste Sensitivity

Taste sensitivity is a complicated and as yet poorly understood mechanism. The testing of taste sensitivity suffers from a lack of standardization, although the American Society for Testing and Materials has begin to compile tables on testing results (Stahl, 1973). The sweet taste modality is the best understood of the four primary tastes of sweet, sour, salty, and bitter (Dastoli, 1974; Shallenberger, 1963). Bitter taste has been studied more frequently than has those of sour or salty (Dastoli, 1974; Kubota and Kubo, 1969). The inheritability of taste sensitivity has been demonstrated by many researchers by means of studies with phenylthiocarbamide (PTC) (Fox, 1932; Harris and Kalmus, 1949).

Anatomy of Taste

The tongue, with its taste buds, has been shown to be the major site of taste reception, although there are taste buds on the soft palate which may play some role in taste (Henkin, 1967). There are three types of taste buds: circumvallate, fungiform, and filiform. The latter contain no taste receptor cells and hence do not serve as receptor sites. The taste buds are small, round structures and contain approximately 20 receptor cells. These cells are long and display hair-like projections which extend beyond the surface of the bud via a pore. These hairs are the receptor surfaces; chemical stimuli in contact with these sites causes messages to be sent to the brain through sensory neurons. The brain, or primary somatic sensory area, is served by the cranial nerves (Griffiths, 1974).

Taste sensation is due thus to the stimulation of receptor cells, which turn over at the rate of every 3-5 days. It has been fairly well established that no single type of taste bud is responsible for sensitivity to just one taste modality; different cells do show different patterns of sensitivity (Alpern, et al., 1967). It is well known that the tip of the tongue is most sensitive to sweet, while the sides of the tongue are more sensitive to salty and sour. The back of the tongue has been shown to be more sensitive to bitter taste (Griffiths, 1974). Alpern, et al. (1967) have suggested that new taste cells form at the edge of the taste bud and migrate to the center of the bud. In doing so, the cells display a change in specificity for taste modalities as they mature. Therefore, the authors concluded that taste receptor cells are not stable over time and this accounts for the lack of specificity of individual taste buds for specific tastes.

There have been numerous attempts to explain the mechanism of taste reception. Beidler (1954) suggested that the sensation of taste depends upon the absorption of the taste modality molecules onto the surface of the receptor sites. This is the most commonly accepted theory; other theories include the enzymatic theory of taste proposed by Baradi and Bourne (1953) and the theory of sweet taste suggested by Shallenberger (1963). Recently, Dastoli and Price (1966) isolated a taste receptor protein from bovine tongues which complexes with sweet tasting substances. The degree of binding is dependent upon the degree of the sweetness of the compounds.

Dastoli, et al. (1968) studied proteins of pig tongues and the relationship of these proteins to bitter stimuli. They tested proteins from the tip of the tongue (which are sensitive to sweet but not to bitter) and proteins from the back of the tongue (which are sensitive to bitter but not to sweet). The preferential complexing of these proteins with their respective taste modality led the researchers to postulate the presence of a bitter sensitive protein.

The presence of a possible sweet receptor protein is in accordance with the ideas put forth by Shallenberger (1963). He proposed that sweet tasting compounds have a certain number of hydroxyl (OH) groups. Sweet taste is said to decrease when hydrogen bonding takes place between the -H groups of the OH and other electronegative portions of the taste molecule. Shallenberger generalized his theory by stating that proton donor groups and proton acceptor groups must be 3 Å away from each other. Intermolecular bonding may be implicated in the rapidity with which sweet tastes are perceived. H-bonding appears to affect the reasonance energy, solubility, and rate of stimulus diffusion into the receptor sites of the taste buds (Shallenberger, 1963).

On the other hand, Kubota and Kubo (1969) have tried to identify commonalities among bitter-tasting substances which would account for the bitter taste modality. They suggested that in plants from the Isodon series proton acceptors and donors, similar in nature to those suggested for sweet taste by Shallenberger (1963), are responsible for bitter taste. The donors and acceptors should be within 1.5 Å of each other. The proton donor groups include O<u>H</u>, C<u>H</u>OCOCH$_3$, C<u>H</u>OOOCH$_3$, and C<u>H</u>CO; proton acceptor groups can be carbonyls such as CHO, CO, COOH, COOCH$_3$, and OCOCH$_3$, plus double bonds such as C=C-O. Proton acceptor and donor proteins present in taste bud microvilli act as receptors and form hydrogen bonds with bitter units. Intramolecular bonding, in contrast to the situation in sweet taste, enhances bitter taste; such bonding inhibits sweet taste.

Genetics of Taste

Fox (1932) suggested that phenylthiocarbamide (PTC) represented a genetic polymorphism of taste sensitivity. Since that time, various researchers have tried to explain why this autosomal recessive trait exists both in human and primate populations (Harris and Kalmus, 1949; Fisher, *et al*., 1939; Pons, 1960; Greene, 1974; Mendes de Araujo, *et al*., 1972). Some researchers (Greene, 1974; Mendes de Araujo, *et al*., 1972) suggested that PTC taste sensitivity may be related to the incidence of goiter; others (Fischer and Griffin, 1963;

Kalmus, 1971) proposed that PTC may be related to the "food rejection" theory.

The "food rejection" theory has a basis in the fact that PTC and related compounds have a N-C=S linkage which is similar to that found in plants containing thiourea compounds. These compounds have been shown to have antithyroid properties; thus, by being sensitive to PTC, it may be possible that human groups would avoid eating large quantities of foods containing these compounds (Kalmus, 1971). Goitrogenic foods include cabbage, kale, Brussels sprouts, cauliflower, broccoli, kohlrabi, turnips, rutabaga, garden cress, radish, horseradish, brown mustard, and others (Van Etten, 1969). Furthermore, studies have shown that food preferences can be correlated with degree of PTC taste sensitivity and with degree of bitter taste sensitivity, particularly to quinine sulfate (Glanville and Kaplan, 1965). The fact that 70% of Caucasians can taste PTC, while 30% cannot, suggests that there may be more involved with this genetic trait than is known at the present time (Manlapas, et al., 1965).

Factors Affecting Taste Acuity

Several factors can influence taste sensitivity. Among these factors are the disease state of the individual, the time of day that taste testing occurs, degree of hunger, sex, copper and zinc status, experience with certain tastes, age, and possibly body size.

Henkin has done a great deal of investigation into the effects of disease states on taste sensitivity (Henkin, 1967, 1969; Henkin and Bradley, 1969; Henkin, et al., 1969). Zinc metabolism is related to taste acuity, as is copper metabolism. Just how these metals work is not entirely clear. Henkin and Bradley (1969) suggested that thiols, which decrease taste acuity, may engage in sulfhydryl disulfide interchange equilibria with a disulfide-containing protein. Thiols and metals are thought to be in chemical equilibria through a series of reactions that include chelation. For example, (Me^{++} is a metal like Cu^{++} or Zn^{++}, R is the major portion of the protein and SH is the sulfhydryl portion of the protein):

$$2RSH + Me^{++} = RS_2ME + 2H^+$$

If RSH is increased, then taste acuity decreases. If the Me^{++} concentration is decreased, then taste sensitivity also decreases (Henkin, 1969).

Carbohydrate-active steroids also can affect taste acuity, possibly through the effect of these hormones on nerve impulses (Henkin, 1967). Henkin (1967) suggested that taste acuity may be higher at the end of the day, because carbohydrate-active steroid activity is higher at that time.

Sex differences in taste sensitivity have also been observed. Hamilton and Timmons (1976) studied sex differences in sensitivity to sugar solutions among rats. They found that the ingestion of simple sugars can lead to a reduction of total caloric intake, possibly explainable by Mayer's glucostatic theory. This suggested that there was an overresponse to the caloric value of the sugar, leading to the activation of a caloric feedback mechanism. Female rats were more sensitive to taste than were male rats. Moskowitz, et al.

(1975) found that human males preferred higher concentrations of sucrose and lactose than did female humans. Korslund (1962) observed that preschool girls were slightly more sensitive to taste than were boys.

Hunger and taste sensitivity have been studied to some extent; Pangborn (1959) found that hunger did not greatly influence taste thresholds for sweet taste modalities. More recently, Kaplan, et al. (1969) found that L-quinine sulfate testing after eating caused subjects to become more sensitive to the substance. The authors stated that this change between pre-lunch and post-lunch sensitivities does not occur for all substances. A special point was made of the fact that it did not occur for 6-n-propylthiouracil (PROP), similar in composition to PTC.

The question of heredity and taste acuity is difficult to study, because of possible environmental factors influencing taste. Moskowitz, et al. (1975) studied taste acuity in a group of Indian laborers. The diets of these people included many more sour foods than are included in Western diets. Six concentrations each of glucose, NaCl, citric acid, and quinine sulfate were tested. The concentration of citric acid at high levels was reported to be pleasant by the Indians, while Western subjects found high levels to be extremely unpleasant. It was concluded that dietary history, and to some extent, genetics accounted for the differences between the two groups. Greene, et al. (1975) studied the effects of heredity and experience in the development of taste preference in man. A sample of 311 monozygotic and dizygotic twins, aged 9-15, were studied.

Sucrose, lactose, and NaCl were tested. In both Black and white racial groups, genetic effects were non-existant for all of the taste modalities. That environment plays an extremely important role was concluded. There were differences between the two racial groups: Blacks preferred higher concentrations of all three modalities than did Caucasians. Steiner (1974) studied neonates and their reactions to the four basic tastes. He concluded that facial responses observed indicated an innate communication signal of pleasure or displeasure, not influenced by environment, since none of the babies had ingested any food after birth.

Taste acuity and response to taste in relationship to body size has been discussed previously in the section dealing with hypothalamic obesity. Henkin (1967) suggested that changes in taste acuity may be related to change in appetite; certainly cancer patients and post-surgical patients deficient in zinc report diminished taste acuity accompanied by a decrease in appetite. This can be taken to be a reflection of body state. After years of study, Fischer, et al. (1966) stated that they had come to the general conclusion that extremely sensitive tasters of both quinine and 6-n-propylthiouracil (PROP) can be described as Sheldonian ectomorphs, while those persons insensitive to these modalities tend to be endomorphic.

Glanville and Kaplan (1965) studied food preferences and taste sensitivity for bitter compounds with 39 husband-wife pairs, 16 pairs of monozygotic twins, and 10 pairs of dizygotic twins. A food preference questionnaire was given to the subjects after taste sensitivities for quinine sulfate and PROP were determined. There were high correlations between a score on the preference questionnaire (indicating preference for highly seasoned or strong-tasting food) and high taste thresholds for quinine and PROP. Thresholds for quinine and PROP were also correlated. The highest correlation was between food score and PROP threshold. Korslund (1962), Fischer, et al. (1963) and others have also observed that food dislikes tend to increase as taste sensitivity increases.

Thus, a relationship between sensitivity to the taste of bitter substances and weight or body size of subjects may be possible, because food preferences appear to be related in part to bitter sensitivity. Sucrose sensitivity also appears to be related to body size, since aversions to sucrose have been found in some obese subjects while in others no such aversion has been recorded.

Taste Behavior in Preschool Children

Korslund (1962, 1967), Gauger (1929), and Gustafson (1952) have done specific studies dealing with taste sensitivity or taste preference of preschool children. Gustafson (1952) studied the discriminatory behavior of 28 children from the Florida State Nursery School; the children were tested on their ability to distinguish between various fruit juices. A paired comparison method was used. In conclusion, the author stated that the children were not able to distinguish between juices unless the juices were extremely different.

Gauger (1929) examined the taste responses of preschool children and discussed the possibility of modifying those responses in order to increase food likes. She used 20 subjects aged 18 to 40 months. Her criteria for stimuli were as follows:

1. Colorless; liquid
2. Easily standardized, procured, prepared, and measured
3. Low in calories
4. Not harmful to the subjects
5. Easily administered

Fifteen taste stimuli were presented to 8 children for 3 days. Satisfaction and dissatisfaction were assessed by two adult judges. Paired comparison or stimuli methods were used and facial responses were judged according to various behaviors which were either associated with satisfaction or dissatisfaction. Exposure to all stimuli over a period of one year resulted in modified responses to even unpleasant stimuli. The author concluded that such methods could be used to modify the eating habits of preschool children.

Korslund (1962, 1967) has done the most recent work on the taste sensitivity behavior of preschool children. Using 25 subjects, she obtained difference thresholds for all of the four basic taste modalities. A modified paired comparison method was used. Two tests for each substance were carried out and scores were given to the tests to demonstrate high or low sensitivity. Questionnaires were given to mothers to determine aspects of eating behavior. The subjects were grouped into three groups: those having high, medium, or low taste sensitivities. Food likes and dislikes were correlated with these groups; grapefruit juice and cooked cereal were the only foods found to correlate significantly to taste sensitivity. The author observed that children with low sensitivities were always hungry for meals, had more food likes, and had slightly larger food intakes than did children with high taste sensitivities.

