BIRTHWEIGHT DOUBLING TIME AND ITS ASSOCIATION WITH INCREASED SKINFOLD MEASUREMENTS

A THESIS

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be accepted as fulfilling this part of the requirements for the Degree of MASTER OF SCIENCE.

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CHAPTER I

INTRODUCTION

Wherever people congregate, one can see that people come in every possible size--fat, thin, short, tall, husky, and fragile. Infants come in a variety of sizes, too, but healthiness is often confused with heartiness, and the large, plump infant is most often applauded for growing so well. The infant's weight gain, therefore, becomes synonymous with how well he is doing. However, health in its broadest sense can be assessed through many factors. These include not only parameters of normal physical growth, but also the infant's emotional development, level of activity, and freedom from those conditions which predispose to future disease.

The contrast between the fat, overfed infant, and the quest of adults for slimness, has prompted investigators to search for clues in contemporary infant feeding practices which might explain the origins of obesity. This search has led to the development of two theoretical explanations, both grounded in scientific explanation, which might shed light on the link between infant overnutrition and later obesity. First, the first year of life is crucial for the determination of absolute number of adipose cells by hyperplasia of the natal complement of fat cells which takes place under the stimulation of excess calories. Current nutritional theory now stresses the importance of this absolute increase in the number of fat cells as a determinant of obesity in later life. Second, it is during the period of infancy that the individual's eating pattern begins to be shaped. These patterns are what determine for the adult the internal and external cues that trigger what developmentalists call "food-searching behavior." Thus, infant feeding patterns may develop both physical and psychological propensities to adult obesity.

Many changes in infant nutrition and feeding practices have occurred in the past half-century. Among these are the shifted emphasis from undernutrition to over-nutrution which occurred in the 1920's after the importance of certain vitamins was realized. This emphasis was strengthened by the great depression and two world wars, which dramatized to the American public the effects of undernutrition. In addition, the trend from breast- to bottle-feeding increased, and the age for introduction of solid foods to infants became progressively earlier (Fomon 1967). These changes have all contributed to some degree to the evolution of children that are bigger, taller, and reach puberty earlier than those of twenty or thirty years ago (Trowell 1975). As the relationship between diet and disease is further explored, the tendency to equate maximum growth with optimal growth must be questioned.

The fact that an infant's growth must be looked at in individual perspective is illustrated by the following poem by John Kendrick Bangs:

> I met a little Elfman once,
> Down where the lilies grow.
> I asked him why he was so small,
> And why he did not grow.
> He slightly frowned and with his eyes
> He looked me through and through.
> "I'm quite as big for me," he said,
> "As you are big for you" (Illingworth 1975, p. 66).

This study, through analysis of several dimensions of an infant's growth, will attempt to increase understanding of some factors which contribute to physical growth.

Statement of Problem

The problem of this study was to determine when birthweight doubling occurred and whether or not it was associated with increased skinfold measurements.

Purposes

The purposes of this study were to

1. Analyze data related to growth, adiposity, and feeding practices of male and female infants

2. Determine, through analysis of anthropometric data, whether a relationship existed between skinfold thicknesses and the time at which infants doubled their birthweights

3. Compare birthweight doubling time of male and female bottle-fed and breast/combination-fed infants

4. Compare measurements (weight, length, head and chest circumferences, triceps and subscapular skinfold thicknesses) of male and female bottle-fed and breast/ combination-fed infants

5. Compare measurements and birthweight doubling time of Caesarean and vaginally-delivered infants

Background and Significance

The growth and development of an infant is intimately related to his health and nutrition. An infant's weight gain is perhaps the single most important method for confirming the adequacy of food intake (Illingworth 1975). The time at which an infant doubles his birthweight has traditionally been used as a landmark of physical growth (Neumann and Alpaugh 1976). Although several authors state that five to six months is the average time for birthweight doubling to occur (Nelson 1975, Watson 1973, Illingworth 1975), evidence was presented as early as 1965 that four months was probably a more average birthweight doubling time (Hooper 1965). Neumann and Alpaugh (1976) recently reexamined the problem and found the mean age for birthweight doubling to be 3.8 months. This finding carries an imperative to determine more clearly the significance of early weight gain, and the factors contributing to it. Are infants becoming larger in all parameters, or are infants merely more obese? The possibility that increased fat deposition contributes to earlier birthweight doubling time may be especially meaningful, since studies suggest a link between early excessive weight gain and later obesity (Asher 1966, Eid 1970, Crawford et al. 1974, Heald 1965).

Obesity among adults has generally been accepted as a major health problem. But concurrence about the significance of obesity in infancy or childhood has not been as great, probably due to the lack of data which clearly delineates the problem. Obesity among infants less than one year of age was shown to be common in England by three studies (Hutchinson-Smith 1970, Taitz 1971, Shukla et al. 1972). Taitz' study gave credit to the assumption that fat babies were overfed babies. Several studies associate rapid excessive weight gain in infancy to obesity in later childhood or adolescence (Asher 1966, Crawford et al. 1974, Eid 1970, Heald 1965). Asher and

Eid indicated that infants who demonstrated obesity at age five to six months, compared with those infants who did not demonstrate early excessive weight gain, were more likely to be obese at age five to eight years. However, the studies of Melbin and Vuille (1973) with Swedish urban children did not agree that infant overnutrition was an important cause of obesity.

Studies which explored adipose tissue cellularity have enhanced speculation that an increase in adipose tissue mass in infancy may correlate with later obesity. An increase in adiposity may occur in several ways--through hyperplasia (an increase in the number of cells), hypertrophy (enlargement in cell size), or through a combination of both processes. Studies with rats have demonstrated that overnutrition early in life results in hyperplasia of adipocytes, whereas later it causes only hypertrophy, since the total cell number of adipocytes has become fixed (Hirsch and Han 1969, Johnson et al, 1971). Brook, Lloyd, and Wolff (1972) indicated that an increase in the total number of cells tends to occur only in those children who were overweight during the first year of life. Brook (1972) further suggested that a sensitive period exists for adipose cells, which extends from the latter part of fetal life through the first year after birth. It is during this sensitive period that the rate of cell multiplication is affected by external influences, including nutrition.

It has generally been thought that increased adipose tissue cellularity will persist throughout life (Lloyd 1975). In the quest for clues about the origin of obesity, these studies concerning adipocytes have given rise to the premise that their presence in excess may be related to the persistence of or subsequent development of obesity in later life. A second premise is that obesity due to adipose hyperplasia may be more difficult to treat than obesity due to cell enlargement. No evidence supports these speculations as yet, nor has it been shown that all obese infants have increased cellularity (Lloyd 1975).

In addition, the determination of the exact proportion of adiposity in relation to total body mass has proved to be quite a methodological problem. Several methods exist for calculation of the number of fat cells through the use of a few milligrams of adipose tissue, but each method allows some error or variability. For example, after fixation with osmium tetroxide, adipose cells can be counted and sized. However, those cells containing very little lipid, but which may be the precursors of mature fat cells, are not included in the count (Hirsch 1970).

Biopsies may be taken to determine adiposity, yet biopsies from a single site may be misleading since the size of fat cells varies regionally in the body (Khan et al. 1974). Other methods to determine adiposity which are used with varying degrees of success are radiology, ultrasound, underwater weight, and electrical conductivity.

Measurements of skinfold thicknesses have been used for the past 25 years as an index of the amount of subcutaneous fat. Although skinfold measurements probably cannot estimate total body weight with as much accuracy as underwater weighing or some of the chemical dilution methods (Tanner 1955), skinfold measurements provide a simple, rapid, harmless, and noninvasive method of fat estimation (Nutritional Reviews 1975). Tanner (1962) and Garn (1962) found that correlation between skinfold measurements, radiological findings of fat width, and direct measurement of fat at surgical operations is high. Edwards and White (1962) advocated that skinfold measurements alone gave a better indication of fat mass than the traditional height-weight indices, and the prediction of the amount of adipose is improved further by combining skinfold measurements with other measurements of body size (such as surface area or body weight).

Accuracy in the measurement of body fat has not been the only obstacle in the study of obesity. Multiple factors contribute to why an infant gains weight at the rate he does. Many of these factors, such as genetic endowment, metabolic abnormalities, energy expenditure, and emotional disturbances in parents or infants, do not easily lend themselves to analysis. However, many other factors have been studied. These include nutritional individuality, self-regulation of food intake, difference between breast- and bottle-feeding, and the time of introduction of solids (Lloyd 1975).

Nutritional individuality refers to the broad range of individual energy requirements in childhood (Widdowson 1962). The energy requirement variation between infants, and also considerable day-to-day variation in individual infants, was emphasized by Dugdale (1967). It is possible that artificial feeding may tend to nullify this nutritional individuality. Lloyd (1975) stated that since artificially-fed babies are usually fed according to criteria based on "average" requirements, it is possible that infants will sometimes be encouraged to take more formula than they require, and some infants will lay this surplus down as fat.

Differences between breast- and bottle-feeding practices of mothers may contribute to variations in infant growth patterns. More rapid weight gain in bottle-fed infants has been reported by several authors (Eid 1970, Fomon 1974, Shukla 1972). Although the reasons for a more rapid gain are undoubtedly complex, one consideration is that the bottle-fed infants have been overfed. The breast-fed infants may be able to more effectively control their intake, perhaps escaping the risk of being "conditioned" to chronic overeating problems (Neumann and Alpaugh 1976). Excessive calorie intake is a second consideration, since errors in the reconstitution of formula feedings are not uncommon. In most cases, the errors are in the excessive concentration of the formula. Errors of this type increase the calorie intake of infants, but they also raise dangers of hypernatremia from such feedings (Oates 1973, Shaw et al. 1973, Wilkinson et al. 1973).

Another factor being explored in the study of infant obesity is the effect of early introduction of solids upon excessive weight gain. Until about 1920, solid foods were rarely offered to infants before the age of one year (Fomon 1967). This practice has changed greatly--a 1964 study found that 83% of two-month-old infants seen in a

Washington, D.C. clinic had begun to receive solids when seen for their first clinic visit (Epps and Jolley 1963). Two more recent British studies found that about 20% of infants start on solids during their first month (Shukla et al. 1972, Oates 1973). Sackett (1956) demonstrated that introduction of cereals and strained foods as early as the first two weeks of life is possible. However, the advantages or disadvantages of such practices have not yet been determined.

Disagreements exist regarding whether artificially-fed infants are fed solids earlier than breast-fed infants (Neumann and Alpaugh 1976, Lloyd 1975). However, evidence indicates that the milk intake, from whatever the source, is not reduced concurrently with the introduction of solids. It seems likely that this could only result in increased energy intake, although the exact contribution of early introduction of solids to obesity is unknown (Lloyd 1975).

Treatment of obesity at any age is known to be difficult. Updated methods of evaluation of physical growth must be developed, so that the earliest signs of excessive weight gain can be appreciated. The opinions and guidance of those involved in the health care profession are sought constantly by parents concerned with the growth of their children. The factors which contribute to the normal growth of healthy infants need further clarification. Of equal importance, the determinants of the development of infant obesity also need to be scrutinized.

Definition of Terms

For the purposes of this study, the following terms were defined.

1. Breast-fed infants--those infants whose only source of milk was from breast-feeding for a minimum of three months (Neumann and Alpaugh 1976), except for an occasional replacement bottle of formula or cow's milk (no more than one artificial feeding per 24-hour period) (Nelson 1975, Fomon 1967)

2. Bottle-fed infants--infants who received proprietary formula or cow's milk by bottle (excluding skimmed-milk-fed infants) (Neumann and Alpaugh 1976)

3. Combination-fed infants--those infants who were partially breast-fed and supplemented with bottle-feedings (more than one bottle-feeding per 24-hour period), or who were breast-fed for less than three months and then switched to bottle-feedings (Neumann and Alpaugh 1976)

4. Solids--any nonliquid food fed by spoon or placed in the bottle along with the feedings (Neumann and Alpaugh 1976)

5. Infant--a child within the age range of birth to 18 months (Chinn 1974)

6. Normal infant--those infants who were products of normal, full-term pregnancies; who were products of vaginal or Caesarean-section deliveries; whose Apgar scores were seven or greater at one and five minutes after birth (Barnett 1973, Goerzen and Chinn 1975); who had no obvious deformity or illness; and whose birthweights ranged from 2500 grams (5.51 pounds) to 4100 grams (9.03 pounds) (Neumann and Alpaugh 1976)

7. Normal full-term pregnancy--a pregnancy lasting between 37 and 42 weeks (Schaffer and Avery 1971, Nelson 1975, Goerzen and Chinn 1975) that was not complicated by a serious infection or medical condition (Goerzen and Chinn 1975)

8. Obesity--the generalized excessive accumulation of subcutaneous fat and fat in other tissues (Nelson 1975). An infant was classified as obese if his skinfold measurements were more than two standard deviations greater than the mean (Fomon 1974, Fry et al. 1975 Table II--Means and Standard Deviations of Skinfolds and Arm Circumferences)

Limitations

The investigator had no control over the

1. Quality or amount of prenatal care received by the mother during her pregnancy

2. Ordinal position held by the infant in his family

3. Actual amount of breast milk, formula, or solids that an infant received

4. Time that the infant started solids

5. Parameters of stimulation that an infant received in the home

6. Number of bottle-feedings that breast-fed infants received prior to discharge from the hospital nursery

7. Choice of brands of formulas or solid foods given to the infant nor the accuracy in mixing the formulas

8. Timing of the collection of the infant's measurements in relation to preceding feedings, urination, or defecation of the infant (Illingworth 1975)

9. Degree of maternal-infant bonding that occurred

10. Race of social class to which mothers and infants belonged

11. Attitudes of the mother about her infant or her choice of feeding technique

12. Accuracy of the infants' birthweights, head, and chest circumferences recorded in the neonatal charts

Delimitations

The investigator was able to control the

1. Performance and recording of all measurements and feeding data, with the exception of the initial (birth) measurements of weight, head, and chest circumferences; and also with the exception of the measurements of the final seven infants to double their birthweights (see chapter III, Collection of Data)

2. Admission of infants to the study. All study infants were normal healthy infants who were products of normal full-term pregnancies

3. Disqualification of infants from the study. Infants were disqualified if they

   a. Developed any condition that required hospital admission

   b. Developed more than three infections involving the respiratory tract (Nelson 1975)

   c. Were diagnosed to have malabsorption syndrome of any type or who developed episodes of vomiting and diarrhea which persisted for longer than five days (personal communication with John D. Nelson, M.D., Professor of Pediatrics, Chief--Division of Pediatric Infectious Disease, UTHSC; December 11, 1976)

Summary

Neumann and Alpaugh's study with 357 infants in 1976 showed that the average time at which an infant doubles his birthweight occurred earlier than the average time stated in several pediatric textbooks (Nelson 1975, Watson 1973, Illingworth 1975). It is unclear whether this finding indicates that today's infants are larger in all physical parameters, or whether increased early fat accumulation contributes to the earlier average birthweight doubling time.

