Comparison of Growth in Preterm, Low-Birth-Weight Infants Fed Human Milk Versus Standard Infant Formula from 40-56 Weeks Postconceptual Age

Laurie Jean Moyer

Utah State University

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COMPARISON OF GROWTH IN PRETERM, LOW-BIRTH-WEIGHT INFANTS FED HUMAN MILK VERSUS STANDARD INFANT FORMULA FROM 40-56 WEEKS POSTCONCEPTUAL AGE

by
Laurie Jean Moyer

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Nutrition and Food Sciences

Approved:

UTAH STATE UNIVERSITY - Logan, Utah

1982
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To my family, Dave, Colby and Breanna, for ignoring long hours, laundry piles and convenience foods, much love and gratitude.

I dedicate this work to my father, Robert, and in memory of my mother, Shirley.

Laurie Jean Moyer
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Comparison of Growth in Preterm, Low-Birth-Weight Infants Fed Human Milk Versus Standard Infant Formula from 40-56 Weeks Postconceptual Age

by

Laurie Jean Moyer, Master of Science
Utah State University, 1982

Major Professor: Dr. Barbara Prater
Department: Nutrition and Food Sciences

The purpose of this study was to compare growth following hospitalization in preterm, low birth weight infants fed their own mother's milk versus preterm, low birth weight infants of similar weight and gestational age given standard infant formula upon demand. Growth measurements were taken 40, 42, 48 and 56 weeks postconceptual age.

A total of 28 healthy, preterm, low birth weight infants completed the study. Seventeen infants received standard infant formula (Similac) and 11 were breast-fed upon demand. Introduction of solid foods was delayed until the infant was greater than 56 weeks postconceptual age. Weight, length, occipital frontal circumference, mid-upper arm circumference, triceps and subscapular skinfold measurements were obtained.
at 40, 42, 48 and 56 weeks postconceptual age in our nutrition follow-up clinic.

Analysis of variance with feeding as well as age, sex, gestational age at birth, birth weight, birth length and birth head circumference as factors was performed utilizing Duncan's Multiple Range Test. Weight, mid-upper arm circumference, and triceps and subscapular skin-fold measurements were shown to be significantly greater in infants fed formula versus human milk from birth to 40 weeks postconceptual age. Gestational age at birth and increasing chronological age was also shown to influence these measures. Statistical significance was less than the one percent level. However, no statistical or clinical differences were found in rates of growth of preterm, low birth weight infants fed either human milk or standard infant formula from 40 to 56 weeks postconceptual age. Both feeding groups experienced growth within the 10 to 90th percentiles of accepted infant norms for all parameters.

It was concluded that preterm, low birth weight infants allowed to be breast-fed upon demand post-hospitalization experienced acceptable rates of gains from 40 to 56 weeks postconceptual age. Use of commercial formula was not found to be more advantageous than breast feeding.
CHAPTER I

INTRODUCTION

The purpose of this study was to compare growth in premature, low-birth-weight infants fed breast milk versus proprietary formula post hospitalization.

Background of the Problem

The adequacy of the use of human milk as a feeding for the preterm (<37 weeks gestational age) infant is presently receiving much debate (Fomon, et al., 1977; Räihä, et al., 1976). Of special concern are low-birth-weight (LBW) infants (birth weight less than 2500 grams). These infants have not been able to benefit from the normal accretion of nutrients that occurs during the last trimester of pregnancy. They may have been subjected to trauma, stress and/or exposure to infection during birth. Many times their acute illnesses secondary to prematurity prevents the provision of sufficient calories to maintain birth weight. Decreases in weight of five to ten percent in the initial postnatal days are considered acceptable in the full term as well as preterm infant (Rickard and Gresham, 1974). However, weight losses of greater than ten percent of birth weight are not uncommon in the critically ill neonate (NBICU, UUMC, 1981).

The Committee on Nutrition, American Academy of Pediatrics, 1977, has stated that the optimal diet for the LBW infant is an intake which supports growth approximating the third trimester of pregnancy without placing stress on still developing metabolic and excretory systems.
The diet would also need to provide adequate energy and nutrients to promote "catch up" growth (Fomon, 1974) to correct losses exceeding ten percent of birth weight. Recommended growth increases are defined as: weight $\geq$ 20 grams/day, length = 1 centimeter/week and occipitofrontal head circumference (OFC) = 1 centimeter/week. These growth parameters are based upon studies of fetal accretion rates (Lubchenco, et al., 1963; Widdowson and Dickerson, 1964, Ziegler, et al., 1979).

The LBW infant requires greater amounts of nutrients than a full term healthy newborn. Advised nutrient intakes are based upon analysis of body composition of stillborn infants at various gestational ages and the rate of accretion of those nutrients (Widdowson and Dickerson, 1964). The advised intakes account not only for growth but dermal and urinary losses and intestinal absorption (Ziegler, et al., 1979). The U.S. Recommended Dietary Allowance (RDA) for infants was utilized for those nutrients not determined by fetal accretion rates (Food and Nutrition Board, National Research Council, 1980). The LBW infant is susceptible to multiple deficiencies secondary to their limited nutritional reserves, exposure to infection, trauma and/or acute illness. Nutrients of special concern include protein, major minerals, calcium, phosphorus, sodium, potassium, magnesium, vitamins (D, E, K, C, $B_{12}$), folate and trace minerals (iron, copper, zinc, manganese). Comparison of advised nutrient intake and composition of pooled human milk (per 100 Kcals) would indicate that the use of human milk as a feeding for the LBW infant would lead to the development of specific nutrient deficiencies (Ziegler, et al., 1979; Forbes, 1978) (Table 1). These deficient nutrients include protein, sodium chloride, calcium, phosphorus, magnesium, iron, vitamins A, D, E and folate. Studies have shown lesser
daily rates of gain in weight at same caloric intake in preterm infants fed pooled term human milk versus preterm infants receiving formula with higher protein content (1.7 grams/dl versus 3.0 grams/dl) (Raihā, et al., 1976). The advised energy intake ranges between 120-130 Kcals/kg body weight/day to achieve desired growth (Sinclair, et al., 1970). Caloric concentration of human milk is variable (range 16-22 Kcals/oz or 56-72 Kcals/dl) (Lawrence, 1980) and the LBW infant, especially those <1500 grams, may not be able to consume a volume large enough to achieve adequate calories or nutrients (Fomon, et al., 1977; Forbes, 1978).