Anthropometric Measurements and Preschool Children

A great deal of work has been done on the measurement of overweight and obesity by means of anthropometric measurements. For survey purposes, several methods have been developed which are to ensure accurate but rapid measurement of overweight and obesity. Most standards for height and weight include preschool children's measurements, but hithertofore most work with anthropometry has been directed toward adults.

Wolff and Lloyd (1973) said that children who are 10% above the standard weight-for-height for age can also be obese. Many of the methods developed for measuring obesity in the adult are not applicable to children. Ranges for the prevalence of obesity as reported by numerous other researchers were reported by Wolff and Lloyd. In one study of 200 babies, 35% exceeded weight-for-length by 20%. Results of another study of 300 babies showed that 16.7% weighed greater than 20% above the expected value and that 27.4% weight between 10 and 20% above the expected value.

The Committee on Nutrition recommended that the Harpenden or Lange calipers be used in measuring triceps skinfolds in children. The use of skinfold thickness measurement is primarily to assess thickness of subcutaneous fat; however, the layer of skin also measured in the process should be taken into consideration. The

Committee on Nutrition (1968) emphasized that there is insufficient data on skinfold thickness in children, and that an estimation of body fatness in individuals is difficult to do.

Abrahams, et al. (1977) studied 108 white children aged 5 in Missouri. Fifty percent of the sample was found to be less than the Stuart-Meredith 10th percentile for height. Twelve percent of the males and 4% of the females were above the 90th percentile for height. Forty percent of both sexes were below the 10th percentile for weight; 2% of the males and 8% of the females were above the 90th percentile for weight. Data fitted into a Wetzel grid showed that 9% of both males and females were obese. This is in accord with Forbes (1972), who observed that prior to puberty there is no difference in body mass in relation to height between males and females.

Triceps and subscapular skinfold thicknesses were measured by Brook, et al. (1975) in 78 pairs of identical twins, 144 pairs of fraternal twins, and 117 pairs of fraternal twins of unlike sex. It was found that in children under age 10, environmental factors accounted for a large percentage of the variation in body fat, while in older children genetic factors accounted for variations in body size.

Crispin, et al. (1968) studied 40 children, aged 3.5 - 5.5 years, from two socio-economic groups. All anthropometric measurements except skinfold thicknesses were higher for the higher socio-economic group. The high socio-economic status (SES) group had higher mean birthweights. A high correlation between weight and height was found in the high SES group (r = 0.876), while a significant correlation was found between average skinfold thickness and weight in the lower SES group. Diet and physical measurements were not significantly correlated in the low SES group.

The National Center for Health Statistics (NCHS) has produced new standards for most anthropometric measurements, based on data from the Health and Nutrition Examination Survey (HANES), the National Preschool Survey, and the Fels Study. Methodology is described in the publication dealing with clinical and anthropometric results (Abraham, 1975). There are new growth charts for children aged 2-18 (NCHS, 1976). According to the results of the HANES study, income is related to the size of skinfolds; the higher the income, the higher the skinfold measurement. This generally holds true for height and weight. Blacks tended to be larger than whites in the preschool age group. Crawford, et al. (1978), in studying anthropometric measurements in preschool children in California, found that their anthropometric data did not correlate well with that from the HANES study. The HANES data contained only results from 50% of HANES available data; the discrepency between the two sets of data pointed up the limitations of the HANES standards.

Buzina (1974) stated that interpretation of body weight data is difficult, especially where there are changes in body weight, as there is in growing children. He suggested that in studying preschool children, differences in body weight due to genetic origins should be studied. Dugdale (1971) proposed that the index, Wt. x

$10^4/\text{Ht.}^{1.6}$, be used for children aged 1-5 years, especially when exact age is unknown. Buzina (1974) was in agreement with this proposition. Other indices, including Ponderal Index, Upper Arm Muscle Diameter (UAMD) and Body Mass Index, have been suggested for the assessment of body fatness or body size in children (Prasad and Rangaswamy, 1975; Jelliffe and Gurney, 1973).

The use of the triceps skinfold has been advocated by Seltzer and Mayer (1967) as being the more reliable of both triceps and subscapular skinfold measurements. The triceps skinfold was found to: 1) correlate more significantly with body density values obtained by underwater weighing, 2) be the least inconvenient and embarrassing for the subjects, 3) be easily measured and easily reproducible, and 4) be most representative of total body fatness.

Burkinshaw, et al. (1973) studied observer error in taking skinfold thickness measurements. Two sets of measurements were taken on 21 subjects by three observers using Harpenden calipers. One observer had several years of experience. The first observer marked the site of the measurement in one set of observations and left the site unmarked in the second set of observations. When the sites of measurements were marked, the values obtained by all three observers were in close agreement. When the site was not marked, the less experienced observers obtained values which averaged 2 mm higher than those obtained by the experienced observer.

Brief Summary of Literature Review

Obesity has been shown to have many possible causes. Such causes can include problems due to hypothalamic malfunction, hypercellularity, early dietary behavior, meal-taking behavior, among others not discussed. That taste sensitivity or responsiveness is related to some types of obesity is generally agreed upon by many researchers.

Environmental factors can influence the incidence of obesity among preschool children. Factors such as family income, urbanization, mother's education, number of siblings, parental occupations, and food habits play an important role in the incidence of childhood obesity. There are sex differences in the incidence of obesity, according to some researchers.

Because taste mechanisms appear to be related to obesity in some manner, taste sensitivity may be an important etiological factor in the incidence of obesity. Taste is probably controlled by genetic means; certain sensitive proteins have been found which are taste specific. Food rejection or acceptance may be related to taste for bitter compounds, and many factors influence sensitivity to taste.

Studies of taste sensitivity in preschool children have been exceedingly rare. One researcher concluded that children's food preferences are related to taste sensitivity. No studies have been found examining taste sensitivity and body fatness in preschool children.

Physical measurements of obesity in preschool children are limited by the lack of standards for comparison. Most work has been done with adults and obesity indices for adults will not always be applicable to children. Standards such as those published by the National Center for Health Statistics are a beginning in the establishment of standards for preschool children's body measurements.

The present study sought to examine some of the observations made in the literature and to go a step further by scrutinizing certain possible relationships which have been lacking in the literature; the most important of these being the relationship between taste sensitivity and body fatness.

CHAPTER III

METHODOLOGY AND PROCEDURE

Subjects

The subjects for this study were 25 children attending the Wallace Hall Child Development Laboratory School. The children were of two age groups, three years and four years; ages in months as of February 28, 1978 ranged from 42 to 61 months. The subjects were recruited via a parents' meeting and by conversations with parents as they brought the child to school. Copies of letters to parents and the permission form are to be found in Appendix A.

Anthropometric

The methodology described in the Health and Nutrition Examination Survey (HANES) study (Abraham, 1975) was used. Measurements taken were weight, height, triceps skinfold, and arm circumferences. These measurements were selected primarily because of the facility of measurement; the subjects did not necessarily have to remove their clothing, although some of the children with long-sleeved shirts did have to do so.

Weight was recorded on a beam-balance scale. Weight measures were read to the nearest 0.1 pound and converted to kilograms by dividing pounds by 2.2. Because the time of the day can influence readings, the subjects were weighed in the morning. This time was selected because elimination might have taken place by then, the children might have had less full stomachs, and exercise losses of sweat were probably less than they would have been later in the day. Furthermore, the time was convenient for the personnel at the school. The children were weighed only once, since the results compared closely with weights obtained by the school nurse two weeks previously.

Height was recorded in inches and was obtained by having the subject stand up against the measuring rod on the scale. Each subject's heels and back were aligned squarely on the front edge of the scale; shoes were not removed. The child was directed to stand up straight in a natural position, and the metal bar was lowered onto the head. Height was read on the measuring stick on the scale. As in the case of weight measurements, one measure of height was taken because of the close comparison with the nurse's measurements. Height in inches was converted to height in centimeters by multiplying inches by 2.54.

Arm circumference was measured on the right arm. The arm was flexed at a 90 degree angle. A midpoint between the acromion process and the oleocranon was measured with a steel tape measure and marked with a felt-tipped marking pen. To measure the arm circumference, the subject's arm hung loosely at his side. The tape measure was wrapped tightly enough around the arm so that tape measure did not slip, but not tightly enough to cut into the skin. The tape was perpendicular to the long bone. Two measurements were taken, each on separate days; measurements were recorded to the nearest centimeter at the midpoint marked with the felt marker.

The triceps skinfold was also measured on the right arm, just as it was for the arm circumference. The same midpoint was also used. The arm was relaxed and hanging loosely at the subject's side. The fat fold was grasped with the thumb and index finger of the experimenter at a point one centimeter above the midpoint. The Lange caliper was applied to this fold. Two measurements were taken, one on each of two different days.

All of the above measurements were taken once by the experimenter and once by her assistant in order to verify results. The data was recorded on the form found in Appendix B. The following indices were calculated:

1. Ponderal Index $= \dfrac{\text{Height (in.)}}{\sqrt[3]{\text{Weight (lbs.)}}}$

2. Upper Arm Muscle Diameter = Arm circumference (cm) - Triceps Skinfold (mm)

3. Body Mass Index $= \dfrac{\text{Weight (lbs.)}}{\text{Height (in.)}}$

Socio-Economic Data

Data on the father's occupation, the mother's occupation, parental education, number of children in the family, subject's birthweight, and other such factors were collected via a questionnaire sent home to the parents and via the files kept on each child by the school. The data recording forms are to be found in Appendix C.

Food preference data and food intake data were obtained by means of: 1) a checklist of foods, which were classified by the child's mother as liked, accepted, not eaten, or never tasted; many of the foods were chosen for the checklist because of the linkage with bitter taste (i.e., vegetables), and 2) a two-day food record, which was kept by the experimenter at school for the noon meal and by the parents at home for all other meals and snacks. A copy of the menu for the two days at school is in Appendix D, and the forms for recording food intake are to be found in Appendix D.

Taste Sensitivity

The method of testing taste sensitivity is not really standardized; however, the procedure provided by Harris and Kalmus (1949) has provided a guideline for the methodology most commonly used by researchers studying phenylthiocarbamide (PTC) and other bitter compounds. Because their procedure requires that the subjects sort a series of 8 samples, it was deemed inappropriate for the testing of young children. Instead, the modified paired-comparison method designed by Korslund (1962) was followed in order to assess difference thresholds (when the taste of the sample is first sensed to be different than water) for quinine sulfate and sucrose.

Samples

There were 18 samples tested in total; 12 samples were sucrose and 6 were quinine sulfate. Solution concentrations were arrived at by taking the range of molarities commonly reported by other investigators (Amerine, *et al.*, 1965; Stahl, 1973) and adapting those molarities to fit the number of samples appropriate for the testing of preschool children. Pangborn (1959) reported that adult subjects could taste sucrose between 8 X 10^{-3}M and 2.2 X 10^{-2} M; therefore, solutions were made up with the molarities listed in Table III-1.

Originally, six solutions (numbers 1-6) were made as discussed above for sucrose; after testing the children, it was apparent that many children were not tasting any differences even at the higher levels. It was decided to repeat the testing with increased concentrations of sucrose. Again six samples were prepared, numbered 7-12, each following the same increment in concentration observed in the first set of samples numbered 1-6. The concentrations for the second set of sucrose samples are also listed in Table III-1.

The thresholds reported for quinine sulfate taste sensitivity range from 4.0 X 10^{-7} to 1.1 X 10^{-5} M (Pfaffman, 1959). Six solutions were made by subtracting 4.0 X 10^{-7} M from 1.0 X 10^{-4}M and dividing the difference by five. The level 1.0 X 10^{-4} M was chosen because Korslund's (1962) solution concentrations for quinine sulfate began at 1.6 X 10^{-4} M. A more diversified range of concentrations was sought by modifying Pfaffman's ranges. The concentrations used for solutions of quinine sulfate are also listed in Table III-1.