This study determined when 29 infants doubled their birthweights, and whether or not they were obese at the time of doubling. Comparisons of the age at which birthweight doubling occurred, various anthropometric measurements, and the age at which solids were introduced were made between the bottle-fed group and the breast/combination-fed group, and also between male and female groups.

Chapter II, Review of Literature, contains a discussion of the risk factors associated with obesity, and the effects of obesity at all ages. Studies of the significance of infant and childhood obesity are reviewed,

along with studies on adipose tissue cellularity. This chapter also includes a discussion of the problems involved with accurate determination of adiposity and the importance of skinfold measurements, and an overview of the historical development of current feeding patterns, including trends in breast- and bottle-feeding and the introduction of solids to infants. Chapter III, Procedure for Collection and Treatment of Data, includes full descriptions of the study's settings, population, and tools. It also discusses specifics of the data collection and the treatment of data.

The fourth chapter is the Analysis of Data. The results and interpretation of the findings and of statistics used in the study are presented in this chapter. Finally, chapter V, Summary, Conclusions, Implications and Recommendations,includes a review of the entire study and a discussion of all the possibilities derived from the study. Implications which may be extracted from the study's results are discussed, and suggestions for further study are offered in this final chapter.

CHAPTER II

REVIEW OF LITERATURE

The growth and development of an infant is generally of prime concern to those involved in the care of the infant, including parents, health professionals, relatives, and friends. The extent to which an infant thrives is related intimately to his health and nutrition, through both simple and complex relationships.

One traditional landmark of physical growth has been the time at which an infant doubles his birthweight. This has generally been thought to occur at five to six months (Nelson 1975, Illingworth 1975, Watson 1973). However, as early as 1965, Hooper reported that four months might be a more average birthweight doubling time. In re-examining the problem recently, Neumann and Alpaugh (1976) found the mean age for birthweight doubling among 357 infants to be 3.8 months.

The implications of possible earlier birthweight doubling times among infants have yet to be fully understood. There are, however, two major concerns. First, it is possible that today's infants have had accelerated growth in all physical parameters, compared to infants of decades ago. A second alternative is that the changing birthweight doubling time is a manifestation of an increasing incidence of infantile obesity. In either event, it would appear likely that such changes could be related to recent alterations in infant feeding practices. An understanding of the many facets of this complex nutritional problem requires a review of the literature relevant to these two topics, infant obesity and feeding practices.

Obesity afflicts 7 to 25% of adults in the United States and other affluent industrialized countries (Jelliffe 1975). It has also been estimated that 12% of prepubertal children and 16% of adolescents are obese (Hammar 1975). Knittle and Ginsberg-Fellner's preliminary results in 1974 from studies of more than 700 three- to five-year-old children in Manhattan reveal a prevalence of obesity greater than 13%, making it apparent that obesity is also a problem in the U.S. nursery school population.

According to Jelliffe (1975), there is little doubt that obesity is common in some communities, and probably on the rise. It is becoming a problem shared by not only the wealthy, long-industrialized nations, but also those nations in which the effects of modernization are just now being felt. Although no exact figures are available for the incidence of obesity among American infants, infant obesity is recognized as a problem commonly encountered in pediatric practices. Also, in 1971 Taitz demonstrated that 59.6% of infants seen at British well-baby clinics were overweight as early as six weeks of age. The following year Shukla et al. (1972) reported that 44.4% of 300 normal infants in a British community were overweight or obese.

The disadvantages of obesity in adulthood are generally well-known and appreciated. Less appreciated, however, is the fact that disturbing physical and psychological side effects may accompany obesity at any age. Therefore, it remains a major concern to determine whether infant obesity is truly linked to later obesity in childhood, adolescence, or adulthood.

Several studies associate rapid excessive weight gain in infants to obesity in later childhood or adolescence (Asher 1966, Eid 1970, Heald and Hollander 1965, Crawford et al. 1974). Recent Swedish studies, however, revealed only a weak correlation between velocity of weight gain in infants and the degree of overweight at age seven years (Melbin and Vuille 1973).

Eighty percent of overweight children followed by Haase and Hasenfeld in 1958 were still overweight when re-examined at 20 to 36 years (Charney et al. 1976). In similar studies, Abraham and Norsieck (1960) also found 80%

persistence of obesity, and Lloyd, Whelen, and Wolff (1961) found that 75% of obese children were still obese eight years later. Fisch et al. (1975) reported that extremely obese or lean newborns tend to persist in their original physique at four and seven years. It has been found by Charney et al. (1976) that a child's weight status in the first six months of life has a definite relationship to weight status in the third decade, and infants with weights greater than the 75 percentile have a significantly higher rate of adult obesity than lighter infants. In their retrospective studies, Rimm and Rimm (1976) found that severely obese adult females were 2.4 times more likely than normal weight females to have been fat children, and they conclude that the risk of fat children developing severe obesity is substantially greater than for nonfat children.

Although the phrase "fat children tend to become fat adults" is supported by some research, several authors state that the results as yet are inconclusive and need further follow-up; they caution that it is by no means sure that most fat infants become fat children, nor that juvenile-onset obesity leads to an overly fat adulthood (Fomon 1974, Garn 1976).

There appear to be several important risk factors which may have some bearing on obesity. Socioeconomic factors play a major role. The 1976 Ten State Nutrition Survey found that children of all ages from higher socio-economic levels were fatter than those from families with lower incomes. Males at all ages continued to manifest this relationship between oncome and fatness, but females demonstrated a remarkable income-related reversal of fatness after late adolescence, when poorer girls and women became fatter, and richer girls and women became leaner (Garn and Clark 1976). Gold (1976) likewise stated that obesity is six times higher with females reared in lower social classes. Charney et al. (1976) concurred that belonging to a lower socioeconomic class may correlate with the tendendy toward obesity, but they could identify no correlation with sex.

Sometimes risk factors are so interrelated that it is difficult to dissect them to view each one clearly. This is the case with the factors of socioeconomic level and race. The Ten State Nutrition Survey in 1976 showed that although black males tend to be thinner than white males at all ages, black females remain thinner through adolescence, after which they are considerably fatter than their white peers (Garn and Clark 1976).

A third risk factor sometimes correlated with the tendency toward obesity is an infant's birthweight. Even pediatric texts offer different opinions on this factor. Fomon (1974) stated that infants with increased birthweights are likely to become obese adults, but Barnett (1973) stated that the birthweights of obese and non-obese children do not differ. This discrepancy parallels the lack of agreement reflected in both older and more recent studies. High birth weights in obese children have been found by Bauer (1929), Bjoreson (1962), Illingworth et al. (1950), Asher (1966), and Shukla et al. (1972). However, no difference was found in the studies of Bruch (1939), Wolff (1955), and Heald and Hollander (1965).

There appears to be general agreement that the tendency toward obesity does run along family lines. At the same time, almost every study acknowledges the difficulty of separating true hereditary traits from the environmental and social forces influencing members of the same family. Seven to ten percent of children of normal weight parents will become obese (Jelliffe 1975, Gold 1976). Introduction of one obese parent increases the risk of obesity of children of a couple to 50%, and the risk is further increased to 80% if both parents are obese (Jelliffe 1975, Collins 1975, Garn and Clark 1976). Lean parents do tend to have lean children, just as fat parents tend to have fat children. By age 17, the children with two obese parents are three times as fat as children of a lean couple (Garn 1976). Garm and Clark (1976) likewise reported a considerable degree of sibling resemblance--if one child is identified as obese, a 40% chance exists that a second child in the family is obese. However, Garn and Bailey (1976) also found that adoptive parent-child pairs show fatness similarities comparable to those of biological parent-child pairs, and genetically-unrelated siblings demonstrate fat similarities comparable to those of true siblings. Therefore, although familial tendency to obesity is generally acknowledged (Jelliffe 1975, Gold 1976, Garn and Bailey 1976, Charlen et al. 1976), the genetic hypothesis is not generally accepted as sufficient explanation of fatness similarities found in genetically-related individuals living together (Jelliffe 1975, Garn and Bailey 1976). At this time other possibilities, such as overabundant eating patterns or similarities in caloric intakes, energy expenditures, and attitudes toward food must also be considered.

Of the many possible risk factors for obesity, the four mentioned above--socioeconomic level, race, birthweight, and genetic influence--appear to have been researched the fullest to date. Charney et al. (1976) further identified level of education as a factor correlating with obesity, and also several factors for which they could identify no correlation--length, rate of weight gain, sex, year of birth, whether or not an infant is breast-fed, and ordinal position in family.

What are the implications of infantile obesity? For what reasons is an overweight infant considered "at risk?" One approach to answering these questions adequately is to consider the possible effects of obesity on a spectrum of immediate- to long-range complications.

At one end of the spectrum are the possible immediate effects of infantile obesity, including increased incidence of acute respiratory infections, overburdening of immature kidneys with a heavy metabolic load, and annoying skin complaints. In 1971, Tracey et al. identified almost two times as many acute respiratory infections in obese infants as normal. The reasons for this increased incidence are not fully understood, but one possibility is thought to be the additional burden of extra fat on the chest and respirations, leading to underventilation of the lungs. A second possibility is alterations in the infant's immune defenses (associated directly with obesity or indirectly with the early abandonment of breast-feeding and its associated immunological benefits) (Tracey 1971).

If the cause of an infant's obesity is overnutrition or overconcentration of formulas, the infant may be at risk for overburdening of his immature kidneys, which can occur when an infant's diet has an excessively high renal solute load. This may happen if an infant is fed large amounts of cow's milk formulas and other foods, and especially if the infant's formula is overconcentrated. The latter also subjects the infant to the dangers of hypernatremic dehydration (Jelliffe 1975).

Common skin complaints can become especially problematic if folds of fat make treatment a problem, due to irritation and inadequate ventilation of skin surfaces. Jelliffe (1975) also pointed out another immediate effect of infantile obesity, the "double vicious circle effect" (1975, p. 145). This occurs when a fat infant becomes less mobile, decreases his amount of kicking and movements, and thus decreases his energy expenditure; at the same time, the fat infant may be assumed to need more food, because of his larger size. Therefore, the infant is steered in two ways toward continuing obesity.

As a child develops, persistent obesity may cause delay and difficulty in walking, accident proneness, increased chances of developing postural deformities, or it may add a severe load if the child is burdened by a fracture or a neurologic disease such as cerebral palsy (Jelliffe 1975). Garn et al. (1956) found that obese children have higher lipid levels, are skeletally and dentally advanced, excrete larger than normal amounts of urinary 17-ketosteroids, are somewhat taller until puberty, and attain sexual maturation earlier than lean children (Garn 1976). Bruch noted that obese children exhibit a marked behavioral immaturity in contrast to their advanced physical development (Gold 1976). Other common emotional sequelae of obesity in older children and adolescents are defective body images, feelings of rejection and depression, social isolation, and increased difficulty with interpersonal relationships (Gold 1976, Rimm and Rimm 1976, Meyer and Neumann 1977).

At the far end of the spectrum of complications are problems associated with obesity later in life that contribute to obesity's reputation as a major health problem. These include increased incidences of coronary artery disease, atherosclerosis, and diabetes, resulting in decreased length of life and increased mortality rates. Also included are health problems related in various ways to obesity, such as hypertension, varicose veins, arthritis, cerebral vascular accidents, back pain, and dental problems (Jelliffe 1975, Collipp 1975).

Studies exploring the actual composition of adipose tissue have yielded the knowledge that the adipose organ expands by both hyperplasia (increase in cell number) and hypertrophy (increase in cell size). Studies with rats done by Hirsch and Han (1969) and Johnson et al. (1971) have demonstrated that overnutrition early in life results in adipocyte hyperplasia, but later in life results only in adipocyte hypertrophy. These researchers concluded that the rat's actual complement of adipose cells is determined very early in the animal's life. Brook (1972) reported that the time period extending from 30 weeks in utero to 9 to 12 months seems to be a critical time for formation of adipose cells in humans. He postulated that it is during critical peak replication periods that a hypercaloric intake may cause an increase in the number of adipose cells.