Sucrose and quinine sulfate samples were weighed on a Mettler Balance, Model H33. Sucrose samples were weighed in amounts needed for 100 ml of each concentration, while the quinine sulfate samples were weighed in amounts appropriate for 200 ml of each concentration. All samples were made up in volumetric flasks of the size needed. Samples were weighed in amounts stated above to ensure greater

Table III-1. Concentrations of Taste Substances in Moles Per Liter

Solution Number	Molarity	g/1
	Sucrose	
1	5.0×10^{-3}	1.71
2	1.0×10^{-2}	3.42
3	1.5×10^{-2}	5.13
4	2.0×10^{-2}	6.85
5	2.5×10^{-2}	8.56
6	3.0×10^{-2}	10.30
7	3.5×10^{-2}	11.98
8	4.0×10^{-2}	13.69
9	4.5×10^{-2}	15.40
10	5.0×10^{-2}	17.11
11	5.5×10^{-2}	18.83
12	6.0×10^{-2}	20.54
	Quinine Sulfate	
1	4.00×10^{-7}	3.13×10^{-4}
2	2.03×10^{-5}	1.59×10^{-2}
3	4.02×10^{-5}	3.15×10^{-2}
4	6.01×10^{-5}	4.71×10^{-2}
5	8.00×10^{-5}	6.27×10^{-2}
6	1.00×10^{-4}	7.82×10^{-2}

accuracy. Sample 1 of quinine sulfate was mixed in the amount for 1 liter. These quantities of solutions were sufficient for the testing procedure. The samples were made on the night prior to testing and stored at room temperature in covered glass jars. Reagent grade sucrose and quinine sulfate were purchased from Fisher Scientific Company. All solutions were mixed with ion-free water.

Testing Procedure

Testing took place in an isolated room near the classroom area. The child was encouraged to come with the experimenter and her assistant to play a game. Testing took place between 8 and 10 a.m. The atmosphere in the testing room was business-like, with talking limited to the details of the test.

The testing samples were arranged on a plastic tray covered with paper towels; all samples were poured into clear plastic tasting cups in approximately 2 ml amounts. Ion-free water was used as the standard; the trays were arranged with the water sample in the middle of the tray and the other two modalities, quinine sulfate and sucrose, lined up in increasing order on either side of the water. Twelve samples were tested at once, six of sucrose and six of quinine sulfate, for the first testing day. On the second day of testing, only the six additional sucrose samples were tested.

In the modified paired-comparison method, the child was presented with the sample of ion-free water and asked to take a sip. He was then asked, "What is it like?" When the response was given as being water, sample 1 of sucrose was given. The child was asked if it were the same as water. If it was, then sample 2 was given and so on until the child responded that the sample in question tasted differently from water. The subject was asked after every sample what he thought it was like. The same procedure was followed with quinine sulfate, which was tested after sucrose because it was felt that the bitter taste of the substance might cause some children to refuse to continue testing. Facial responses were recorded by the assistant, along with the difference threshold sample number and verbal remarks. One child identified water as "dirty" and all subsequent samples as dirty until there was a difference. "Dirty" became "sweet" for sucrose and "yuck" for quinine sulfate. A scale of +2 to -2 was used to rate facial expressions ranging from extreme pleasure to extreme displeasure. All data was recorded on the form found in Appendix E. For each subject, quinine sulfate taste testing took one day and sucrose taste testing took two days.

Analysis of the Data

Extensive correlations were made of anthropometric measurements, socio-economic parameters, food intake, and taste thresholds. This was done as an initial screening technique to look for relationships which were statistically significant. The subjects were classified by their taste threshold and the thresholds were designated as being extremely sensitive, moderately sensitive, moderately insensitive, or extremely insensitive. These classifications are outlined in Table III-2.

Table III-2. Sample Numbers, Concentrations, and Associated Threshold Classifications

Sample Number	Concentrations (M)	Threshold Classification[a]
	Sucrose	
1	5.0×10^{-3}	I
2	1.0×10^{-2}	I
3	1.5×10^{-2}	I
4	2.0×10^{-2}	I
5	2.5×10^{-2}	II
6	3.0×10^{-2}	II
7	3.5×10^{-2}	II
8	4.0×10^{-2}	II
9	4.5×10^{-2}	III
10	5.0×10^{-2}	III
11	5.5×10^{-2}	III
12	6.0×10^{-2}	III
	None Tasted	IV
	Quinine Sulfate	
1	4.00×10^{-7}	I
2	2.03×10^{-5}	I
3	4.02×10^{-5}	II
4	6.01×10^{-5}	II
5	8.00×10^{-5}	III
6	1.00×10^{-4}	III
	None Tasted	IV

[a]Threshold classifications signify the following: I = extremely sensitive, II = moderately sensitive, III = moderately insensitive, and IV = extremely insensitive.

Subjects were also classified according to sensitivity to quinine sulfate, based on their distribution among the four initial threshold categories. These classifications are shown in Table III-3. Attempts to classify the subjects as sensitive tasters of both modalities were not feasible because of the small variation in the range of sensitivity of the quinine sulfate testers. A major portion of the analysis was directed toward determining differences between these two groups. Analysis of variance was done on the anthropometric, taste sensitivity, and eating behavior parameters of these two groups. Correlations of all variables to these groupings of subjects were made.

Food intake data were analyzed in several ways. Caloric intake was determined by means of a computer program based on the USDA's Handbook 72 (1971). Foods on the checklist of food likes and dislikes (Appendix D) were coded as follows:

1 = Liked

2 = Accepted

3 = Will not eat

4 = Never tasted.

A frequency count was made of the number of subjects liking, accepting, disliking, and never tasting the foods. The number of foods not eaten (disliked) were counted; this raw number was used as such in analysis. The percentage of foods liked by each subject was calculated, based on the total number of foods actually tasted by the subject.

Table III-3. Classification of Subjects Into Two Groups Based on Sensitivity to Quinine Sulfate

Most Sensitive Quinine Tasters (Group 1)		Less Sensitive Quinine Tasters (Group 2)	
Subject Number	Threshold Classification	Subject Number	Threshold Classification
1	I	6	II
2	I	7	II
3	I	9	III
4	I	13	II
5	I	14	II
8	I	15	II
10	I	17	III
11	I	19	II
12	I	23	II
16	I	24	II
18	I	25	II
20	I		
21	I		
22	I		

The indices for body fatness or body size; Ponderal Index, Upper Arm Muscle Diameter, and Body Mass Index; were calculated by hand and correlated via computer with all other variables. The weight-for-height standard percentiles of the National Center for Health Statistics (1976) were determined for each child using the appropriate growth chart for sex; a code was developed based on these percentiles (Table IV-4).

CHAPTER IV

RESULTS

Taste Sensitivity

In the analysis of the data on taste sensitivity, the major tool used was the classification of subjects by taste threshold. The classifications of taste thresholds on the basis of solution concentration are outlined in Table III-2. The grouping of subjects by age in months, sex, and taste threshold classification for both quinine sulfate and sucrose is portrayed in Table IV-1. It appeared that more girls than boys were sensitive to taste at lower concentrations. For example, threshold I for quinine sulfate was tasted by seven of nine girls (approximately 78%), while the same threshold was tasted by seven of sixteen boys (approximately 44%). Threshold III for quinine sulfate was tasted by 12.5% of the boys; all of the girls tasted quinine sulfate prior to the concentrations represented by threshold III. In the case of sucrose, there was also an apparent sex difference: threshold I was tasted by 22% of the girls, while none of the boys tasted sucrose in this range of concentrations. Sucrose was not tasted in any concentration (Threshold IV) by 33% of the girls and nearly 44% of the boys, suggesting that perhaps boys are more insensitive to sucrose than are girls (Figure 1).

Table IV-1. Subjects Listed by Subject Number, Sex, Age in Months, and Taste Threshold Classifications

Subject Number	Sex	Age in Months	Sucrose[a]	Quinine[a]
1	M	47	IV	I
2	F	42	IV	I
3	F	61	II	I
4	M	47	III	I
5	F	56	I	I
6	M	42	III	II
7	M	46	III	II
8	M	54	IV	I
9	M	45	IV	III
10	M	50	IV	I
11	M	47	IV	I
12	F	40	I	I
13	M	58	II	II
14	M	51	I	II
15	F	54	II	II
16	F	54	III	I
17	M	42	IV	III
18	F	59	II	I
19	F	57	IV	II
20	F	48	IV	I
21	M	50	II	I
22	M	51	II	I
23	M	59	II	II
24	M	54	II	II
25	M	44	IV	II

[a]I = extremely sensitive, II = moderately sensitive, III = moderately insensitive, and IV = extremely insensitive.

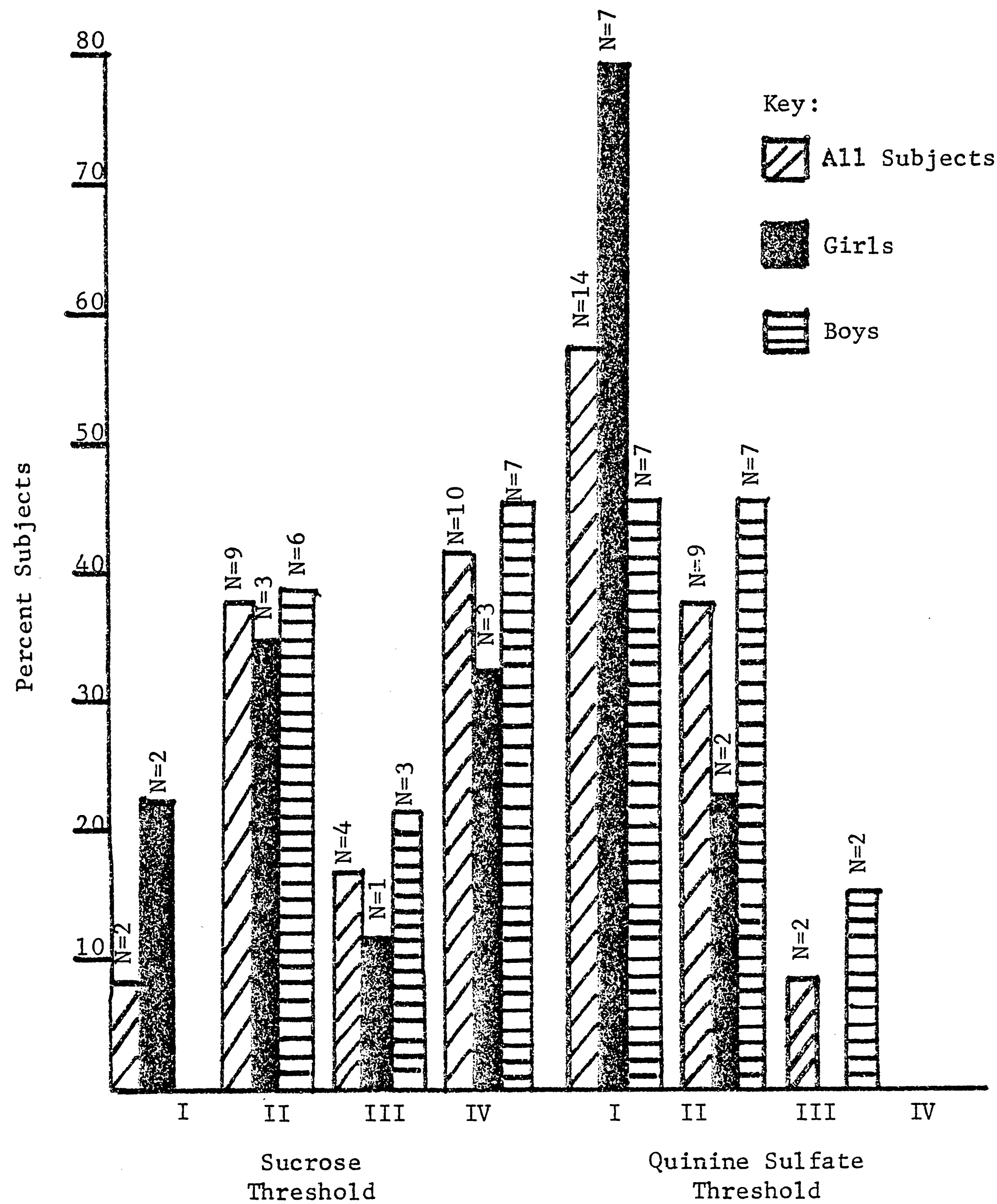

Figure 1. Percentage of Subjects by Taste Threshold Classifications

For ease of analysis, all subjects were grouped into taste groups. These taste groups were based on quinine sulfate taste thresholds (Table III-3). There were two groups, those most sensitive to quinine sulfate (Group 1) and those less sensitive to quinine sulfate (Group 2). Taste sensitivity to quinine sulfate was split into two nearly equal groups. Fourteen of the 25 subjects were extremely sensitive to quinine sulfate while eleven were less sensitive.

Age in months was not correlated with quinine sulfate taste sensitivity; however, sucrose taste sensitivity did correlate positively with age in months ($p. < .05$).

Anthropometric Data

Anthropometric measurements revealed that none of the 25 children involved in this study were grossly obese nor grossly underweight. Means for all anthropometric parameters show that there were differences in these parameters between age and sex groups (Table IV-2). As anticipated, the three year olds were smaller as a group than were the four year old in all parameters except arm circumference and Ponderal Index. Girls tended to be smaller than boys in all parameters except height; the girls as a group were an average of .50 cm taller than the boys. The variable of sex correlated significantly ($p < .01$) with all body fatness parameters except for present weight and triceps skinfold. The boys appeared to have more body fatness than girls. These results are tabulated in Table IV-4.

Table IV-2. Anthropometric Measurements: Means for Age and Sex

Measurement	Means for Age and Sex			
	3 Years Old		4 Years Old	
	Male	Female	Male	Female
Weight (kg)	17.00	15.40	19.90	17.70
Height (cm)	103.30	103.29	111.59	110.28
Triceps (mm)	10.25	9.33	11.00	10.00
Arm circumference (cm)	16.75	15.30	16.88	15.67
Upper Arm Muscle Diameter (cm)	13.65	12.67	13.51	12.67
Ponderal Index	12.15	12.56	12.47	12.93
Body Mass Index	0.92	0.83	0.99	0.89

The relationships found between taste sensitivity modalities and body fatness indices are illustrated in Table IV-3. Sensitivity to sucrose was found to be significantly correlated with Ponderal Index and Upper Arm Muscle Diameter, while sensitivity to quinine sulfate correlated positively with the code for weight-for-height percentiles and negatively with Ponderal Index. There were no other significant correlations between body fatness indices and the individual taste modalities. The code for weight-for-height percentile was significantly correlated with all body fatness parameters (Table IV-3). No children were above the 95th percentile, which is a currently accepted cut-off point for obesity (Fomon, 1977).

On the basis of the code for weight-for-height percentiles (Table IV-4), it was determined that 56% of the subjects were above the 50th percentile, 8% exactly at the 50th percentile, and 36% were below the 50th percentile. These figures are for all subjects, inclusive of age and sex. When divisions of the subjects into age and sex groups were made, age differences were not really apparent. Both 3 and 4 year olds followed the same percentage distribution as was seen when all subjects were classified by percentiles. Sex divisions, on the other hand, did suggest a difference: 75% of the boys were above the 50th percentile, none were at the 50th percentile and 25% were below the 50th percentile. The distribution of girls showed that 22.2% were above the 50th percentile, 22.2% were at the 50th percentile, and 55.5% were below the 50th percentile. These results are summarized in Table IV-5.

Table IV-3. Correlations of Code[a] with other Body Fatness and Body Size Parameters, and all Body Fatness and Body Size Parameters with Taste Sensitivity and Sex

Body Fatness or Size Indices	Correlation Coefficients			
	Quinine	Sucrose	Sex	Code
Body Mass Index	.28	-.04	.46[b]	.85[b]
Ponderal Index	-.36[c]	-.43[b]	-.63[b]	-.72[b]
Upper Arm Muscle Diameter	.16	.41[b]	.46[b]	.52[b]
Triceps Skinfold	.05	-.24	.24	.68[b]
Weight	.20	-.13	.32	.66[b]
Arm Circumference	.12	.21	.53[b]	.80[b]
Code	.40[c]	.14	.50[b]	-

[a]Code stands for weight-for-height percentiles (National Center for Health Statistics, 1976).

[b]$p < .01$.

[c]$p < .05$.

Table IV-4. Code Assigned to Each Subject by Weight-for-Height Percentiles

Subject Number	Percentile	Code[a]
1	50-75	1
2	10-25	-3
3	50	0
4	25-50	-1
5	50-75	1
6	75-90	3
7	75-90	3
8	75-90	3
9	25-50	-1
10	50-75	1
11	50-75	1
12	10-25	-3
13	75-90	3
14	90	4
15	10	-4
16	5	-5
17	75-90	3
18	25-50	-1
19	75-90	3
20	50	0
21	25-50	-1
22	10-25	-3
23	75	2
24	50-75	1
25	50-75	1

[a]Codes signify: 5 = 95, 4 = 90, 3 = 75-90, 2 = 75, 1 = 50-75, 0 = 50, -1 = 25-50, -2 = 25, -3 = 10-25, -4 = 10, -5 = 5. Percentiles are taken from HANES (NCHS, 1976).

Table IV-5. Percent of Subjects Classified by Percentiles

Code	All Subjects		Age				Sex			
			3 Years		4 Years		Male		Female	
	N	%	N	%	N	%	N	%	N	%
5	0	0	0	0	0	0	0	0	0	0
4	1	4	0	0	1	7.1%	1	6.3%	0	0
3	6	24%	3	27%	3	21.4%	5	31.3%	1	11.1%
2	1	4%	0	0	1	7.1%	1	6.3%	0	0
1	6	24%	3	27.3%	3	21.4%	5	31.3%	1	11.1%
0	2	8%	1	9%	1	7.1%	0	0	2	22.2%
-1	4	16%	2	18.2%	2	14.3%	3	18.8%	1	11.1%
-2	0	0	0	0	0	0	0	0	0	0
-3	3	12%	2	18.2%	1	7.1%	1	6.3%	2	22.2%
-4	1	4%	0	0	1	7.1%	0	0	1	11.1%
-5	1	4%	0	0	1	7.1%	0	0	1	11.1%

Subjects were further classified by code for weight-for-height percentiles according to the two quinine sulfate taste sensitivity groups (Table IV-6). For extremely sensitive tasters of quinine sulfate, the mean code was -.71, while for the more insensitive quinine tasters, the mean code was 1.6. Analysis of variance showed this difference to be statistically significant ($p < .05$).

Correlation of body fatness parameters with each other resulted in the Body Mass Index being correlated with weight, height, triceps skinfold, arm circumference, UAMD, Ponderal Index, and code for percentiles. Ponderal Index was more closely related to height than to weight; triceps skinfold also correlated with Ponderal Index, as did arm circumference and UAMD. The results of these cross correlations are summarized in Table IV-7.

Eating Behavior and Early Diet

Eating Behavior

The frequency of foods liked, accepted, disliked, and never tasted is outlined in Table IV-8. Based on the checklist of 51 foods completed by the parents (Appendix D), it was found that the most frequently disliked foods were vegetables and pickles of all types. Foods most frequently liked included milk, ice cream, raw carrots, orange juice, raisins, potatoes, dry cereals, white bread, rice, candy, cake, jelly or jam, potato chips, doughnuts, cookies, and coca cola. These foods were all liked by 20 or more children. The only food liked by all of the children was potato chips. Foods commonly never tasted included turnip greens, kale, garden cress,

Table IV-6. Taste Group Distribution of Subjects and Their Code for Weight-for-Height Percentiles

	Subject Number	Code for Percentile
Most Sensitive Quinine Tasters	1	1
	2	- 3
	3	0
	4	- 1
	5	1
	8	3
	10	1
	11	1
	12	- 3
	16	- 5
	18	- 1
	20	0
	21	- 1
	22	- 3
		Mean = -.71
Less Sensitive Quinine Tasters	6	3
	7	3
	9	- 1
	13	3
	14	4
	15	- 4
	17	3
	19	3
	23	2
	24	1
	25	1
		Mean = 1.6

Table IV-7. Cross Correlations of Body Fatness and Body Size Parameters

	WT	HT	TRI	ARM	UAMD	PI	BM[a]
WT	-	.81[a]	.56[a]	.67[b]	.48[b]	-.11	.95[b]
HT		-	.24	.25	.20	.45[c]	.59[b]
TRI			-	.55[b]	.001	-.41[c]	.67[b]
ARM				-	.80[b]	-.54[b]	.79[b]
UAMD					-	-.37	.54[b]
PI						-	-.39[c]
BM							-

[a]WT = weight, HT = height, TRI = triceps skinfold, ARM = arm circumference, UAMD = upper arm muscle diameter, PI = Ponderal Index, BM = Body Mass Index.

[b]$p < .01$.

[c]$p < .05$.

Table IV-8. Frequency of Foods Liked, Accepted, Disliked, and Never Tasted by Preschool Children

Food	Likes	Accepts	Dislikes	Never Has Tasted
Milk	21	4	0	0
Cheddar Cheese	16	5	2	1
Cottage Cheese	12	6	4	2
Ice Cream	24	1	0	0
Carrots, Raw	20	3	2	0
Carrots, Cooked	9	13	3	0
Sweet Potatoes	7	13	5	3
Spinach	6	9	3	1
Broccoli	12	9	3	1
Peas	17	8	0	0
Green Beans	16	7	1	1
Turnip Greens	0	4	4	17
Radish	1	7	12	5
Cabbage	5	11	6	3
Brussels Sprouts	0	9	8	8
Lettuce	15	5	5	0
Celery Sticks	14	4	7	0
Tomatoes, Fresh	9	7	9	0
Tomatoes, Canned	6	5	11	3
Kale	1	3	7	14
Cauliflower	11	5	4	5
Orange Juice	22	3	0	0
Raisins	22	3	0	0
Nuts	23	2	0	0
Potatoes	21	3	1	0
Garden Cress	2	3	5	15
Mustard	9	5	5	6
Baked Beans	15	4	4	2
Dry Cereals	23	1	1	0
Cooked Cereals	15	4	4	2
White Bread	21	4	0	0
Whole Wheat Bread	18	6	0	1
Rice	23	2	0	0
Pie	16	7	1	1
Candy	23	1	1	0

Table IV-8--Continued.

Food	Likes	Accepts	Dislikes	Never Has Tasted
Cake	21	4	0	0
Jelly or Jam	21	4	0	0
Olives	8	4	5	7
Potato Chips	25	0	0	0
Spaghettio's	12	6	0	7
Sour Pickles	6	5	11	3
Dill Pickles	8	7	7	3
Sweet Pickles	8	7	5	5
Rutabaga	0	1	5	19
Kohlrabi	1	3	1	20
Canned Soups	16	6	1	2
Franco American Raviolio's	8	5	3	9
T.V. Dinners	5	8	0	12
Doughnuts	24	0	1	0
Cookies	24	1	0	0
Coca Cola	23	1	1	0

rutabaga, kohlrabi, and T.V. dinners. These foods were never tasted by ten or more of the children.

The foods most frequently disliked by the percent of subjects having tasted the foods are listed in Table IV-9. Subjects were further divided into whether or not they were sensitive or more insensitive quinine sulfate and sucrose tasters. Radishes, canned tomatoes, kale, garden cress, sour pickles, and rutabaga were disliked by 50% of the total number of subjects having tasted these foods. A greater percent of children disliking these foods were extremely sensitive quinine tasters.

The percentage of foods liked (of all foods tasted) ranged from 40.5 to 86.3% for all subjects. Quinine sulfate taste threshold was correlated with the percent of foods liked ($p < .05$). Sucrose was not related to the percent of foods liked. See Appendix D for a listing of percent of foods liked by each subject.

The number of foods disliked ranged from 0 to 20 for all subjects. Sensitivity to quinine sulfate was not correlated with the number of foods disliked. Sucrose taste sensitivity also was not correlated with the number of food dislikes.

Individual foods, when correlated with quinine sulfate and sucrose taste thresholds, were not always significantly correlated. The foods which were significantly correlated with taste thresholds are listed in Table IV-10. Peas and sweet pickles were both negatively correlated with quinine sulfate and sucrose taste thresholds. Cooked carrots and cauliflower were negatively correlated with quinine sulfate taste sensitivity. Sucrose taste sensitivity was

Table IV-9. Foods Most Frequently Disliked[a]

Food	Number of Children Disliking Food	Sensitive Quinine Tasters[b]	Sensitive Sucrose Tasters[b]
		percent	percent
Sweet Potatoes	5	80.0	40.0
Radish	12	50.0	41.0
Cabbage	6	85.7	42.8
Brussels Sprouts	8	71.0	42.8
Lettuce	5	50.0	50.0
Celery Sticks	7	71.0	57.0
Tomatoes, Fresh	9	66.6	44.4
Tomatoes, Canned	11	66.6	50.0
Kale	7	57.1	42.8
Garden Cress	5	60.0	40.0
Mustard	5	75.0	50.0
Olives	5	25.0	25.0
Sour Pickles	11	63.6	54.5
Dill Pickles	7	62.5	62.5
Sweet Pickles	5	83.3	83.3
Rutabaga	5	83.3	33.3

[a]Foods listed were disliked by at least 5 subjects.

[b]Percent of tasters is based on the number of children disliking the food where 5 or more children disliked the food; i.e., column 2 of this table. Threshold classifications I and II were designated as being the thresholds for sensitive sucrose tasters, whereas threshold classification I was assigned to sensitive quinine sulfate tasters.