Brook, Lloyd, and Wolff (1972) studied the size and number of adipose cells in obese children and adults and found that the total number of adipose cells was increased in children already obese at one year of age, and in adults who dated their obesity to childhood. In 1976, Ravelli et al. reported the results of their follow-up study with 300,000 19-year-old males exposed to the Dutch famine of 1944-45. They found that famine exposure affecting the mother during the third trimester of pregnancy or the infant during the first months of life produced significantly lower obesity rates than famine exposure affecting the mother during the first half of pregnancy. This finding is consistent with the inference that nutritional deprivation affected a critical period of development for adipose tissue. Dugdale and Payne (1975) also concluded that cyclical changes in fat and lean tissue exist which they believe confirm the existence of such critical periods.

The adipose cell theory--that nurtitional alterations occurring after certain periods affect only the size of adipose cells, not the number of cells--is widely accepted as a possible explanation for obesity. However, several researchers urge that difficulties with sizing and counting procedures of adipocytes support the need for caution in acceptance of this theory (Widdowson and Shaw 1973, Hirsch and Knittle 1970, Ashwell and Garrow 1973, Khan et al. 1974). Other research findings indicated that the adipose cell theory may be too simplistic an explanation of obesity, and that the fat cell number may be affected by weight changes later in life (Wilkinson and Parkin 1974).

Generally it has been thought that hypercellular adiposity will persist throughout life (Lloyd 1975). It is speculated that obesity due to adipose hyperplasia is more difficult to treat than hypertrophic obesity, and this speculation gives rise to the philosophy that prevention of obesity should be emphasized far more than treatment. Knittle and Ginsberg-Fellner's (1975) data indicated that long-term maintenance of reduced weight has been found almost exclusively in youngsters whose initial total fat cell number was below the lower normal adult range. Weight reduction programs with obese children whose fat cell number was above adult normal values have been extremely discouraging. Interestingly, Ashwell's survey in 1975 of more than 2,000 men and women who claimed slimming indicated that persons who had been fat since childhood (indicating probably hypercellular obesity) lost just as much weight as persons who became fat as adults (indicating probably hypertrophic obesity). These results suggest that treatment of early-onset obesity may not be an unrealistic objective (Ashwell 1975).

Several other explanations for obesity have been offered. One study with rats suggested that chronic, nonspecific stress is capable of inducing hyperphagia and weight gains (Rowland and Antelman 1976). In response to

Ravelli's (1976) study with survivors of the Dutch famine, Kruskemper (1976) pointed out that the process of learning to properly discriminate stimuli has a critical phase between 3 and 12 months of life, and, therefore, psychologic processes may have been related to the biologic, somatic factors influencing obesity in these subjects. Bruch (1975) also reported that fat children's "lack of willpower," the most persistent explanation for fat people's inability to reduce, has been shown by recent investigations to be related to the abnormal development of hunger awareness. This tends to happen with well-meaning, overeager, but insecure or anxious mothers who indiscriminately feed their children whenever they express discomfort. This may result in fat children who eat whenever they see food, using it to relieve various states of tension or dissatisfaction (Bruch 1975).

Court (1976) reported that some children seem to have a higher "set point" for fat stores--weight gain of these children parallels that of normal children but apparently is set at a higher level, the reason for which is not understood. Turtle (1976) discussed two concepts which have been considered since 1973. The first is the recent recognition of the role of central appetite-control mechanisms and feeding patterns. Central glucoreceptors which respond to insulin and glucose exist, and disorders at this level may account for abnormal feeding patterns. The second concept is that some obese persons have decreased numbers of insulin receptors in their adipose tissue cells. This leads to decreased responses to insulin and increased insulin secretion (by an undefined feedback mechanism). Finally, Knittle (1975) stated that a large percentage of gestational diabetic women are frankly obese and subsequently bear children who also develop obesity. This explanation suggests a new possibility for the matrilineal transmission of obesity, the role of in utero or environmental factors secondary to obesity in pregnancy.

As the quest for the etiology of obesity continued, realization emerged that the use of weight alone falls far short in the accurate description of whether or not a child is overweight. Although standards for height and weight are useful for assessment of health and nutrition, they are not considered sufficient by themselves to answer many important questions about appropriate growth. Many additional techniques have been developed in the attempt to determine the exact proportion of adiposity in relation to total body mass, among them radiology, ultrasound, and the use of underwater weighing and electrical conductivity. Direct measurement of adiposity can be achieved during surgical operations or by biopsies of adipose tissue. However, the obvious drawbacks of inconvenience and the invasive nature of these techniques preclude their widespread use. Additional problems with exact determination of adiposity include the regional variations of the size of fat cells in the body (Khan et al. 1974), and difficulties in the actual counting of adipocytes, since precursors of mature adipocytes may contain too little lipid to be counted by current techniques (Hirsch and Knittle 1970).

By combining somatic measurements with skinfold measurements, the prediction of the amount of adipose can be improved (Edwards and Whyte 1962). Skinfold measurements have been used to some extent for the past 25 years. This method has advantages of being simple, rapid, harmless, and noninvasive. Skinfold measurements have also been found to correlate highly with radiological and direct surgical measurements of adiposity (Tanner and Whitehouse 1962, Garn 1962).

Skinfolds can be measured accurately only at sites where a proper fold of subcutaneous tissue and skin can be raised. The triceps and subscapular sites are the two most commonly-used sites. Tanner and Whitehouse (1975) suggested that these two sites together should be regarded as the minimal number, since considerable differences in growth curves between limb and body fat has been demonstrated. Studies have used various other combinations of sites, and McGowan et al. (1974) found in their study with newborns that the flank and quadriceps sites yielded the most reliable results. Most studies with infants indicate that skinfold measurements are of definite value in the more accurate determination of adiposity (Hutchingson-Smith 1973, Tanner and Whitehouse 1962, Brans et al. 1974, Tanner and Whitehouse 1955, Nutritional Reviews 1975, Parizkova 1961). However, Frisancho and Garn (1971) found that skinfold measurements may serve as indicators of nutritional status only at extremes of leanness and fatness, and Hernesniemi et al. (1974) could determine only weak correlations between skinfolds in infants and adolescents.

Fomon (1974) stated that skinfold thicknesses are generally greater in females; Gampel (1965) found slightly thicker skinfolds in newborn females also. Although McGowan et al. (1974) found significantly greater skinfold thicknesses in females than males in a population whose weights were greater than two kilograms, they also reported that variations exist in results about sex differences. Studies conflict on whether or not maternal skinfolds and obesity are associated with increased skinfold thicknesses in newborns (Whitelaw 1976, Gampel 1965).

Maximum skinfold thicknesses are reported as being reached at approximately nine months (Hutchinson-Smith 1973, Hammar 1975); Tanner and Whitehouse (1962) found the age to be 9 to 12 months. However, information presented at the March 1977 Infant Nutrition Symposium (A 23-City Live televised Symposium on Infant Nutrition," presented on March 23, 1977, L. J. Filer, Jr. M.D., Ph.D., Chairman) indicated that skinfold thicknesses achieve a peak at three months of age rather than nine months.

Many aspects of infant feeding practices emerge as influential when one considers infant obesity. Some aspects may permit quantitation, such as caloric value of various types of feedings and amounts of various nutrients in milks and foods, and thus allow easier analysis of their effects on infant obesity. Others are obviously influential and significant--for example, emotional disturbances in infants or parents, cultural practices, or pressures felt by mothers from friends, family, health professionals, or baby food manufacturers--but do not lend themselves easily to analysis (Jelliffe 1975).

Infant feeding practices, essentially stable for man's entire history, have changed drastically in the twentieth century. Until the early nineteenth century, few infants survived unless they were breast-fed. It was estimated that seven out of eight artifically-fed infants in London died at that time. Therefore, employment of a wet nurse was common, with elaborate rules for selection (Fomon 1974). Breast-feeding remained the most common mode of infant feeding until well into the twentieth century--a survey from 1911 to 1916 showed that 58% of infants were still breast-fed at one year age of age (Fomon 1974). However, Martinez and Salber in 1973 reported that only 10 to 15% of U.S. infants were breast-fed at age two months (Fomon 1974), and in 1977, Hambraeus reported that only 25% of U.S. infants were breast-fed at age one week, and only 5% at age six months.

In the early twentieth century, many events occurred in the United States which eventually had profound effects on infant feeding practices. This time period saw the development of safer water supplies and sanitary standards for the handling and storage of milk. The impact of the resulting introduction of evaporated milk in the 1920's was great. New discoveries also facilitated the development of easily-cleaned and sterilized bottles and nipples. Knowledge about the alteration of curd tensions paved the way for new methods of processing cow's milk so it could be more easily digested. Widespread marketing of homogenized milk began about 1940. Also, the need for vitamins C and D was clarified about 1930, and this also contributed to the success of bottle-feeding (Fomon 1974).

Commercial formula services began operating in the early 1960's,and by 1970 nearly all U.S. hospitals were using ready-to-feed formulas. Within several decades, the infant formula/food business had mushroomed into a mulimillion dollar industry.

Studies indicated that breast-feeding is less common among the lower classes than upper classes in Great Britain, Sweden, and the United States (Fomon 1974, Hammar 1975). The factors responsible for the decline of breast-feeding which has occurred since women have had an effective alternative method of feeding are numerous and interrelated. They include rapid urbanization, recent industrialization in some countries, the changing roles of women and their increased participation in the work force, and the availability of infant formulas and foods. Also included are commercial pressures, changes in family life, changes in attitudes and value systems, and lack of education and interest on the part of health professionals (Harfouche 1970, Jelliffe, D. 1975, Jelliffe, E. 1977).

It is obvious that artificial feeding is here to stay, and that it is generally an adequate means of providing nutrients to infants. But differences do exist between breast- and bottle-feeding, and it is necessary to examine these differences in order to fully appreciate both methods.

Recent knowledge has indicated that the differences between human and cow's milks are more diverse and subtle than was originally suspected (Jackson 1977). Provided that the mother is well-nourished, human milk will provide all the necessary nutrients until about six months of age, with the exception of vitamin D. Fluoride must also be provided, since human milk has a lower content of fluoride than cow's milk; iron supplementation is usually given with both human and cow's milk, because both are considered to be poor iron sources, and an infant's iron stores from birth usually last only approximately six months. However, Jackson et al.'s study in 1964 found that babies wholly breast-fed for six months with no iron or vitamin supplementation thrived as well as artifically-fed infants, in terms of weight gain, height, hemoglobin, and bone development.

It has been found recently that the protein content of human milk is 0.90%,it was originally thought to be

1.10 to 1.20% (Alfin-Slater and Jelliffe 1977). This is considered a low normal, adequate to sustain proper growth until about four to six months of age (Jelliffe and Jelliffe 1971). Cow's milk contains 3.40% protein, and most artificial formulas contain a percentage of protein approximately midway between that of human and cow's milk (Hambraeus 1977). Trowell (1975) pointed out that the recognition of kwashiokor (protein-energy malnutrition) contributed to the overstatement of infant protein requirements from 1950 to 1970. The change in attitude about protein requirements is reflected in the World Health Organization's 1973 statement on energy-protein requirements, which recommended a reduction in the "theoretical safe level of protein intake" in the very early years of life (Trowell 1975).

Human milk has been found to have over 100 constituents, and the unique blend of these substances is considered to be one of its major assets (Trowell 1975, Hambraeus 1977, Jelliffe and Jelliffe 1971). It provides nourishment of proteins, calories, salts, vitamins, and fluids in proportions best suited to an infant's needs (Gerrard 1974). Other advantages includes its curd tension, which is thought to contribute to the highly efficient utilization of human milk (Jelliffe and Jelliffe

1971); lower salt content, contributing to the uncommonness of hypernatremia in breast-fed infants (Trowell 1975); and the presence of lactoferrin, an iron-binding protein which has been suggested to contribute largely to the marked resistance against E.coli-caused gastroenteritis observed in breast-fed babies (Hambraeus 1977).

Human milk also exhibits chronobiological changes in nutrient content. Some examples are the diurnal fluctuations in fat content, and also fluctuations in fat content between fore and hind milk of an individual feeding (Alfin-Slater and Jelliffe 1977, Hytten 1954, Wheeler 1973). These changes in fat content are possibly linked with appetite-control mechanisms and prevention of obesity (Jackson 1977). Protein contents also differ between colostrum and subsequent mature milk (Alfin-Slater and Jelliffe 1977).

There are several other qualities of human milk which do not occur in cow's milk or artificial formulas. Breast-fed infants tend to have their earliest illness at a later date, have fewer and milder illnesses, and a lower mortality rate than bottle-fed infants (Harfouche 1970, Hooper 1965). If breast milk is given alone, it provides a continuing supply of antibodies, documented particularly with respect to E. coli and polio virus (Gerrard 1974).

The immunoglobulins secreted in human milk afford protection, particularly against respiratory and gastrointestinal infections and allergic reactions, during a young infant's transition to immune independence (Gerrard 1974, Jelliffe and Jelliffe 1975). Many researchers include among breast milk's unique qualities the special opportunities it affords for fostering a close mother-infant relationship (Bernal and Richards 1970, Harfouche 1970, Gerrard 1974, Jelliffe and Jelliffe 1975), yet little information is available on the specifics of this particular aspect of breast-feeding. Finally, another quality unique to breast milk is that it will be affected by nearly all agents taken by the lcatating mother. Oral contraceptives influence and reduce milk production; other drugs lead to reduced nutrient content; and pesticides occur in higher concentrations in human milk than cow's milk, but have not been considered serious enough to discourage breast-feeding (Hambraeus 1977).