Table IV-10. Food Preferences Correlated with Taste Modalities

Food	Correlation Coefficients	
	Quinine Sulfate	Sucrose
Cooked Carrots	-.37[a]	-
Peas	-.42[b]	-.45[b]
Green Beans	-	-.53[a]
Cauliflower	-.42[a]	-
Orange Juice	-	-.39[b]
Raisins	-	-.39[b]
Cooked Cereal	-	.38[a]
Sweet Pickles	-.41[a]	-.42[a]
Doughnuts	-	-.34[a]
Cookies	-	-.34[a]

[a] $p < .10$.

[b] $p < .05$.

negatively correlated with green beans, orange juice, raisins, doughnuts, and cookies; a positive correlation was found between cooked cereal and sucrose.

Food likes and dislikes were analyzed in terms of: 1) whether or not the child was always hungry for meals or had to be coaxed to eat, and 2) body fatness parameters. The numbers of foods disliked did not correlate with the child being hungry or with the child being coaxed to eat. Taste sensitivity was unrelated to the child being either hungry or coaxed to eat. Food dislikes also were not correlated significantly with any of the body fatness parameters nor was the percent of foods liked correlated with any of the body fatness parameters. However, the percent of foods liked did correlate significantly with the child being coaxed to eat ($p < .05$) (Appendix B).

Caloric intake from the two-day food records was analyzed via computer and Handbook 72 (USDA, 1971). The results showed that 9 subjects consumed 100% or more of the RDA for calories, 11 subjects consumed 66-100% of the RDA for calories, and 5 subjects consumed 50-66% of the RDA for calories. Caloric intake was correlated with present body weight (.42, $p < .01$), arm circumference (.47, $p < .01$), and Body Mass Index (.44, $p < .05$). Caloric intake was not correlated with quinine sulfate taste threshold; sucrose threshold was related more with caloric intake but was not highly significant. Numbers of foods disliked did not correlate with caloric intake.

Early Diet

Birthweights of the subjects ranged from 5.00 to 9.67 pounds, with a mean birthweight of 6.67 pounds for all subjects. The mean birthweight for girls was 7.09 pounds and for boys 7.88 pounds. Birthweight did not correlate significantly with present body weight nor did it correlate with other body fatness parameters. Taste sensitivity was not related to birthweight. Birthweight did correlate significantly with the age fed solids (.61, $p < .01$), but not with breastfeeding.

Breastfeeding occurred in the case of 14 subjects (56%). Six of the girls (66.6% of girls) and eight of the boys (50% of boys) were breastfed. Breastfeeding was not correlated with body fatness parameters, nor was it correlated with quinine sulfate taste threshold. There appeared to be a slight relationship between breastfeeding and sucrose taste threshold, but it was not significant. The type of solids fed as supplementary foods was positively correlated with breastfeeding (.47, $p < .05$), for example, cereals, commercial baby foods, or pureed table foods. The incidence of breastfeeding did not, however, correlate with the number of foods disliked.

The age at which the subjects were first fed solid foods ranged from 1 to 52 weeks. The mean age at which solids were fed was 13.2 weeks. Although the age fed solids did not correlate with any of the body fatness parameters, a plot of present weight against age fed solids suggested that as the number of weeks increases before solids are fed, the present body weight tends to be slightly lower. Even if solids are fed before the fifth or sixth week of life, there is great variation among present weights (Figure 2). After that point, the variation in present body weights diminishes. The age at which subjects were fed solid foods did not correlate with quinine sulfate taste threshold or with sucrose taste threshold. Breastfeeding was slightly but significantly related to the age at which subjects were fed solid foods ($p = .1$). The types of foods fed as solids were not related to the age at which they were fed.

Liking for individual foods was related to the age at which solids were fed. The eating of candy, cake, and cookies as snacks was related to the age at which solids were fed (.44, $p < .05$). Dislike for broccoli (.42, $p < .05$), baked beans (-.37, $p < .1$), pie (.37, $p < .1$), doughnuts (.61, $p < .01$), cookies (.61, $p < .01$), and coca cola (.46, $p < .05$) was related to the age at which the subjects were fed solids.

The types of solids fed; whether they were cereals, commercial baby foods, or pureed table foods; also were not related to present body weight or to other body fatness indices. Taste sensitivity variables did not correlate with the types of foods fed as solids. The types of foods fed as solids did correlate with the number of food dislikes (.47, $p < .05$) and with percent of foods liked (-.33, $p < .1$).

Sensitive and Insensitive Quinine

It was deemed necessary that a comparison be made between the sensitive and more insensitive quinine sulfate tasters. Consequently, the subjects were grouped into taste groups: all subjects

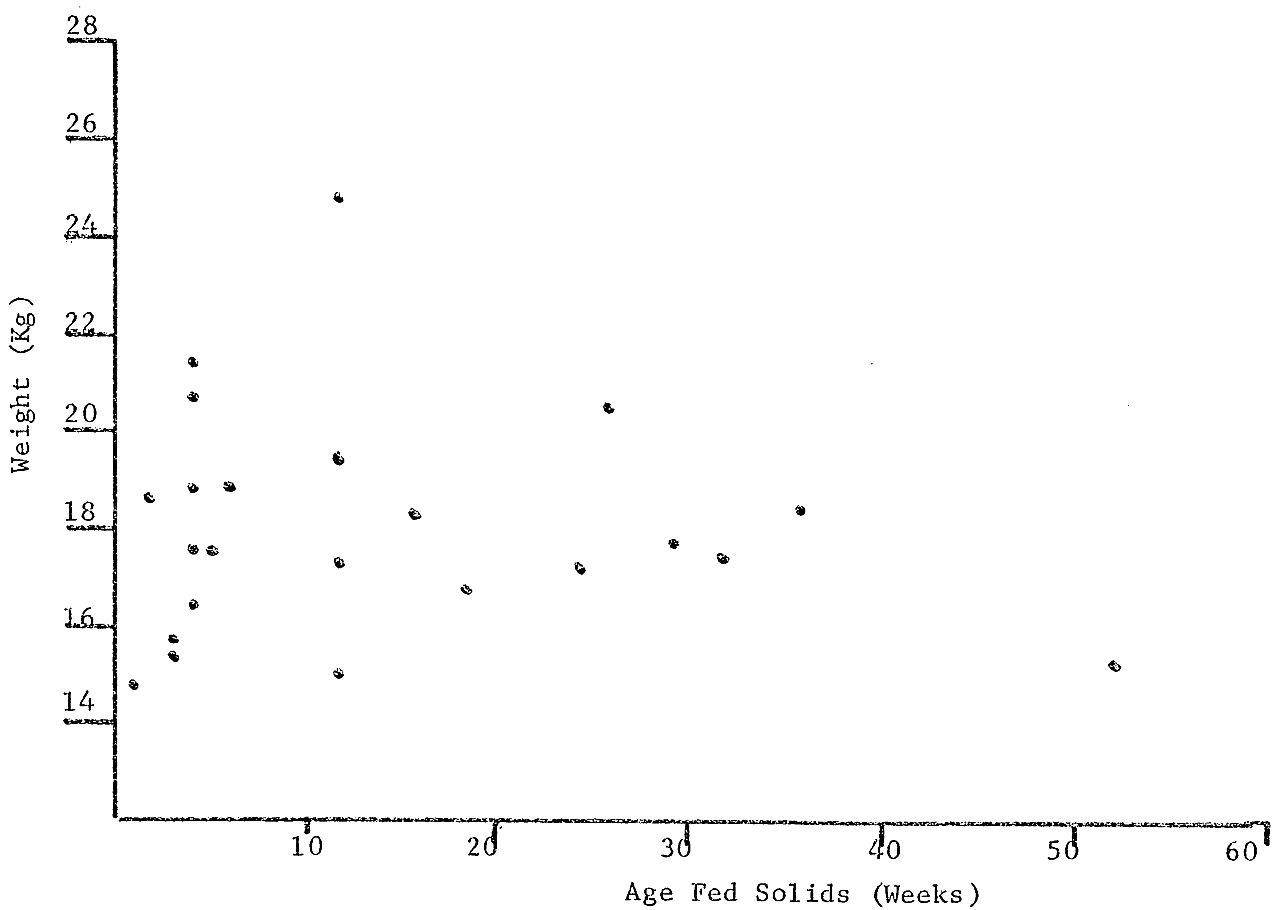

Figure 2. Age Fed Solids Plotted Against Present Body Weight

in taste group 1 were designated as sensitive tasters of quinine sulfate and all subjects in group 2 were designated as more insensitive quinine sulfate tasters. Classifications of tasters by threshold concentration of quinine sulfate and sucrose are shown in Table IV-11. Eleven of the 14 sensitive tasters first tasted quinine sulfate at 2.03×10^{-5} M. Group 1 contained 14 subjects (56% of sample) and group 2 contained 11 subjects or 44% of the sample. There were 7 girls and 7 boys in group 1; 77.7% of the girls and 43.7% of the boys were in this grouping. In group 2, there were 2 girls and 9 boys; 22.2% of the girls and 56.25% of the boys were in this grouping. It appeared, therefore, that a greater proportion of the girls than the boys were sensitive quinine sulfate tasters.

Eight of the subjects in group 1 were breastfed (57%) and six subjects in group 2 were breastfed (54%). More subjects in the sensitive grouping were fed pureed table foods as solid foods than were those in the more insensitive grouping: 42.8% of sensitive tasters as opposed to 9% of the more insensitive tasters were fed pureed table foods. Cereal was the first solid food for 2 of the subjects in group 1 (14.28%) and for 7 of the subjects in group 2 (63.6%). Commercial baby foods were fed as solids to 6 (42.8%) of the sensitive group subjects and to 3 (27.2%) of the more insensitive group subjects. The two groups also differed in that mean birthweight for group 1 was 6.29 pounds as opposed to 7.16 pounds for group 2.

Although current body weights of both groups did not correlate with birthweights, there were differences in body fatness between the two groups. Mean values for all body fatness or body size

Table IV-11. Classification of Tasters by Quinine Sulfate Threshold Concentration and Sucrose Concentration

Subject Number	Threshold (Sample Number)	Concentration of Quinine Sulfate (Molarity)	Threshold (Sample Number)	Concentration of Sucrose (Molarity)
1 (S)[a]	2	2.03×10^{-5}	-	-
2 (S)	2	2.03×10^{-5}	-	-
3 (S)	2	2.03×10^{-5}	2	1.0×10^{-2}
4 (S)	2	2.03×10^{-5}	12	6.0×10^{-2}
5 (S)	2	2.03×10^{-5}	2	1.0×10^{-2}
6 (IS)	3	4.02×10^{-5}	11	5.5×10^{-2}
7 (IS)	3	4.02×10^{-5}	8	4.0×10^{-2}
8 (S)	1	4.00×10^{-7}	-	-
9 (IS)	5	8.00×10^{-5}	-	-
10 (S)	2	2.03×10^{-5}	-	-
11 (S)	2	2.03×10^{-5}	-	-
12 (S)	2	2.03×10^{-5}	3	1.5×10^{-2}
13 (IS)	4	6.01×10^{-5}	7	3.5×10^{-2}
14 (IS)	3	4.02×10^{-5}	4	2.0×10^{-2}
15 (IS)	3	4.02×10^{-5}	5	2.5×10^{-2}
16 (S)	1	4.00×10^{-7}	9	4.5×10^{-2}
17 (IS)	5	8.00×10^{-5}	-	-
18 (S)	1	4.00×10^{-7}	7	3.5×10^{-2}
19 (IS)	3	4.02×10^{-5}	-	-

[a] S = Sensitive, IS = Insensitive quinine sulfate tasters.

Table IV-11--Continued.

Subject Number	Threshold (Sample Number)	Concentration of Quinine Sulfate (Molarity)	Threshold (Sample Number)	Concentration of Sucrose (Molarity)
20 (S)	2	2.03×10^{-5}	-	-
21 (S)	2	2.03×10^{-5}	7	3.5×10^{-2}
22 (S)	2	2.03×10^{-5}	6	3.0×10^{-2}
23 (IS)	3	4.02×10^{-5}	6	3.0×10^{-2}
24 (IS)	3	4.02×10^{-5}	8	4.0×10^{-2}
25 (IS)	3	4.02×10^{-5}	-	-

indices are listed in Table IV-12. The more insensitive group was taller than was the sensitive group. The more insensitive group was also heavier than was the sensitive group. Mean values for height and weight for each group which illustrate these differences are to be found in Table IV-12. All body fatness or body size indices for the more insensitive group were larger than for the sensitive group, as is indicated in Table IV-12. Significant differences were discovered between the two groups for present body weight ($p < .1$), Body Mass Index ($p < .05$), and the code for weight-for-height percentiles ($p < .05$). Sucrose taste threshold classification was correlated with Ponderal Index for the sensitive group (-.61, $p < .01$). For the less sensitive group, there were no significant correlations between sucrose and body fatness or body size indices. Sensitivity to quinine sulfate was negatively correlated with height for the more insensitive group (-.59, $p < .05$). Nine sensitive quinine sulfate tasters were above the median Ponderal Index, while five sensitive quinine sulfate were below the median. For insensitive tasters of quinine sulfate, 8 were below the median for the Ponderal Index, one at the median, and 3 above the median. The larger the Ponderal Index, the thinner the person; therefore, there were almost an equal number of sensitive and insensitive tasters above and below the median who were thinner and larger, respectively.