Breast-feeding fulfills essentially all an infant's nutritional needs for the first four to six months of life. However, evidence has shown that in situations where breast-feeding is not possible or convenient, artificial formulas have a place. Economic and hygenic conditions in affluent societies have made it possible to make optimal use of artificial formulas, thus contributing to the reduction of perinatal mortality. Today's artificial formulas are much more adapted to infant needs than those first marketed, and they can be used in infant feeding with satisfactory results (Hambraeus 1977).

Another aspect of infant feeding practices which has undergone remarkable changes in the past half-century is the time of introduction of solid foods to infants. Solids were rarely offered to infants before one year of age until 1920. In 1935, Marriott suggested that six months of age was appropriate for the introduction of solids. Fifty-eight percent of physicians responding to a 1954 survey recommended solid foods before three months. Sackett demonstrated in 1956 that introduction of cereal and strained foods was possible as early as the first two weeks of life. The trend continued--Epps and Jolley reported in 1963 that 83% of two-month-old infants seen during their clinic visits in Washington, D.C. had begun to receive solids. In 1970, solid foods supplied 31% of U.S. infants' caloric intakes at age 3 months, and 64% at 12 months (Fomon 1974).

Fear of undernutrition has a historical basis, and pediatric emphasis until recently has been placed traditionally almost exclusively on the detection of growth failure. The philosophy developed that "a healthy baby cannot be overfed," but several recent studies have shown that this is not always the case (Jelliffe 1975). Fomon et al. in 1964 demonstrated that the median intake of infants could be increased appreciably by encouraging infants to take the largest amount they would accept consistently, rather than the smallest amount to relieve hunger.

Several ill-effects of early introduction of solids have been identified. Among these are increased incidence of allergies (Jelliffe 1975, Guthrie 1966), diarrhea from excessive starch, decreased suckling in a breast-fed infant, resulting in decreased breast milk production (Jelliffe 1975). The extra calories from solids may result in an excessively high renal solute load, which burdens the young infant's kidneys.

The excessive calories may also lead to obesity in two ways. First, they may cause the infant to be chronically thirsty, with the result that his cries from thirst may be interpreted as the need for more food. Second, as noted by several authors, tradition weaning (a gradual shift from breast- or bottle-feeding to solids) has given way to a "double-feeding" concept. Early introduction of solids occurs without an appreciable decrease in milk intake. It is likely that the additional calories and nutrients must result in increased energy intake (Lloyd 1975, Myres 1974, Jelliffe 1975). Shukla showed that infants fed in this manner received 13 to 24% extra calories above the Recommended Dietary Allowances (Jelliffe 1975).

Reasons given for early introduction of solids are many and varied. Included among them is the unproven idea that it assists in making a wide range of food items more acceptable in later infancy. Concern with iron-deficiency anemia prompts early solid food introduction, but a well-born infant's iron stores should not begin depleting until four to six months of age. Another possibility is the belief that solid-fed infants may be more likely to sleep through the night than infants fed only liquid diets; however, two studies have discounted this belief (Guthrie 1966). Mothers' anxieties and concerns for rapid growth and large infants in our Western "achievement-oriented" society have also been identified as possible reasons for early solid food introduction (Jelliffe 1975).

Jelliffe (1975) considered several forces to be responsible for the trend to overfeed. The historically-based "fear of undernutrition" is still at work, although the past ten years have seen increased emphasis placed on the dangers of overnutrition. Although the body image ideal has changed during history from plump to slim for adults, it has not changed for infants--larger, fatter infants still generally represent healthiness. The feeding process is overlaid with symbolic and psychological considerations, and a family's anxieties or needs--to overprotect, indulge, or safeguard an infant against disease--may be manifested in its feeding practices. Commercial influences are extensive, including the use of convenient, calorie-dense processed foods; the expansion of an increasingly-competitive market to include infants in the earlier months of life; and the practices of infant food companies--sponsorships of medical meetings, advertising in medical journals, and endorsement by use and association from using free samples. Finally, the lack of nutritional knowledge in the health profession has contributed to infant overfeeding. Increased recognition of the importance of nutrition in medical and nursing schools slowly seems to be replacing the attitude that infant nutrition is simple (Jelliffe 1975).

Infant feeding practices--whether an infant is fed by breast or bottle or a combination of both, and the time and extent to which he is introduced to solid foods--definitely influence the rate at which an infant gains weight. But the mechanisms and various interactions are varied and subtle, and far from being understood fully. Nutritional individuality is the broad range of energy requirements in childhood. It exists not only between infants, but also on a day-to-day basis in individual infants (Dugdale 1967). Differences in physical activity, in basal metabolic rate, and even energy expenditure while sitting contribute to nutritional individuality, and energy requirements vary as much as twofold between children of the same sex, age, and weight (British Medical Journal 1975). Both artificial feeding, and strictly-scheduled solid food introduction can tend to nullify this nutritional individuality.

Furthermore, an "artificial end-point" is introduced as bottle-fed infants are frequently encouraged to drain every drop from their bottle (Fomon 1974). It is much easier for a breast-fed infant to accomplish self-regulation of his intake. The fact that the mother is not aware of exactly how much milk the infant receives, but rather bases the infant's satisfaction on when he ceases to suck and swallow, is considered to be a quality of breast-feeding that counteracts overnutrition.

Several authors have reported more rapid weight gain in bottle-fed infants (Eid 1970, Fomon 1974, Shukla 1972). Jelliffe (1975) stated that obesity is less common in breast-fed infants. One possible explanation for these findings is the overriding of an infant's natural attempts at self-regulation, resulting in overfeeding. Another explanation may be excessive concentration of formula, since this has been found to be a frequent cause of excessive caloric intake (Oates 1973, Shaw et al. 1973, Wilkinson et al. 1973, Taitz 1977). At this time it is still unclear whether breast-fed or bottle-fed infants begin solid food earlier (Neumann and Alpaugh 1976, Lloyd 1975).

Infant nutrition recommendations in 1975 included strong encouragement of breast-feeding for the first six to eight months of life, use of an iron-supplemented proprietary formula if breast-feeding was not acceptable, and delay of solid food introduction until six months of age (Hammar 1975). These guidelines were echoed recently in the recommendations given at the March 1977 Symposium on Infant Nutrition, at which breast milk or formula, without the additions of solid foods, was advised for the first six months of an infant's life (A 23-city Live Televised Symposium on Infant Nutrition," presented on March 23, 1977, L. J. Filer, Jr., M.D., Ph.D., Chairman).

The preceding review of literature has been written in an attempt to examine some nutritional problems of infancy, including obesity and feeding practices. As is clear from this review, infant feeding practices have undergone significant changes only within the past half century. Also apparent is the concomitant emergence of infant obesity as a major nutritional concern. Unfortunately, considerable question remains as to the complex interrelationship between the noted changes in infant nurturing and the development of obesity. Further in-depth research will be needed to shed additional light on this problem.

CHAPTER III

PROCEDURE FOR COLLECTION AND TREATMENT OF DATA

This study was conducted by the descriptive research process, a process which is primarily concerned with obtaining accurate and meaningful descriptions of the phenomena under study (Abdellah 1975). It utilized a nonexperimental method of data collection, since the investigator did not consciously manipulate the conditions of the study. The nonexperimental approach can be applied only where the phenomena the investigator is interested in already exists and is available for study (Abdellah 1975). The study was exploratory and prospective in nature and yielded data about the measurements of physical growth of normal infants.

Setting for the Study

The study was conducted in several settings. Two private general hospitals in a metropolitan area of 1.5 million persons in the southwestern United States were used to obtain the sample and the initial physical measurements of the infants. The size of both hospitals was approximately

550 beds. Neither hospital was associated with a medical school; one of the hospitals served as a teaching facility for several schools of nursing. The hospital room of the mother was used by the investigator to explain the purposes of the study to the mother and to obtain her permission for her infant to be included in the study.

The newborn nursery of each hospital was the setting where the investigator obtained the initial physical measurements of the infants. Approximately 60 infant beds divided between three rooms made up the nursery of one hospital; one of the rooms was reserved specifically for premature infants. The second hospital's nursery was comprised of 50 infant beds in two rooms, with no separate facilities for premature infants. Skinfold measurements were obtained while the infant was in his bassinette; head and chest circumferences and birthweights were obtained from individual neonatal charts; and the measurement of length was done with the infant measuring board placed on a flat surface in each nursery.

It was originally intended that follow-up measurements would be obtained priarmily at the office of the infant's private pediatrician. However, only occasionally during the study did the predetermined time for an infant's measurements coincide with a visit to the pediatrician. At these coinciding times, all measurements were obtained in the room of the office containing the infant scales, with the mother present. Skinfold measurements, head and chest circumferences were done while the infant lay on the examining table. Measurement of length was done with the infant measuring board placed on a flat surface; and weight was done with the investigator's infant scales placed on a flat, unrugged surface. The mother was also present while these measurements were being obtained.

The vast majority of follow-up measurements were taken at the infants' homes. All measurements were taken with the mother present and in a room convenient to the mother (usually the living room). The measurements of skinfolds, head and chest circumferences were taken as the infant lay on a flat surface, usually a floor or rug which was covered by a blanket. The infant measuring board was placed on a flat surface to obtain length measurement. To obtain an accurate weight, the infant scale was positioned wherever a flat, unrugged surface was available, usually in the kitchen or dining area.

Population

Written consent to use the facilities, approach the mothers of the infants, and obtain information about the infants was obtained from the private institutions. Written consent to use the pediatricians' offices as the sites for follow-up measurement was also obtained from eight selected pediatricians.

Normal infants who were products of normal full-term pregnancies were eligible for admission to the study. Information which determined if the infant satisfied these criteria was obtained from the neonatal and obstetrical charts.

When the infant was classified as eligible for admission to the study, the investigator approached the mother of the infant to request permission to enroll her infant in the study. Information was presented verbally to each mother by the investigator at the time of the encounter, and also by means of an introductory letter (appendix A). Included in the information presented to the mother was a brief description of the study's purposes and guarantee of the anonymity of the mother's and infant's participation in the study. The investigator emphasized to the mother that the demographic data were confidential and would be used by the investigator only in regard to study information and to facilitate communication and visits between the investigator and the mother. The introductory letter reinforced this information and included the investigator's name and telephone number. If the mother agreed that her infant could be included in the study, she signed the consent form stating that the involvement of her and her infant in the study was understood (appendix C).

The sample for the study was derived from the hospital nurseries' populations of normal infants who were products of normal full-term pregnancies. The infants who would be followed at selected pediatrician's offices, who lived within a 25-mile radius of the hospitals, and whose mothers consented to their inclusion in the study constituted the sample for the study.

The investigator selected the sample during eight-hour periods from 9:00 a.m. to 5:00 p.m., beginning on Wednesday, January 12, 1977. This selection process continued for 21 days, until 32 infants were enrolled in the study. At this point, each category (male-bottle-fed, female-bottle-fed, male-breast/combination-fed, female-breast/combination-fed) contained at least seven infants. All infants were enrolled in the study prior to their discharge from the hospital. Three infants were dropped eventually from the study--two of these infants moved out of the area, and the third was out of town during the month she doubled her birthweight. The remaining 29 infants were followed by the investigator through the doubling of their birthweights.

Tools

Measurements done at intervals on the infants included weight, length, head and chest circumferences, and triceps and subscapular skinfold measurements. Barnett (1973) stated that the most important measurements of physical growth are weight, body length, head and chest circumferences. Comparisons of these values with the normal averages of the measurements and with each other is necessary to properly establish the significance of the measurements (Barnett 1973). Serial measurements give better estimations of growth or growth failure than isolated measurements (Jelliffe 1966). Accuracy and continuity of measurements in each area in which changes can be observed is a prerequisite if the appraisal of an infant's growth is to be useful (Nelson 1975).

The measurements of weight, length, head and chest circumferences are common procedures at medical facilities that deal with infants. However, measurement of skinfold thicknesses is done much less frequently. In order to perform this measurement as accurately as possible, the investigator researched the procedure (Jelliffe 1966, Tanner and Whitehouse 1955, Edwards and White 1962, Brans et al. 1974), then performed the procedure adhering to the guidelines for skinfold measurement given by Jelliffe (1966). The measurement of triceps and subscapular skinfolds was performed routinely with infants and children seen at the nutrition clinic of a children's hospital in the area. Prior to the data collection, the investigator attended a session of the nutrition clinic, and practiced the procedure with three children. Supervision was given by the clinic's head nurse, who was experienced with the procedure.

Weight

The anthropometric measurement most frequently used in weight (Barnett 1973, Jelliffe 1966), which reflects proportions of fat, muscle, bone, and the presence of pathological weight, for example, weight due to splenomegaly or edema (Jelliffe 1966). Weight and height indices are used frequently in combination to assess the growth patterns of infants and children.

The investigator rented a beam-balance scale from a rental agency. Accuracy of the scale was verified by a scale manufacturer prior to data collection. Prior to each weight, the scale was balanced (Jelliffe 1966). This was done by adjusting the calibration mechanism manually while the scale was resting on a flat, unrugged surface. The infants were weighed nude to the nearest one-eighth ounce, with one sheet of paper towel placed between the infant and scale. A relatively calm state was necessary to obtain accurate weights on the infants. Those infants who were crying or flailing their extremities were not weighed until they were comfortable and capable of laying on the scale in a placid manner. The infants' weights were compared with the Harvard Anthropometric Chart standards for weight.