The two groups also displayed some differences in eating behavior. The mean age at which the groups were fed solids was 16.14 weeks (S.D. = 15.2) for the sensitive group and 9.45 weeks (S.D. = 9.3) for the insensitive group. This difference was not significant.

Table IV-12. Comparison of Most Sensitive Quinine Sulfate Tasters With Less Sensitive Quinine Sulfate Tasters

Parameter	Most Sensitive[a] Tasters Mean Values (N = 14)	S.D.	Less Sensitive[b] Tasters Mean Values (N = 11)	S.D.
Weight (kg)[c]	17.11	1.6	18.97	2.8
Height (cm	106.79	4.3	108.69	6.3
Triceps (mm)	10.07	1.4	10.81	2.4
Arm Circumference (cm)	16.14	1.1	16.64	1.2
UAMD	13.11	0.96	13.43	0.96
Ponderal Index	12.59	0.36	12.36	0.37
Body Mass[d] Index	0.89	0.06	0.97	0.10
Calories (kcal)	1359.4	355.6	1457.4	293.5
Birthweight (lbs.)	6.29	2.9	7.16	2.6
Age Fed Solids (weeks)	16.14	15.2	9.45	9.3
Number Foods Disliked	7.85	5.3	5.09	2.9
Age in Months	50.42	5.9	50.18	6.6
Percentage Foods Liked[c]	57.7%	14.35	66.5%	8.9
Code[d] (Weight-for-Height)	-.71	2.16	1.6	2.3

[a]Tasters who tasted quinine sulfate at Threshold I.

[b]Tasters who tasted quinine sulfate at Threshold II or higher.

[c]$p < .1$.

[d]$p \leq .05$.

Sensitivity to sucrose was negatively correlated with the age at which sensitive tasters were fed solids (-.51, $p < .05$). Quinine sulfate taste sensitivity was not related to the age at which sensitive tasters were fed solids. Taste sensitivity to neither taste modality was significantly correlated with age fed solids for the more insensitive group.

Differences in the numbers of foods disliked by each group are also shown in Table IV-12. The sensitive group disliked an average of 7.85 foods while group 2 disliked an average of 5.09 foods. This difference was not statistically significant. Quinine sulfate and sucrose taste thresholds were correlated significantly with the number of foods disliked by group 1. Sensitivity to quinine sulfate was not related to food dislikes for group 2; however, there was a significant correlation between sucrose taste sensitivity and the numbers of foods disliked (-.57, $p < .05$).

The percent of foods liked was correlated with calories for group 2 (.57, $p < .05$), but not for group 1. There was also a correlation between the percent of foods liked and the child being hungry for meals for the more insensitive group (.66, $p < .05$). This relationship did not exist in the sensitive group. However, for the sensitive group, there was a negative correlation between the percent of foods liked and the child being coaxed for meals (-.49, $p < .05$). There was no such relationship found in group 2. The percent of foods liked did not correlate with any body fatness indices for either group. The average percent of foods liked was 57.7% for group

1 and 66.5% for group 2. This difference was statistically significant at the .1 level.

Caloric intake was not statistically different between the two groups. Arm circumference (.55, $p < .01$) and UAMD (.76, $p < .01$) were correlated with caloric intake in group 1. For group 2, UAMD was the only body fatness parameter associated with caloric intake (.53, $p < .1$). For the more insensitive group, caloric intake was not significantly correlated with either quinine sulfate or sucrose taste sensitivity. Caloric intake was slightly related to both quinine sulfate and sucrose taste sensitivity for the sensitive group.

Because it appeared that there were differences in percent of foods liked between the two taste groups, an examination of taste sensitivity and preference for individual foods was undertaken for both groups. Correlations of individual foods with either quinine sulfate or sucrose taste sensitivity are shown in Table IV-13 for the sensitive group. A list of foods liked and disliked by the insensitive group and correlated with the taste modalities is shown in Table IV-14. There were more foods which correlated with taste variables for the sensitive group. Twelve foods correlated with sucrose taste sensitivity and five foods with quinine sulfate taste sensitivity for the sensitive group. Vegetables and sweet tasting foods were those foods correlated with taste variables.

For the more insensitive group of tasters, there were fewer foods associated with taste sensitivity. The foods found to be related to taste sensitivity were cottage cheese, cooked carrots,

Table IV-13. Food Preferences Correlated with Taste Variables for Group 1 (Sensitive Quinine Sulfate Tasters)

Food	Correlation Coefficients	
	Quinine Sulfate	Sucrose
Cottage Cheese	.47	-
Carrots, Raw	-	.49
Carrots, Cooked	-	.51
Broccoli	.52	-.51
Peas	.52	-.63[a]
Green Beans	.45	-.65
Radish	-	.54
Celery Sticks	.48	-
Orange Juice	-	-.49
Raisins	-	-.49
Cake	-	-.45
Doughnuts	-	-.45
Cookies	-	-.45
Coca Cola	-	-.45

[a]Significant at $p < .05$; all others significant at $p < .1$.

Table IV-14. Food Preferences Correlated with Taste Variables for Group 2 (More Insensitive Quinine Sulfate Tasters)

Food	Correlation Coefficients	
	Quinine Sulfate	Sucrose
Cottage Cheese	.59[a]	-
Carrots, Cooked	-	-.66[b]
Radish	-.61[a]	-.66[b]
Brussels Sprouts	.74[b]	-
Sour Pickles	-.67[b]	-.71[b]
Coca Cola	.66[b]	-

[a] $p < .1$.

[b] $p < .05$.

radishes, Brussels sprouts, sour pickles, and coca cola. In this group, more foods were negatively correlated with quinine sulfate taste threshold.

CHAPTER V

DISCUSSION

Taste Sensitivity

The difference thresholds for quinine sulfate and sucrose for the children in this study tend to follow trends observed by other researchers. Korslund and Eppright (1967) suggested that preschool children could taste sucrose within a range of 2×10^{-2} M to 6×10^{-2} M. Amerine, *et al*. (1965) quoted research results which suggested that persons aged 15-89 years of age could first taste sucrose at concentrations ranging from 1.6×10^{-2} M to 2.7×10^{-2} M. Pfaffman (1959) found that difference thresholds for sucrose ranged from 5×10^{-3} M to 1.6×10^{-2} M. In this study, the range of concentrations used for sucrose was 5×10^{-3} M to 6.0×10^{-2} M, which spans both Pfaffman's (1959) and Korslund's (1962) concentrations (Table III-2).

It appeared that the children in the present study were unable to taste sucrose at the lower concentrations offered. Because it was impossible to calculate a mean or median threshold (some subjects never identified a difference between samples and water), comparison with median values reported by other researchers was not possible. However, it did appear that the children in this study were not as sensitive to sucrose as were those studied by Korslund (1962, 1967). This may be due to the fact that the study done by Korslund did not include 3 year old children and that children at that age are unable to verbalize their reactions as well as older children. Another possible explanation may be that many preschool children may be accustomed to eating extremely sweet foods and that adaptation to sweet taste may occur. The fact that testing occurred close to breakfast time suggests that perhaps sensitivity was influenced by satiation. Amerine, et al. (1965) reported that some researchers found that meal deprivation led to a small lowering of thresholds for sucrose and other taste modalities, not including quinine. Alternately, meal taking tended to cause taste adaptation, thereby increasing taste thresholds.

The difference thresholds found for quinine sulfate, on the other hand, suggested that the children were more sensitive to quinine sulfate than were the children studied by Korslund (1962). The range of concentrations used in the present study was 4×10^{-7}M to 1.00×10^{-4}M (Table III-2). These concentrations were similar to those suggested by Pfaffman (1959). The concentrations used by Korslund (1962) ranged from 1.6×10^{-4}M to 3.0×10^{-4}M. She stated that four of her subjects never tasted a difference from water; in the present study, all of the children tasted a difference between the sample and water (Table IV-2). Only three children tasted the lowest concentration, sample 1; the other quinine sulfate tasters began tasting at the next concentration, sample 2, or higher. Because most of the children were first able to taste quinine sulfate at sample 2, it may be that finer demarcations of concentrations between sample 1 and sample 2 would show a greater variability of taste sensitivity for quinine sulfate.

Although this study was not designed to measure genetic differences in taste between siblings nor to determine if children were more sensitive to taste than are adults, some results did suggest such trends. There were two pairs of siblings among the subjects; one pair was a sister-brother combination and the other was an identical twin sister combination. In both pairs, one of the children was more sensitive to quinine sulfate than was the other. This phenomenon raises questions about the genetics of taste; however, these results by no means discount the argument that taste sensitivity may be genetically determined (Kalmus, 1971).

In the case of adult versus child taste sensitivity, Amerine, et al. (1965) quoted the results of a study by Blakeslee and Salmon done in 1935; these researchers found that of 47 adult subjects, 2 could taste quinine sulfate at 3.9×10^{-5} M and that 15 subjects first tasted quinine sulfate at 1.25×10^{-3} M. These thresholds were higher than those found in the present study, suggesting that for quinine sulfate children may be more sensitive to taste than are adults.

Sex differences in taste sensitivity, as well as possible age differences, also appeared to be present in the present study. (See Figure 1.) Other researchers have suggested that there are taste sensitivity differences between male and female organisms (Hamilton and Timmons, 1976; Moskowitz, et al., 1975; Tilgner and Barylko-Pilkielna, 1959; and Korslund, 1962). Korslund (1962) found that girls were more sensitive to taste for all of the four basic tastes than were boys. The results of the present study tend to support this observation (Figure 1). The reasons for this sex difference in taste are obscure; one speculation may be that females, because of their role in the perpetuation of the species, were protected from eating poisonous material by their greater sensitivity to bitter tastes. Many poisonous materials are bitter in taste (Fischer and Griffin, 1963) and when mankind was evolving, diets were primarily vegetarian; therefore, many plants which were poisonous could be avoided by means of taste and females thus were protected from unintentional death or severe illness. For pregnant or lactating females, this possible situation also protected the young.

Not only was there a difference between the two sexes in taste sensitivity to both quinine sulfate and sucrose, there was a difference between the subjects as a group in terms of taste sensitivity to quinine sulfate. Nearly half of the subjects in the present study were classified as extremely sensitive to quinine sulfate and the other half classified as more moderately sensitive or insensitive. This suggested that a genetically based quinine dimorphism may exist. This observation confirms observations made by Fischer and Griffin (1963), Korslund (1962), and Glanville and Kaplan (1965). The two groups of subjects (group 1, or those extremely sensitive to quinine sulfate and group 2, those less sensitive to quinine sulfate) did have differences in body size and eating habits. In fact, the difference in percentile values of weight-for-height was statistically significant, as were differences in percent of foods liked.

More sensitive quinine sulfate tasters appeared to have been fed pureed table foods more often as supplements to early feeding than were the more insensitive tasters. Food preferences were also related to taste sensitivity (Tables IV-13, IV-14). These phenomena suggest that sensitivity to quinine sulfate or bitter tastes in general may indeed be related to food intake patterns and, hence, body size.

Anthropometric Measurements

In comparing the mean height, weight, and triceps skinfold measurements of the subjects in this study (Table IV-2) to the means found by other researchers in their studies, it is apparent that the children in this study tended to be larger. The children in the present study were on the average heavier by 1.5 kg, taller by 7.5 cm, and larger in triceps skinfold by 1.5 mm than were those in the Crawford study (Crawford, et al., 1978). The children from the Health and Nutrition Examination Survey (HANES) study (Abraham, 1975) were also smaller than the children in the present study.

Possible explanations for these differences may lie in the nature of the population sampled. Both Crawford, et al. (1978) and HANES (Abraham, 1975) studied a more varied population composed of various socio-economic groups. In the present study, the children were for the most part the offspring of extremely well-educated, relatively affluent parents. As some authors have suggested, children from higher socio-economic stratas tend to have some anthropometric measurements which are larger than those of less affluent groups (Crispin, et al., 1968). Other factors which may explain the differences in the means between this study and the others include the factor of the weather at the time of the present study. Children may have weighed more because of added clothing worn during the cold months and winter shoes may have added some error to height measurements. However, triceps skinfold were taken on bare arms, so that these measurements are conceivably free from this type of error.

Differences in measurements between the two age groups, three year olds and four year olds, are to be expected because of the nature of the growth process in children. As the child gets older, his relative body mass increases. However, the percentage distribution of children over, at, and below the median percentile for weight-for-height remains fairly constant with age (Table IV-5). The differences in anthropometric measurements between the sexes (Table IV-2) are somewhat difficult to interpret. Contrary to evidence presented by Forbas (1972) and Abrahams, et al. (1977), Crawford, et al. (1978) found sex differences in anthropometric measurements at both three and four years of age. The present study showed that except for height in three year olds there were differences between boys and girls at both ages in all measurements. These findings are in agreement with those of Crawford, et al. (1978). This difference in body size between the sexes may be genetically determined, since males generally are larger than females, but hormones at puberty are also responsible for later differences in body size between the two sexes.

Correlations of taste sensitivity data with body fatness parameters resulted in relationships between Ponderal Index and quinine sulfate, weight-for-height percentiles and quinine sulfate, Ponderal Index and sucrose, and Upper Arm Muscle Diameter (UAMD) and sucrose. The negative correlation (Table IV-3) between Ponderal Index and quinine sulfate taste sensitivity suggested that as body mass decreases, sensitivity to quinine sulfate increases. This phenomenon is in partial agreement with the suggestions made by Fischer, et al. (1966) that persons sensitive to both 6-n-propylthiouracil (PROP) and quinine tended to be smaller or ectomorphic. The code for the National Center for Health Statistics' weight-for-height percentiles, perhaps the most accepted standard for all body fatness indices used in this study, was related to quinine sulfate taste sensitivity (Table IV-3). This also indicates that quinine sulfate taste sensitivity is related to more than one indicator of body fatness, thereby suggesting a definite relationship between sensitivity to taste and body fatness.

Sensitivity to sucrose correlated negatively with Ponderal Index and positively with UAMD, indicating that as sucrose taste sensitivity increases, body size decreases. This apparent relationship of sucrose sensitivity with body size contradicts the ideas of several researchers who believe that sucrose taste sensitivity is unrelated to body size. Instead, they believe that responsiveness to sucrose, i.e., ratings of pleasantness or aversion to large concentrations of sucrose, is the key to understanding the relationship of sucrose to body size (Rodin, 1975, 1976; Grinker, et al., 1972; Cabanac and Duclaux, 1970).

The fact that these indicators of body fatness, percentile for weight-for-height and Ponderal Index, are related to taste modalities suggest that taste may play a role in controlling food intake and hence, body fatness. This interaction between taste sensitivity and eating behavior will be discussed in the next section.

Eating Behavior and Early Diet

Dislike for certain foods appears to be a characteristic of preschool children. In the present study, vegetables and pickles were the most disliked foods (Table IV-9). Dislike for vegetables was found to be a trend by other researchers (Korslund, 1962; Dierks and Morse, 1965; Eppright, et al., 1969; Beyer and Morris, 1974). Liking for certain types of foods is also characteristic of preschool children. Children in the present study tended to like milk, sweets, raw carrots and bland foods like white bread and rice (Table IV-8). Korslund (1962) found that milk, sweets, and white bread were popular. Other researchers found that meat was a favorite food (Beyer and Morris, 1974; Dierks and Morse, 1965). One drawback to the method used to determine food likes and dislikes in the present study was the fact that the mothers checked off the list containing the foods liked or disliked. This method introduced bias into the results, because the child himself was not reporting his own behavior.

It has been suggested that dislike for certain foods may be related to taste sensitivity (Korslund, 1962; Fischer and Griffin, 1963; and Glanville and Kaplan, 1965). Glanville and Kaplan (1965) suggested that bitter taste sensitivity may be directly related to food likes and dislikes. In the present study, foods liked or disliked were related to taste sensitivity to both quinine sulfate and sucrose (Tables IV-9, IV-10, IV-13, IV-14). In the present study, the percent of foods liked was correlated with sensitivity to quinine sulfate; the higher the sensitivity for quinine sulfate, the fewer foods liked in relation to the total number tasted. This relationship was not seen for sucrose, suggesting that the "food rejection" theory may play a role (Fischer and Griffin, 1963; Kalmus, 1971).

Although the "food rejection" theory is based upon the tasting of phenylthiocarbamide (PTC - a bitter substance and a genetically controlled taste), the fact that PTC is bitter like quinine sulfate suggests that bitter sensitivity is related to the intake of certain foods. Van Etten (1969) stated that such foods as cabbage, kale, Brussels sprouts, cauliflower, and radishes (among others) contain a bitter taste due to the presence of PTC-like compounds. It may be that persons sensitive to quinine sulfate and other bitter substances have more food dislikes than those persons less sensitive to quinine sulfate. This phenomenon is supported by the evidence cited in Table IV-9, where the majority of the children disliking certain foods were also sensitive quinine sulfate tasters.

The number of foods disliked was not correlated with taste sensitivity, possibly because the raw number of food dislikes was not a sensitive enough variable to yield any such relationship.

However, individual food preferences on the checklist (Appendix D) did correlate with taste sensitivity. The fact that individual foods did correlate with taste modalities indicates that taste sensitivity is indeed a factor influencing eating behavior.

The relationship of food likes and dislikes to body fatness was not clear-cut. The percent of foods liked did not relate to body fatness parameters, suggesting that the total number of foods liked out of all foods ever tasted may not play a role in determining body fatness. Individual foods may play a role and an examination of more types of foods may prove more rewarding. Liking for milk was positively correlated with height, for example, and Ponderal Index was related to cooked cereal. Furthermore, types of foods chosen for the food checklist can be modified to include a wider variety of foods.

Another facet of eating behavior, caloric intake, provides still another way of looking at children's diets. Caloric intake among subjects in the present study was slightly larger than that reported by Beyer and Morris (1974). In both the present study and the Beyer-Morris study, subjects were above the RDA for calories. However, activity levels and other factors are not easily measured and, therefore, any statement about caloric excess must be made with care.

Caloric intake was not related to quinine sulfate taste sensitivity; sucrose taste sensitivity was related to caloric intake. This is probably due to higher intakes of calories by the less sensitive sucrose tasters. Foods high in sucrose tend to be more calorically dense than are foods with a bitter taste, thus accounting in part for the lack of a relationship between calories and quinine sulfate. The theory postulated by Jacobs and Sharma (1969) implies that animals will eat for calories when their bodies reach the point where the calories are not absolutely needed. The same animals will eat for taste or palatability when their bodies demand an intake of calories. Higher intakes of calories by less sensitive sucrose tasters suggests that perhaps these subjects are not eating for gustation; rather, they are eating for the sake of eating. Wooley, et al. (1972), however, question whether or not calories can be perceived by organisms.

The question of hunger and taste sensitivity was examined in the present study by asking the parents if the child was always hungry for meals or if he had to be coaxed to eat. There was no relationship between taste sensitivity factors and being hungry for meals or being coaxed to eat. If a child is hungry for meals, his food likes do tend to be higher than if he has to be coaxed to eat. Korslund (1962) found a relationship between being hungry for meals and lower taste sensitivity. The results of this study do not bear out her findings.

The early diet of the subjects was also examined in the present study as a means of determining eating patterns. The lack of a relationship between birthweight and present body found in this study suggests that Fisch, et al. (1975) and others (Influence, 1977) may not be entirely correct in stating that such a relationship exists. The fact that birthweight did correlate with age fed solids suggests that children who are heavier at birth tend to be fed solids earlier, perhaps because they are viewed as being more mature because of their larger size and thus ready to digest solids. That taste sensitivity was not related to birthweight indicates that either no role is played by innate taste ability in determination of body size at birth or that taste sensitivity becomes more important in determining body fatness once foods are actually ingested.

Although the following observations were not part of the objectives of this study, it was found that a larger percentage of female children were breastfed than were male children. Certainly the fact that most of the children were the offspring of more educated families suggests that breastfeeding would be prevalent, given the current trend toward breastfeeding in this economic group (Jelliffe, 1976). The trend has also been for the college-educated to prepare supplementary baby foods from homemade dishes. This trend was supported by the results of this study, in that a larger proportion of breastfed children were also fed home-prepared baby food. No information was found in the literature to explain the dichotomy between the sexes in terms of breastfeeding.

Jelliffe (1973) and Dwyer and Mayer (1973) suggested that the age at which subjects were fed solids could influence later obesity. Wurtmann (1976) confirmed this in his study with rats. In the present study, no definite relationship was found between the age at which solids were fed and body size; however, there appeared to be a relationship between body weight and age fed solids that suggested that as age fed solids increased, present body weights do not vary as much as if solids were fed earlier (Figure 2). This suggests that there may indeed be vulnerable period for fat cell production as postulated by Gurr, et al. (1977) and Brook (1972). The data from this study also suggest that the feeding of solids may be influenced by the incidence of breastfeeding; solids appear to be withheld longer in cases where the child was breastfed.

Taste sensitivity did not relate either to the age at which solids were fed or to the type of solids fed. An explanation for this may lie in the simple fact that the child has no control over his food intake at this early age; therefore, the types of foods fed appeared not to be related because the question put to the parents about the types of foods did not try to measure individual foods fed, like strained carrots or other such foods. Perhaps a more specific attempt to determine the types of individual foods liked and disliked at that early age would show a significant relationship with taste sensitivity.

Current food intake did appear to be related to age at which solids were fed. Many of the foods liked were sweet in taste, suggesting that the earlier foods are introduced, the more likely the child is to accept them at a later date. The fact that the majority of the foods in question here were sweet (p. 63) in taste points out that current infant feeding practices may not be optimum. Another interesting fact is that food dislikes appear to be related to the feeding of commercial baby foods as solids.

Suggestions for Future Research

Future studies designed to measure body fatness in relationship to taste sensitivity and eating behavior should:

1. Modify quinine sulfate concentrations to include a wider range between 4.0×10^{-7} M and 2.03×10^{-5}M, in order to determine a finer gradation between sensitive tasters.
2. Include the other two basic tastes, sour and salty.
3. Modify the food checklist to include a wider variety of foods.
4. Attempt to have an equal distribution between the numbers of females and males in the sample.
5. Attempt to procure larger numbers of subjects from a wider range of social and economic backgrounds.
6. Examine the relationship between the mother's opinion on the child's food likes and dislikes and the child's opinion on his own likes and dislikes.
7. Include obese and underweight subjects in the sample.
8. Use PTC (phenylthiocarbamide) as part of the taste sensitivity tasting, in order to better test Fischer, et al.'s (1966) hypothesis that sensitive quinine and PTC tasters tend to be ectomorphic.
9. Attempt to isolate an efficient methodology for rapid taste testing, which could be used to screen for potential weight problems.
10. Control for zinc and copper status of one group of subjects and not for a second group of subjects.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Twenty-five children aged 3-4 years of age, were studied to determine if there was a relationship between body fatness, eating behavior, and taste sensitivity to quinine sulfate and sucrose. Anthropometric measurements such as height, weight, triceps skinfold, and arm circumference were made. Taste sensitivity was determined by a paired-comparison method using quinine sulfate and sucrose in increasingly larger concentrations. Eating behavior patterns were determined by means of a two-day food record, a checklist of food likes and dislikes, and a questionnaire filled out by the parents on the child's early diet. Data were analyzed by means of simple correlations, means, and analysis of variance.

There were sex differences in taste sensitivity, with girls being more sensitive to both quinine sulfate and sucrose than were boys. There also was an apparent quinine dimorphism among the sample. Fourteen subjects were extremely sensitive to quinine sulfate, whereas eleven were classified as being less sensitive. There were statistically significant differences in body fatness between the two groups of quinine sulfate tasters. Sucrose taste sensitivity also was related to body size through correlations with the Ponderal Index and Upper Arm Muscle Diameter (UAMD). Sucrose taste sensitivity was unrelated to the code for standard weight-for-height percentiles.

There were also sex differences in most anthropometric measurements, except for height in the three year olds. Girls were smaller than boys. There were age differences in body measurements, which were due to the normal growth process of the children. More boys than girls were above the 50th percentile for the weight-for-height percentiles, but none of the children were above the 95th percentile, the cut-off point for obesity. One child was in the 5th percentile.

Foods most disliked by the subjects in this study included vegetables and pickles. Foods most liked included milk, sweets, and bland foods. Taste sensitivity to quinine sulfate was associated with dislike for certain foods; sucrose taste sensitivity was also related to dislike for certain foods. Taste sensitivity thus was related to food likes and dislikes. Caloric intake was not correlated with quinine sulfate taste sensitivity, but did correlate with sucrose taste sensitivity.