Length

The measurement of an infant's length assesses bone growth (Barnett 1973). Recumbent length of the infants was measured with a wooden length-board. The board was placed on a flat surface and, with the mother's assistance, the infant was laid next to it with his head firmly placed against the headboard and his eyes looking vertically. With the knees extended and the feet flexed at right angles to the lower legs, the length was read to the nearest 0.1 centimeter (Jelliffe 1966). The results were compared with the Harvard Anthropometric Chart standards for recumbent length (Nelson 1975).

Head Circumference

Head circumference reflects the growth of the scalp tissues and skull and, more importantly, the growth of the brain (Jelliffe 1966). A nonstretchable paper tape was used to measure head circumferences of the infants. The maximal circumference was measured by placing the tape around the frontal bones just superior to the supraorbital ridges, passing the tape around the head at the same level on each side, and laying it over the maximum occipital prominence at the back of the head. The measurements were made to the nearest 0.1 centimeter (Jelliffe 1966). The results were compared with the standards for head circumference given by the Harvard Anthropometric Chart.

Chest Circumference

Chest circumference, when used in a ratio with head circumference, may indicate growth adequacy or failure, wasting of the muscle and fat of the chest wall, or protein-calorie malnutrition (Jelliffe 1966). The infants' chest circumferences were measured with a nonstretchable paper tape. The measurement was done with each infant lying quietly on his back. The measurement was taken at the nipple line, to the nearest 0.1 centimeter (Jelliffe 1966). The results were compared with the standards for chest circumference given by the Harvard Anthropometric Chart.

The purpose of including the measurement of head and chest circumferences in the study was to provide further indications of the adequacy and normalcy of the study infants' patterns of growth.

Skinfolds

The degree of subcutaneous fat was calculated by skinfold measurements taken at two sites--the triceps and subscapular skinfolds. The site selected on the triceps muscle was halfway down the posterior arm, between the tip of the acromion process of the scapula and the olecranon process of the ulna. With the mother holding the infant in any position that allowed the infant's arm to remain in a relaxed position at his side, a skinfold parallel to the long axis of the arm was picked up with the thumb and the forefinger. The Harpenden caliper was applied directly below the measurer's fingers, and the infant's skin was pinched up firmly and held between the measurer's fingers the entire time the measurement was taken (Tanner 1966, Jelliffe 1966).

The mother also held the infant while the subscapular skinfold was measured just below the angle of the left scapula. This measurement was made at a time when the infant's shoulder and arm were relaxed. The skinfold was grasped in a line running approximately 45 degrees to the spine (Tanner 1966, Jelliffe 1966). Both skinfold measurements were taken to the nearest 0.05 millimeter (Nutritional Review 1975).

Three measurements were made at each skinfold site, and the average of the three measurements represented the skinfold measurement of that site (Jelliffe 1966). The measurements were taken on the left side of the infant's body, in accordance with the established procedure for anthropometric measurements (Jelliffe 1966). The results were compared with the standards for means and standard deviations of skinfold measurements given by Fry (1975).

Data Collection

Collection of data began on January 12, 1977, and continued until all 29 of the study infants doubled their birthweights, September 28, 1977. The first 21 days of collection involved enrolling infants into the study and obtaining their initial measurements. With the first 72 hours of life, measurements of length and skinfold thicknesses of study infants were taken in the newborn nursery by the investigator. The infants' initial (birth) weights, head and chest circumferences were obtained from the individual neonatal charts.

Follow-up visits began on March 23, 1977, and continued until the last study infant had doubled his birthweight, September 28, 1977. Follow-up measurements were obtained by the investigator as soon as the infant approached his doubled birthweight. Phone communications with the mothers were used by the investigator to determine when to begin individual follow-up measurements, based on recent weights (obtained from either home scales or from visits to the pediatrician). In the event that the mother had not recently weighed her infant, the investigator made a visit to the home to determine how close the infant was to doubling his birthweight. The number of follow-up visits necessary to obtain measurements immediately before and after the time of birthweight doubling varied with each infant, depending on the predictability of the infant's weight gain. Occasionally an infant's weight was doubled on the very day of measurement. Birthweight doubling time was obtained by interpolation, using the closest recorded weights bracketing the doubled birthweight value, and the exact ages at which these weights were obtained. Length at the time of birthweight doubling was also obtained by interpolation.

During the period of data collection, communication by phone was also made by the investigator with the mother, at least once a month, to determine the status of the infant's health, when solid food was introduced, and whether there was any change in the feeding pattern of the infant.

Professional and family commitments required the investigator to leave the area in late June, 1977. At this time, 22 of the 29 study infants had doubled their birthweights and their measurements had been completed.

Follow-up measurements for the remaining study infants were obtained by a colleague of the investigator who was also enrolled in the graduate maternal and child health nursing program at Texas Woman's University College of Nursing. Efforts were expended to insure inter-observer accuracy. Besides reviewing the guidelines for achieving accuracy with each measurement, the investigator and the colleague simultaneously performed measurements for two study infants. This allowed the investigator to check for any discrepancies between her own and the colleague's method of performing the procedures.

Particular attention was paid to the procedure for obtaining skinfold measurements, for the subjective nature of the caliper application is considered to be a disadvantage of this measurement (McGowan et al. 1974). The investigator and the colleague practiced the application and reading of the caliper both on one another and on several study infants prior to actual data collection by the colleague. McGowan et al. (1974) cautioned that repeated practice is necessary to insure smooth application of the caliper, but they also reported that investigation with calipers has demonstrated quite clearly that two operators could achieve acceptable consistency in applying the caliper and obtaining reasonably similar results.

Information obtained during data collection was recorded on the demographic sheets (appendix B). In addition to the anthropometric data, any information regarding feeding techniques and their changes, introduction of solid foods, the infant's health history, travel plans of the family, and appointments with the pediatrician were recorded on these sheets. The records enabled the investigator to classify study infants as bottle-, breast-, or combination-fed, and also to predict roughly an infant's pattern of weight gain, thereby determining when to begin follow-up measurements for each infant.

Treatment of Data

Statistical analysis of data was employed, including simple statistics (mean, median, standard deviation, and range) for each measurement at birth and the time of birth-weight doubling. Calculations of the strengths of association among all the variables measured were done using the Pearson product-moment correlation coefficient. The Student's t-test for two independent groups was also used to compare age at birthweight doubling and other variables between males and females, and bottle-fed infants and breast/combination-fed infants. One-way analysis of variance (analysis of variance for the completely random model) was used to determine if statistical difference existed between groups differentiated by their ages at birthweight doubling; in the instance of significant difference, the situation was analyzed further by the Student-Newman-Kuels (SNK) Multiple Comparisons Procedure (Zar 1974).

CHAPTER IV

ANALYSIS OF DATA

Data analysis began by analyzing the composition of the study group, considering race, sex, type of delivery, method of feeding, and parents' educational levels. Descriptive statistics (mean, median, standard deviation, and range) were then used to summarize 11 variables considered during the study--birthweight, triceps and subscapular skinfolds at birth, ages of infants at birthweight doubling, weight and length percentiles at birthweight doubling, ages infants began solids, and the educational levels of the mothers and fathers. Pearson product-moment correlation was used to determine if significant associations existed between any of the variables. Comparisons of male and female groups, and bottle-fed and breast/combination-fed groups were made to determine if the groups differed significantly in relation to any of the variables. The comparisons were done using the Student's t-test for two independent groups. Significance was declared at the 5% level for all procedures ($p \leq .05$); the term "borderline" was used when a "p" value was greater than .05 but less than .15.

Several facets of the composition of the study group are shown in table 1. The sample was composed of 27 Caucasian infants and 2 Black infants (both female bottle-fed infants). Twenty-seven infants were products of vaginal deliveries, and two infants were Caesarean deliveries (one female bottle-fed infant, one male breast/combination-fed infant). Although one purpose of the study was to compare the anthropometric measurements and birthweight doubling times of Caesarean- and vaginally-delivered infants, the sample was such that no comparison in this area was possible.

TABLE 1

COMPOSITION OF STUDY GROUP

Group	Number	% Distribution
Black	2	6.9
Caucasian	27	93.1
Caesarean-section	2	6.9
Vaginal delivery	27	93.1
Males	13	44.8
Females	16	55.2
Bottle-fed	12	41.4
Breast/combination-fed	17	58.6

N = 29.

Thirteen of the 29 infants were males (44.8%), and 16 were females (55.2%). Twelve infants were bottle-fed (41.4%); 17 were breast/combination-fed (58.6%). Nine infants in the breast/combination-fed group were categorized as breast-fed (31% of the total study group). Table 2 shows the distribution of infants according to sex and method of feeding.

TABLE 2

DISTRIBUTION OF INFANTS ACCORDING TO SEX AND METHOD OF FEEDING

	Bottle-fed	Breast/Combination-fed
Male	6	7
Female	6	10

	Bottle-fed	Breast-fed	Combination-fed
Male	6	4	3
Female	6	5	5

N = 29.

For the total group, the average number of years of education received by the mothers was 14.2 years; average number of years of education for the fathers was 15.5 years. Mothers' and fathers' educational levels were two of the variables analyzed by the Student's t-test for two independent groups. The t-test comparison indicated that the educational levels of the mothers differed significantly between the bottle-fed and breast/combination-fed groups (13.1 years versus 15 years) (table 4). This did not hold true for the father's educational level.

Tables 3 and 4 present the results of statistical comparison of the male and female groups, and bottle-fed and breast/combination-fed groups. Only two instances of significant difference were found. Both occurred between the bottle-fed and breast/combination-fed groups, involving the infants' ages of introduction to solids, and the mothers' educational levels. The t-test results also indicate three instances of "borderline" statistically-significant differences--for the length percentiles at birthweight doubling between bottle-fed and breast/combination-fed groups, and for subscapular skinfolds at birth and age of introduction to solids between male and female groups. References to the differences, or lack of difference, that occurred between groups of infants are included in the discussions of the specific variables.

The frequency distribution of birthweights for the total study group is illustrated in figure 1. Birthweights for the total group averaged 7.73 pounds. The weights ranged from 6.50 pounds to 8.90 pounds; males averaged 7.88

TABLE 3

RESULTS OF STUDENT'S t-TEST FOR TWO INDEPENDENT GROUPS, COMPARISON OF MALE AND FEMALE GROUPS

Variable	Male $\overline{X} \pm 1$ S.D.	Female $\overline{X} \pm 1$ S.D.	t-value	Probability Value
Age at birthweight doubling	128 ± 36 days (4.3 months)	148 ± 49 days (4.9 months)	-1.21	0.24
Triceps (birth)	4.48 ± .54mm	4.52 ± .76mm	-0.17	0.86
Subscapular (birth)	4.64 ± .76mm	5.16 ± .75mm	-1.82	0.08*
Triceps (birthweight doubling)	8.45 ± 1.03mm	8.82 ± 1.34mm	-0.82	0.42
Subscapular (birthweight doubling)	8.19 ± 1.84mm	8.28 ± 1.53mm	0.14	0.89
Introduction to solids	39 ± 34 days	67 ± 60 days	-1.50	0.15*
Weight at birth	126 ± 11 oz. (7.88 lb.)	122 ± 11 oz. (7.60 lb.)	1.08	0.29
Weight % at birthweight doubling	70 ± 32%	54 ± 30%	1.37	0.18
Length % at birthweight doubling	59 ± 29%	45 ± 23%	1.38	0.18
Mother's education	14.1 ± 1.9 yr.	14.3 ± 2.3 yr.	-0.99	0.33
Father's education	15.4 ± 2.3 yr.	15.6 ± 1.9 yr.	-0.54	0.59

*Borderline difference.
N = 29 (13 males, 16 females)

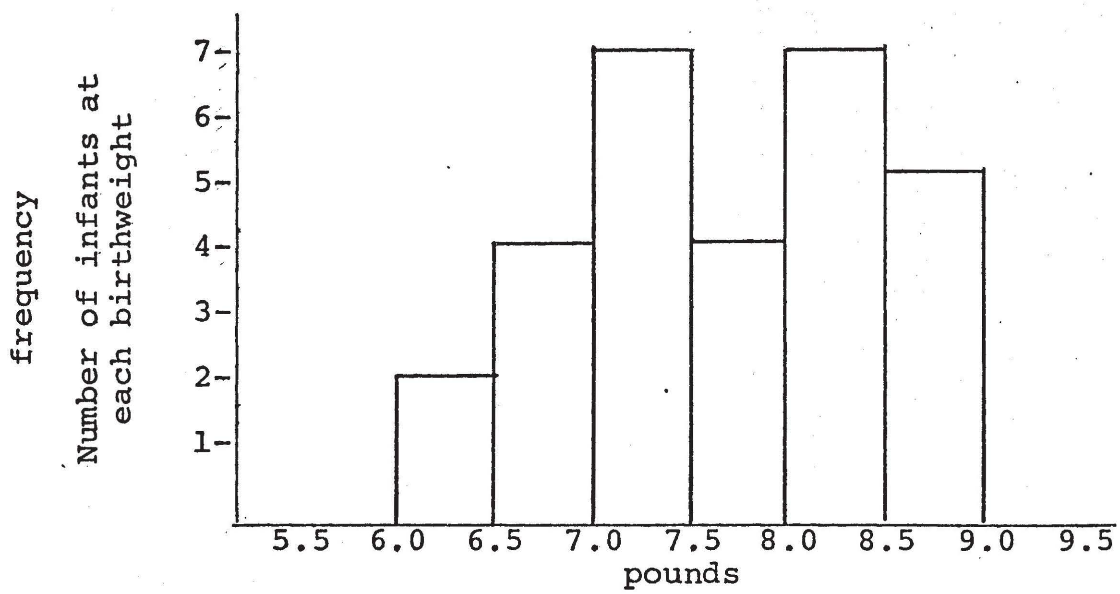
TABLE 4

RESULTS OF STUDENT'S t-TEST FOR TWO INDEPENDENT GROUPS, COMPARISON OF BOTTLE-FED AND BREAST/COMBINATION-FED GROUPS

Variable	Male $\overline{X} \pm 1$ S.D.	Female $\overline{X} \pm 1$ S.D.	t-value	Probability Value
Age at birthweight doubling	132 ± 39 days (4.4 months)	144 49 days (4.8 months)	-0.74	0.47
Triceps (birth)	4.44 ± .50mm	4.55 ± .76mm	-0.41	0.68
Subscapular (birth)	4.87 ± .70mm	4.97 ± .86mm	-0.32	0.76
Triceps (birthweight doubling)	8.88 ± 1,23mm	8.49 ± 1.20mm	0,84	0.41
Subscapular (birthweight doubling)	8.59 ± 1,80mm	7.99 ± 1.53mm	0.97	0.34
Introduction to solids	25 ± 16 days	75 ± 58 days	-2.91	0.01*
Weight at birth	125 ± 10 oz. (7.80 lb.)	123 ± 13 oz. (7.70 lb.)	0.45	0.66
Weight % at birthweight doubling	69 ± 23%	55 ± 35%	1.23	0.23
Length % at birthweight doubling	60 ± 28%	45 ± 25%	1.49	0.15**
Mother's education	13.3 ± 1.8 yr.	15.0 ± 2.0 yr.	-1.31	0.01*
Father's education	15.4 ± 1.8 yr.	15.6 ± 2.3 yr.	0.01	1.00

*Significant difference.
**Borderline difference.
N=29 (12 bottle-fed infants, 17 breast/combination-fed infants).

pounds, and females 7.60 pounds (table 5). The average birthweights for the bottle-fed group (7.80 pounds) and the breast/combination-fed group (7.70 pounds) were similar. The results of the Student's t-test showed that no significant differences in birthweights between male and female groups, or bottle-fed and breast/combination-fed groups existed. The average birthweights of the groups delineated by both sex and method of feeding are also shown in table 5.



N = 29
Mean = 7.73 lb.
Median = 7.73 lb.
S.D. = 11.3 oz.
Range = 6.50 - 8.90 lb.

Fig. 1. Frequency distribution of birthweight for all subjects combined.

TABLE 5

MEAN BIRTHWEIGHTS ($\overline{X} \pm 1$ S.D.)

Males	7.88 lb. ± 11.0 oz.
Females	7.60 lb. ± 11.5 oz.
Bottle-fed	7.80 lb. ± 9.6 oz.
Breast/combination-fed	7.70 lb. ± 12.6 oz.
Male bottle-fed	7.74 lb. ± 7.4 oz.
Female bottle-fed	7.86 lb. ± 12.0 oz.
Male breast/combination-fed	8.01 lb. ± 13.6 oz.
Female breast/combination-fed	7.44 lb. ± 11.0 oz.
Total group	7.73 lb. ± 11.3 oz.

N = 29.

For the total group significant positive relationships were demonstrated between birthweight and the weight/length percentiles at birthweight doubling (weight - $r = .39$, $p = .03$; length - $r = .69$, $p = .0001$). The total group, as well as the female and breast/combination-fed groups, demonstrated significant inverse relationships between birthweight and the age of introduction to solids (total group - $r = -.42$, $p = .02$; females - $r = -0.69$, $p = .002$; breast/combination-fed group - $r = -0.50$, $p = .04$).

The frequency distribution of ages at birthweight doubling is illustrated in figure 2. For the total group, mean age at birthweight doubling was 139 days (4.6 months); ages at birthweight doubling ranged from 81 days (2.7 months) to 252 days (8.4 months). Table 6 shows the mean ages at birthweight doubling for the various groups. Males

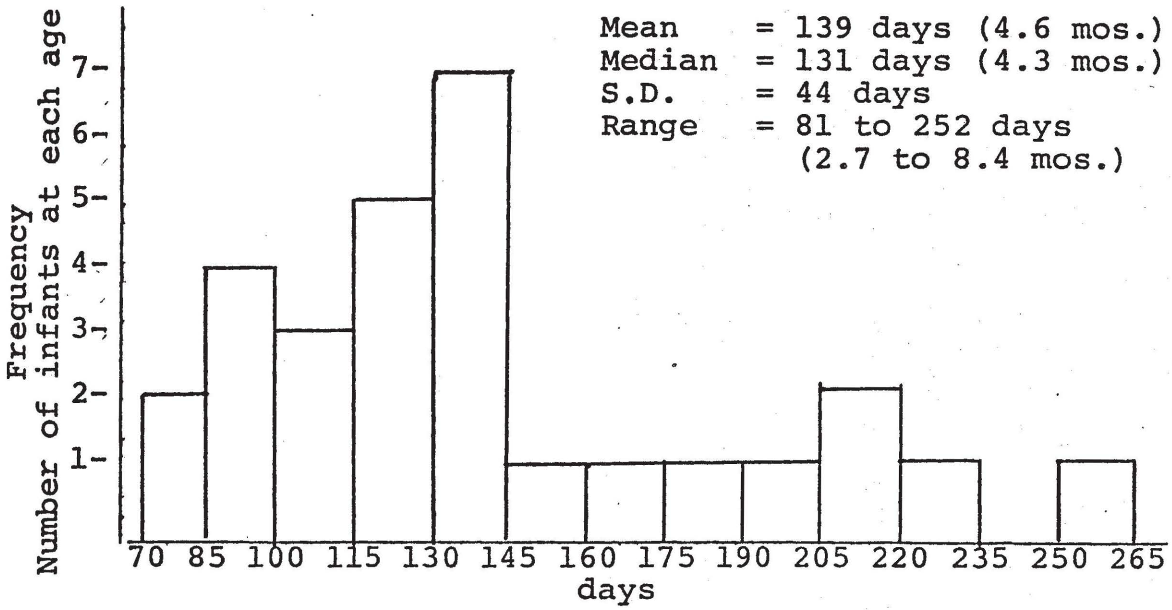


Fig. 2. Frequency distribution of birthweight doubling age for all subjects combined.

TABLE 6

AGES AT BIRTHWEIGHT DOUBLING ($\bar{X} \pm 1$ S.D.)

Males	128 ± 36 days (4.3 mos.)
Females	148 ± 49 days (4.9 mos.)
Bottle-fed.	132 ± 39 days (4.4 mos.)
Breast/combination-fed.	144 ± 49 days (4.8 mos.)
Male bottle-fed	127 ± 36 days (4.2 mos.)
Female bottle-fed	137 ± 44 days (4.6 mos.)
Male breast/combination-fed	129 ± 39 days (4.3 mos.)
Female breast/combination-fed . . .	155 ± 54 days (5.2 mos.)
Total group	139 ± 44 days (4.6 mos.)

N = 29.

averaged 128 days (4.3 months); females averaged 148 days (4.9 months). For the bottle-fed groups, mean age at birthweight doubling was 132 days (4.4 months), compared to

144 days (4.8 months) for the breast/combination-fed group. The table also shows the mean ages at birthweight doubling for groups delineated by both sex and method of feeding. A Student's t-test comparison indicated that no significant differences in ages at birthweight doubling occurred between male and female groups, or bottle-fed and breast/combination-fed groups (tables 3 and 4).

Significant inverse relationships were demonstrated for the total group between the age at birthweight doubling, and two of the variables--subscapular skinfolds at birthweight doubling ($r = -0.62$, $p = .0003$), and weight percentile at birthweight doubling ($r = -0.69$, $p = .0001$). For each of the major subgroups (males, females, bottle-fed infants, and breast/combination-fed infants), significant inverse relationships of similar magnitude were also demonstrated between age at birthweight doubling and these two variables, subscapular skinfolds and weight percentile at birthweight doubling.

Age at birthweight doubling was positively associated with birthweight in the female group ($r = .57$, $p = .02$), and the bottle-fed group ($r = .57$, $p = .05$). No other significant associations between age at birthweight doubling and any other variables were found for the total group, nor any of the major subgroups.

Head and chest circumference measurements of the infants were obtained during data collection. Since these measurements were obtained only to gauge normalcy of growth patterns, no statistical treatment was applied to them. Simple observation of the compilation of birth head circumferences yields that 2 of the 29 infants of the study had birth head circumferences which ranked less than the third percentile (both infants were female breast-fed). By the time of birthweight doubling, head circumferences of both infants had increased to normal (between the 3 and 97 percentiles).

Chest circumferences at birth ranked greater than the 97 percentile for two infants (one female bottle-fed infant, one female breast-fed infant). Chest circumferences of both infants fell within normal limits at the time of birthweight doubling. A third infant had a chest circumference which ranked greater than the 97 percentile at the time of birthweight doubling (female bottle-fed infant).

Table 7 lists the mean triceps and subscapular skinfolds at birth and birthweight doubling for the total group and for the major subgroups. The study group's skinfold results were compared with skinfold norms for Caucasian and Black infants (Fry et al. 1975), listed in table 8. Birth triceps skinfolds averaged 4.50 mm for the total study group; birth subscapular skinfolds averaged 4.93 mm. Mean birth skinfolds for the study group appear low in comparison with the values listed in table 8; however, the norms were derived from infants ranging from birth to two months of age. The average birth skinfolds of the major subgroups were similar, although t-test comparison (table 3) of birth subscapular skinfolds showed a borderline difference between males (mean, 4.64 mm) and females (mean, 5.16 mm). No further statistically-significant differences in skinfolds occurred between males and females or bottle-fed infants and breast/combination-fed infants, either at birth or birthweight doubling.

TABLE 7

MEAN SKINFOLDS (MILLIMETERS) AT BIRTH AND BIRTHWEIGHT DOUBLING

Group	Number	Triceps at Births	Subscapular at Birth	Triceps at Birthweight Doubling	Subscapular at Birthweight Doubling
Males	13	4.48	4.64	8.45	8.19
Females	16	4.52	5.16	8.82	8.28
Bottle-fed	12	4.44	4.87	8.88	8.59
Breast/ combination-fed	17	4.55	4.97	8.49	7.99
Total	29	4.50	4.93	8.65	8.24

TABLE 8

MEANS AND STANDARD DEVIATIONS BY SKINFOLDS IN MILLIMETERS BY RACE AND AGE*

Race	Age	Skinfolds in millimeters ($\overline{X} \pm 1$ S.D.)	
		Triceps	Subscapular
Caucasian	0-2 months	7.79 ± 1.45	7.72 ± 1.43
	2-4 months	8.72 ± 0.72	8.43 ± 0.61
	4-6 months	8.65 ± 0.53	8.39 ± 0.41
	6-8 months	8.20 ± 0.50	8.12 ± 0.58
Black	0-2 months	6.09 ± 1.48	6.56 ± 1.53
	2-4 months	8.56 ± 0.92	8.33 ± 0.73
	4-6 months	8.28 ± 0.82	8.21 ± 0.79
	6-8 months	9.09 ± 0.60	8.62 ± 0.81

*Adapted from P. C. Fry, J. E. Howard, Sr., and B. C. Logan. 1975. Bodyweight and skinfold thickness in Black, Mexican-American, and White infants. Nut. Reps. Int., 11:155.

Use of the Pearson correlation coefficient demonstrated only one association between skinfolds and any of the variables. A significant inverse association occurred between the subscapular skinfold at birthweight doubling and the age at birthweight doubling. This association was significant for the total group ($r = -0.62$, $p = .0003$) and for each of the major subgroups.

In order to further analyze the relationship between skinfolds and age at birthweight doubling, the infants were divided into three groups. Group 1 doubled their birthweights between two to four months of age; Group 2 doubled between four to six months; and Group 3 doubled at six months of age or later. Table 9 lists the mean triceps and subscapular skinfolds for each group at the time of birthweight doubling.

TABLE 9

MEAN SKINFOLDS (MILLIMETERS) OF INFANTS GROUPED ACCORDING TO AGES AT BIRTHWEIGHT DOUBLING

	Group 1 2 to 4 months (n = 11)	Group 2 4 to 6 months (n = 12)	Group 3 6 months or later (n = 6)
Triceps	8.98	8.83	7.71
Subscapular	9.27	8.13	6.57

N = 29.

Simple observation of the mean skinfold values listed in table 9 makes it apparent that infants who doubled their birthweights earlier did have larger skinfolds than infants who doubled at later ages. One-way analysis of variance was used to determine if the differences in the skinfold values of Groups 1, 2, and 3 were statistically significant. No significant differences in triceps skinfolds were found between any of the groups. However, the three groups differed significantly in their subscapular skinfolds. The Student-Newman-Keuls multiple comparisons procedure was then used to further define the differences. The procedure indicated that significant differences in subscapular skinfolds occurred between Groups 1 and 3 and Groups 2 and 3, and that borderline difference occurred between Groups 1 and 2. Therefore, both the early and middle "doublers" (Groups 1 and 2) had significantly larger subscapular skinfolds than the late "doublers" (Group 3); and the difference between the early and middle "doublers" was borderline. None of the three groups differed significantly with respect to the birthweights and skinfold measurements at birth.