Early diet was related in part to current food patterns, because the number of present food dislikes was related to the feeding of commercial baby foods as supplementary foods. Breastfeeding was related only to the age at which solids were fed; current body weights were not related to birthweights. Taste sensitivity to quinine sulfate and sucrose appeared to be unrelated to early diet. Current body size was also unassociated with early dietary factors, except for an apparent relationship between the age fed solids and current weight.

In conclusion, the results of the present study tend to support the hypothesis that body fatness is a function of taste sensitivity. Other factors such as food dislikes were related to taste sensitivity but not to body fatness or body size; the possibility exists that such a relationship may be present, but the numbers of subjects in the present sample did not allow for significant relationships to surface. Early diet did not appear to play an important role in determination of body fatness or body size. Again, such a relationship between early diet and body fatness or body size might be discernible with larger numbers of subjects.

The important factor is that taste sensitivity, especially that to quinine sulfate, was related significantly to weight-for-height percentiles and to the percent of foods liked. These observations indicate that taste sensitivity tests may be possible in pinpointing potential obesity and food patterns at a young age. Future research should concentrate on the potentialities of taste sensitivity testing for the nutrition field.

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APPENDIX A

APPENDIX A-1

Taste Sensitivity, Eating Behavior, and
Body Size of Preschool Children

AUTHORIZATION FOR PARTICIPATION OF MINOR CHILD

Name of Child____

The undersigned, being the (Mother, Father, Guardian) of the above named child, hereby consents for the child named above to participate in the study of Taste Sensitivity, Eating Behavior, and Body Size of Preschool Children.

I have received an oral and written explanation of the study.

Information to be secured will include eating patterns of the child, as well as height, weight, and triceps skinfold thickness of the child. Socio-economic data on the number of children in the family, birth date, early eating habits, and food preferences will be collected. Taste sensitivity to bitter and sweet tastes will be measured.

All information obtained in the study will be held strictly confidential and will be used for statistical purposes only. My child's identify will not be revealed in any publication.

I may withdraw consent at any time.

____
Parent or Legal Guardian

APPENDIX A-2

February 7, 1978

Dear parents:

The study entitled, "Taste Sensitivity, Eating Behavior, and Body Fatness of Preschool Children," seeks to answer some questions about the eating habits and taste sensitivity of children in this age group. Most textbooks state that children are more sensitive to taste than are adults, but because few studies have been done on children's taste sensitivities, it is difficult to confirm this statement. I hope that you and your child will be interested in participating in this study.

My study plan is based on the one designed by my major profession, Dr. Mary K. Korslund, for her master's thesis at Iowa State University. I plan to collect height, weight, and triceps skinfold measurements of the children. Taste sensitivity will be measured using bitter and sweet tasting substances. I will also need information on the eating behavior of the children; i.e., food likes and dislikes, food intake over a two-day period, and food habits in infancy.

Statistical analysis of these data will hopefully throw some light on the question of children's eating habits and taste sensitivity in relation to body size and type.

If you have any questions regarding the study, please feel free to call me at   or Dr. Korslund at   .

Sincerely yours,

Cynthia D. Bertelsen
Graduate Student
Dept. of Human Nutrition
and Foods

APPENDIX A-3

February 16, 1978

Dear parents:

Thank you so much for your permission to use your child as a subject in my thesis research. This letter is to clarify the use of the food recall forms and of the other two forms enclosed.

The two-day food recall record should be done on Feb. 20 and 21 (if you are unable to do this, let me know as soon as possible, and we can set up alternative days); I will keep a record of what the child eats at school. Please measure all foods in cups, tablespoons, and teaspoons or numbers of pieces eaten (i.e., 1 banana, 1 peach half, etc.). Please include all beverages, butter or margarine, mayonnaise, ketchup, or other such things which can be measured in tablespoons or teaspoons.

The short questionnaire and the food likes/dislikes form should be filled in and returned with the food recall form. Please return these forms as soon as possible after February 22 to when you check your child into school in the morning.

Again, I thank you very much for your participation.

Sincerely yours,

Cynthia D. Bertelsen
Graduate Student-Human
Nutrition & Foods Dept.
(Home phone:
after 5 p.m.)

APPENDIX B

APPENDIX B-1

Subject Name and Number ______________________________

ANTHROPOMETRIC DATA RECORDING FORM

Measurement	First Series	Second Series	Averages
Date			
Height (kg)			
Triceps (mm)			
Arm Circumference (cm)			
NCHS Percentiles Weight			
Height			
Triceps			
Indices: UAMD[a]			
Ponderal			
Body Mass			
Weight-by-Stature Percentile			

Visual Assessment of Child's Body Build ______________________________

____

Body Build Score: ____________________

[a]Upper Arm Muscle Diameter

APPENDIX B-2

Relationships of Selected Variables with Food Likes and Dislikes

Variables	Correlation Coefficients: Number Foods Disliked	Percentage Foods Liked	Quinine	Sucrose
Child Hungry	.02	.18	-.05	-.25
Child Coaxed	-.02	-.42[a]	-.01	-.14
Weight	.12	.17	-	-
Triceps	.04	.10	-	-
Arm Circumference	-.02	.13	-	-
Upper Arm Muscle Diameter	.01	.06	-	-
Ponderal Index	.01	-.05	-	-
Body Mass Index	.09	.17	-	-
Code	.10	.15	-	-

[a] $p < .05$.

APPENDIX C

APPENDIX C-1

Questionnaire for Parents of Subjects

1. Child's name ______________________________

2. At what age did your child receive solid foods? ______________

3. What foods did your child receive as solid foods?

   (1) Cereal _________

   (2) Pureed table food __________

   (3) Commercial baby food _________

   (4) Other ___________________________________

4. Is your child currently receiving any medication? _________ If so, what is this medication? ___________________________

5. Has your family (husband's or wife) lived in the southeastern part of the United States for 200 years or more? ____(yes or no)

APPENDIX C-2

Questionnaire Data for Study on Taste Sensitivity, Eating Behavior, and Body Fatness of Preschool Children

1. Subject's name & study number ______________________
2. Address ______________________
3. Location of dwelling is: (1) ____ Urban
   (2) ____ Rural
   (3) ____ Suburban
4. Occupation of the father ______________________
   Occupation of the mother ______________________
5. Years of education of the father ________; the mother ________
6. Number of children in the family other than the subject _______
7. The subject is the oldest, the youngest, etc.? _______________
8. Birth date of the subject ______________________
9. Birth weight and length of the subject _______ lbs. ________oz.
   ____________ inches
10. Was the subject premature? ________ If yes, how many weeks? ___
11. Was the subject breastfed? ________ If yes, how long? _________
12. At what age did the subject first receive solid foods? ________
13. What foods did the subject receive as weaning foods?
    (1) _____ Cereal
    (2) _____ Pureed table food
    (3) _____ Commercial baby food
    (4) _____ Other
14. Does the subject have any chronic illnesses? ______ If so, what are they? ______________________
15. Is the subject taking any medication regularly? _______________
    ____
16. Has your family (husband's or wife's) lived in the southeastern part of the United States for 200 years or more? _______________

APPENDIX D

APPENDIX D-1

Child's Name ________

FOOD CHECK LIST

Foods	Likes	Accepts	Will not eat	Has never tasted
Milk				
Cheddar cheese				
Cottage cheese				
Ice cream				
Carrots, raw				
Carrots, cooked				
Sweet potatoes				
Spinach				
Broccoli				
Peas				
Green beans				
Turnip greens				
Radish				
Cabbage				
Brussels sprouts				
Lettuce				
Celery sticks				
Tomatoes, fresh				
Tomatoes, canned				

APPENDIX D-1--Continued. Child's Name _____

Foods	Likes	Accepts	Will not eat	Has never tasted
Kale				
Cauliflower				
Orange juice				
Raisins				
Nuts				
Potatoes				
Garden cress				
Mustard				
Baked beans				
Dry cereals				
Cooked cereals				
White bread				
Whole wheat bread				
Rice				
Pie				
Candy				
Cake				
Jelly or jam				
Olives				
Potato chips				
Spaghettio's				
Sour pickles				

APPENDIX D-1--Continued.

Child's Name _____

Foods	Likes	Accepts	Will not eat	Has never tasted
Dill pickles				
Sweet pickles				
Rutabaga				
Kohlrabi				
Canned soups				
Franco-American Ravioli-o's				
T.V. dinners				
Doughnuts				
Cookies				
Coca-Cola				

APPENDIX D-2

Home Record

TWO DAY DIETARY RECORD FOR NURSERY SCHOOL-AGE CHILDREN

Name of Child ______________________ Age ________ Date ________

Usual time for: Breakfast ______________ Snacks ______________

Dinner ______________

DAY	BREAKFAST	DINNER	SNACKS
I			
II			

Note: Please measure all foods eaten, if possible, in common household measures; i.e., ¼ cup peas, ½ cup macaroni, etc. Please include all condiments used as well.

Would you say that your child is always hungry for meals? __________

If not, does he have to be coaxed to eat? ______________________

APPENDIX D-3

School Record

TWO DAY DIETARY RECORD FOR NURSERY SCHOOL-AGE CHILDREN

Name of Child ______________________________ Age _________ Date _________

Usual Time for: Lunch ____________________

Day	Lunch
I	
II	

APPENDIX D-4

Menus for Lunch at School
for Two-Day Food
Records
2/20/78 & 2/21/78

Monday, February 20, 1978

Deviled eggs
Broccoli
Apple slices
Toast
Milk
Cherry Pie

Tuesday, February 21, 1978

Swiss steak
Parsley potatoes
Squash
Bread and butter
Milk
Pears

APPENDIX D-5

Percentage of Foods Liked and Taste Group[a] Classification of Subjects

Subject Number	Percentage of Foods Liked[b]	Taste Group
1	42.8	1
2	71.4	1
3	57.5	1
4	70.0	1
5	63.0	1
6	68.3	2
7	63.0	2
8	58.3	1
9	73.3	2
10	51.0	1
11	60.0	1
12	35.1	1
13	77.7	2
14	67.4	2
15	62.0	2
16	62.0	1
17	79.5	2
18	86.3	1
19	72.7	2
20	41.3	1
21	40.5	1
22	69.0	1
23	53.1	2
24	52.7	2
25	61.9	2

[a]Group 1 = Sensitive quinine sulfate tasters, 2 = Insensitive quinine sulfate tasters.

[b]Calculated from total tasted.

APPENDIX E

APPENDIX E-1

Taste threshold tasting recording form: Nursery school children

Response Date __________ Home and Number ______________

Substance Tested _______ Birth Date ____________________

Sex ___________________________

Sample Number	Concentration	-2	-1	0	+1	+2	Verbal Reactions Is this the same? No	Yes	What is it like?
1									
2									
3									
4									
5									
6									
0 (water)									

Do you like it? ________________

Key to facial reactions:

-2 Extreme Displeasure

-1 Displeasure

0 No Change

+1 Pleasure

+2 Extreme Pleasure

Procedure and Questions:

1. Give a sample of #0. "Try a sip of this." "What is it?" (water?)
2. Give a sample of #2. "Does this taste the same?" "What is this like?"
3. Continue the same procedure until the response to question 2 is "No." Again ask "What is this like?"

Subjective evaluation of the child's ability to give an accurate response:

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TASTE SENSITIVITY, EATING BEHAVIOR, AND
BODY FATNESS OF PRESCHOOL CHILDREN

by

Cynthia D. Bertelsen

(ABSTRACT)

The possible relationship between body fatness and taste sensitivity was studied. Twenty-five preschool children aged 42 to 61 months served as subjects. Heights, weights, arm circumferences, and triceps skinfolds were measured. Taste sensitivity to quinine sulfate and sucrose was assessed with paired-comparison tests. Eating habits and food preferences were examined via questionnaires and two-day food records. Analysis of data was by simple correlations, means, and analysis of variance.

There appeared to be a relationship between taste sensitivity and body fatness. Weight-for-height percentiles were positively correlated with sensitivity to quinine sulfate ($p < .05$). There was a negative correlation between quinine sulfate and the Ponderal Index ($p < .05$). Sensitivity to sucrose was negatively correlated with the Ponderal Index ($p < .01$). Subjects were distributed into two groups, those sensitive to quinine sulfate (taste threshold ceiling 2.03×10^{-5} M) and those insensitive to quinine sulfate (taste threshold ceiling non-existant). There were significant

differences between the two groups in terms of body fatness and percent of foods liked. More sensitive tasters liked fewer foods and had less body fat. Diet during infancy was not correlated with either taste sensitivity or body fatness. There was no relationship between the degree of body fatness and the percent of foods liked.

These results support the idea of a relationship between taste sensitivity and body fatness. Subjects more sensitive to taste appeared to have less body fat and to be more discriminating in their food choices than those subjects more insensitive to taste.