Finally, the mean skinfolds of Groups 1, 2, and 3 were compared with Fry et al.'s 1975 norms for Caucasian and Black infants (table 8). Using Fomon's definition of obesity (skinfold measurements more than two standard deviations greater than the mean--Fomon 1974), none of the groups was classified as obese at birthweight doubling. However, it is important to remember that Fry. et al.'s norms present measurements based only on chronological groupings. There are no published standards relating skinfold measurements specifically to the age at which infants double their birthweights.

Weight/length relationships at birthweight doubling were examined for each major subgroup and the total group (table 10), using the estimated Harvard percentiles for group mean weights and lengths for ages. The total group ranked in the 61 percentile for weight and the 51 percentile for length at birthweight doubling. Males were heavier and longer than females at birthweight doubling (males--mean weight = 70%, mean length = 59%; females--mean weight = 54%, mean length = 45%). Bottle-fed infants were heavier and longer than breast/combination-fed infants at birthweight doubling (bottle-fed infants--mean weight = 69%, mean length = 60%; breast/combination-fed infants--mean weight = 55%, mean length = 45%). Although the differences between the groups' mean weight and length percentiles at birthweight doubline appear fairly large, t-test comparison showed that these differences were not statistically significant (a borderline difference existed in mean length percentiles of bottle-fed infants and breast/combination-fed infants). A significant inverse relationship between the age at birthweight doubling and weight percentile at birthweight doubling was demonstrated for the total group ($r = -.69$, p = .0001), as well as for each major subgroup. No significant associations were found between age at birthweight doubling and length percentile at birthweight doubling.

TABLE 10

ESTIMATED PERCENTILES FOR GROUP MEAN WEIGHTS AND LENGTHS AT BIRTHWEIGHT DOUBLING

Group	Number	Percentiles	
		Mean Weight	Mean Length
Males	13	70	59
Females	16	54	45
Bottle-fed	12	69	60
Breast/combination-fed	17	55	45
Total Group	29	61	51

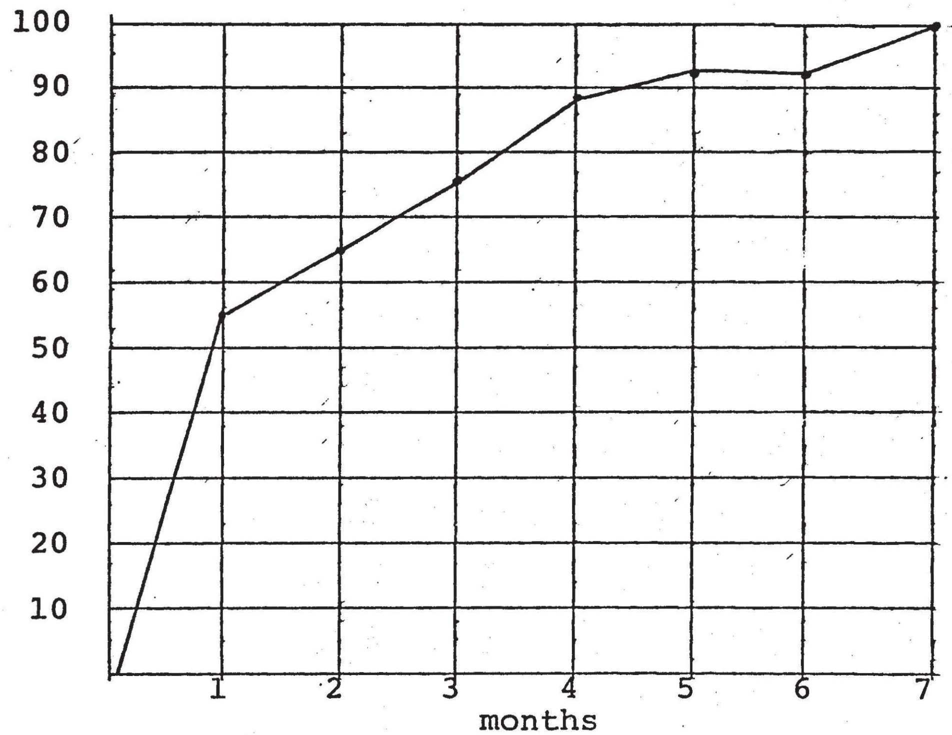
Table 11 presents the mean ages of introduction to solid foods for the total group and subgroups. Solid food introduction ranged from 3 to 186 days, with a mean age of 54 days for the total group. Bottle-fed infants started solids significantly earlier than the breast/combination-fed infants, 25 days versus 75 days (tables 4 and 11). Males started solids earlier than females (39 versus 67 days); this difference was demonstrated to be of borderline statistical significance (tables 3 and 11). Fifty-five percent of the total group started solids by one month of age; 75% began by three months, and 93% by five months (figure 3).

TABLE 11

MEAN AGES OF INTRODUCTION TO SOLIDS

Group	Number	Mean Age in Days
Males	13	54
Females	16	67
Bottle-fed	12	25
Breast/combination-fed	17	75
Male bottle-fed	6	28
Female bottle-fed	6	23
Male breast/combination-fed	7	49
Female breast/combination-fed	10	94
Total Group	29	54

No relationship was found between the ages infants started solids and ages at birthweight doubling, for the total group or any of the major subgroups. These two variables showed a positive relationship only in the male breast/combination-fed group ($r = .75$, $p = .05$).



n = 29.

Fig. 3. Age at Which Infants Began Solids

For the total group, significant inverse relationships occurred between age of introduction to solids and three other variables--birthweight (r = -0.42, p = .02), weight percentile at birthweight doubling (r = -0.41, p = .03), and length percentile at birthweight doubling (r = -0.41, p = .03). Significant inverse relationships between solid food introduction and the above three variables also occurred in the female group, but did not consistently occur in any of the other major subgroups.

Average birthweight doubling occurred at 4.6 months for the study group of 29 infants. No significant differences in mean age at birthweight doubling were shown between males (4.3 months) and females (4.9 months), or bottle-fed infants (4.4 months) and breast/combination-fed infants (4.8 months). Weight percentiles exceeded length percentiles at birthweight doubling for the total group (weight = 61%, length = 51%), and for all the major subgroups, males, females, bottle-fed infants and breast/combination-fed infants.

Two of the 29 infants were categorized as obese at birthweight doubling on the basis of skinfold measurements. Males and females did not differ in their skinfolds at birthweight doubling, nor did bottle-fed infants and breast/combination-fed infants. Infants who doubled their birthweights before six months of age had significantly larger subscapular skinfolds than infants who doubled after six months of age. The earlier an infant doubled his birthweight, the larger was his subscapular skinfold at birthweight doubling. Similar trends occurred with triceps skinfolds, but the triceps results were not significant. When compared with published skinfold norms, none of the groups' skinfold means at birthweight doubling indicated obesity.

Solids were introduced in bottle-fed infants significantly earlier than in breast/combination-fed infants (25 days versus 75 days). Males began solids earlier than females (39 versus 67 days). No relationship between birthweight doubling and the age of introduction to solids occurred for the total group or any of the major subgroups. The age of introduction to solids was associated inversely with birthweight and weight and length percentiles at birthweight doubling.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Obesity is recognized as a major health problem among adults in the United States. Recently more concern has been focused on the problem of obesity among infants and children. Difficulty lies in developing sensitive yet practical measures of obesity for this age group, and in determining if traditional norms to gauge physical growth are appropriate for today's infants and children.

Neumann and Alpaugh's study of 357 infants in 1976 showed the average age for birthweight doubling to be 3.8 months, substantially earlier than the five to six month average stated in most pediatric textbooks (Nelson 1975, Illingworth 1975, Watson 1973). It was not known if a greater mass of fat comprised a significant part of the accelerated weight gain. The purpose of this study was to determine when birthweight doubling occurred, and whether or not it was associated with increased skinfold measurements.

Summary

Twenty-nine infants of normal birthweight were studied to determine when birthweight doubling occurred, and whether or not it was associated with increased skinfold measurements.

The purposes of the study were to analyze data related to growth, adiposity, and feeding practices of infants; to determine whether a relationship existed between age at birthweight doubling and skinfolds; and to compare birthweight doubling age and other variables between male and female groups, and bottle-fed and breast/combination-fed groups.

Measurements of weight, length, head and chest circumferences, and triceps and subscapular skinfolds were obtained on 29 infants within 72 hours of birth. The investigator visited the infants at their homes or pediatricians' offices to obtain these same measurements at intervals closely bracketing the expected times of birthweight doubling. The exact ages of the infants at the time of birthweight doubling were obtained by interpolation. Descriptive statistics (mean, median, standard deviation, and range), Pearson product-moment correlation coefficients, Student's t-test for two independent groups, one-way analysis of variance, and the Student-Newman-Keuls multiple comparisons procedure were used to analyze the data.

Infants' birthweights ranged from 6.80 pounds to 8.90 pounds, with a total group mean of 7.73 pounds. The mean birthweights of male and female groups, and bottle-fed and breast/combination-fed groups, were not significantly different. A positive association was identified for the total group between birthweight and the weight/length percentiles at birthweight doubling. A significant inverse relationship occurred for the total group between birthweight and the age infants were introduced to solids. Therefore, the larger the infant at birth, the earlier the infant began solids, and the greater were his weight and length percentiles at birthweight doubling.

Mean age at birthweight doubling was 4.6 months for the total group. No significant differences in mean age at birthweight doubling were shown between males (4.3 months) and females (4.9 months), or bottle-fed infants (4.4 months) and breast/combination-fed infants (4.8 months). Age at birthweight doubling had significant inverse relationships with two of the variables--subscapular skinfold at birthweight doubling, and weight percentile at birthweight doubling. Thus, the longer it took an infant to double his birthweight, the smaller were his subscapular skinfold and weight percentile at birthweight doubling. No relationship was found between age at birthweight doubling and introduction of solids, for the total group or any of the major subgroups (males, females, bottle-fed infants, and breast/combination-fed infants).

The only difference in skinfolds at birth occurred between male and female subscapular skinfolds (borderline difference). No differences in skinfolds at birthweight doubling occurred between any of the groups. Based on skinfolds, 2 of the 29 infants were identified as obese at birthweight doubling.

Mean skinfolds were then analyzed for groups differentiated by their ages at birthweight doubling. Infants who doubled between two to four months of age and between four to six months of age had significantly larger subscapular (but not triceps) skinfolds than those infants who doubled at six months of age or later. A borderline difference in subscapular skinfolds also existed between the group that doubled at two to four months and those infants that doubled at four to six months of age. Use of Pearson correlation coefficient resulted in a similar finding--the earlier an infant doubled his birthweight, the larger his subscapular skinfold was at birthweight doubling.

None of the groups categorized by age at birthweight doubling was classified as obese, when compared with published norms for skinfolds (Fry et al. 1975). However, the study group's skinfolds were obtained at the ages of birthweight doubling, whereas the published norms were derived solely from chronological groups, with no relationship to birthweight doubling.

The total group ranked in the 61 percentile for weight at birthweight doubling, and the 51 percentile for length at birthweight doubling. Mean weight percentiles exceeded mean length percentiles at birthweight doubling for all groups. Mean percentiles for weight and length at birthweight doubling did not differ significantly between male and female groups nor between bottle-fed and breast/ combination-fed groups.

Fifty-five percent of the infants started solids by one month of age; 54 days was the mean age of introduction to solids for the total group. Bottle-fed infants began solids significantly earlier than breast/combination-fed infants (25 days versus 75 days); males began solids earlier than females (39 versus 67 days). Introduction to solids was associated inversely with three of the variables--weight at birth, and weight and length percentiles at birthweight doubling. Therefore, the larger the infant's birthweight, the earlier he was introduced to solids; the earlier an infant began solids, the greater were his weight and length percentiles at birthweight doubling.

Conclusions

The mean age of birthweight doubling found for the 29 infant study group was 4.6 months. This figure is closer to the tradition birthweight doubling age of five to six months (Nelson 1975, Illingworth 1975, Watson 1973) than to the mean birthweight doubling age of 3.8 months found in 1976 by Neumann and Alpaugh. Statistical differences in birthweight doubling times, which occurred between male and female groups and bottle-fed and breast/combination-fed groups in Neumann and Alpaugh's study, did not occur in this study. Therefore, this study did not support the finding that bottle-fed infants gained weight more rapidly than breast-fed infants (Eid 1970, Fomon 1974, Shukla et al. 1972).

For the study group, numerical differences in ages at birthweight doubling between subgroups were actually larger than numerical differences in Neumann and Alpaugh's study (males and females differed in birthweight doubling ages by 18 days in Neumann and Alpaugh's study, 20 days in this study; bottle-fed infants and breast/combination-fed infants differed by 11 days in Neumann and Alpaugh's study, 12 days in this study). The small sample size of this study was perhaps one contributing factor to the absence of significance with this finding.

Several authors (Bauer 1929, Asher 1966, Shukla et al. 1972, Fomon 1974) have found that infants with increased birthweights are likely to become obese adults. Other researchers find no association between birthweight and obesity (Bruch 1939, Wolff 1955, Heald and Hollander 1965). No predictions about obesity can be made from the birthweights of the study infants. However, analysis showed that the greater an infant's birthweight, the earlier an infant was introduced to solids, and the greater were his weight and length percentiles at birthweight doubling.

Weight percentiles exceeded length percentiles at birthweight doubling for the total group and all the major subgroups. Average weight percentile for the total group was 61%; average length percentile was 51%. Infants with weights ranking greater than the 75 percentile have a significantly higher rate of adult obesity than lighter infants (Charney et al. 1976). Using this criterion solely, none of the groups can be identified as being at risk for obesity at the time of birthweight doubling, since no group's mean weight percentile exceeded the 75 percentile.

Fomon (1974) and Gampel (1965) found skinfolds to be greater in females at birth. Skinfolds obtained during the study showed a borderline difference (females greater than males) in subscapular, but not triceps, skinfolds.

This difference in subscapular skinfolds between sexes did not persist at birthweight doubling.

Analyzing the study groups in a different way (dividing the group according to their birthweight doubling ages) showed that early birthweight doubling is associated with subscapular skinfolds that are not increased above normal values, but are significantly greater than subscapular skinfolds of infants who doubled their birthweights at later ages. This conclusion does not suggest that obesity is not a risk for these infants. Aspects of the comparison done between the study group's skinfolds and current skinfold norms were not optimal--specifically, the study group's skinfolds were obtained at birthweight doubling, and the skinfold norms were derived with no relation to birthweight doubling. Comparison of groups whose skinfolds were measured under identical conditions would yield more decisive information about obesity.

The various results about skinfolds were found to be significant only for the subscapular skinfolds, not the triceps skinfolds. The reasons for this discrepancy are unclear. An impression formed during data collection was that it was considerably more difficult to grasp a skinfold unaffected by underlying muscle tension at the triceps site than at the subscapular site. Other combinations of sites have been used in studies, and McGowan et al. (1974) found flank and quadriceps sites to yield the most reliable results for newborns. Further research is needed to determine if the combination of triceps and subscapular skinfolds, commonly recommended for obtaining skinfolds (Tanner and Whitehouse 1975, Jelliffe 1966), is the optimal combination for obtaining accurate skinfolds on infants.

Fifty-five percent of the infants in the study began solids by one month of age; 75% began solids by three months. These findings concur with the current trend of early introduction of solids (Epps and Jolley 1963, Lloyd 1975). Neumann and Alpaugh's 1976 study indicated a significant difference in the age of introduction to solids between bottle-fed and breast-fed infants. A significant difference between bottle-fed infants was found likewise in this study (25 days, bottle-fed infants; 75 days, breast/combination-fed infants).

The decline in breast-feeding has been documented by Martinez and Salber (Fomon 1974), whose 1973 study showed that only 10 to 15% of U.S. infants were breast-fed at two months of age, and Hambraeus (1977), who found that 5% of infants were breast-fed at six months of age. However, a higher incidence of breast-feeding occurred among the study infants--58.6% of the 29 infants were categorized as breast/combination-fed infants, and 31% were considered totally breast-fed.

Fomon (1974) and Hammar (1975) reported that breast-feeding is more common in the upper-middle classes in the United States. In order to see if this finding explained the study group's high incidence of breast-feeding, it was necessary to determine some indication of the group's socioeconomic status. Educational levels of the parents were analyzed, since educational level and income are known to correlate highly (Hamill et al. 1972). The average number of years of education for the mothers was 14.2 (two completed years of college); fathers' educational levels average 15.5 years (three completed years of college). Families in which the head of the household completed one to three years of college had a median yearly income of $17,970 in 1976. The median yearly income for all families in the United States was $15,000 (U.S. Bureau of Census, 1977). Therefore, based on information relating educational levels and income, it is reasonable to conclude that the median yearly income of the families of the study infants was substantially higher than the median yearly income of all U.S. families.

Parents of the study infants were also well-educated. Mothers' educational levels averaged 14.2 years (two completed years of college); 12.4% of all U.S. females had completed one to three years of college in 1976. The average educational level of the fathers was 15.5 years (three completed years of college); 13.8% of the U.S. male population had completed one to three years of college in 1976 (U.S. Bureau of Census: 1977). Mothers of the breast/combination-fed infants had significantly more education than mothers of the bottle-fed infants (15.0 years versus 13.1 years).

Implications

The problem of infantile obesity needs additional study. The data presented in this study make it evident that the study group manifested discrepancies in the various parameters used to define infantile obesity. Birthweight doubling time did not significantly differ from the traditionally-stated values; skinfold measurements at birthweight doubling fell within normal limits for age. However, the infants who doubled their birthweights earlier had significantly larger subscapular skinfolds than those infants who doubled later; and weight percentiles exceeded length percentiles at birthweight doubling for all groups of infants. It is difficult to reconcile these conflicting pieces of evidence that both support and reject infant obesity as a function of modern feeding practices.

Consequently, it will be important for future studies to examine in more detail those anthropometric measurements and pieces of historical data which truly define obesity in the early months of life.

A second implication of this study pertains to the differences that may exist between various infant feeding regimens as they relate to the development of obesity. From the data collected herein, there appeared to be no inherent increased risk to either method of feeding. Bottle-fed infants neither doubled their birthweights significantly earlier than breast/combination-fed infants, nor did they have significantly larger skinfolds at birthweight doubling. (It is acknowledged that differences occurring between the bottle-fed and breast/combination-fed groups may have been influenced by the inclusion of combination-fed infants in the latter group.) However, it is likely that determination of which method of feeding, if either, poses a more serious threat to the development of obesity is a difficult problem when such feedings are supplemented with solids in the contemporary fashion.

In the area of infant nutrition, guidance from health professionals is sought constantly by concerned parents. Nurses involved in the care of infants and children must have an awareness of the scope and complexity of information pertaining to infant nutrition. Quality in nutritional guidance for infants and children may be achieved by knowledge of the most current nutritional recommendations in combination with awareness and respect for an individual's knowledge and feelings regarding nutrition.

Recommendations

Recommendations for further study include

1. Repetition of the study using a larger sample size

2. Repetition of the study using three groups, bottle-fed infants, breast-fed infants, and combination-fed infants

3. Measurement of infant skinfolds at triceps and subscapular sites and also at several other sites, to determine which sites yield the most reliable results

4. Perform a similar study documenting ages at birthweight doubling and skinfolds at birthweight doubling for infants, but also measure skinfolds at predetermined intervals (for instance, at birth, two months, four months). This would facilitate more reliable comparison of the skinfold results with currently-existing skinfold norms.

APPENDIX A

INTRODUCTORY LETTER

Dear

As a graduate nursing student in maternal and child health at Texas Woman's University, one of my major areas of interest is infant nutrition. In the study I am doing for my thesis, I am trying to clarify the time at which an infant doubles his birthweight. This occurrence has been used traditionally as a lardmark of the physical growth and nutritional well-being of infants.

I would like to request your permission to include your infant in this study. This would entail frequent measurements of your infant's weight, length, head and chest circumferences, and two skinfold measurements. All the measurements are painless and simple. Many of the measurements will be made by me at your pediatrician's office when you bring your infant in for routine checks. I may also occasionally need to see your infant at home at your convenience, to obtain additional measurements.

I would like to stress that all the decisions concerning your infant's nutrition will be made by you and your pediatrician. Once a week I would like to telephone you to keep informed of how your infant is doing and if any changes in the infant's diet have been made.

If you agree to participate in the study, please sign the attached consent form. Your cooperation in this study will help to provide further understanding of the normal growth pattern of infants. Thank you for your valuable time and interest.

Sincerely,

Judy Wientzen, R.N.
T.W.U. Graduate Student

APPENDIX B

DEMOGRAPHIC DATA

Date ______________________________

Infant's Name ______________________ Date of Birth _____________

Hospital No. ______________ Birthplace __________________________

Race _______________ Sex _______________

Apgar Score: 1 min. ______

5 min. ______

Mother's Name ___________________________ Phone ___________________

Hospital No. _______________ Race ___________________________

Address __________________________ City ______________ Zip _________

Level of Education ____________ Husband's Level of Education ___

Type of Delivery: Vaginal ________ Caesarean-Section __________

Why? ____

____

Duration of Pregnancy ______________

Pediatrician ____

Address _________________________________ Phone ____________________

Feeding Plans:

Breast-feed ____________ Bottle-feed ____________ Formula __________

Comments: (Use this section for noting changes in feeding technique, the date of changes, explanations for the change)

____

____

____

____

Category: Breast-fed________ Bottle-fed________

Combination-fed________

Date Infant Began Solids______________________

INFANT MEASUREMENTS

Infant's Name____________________ Birthweight__________

Date of Birth____________________ Doubled Birthweight__________

	Date of Measurements	Weight (g)	Length (cm)	Head Circumference (cm)	Chest Circumference (cm)	Triceps Skinfold (mm)	Subscapular Skinfold (mm)
Birth							
6 weeks							
8 weeks							
10 weeks							
12 weeks							
14 weeks							
16 weeks							
18 weeks							
20 weeks							
22 weeks							
24 weeks							

APPENDIX C

CONSENT FORM

TEXAS WOMAN'S UNIVERSITY

(Form B--Oral presentation to subject)

Consent to Act as a Subject for Research and Investigation:

I have received an oral description of this study, including a fair explanation of the procedures and their purpose, any associated discomforts or risks, and a description of the possible benefits. An offer has been made to me to answer all questions about the study. I understand that my name will not be used in any release of the data and that I am free to withdraw at any time.

__________________________ _______________
Signature Date

__________________________ _______________
Witness Date

Certification by Person Explaining the Study:

This is to certify that I have fully informed and explained to the above named person a description of the listed elements of informed consent.

__________________________ _______________
Signature Date

____
Position

__________________________ _____________
Witness Date

TEXAS WOMAN'S UNIVERSITY
DALLAS, TEXAS 75235

COLLEGE OF NURSING

February 3, 1977

Ms. Judith D. Wientzen
2808 Arroyo, #228
Dallas, Texas 75219

Dear Ms. Wientzen:

The Dallas Center Sub-Committee for Human Research has approved your proposal for "Birthweight Doubling Time and Its Association with Inceased Skinfold Measurements." Following acquisition of agency approval you may now proceed with your data collection as planned.

Sincerely,

Geri Goosen

Geri Goosen
Chairman of Human Research Committee

cc: Dr. Phyllis Bridges
Graduate Dean

GG:js

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HOUSTON CENTER
1130 M.D. Anderson Blvd.
Houston, Texas 77025

AGENCY PERMISSION FOR CONDUCTING STUDY*

THE ______________________________

GRANTS TO Judith D. Wientzen

a student enrolled in a program of nursing leading to a Master's Degree at Texas Woman's University, the privilege of its facilities in order to study the following problem:

"Birthweight Doubling Time and its Association with Obesity"

The conditions mutually agreed upon are as follows:

1. The agency (may) (may not) be identified in the final report.
2. The names of consultative or administrative personnel in the agency (may) (may not) be identified in the final report.
3. The agency (wants) (does not want) a conference with the student when the report is completed.
4. The agency is (willing) (unwilling) to allow the completed report to be circulated through interlibrary loan.
5. Other: ______________________________

Date X ______________________

X ______________________
Signature of Agency Personnel

Judith D. Wientzen
Signature of student

____
Signature of Faculty Advisor

*Fill out and sign three copies to be distributed as follows: Original - Student; first copy -- agency; second copy -- T.W.U. College of Nursing.

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~~THE~~ Dr. Larry H. Patton

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4. The agency is (willing) (unwilling) to allow the completed report to be circulated through interlibrary loan.
5. Other: ______

LARRY H. PATTON, MD., FAAP
AND ASSOCIATES
100 N. COTTONWOOD
RICHARDSON, TEXAS 750[illegible]
PEDIATRICS 231-[illegible]

Date X 6/20/77

X [signature]
Signature of Agency Personnel

Judith D. Wientzen
Signature of student

Signature of Faculty Advisor

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~~THE~~ Drs. Steinberg, Dildy, Morchower, and Crow

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4. The agency is (willing) (unwilling) to allow the completed report to be circulated through interlibrary loan.
5. Other: ______

Date 6/17/78

Signature of Agency Personnel

Judith D. Wientzen
Signature of student

Signature of Faculty Advisor

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AGENCY PERMISSION FOR CONDUCTING STUDY*

THE Dr. F. Payne and Dr. J. Roach

GRANTS TO Judith D. Wientzen

a student enrolled in a program of nursing leading to a Master's Degree at Texas Woman's University, the privilege of its facilities in order to study the following problem:

"Birth Weight Doubling Time and its Association with Obesity"

The conditions mutually agreed upon are as follows:

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2. The names of consultative or administrative personnel in the agency (~~may~~) (may not) be identified in the final report.
3. The agency ~~(wants)~~ (does not want) a conference with the student when the report is completed.
4. The agency is (willing) (~~unwilling~~) to allow the completed report to be circulated through interlibrary loan.
5. Other: ______________________________

Date X 6-11-77

X [illegible signature]
Signature of Agency Personnel

Judith D. Wientzen
Signature of student

Signature of Faculty Advisor

*Fill out and sign three copies to be distributed as follows: Original - Student; first copy -- agency; second copy -- T.W.U. College of Nursing.

APPENDIX D

Personal Communication - Explication of Prolonged Gastroenteritis

While there are no firm guidelines published in the pediatric literature, conventional wisdom and clinical pediatric experience would indicate that after five days of vomiting and/or diarrhea, the diagnosis of severe gastroenteritis can be made. This diagnosis implies that the nutritional status of the infant has been significantly jeopardized.

Date 12/13/76

John D. Nelson, M.D.

Professor of Pediatrics

Chief, Division of Pediatric Infectious Disease

University of Texas Health Science Center

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