Recent studies, however, have looked at the composition of human milk from mothers of premature infants. Gross, David and Bauman (1980) showed that the milk produced by mothers delivering prematurely (28-36 weeks) contained significantly higher concentrations of protein, sodium and chloride than term milk during the first month of lactation. The nitrogen content has also been shown to be higher in the milk obtained from mothers of preterm infants (Schanler and Oh, 1980; Atkinson, et al., 1978). These studies suggest that the milk produced during the first month of lactation by a mother delivering prematurely may be the feeding of choice.

Other benefits exist in addition to the unique composition of "preterm" human milk. These include immune factors (Mata and Wyatt, 1971), increased digestibility and bioavailability of nutrients (György, 1971), low renal solute load (Fomon, 1974) and mother-infant bonding (Klaus, et al., 1970). Because of these factors, mothers desiring to nurse are encouraged to provide their own milk to their premature infant during their child's hospital stay in Intermountain Newborn
Intensive Care Unit, University of Utah Medical Center. Infants are given additional supplementation as stated in the protocol to meet advised intake levels (Table 2).

Little followup data exist examining the growth of preterm, low birth weight infants following hospital discharge in relation to feeding during the first year of life. Studies have been done comparing intake and growth of normal, healthy term infants fed either human milk or commercial infant formula. Fomon, Thomas, Filer, Ziegler and Leonard (1971) showed a more rapid gain in weight and length by bottle-fed term infants than breast-fed infants during the first 112 days of life. It is speculated that this may be the result of overfeeding of bottle-fed infants. Other factors that have been found to influence growth in healthy, term infants include sex (Fomon, et al., 1970) and time of introduction to solid foods (Ferris, et al., 1979; Ferris, et al., 1980).

Restatement of Problem

Previous studies have shown that LBW infants experience a faster rate of weight gain when fed a more calorically dense (80-90 Kcal/dl) formula with a higher protein content (3.6 gram/100 Kcals) than those receiving pooled human milk (72 Kcals/dl, 1.8 gram protein/100 Kcals) (Räihä, et al., 1976; Davidson, et al., 1967). Therefore, the use of human milk as a feeding for the preterm, LBW infant has not been previously encouraged. This has resulted in the majority of these infants being fed proprietary formula during hospitalization and through the first year of life. However, recent data have shown that the composition of "preterm" human milk differs significantly (protein, Na, Cl,
K, Fe) from pooled term human milk during the first month of lactation (Gross, et al., 1980; Schanler and Oh, 1980; Atkinson, et al., 1978; Lemons, et al., 1981). Thus, human milk produced by a preterm, LBW infant's own mother may be the feeding of choice.

Because of the unique composition of "preterm" human milk and other benefits associated with breast feeding, mothers who have given birth to a preterm, LBW infant are now encouraged to provide their own milk to their infant during hospitalization. They are also advised to continue breast feeding their infant during the first year of life as currently recommended (Committee on Nutrition, American Academy of Pediatrics, 1978).

It has not been shown if growth of the preterm, LBW infant fed his own mother's milk upon demand simulates that of the rapidly growing fetus (Widdowson and Dickerson, 1964). It remains to be shown if mothers of infants delivering prematurely can provide sufficient volume and nutrients to their infants to achieve "normal" as well as "catch up" growth during: 1) the infant's hospitalization and 2) into the first year of life. Because of the difficulty of obtaining feeding compliance during hospitalization, e.g., a high number of infants transferred from the Newborn Intensive Care Unit to outlying hospitals to attain acceptable discharge body weight; growth parameters will be monitored post-hospitalization until they attain 56 weeks postcon- ceptual age.

**Objective**

To compare growth following hospitalization in preterm, LBW infants fed their own mother's milk versus preterm, LBW infants of
similar weight and gestational age given standard infant formula upon demand, until 56 weeks postconceptual age (PCA).

Procedure

Infants were followed during the first 56 weeks postconceptual age in the nutrition followup clinic. Maternal pregnancy, labor and delivery history was recorded. Infant growth was assessed by anthropometric measurements taken from healthy preterm (28-36 week gestation) appropriate for size low birth weight (< 2500 gram) infants fed either their own mother's milk or standard infant formula (Similac*).

Anthropometric measurements included weight (grams), length (centimeters), occipital frontal circumference (OFC, cm), mid upper arm circumference (MUAC, cm) and triceps and subscapular skinfolds (mm). Measurements were made utilizing the following: weight (Toledo Scale), height (foot board), OFC and MUAC (metal tape) and skinfolds with Lange Caliper. Measurements were taken serially at the following intervals: 40, 42, 48 and 56 weeks postconceptual age. All measurements were performed by the same observer.

Weight, length and OFC were plotted serially on a growth record developed by the National Center for Health Statistics comparing gestational age to fetal and infant norms. Skinfold measurements were compared to measurements published by Karlberg, Engström, Lichenstein and Svennberg (1968) and graphed by Fomon (1977) for birth to six years, once the infant has reached his EDC or original due date.

*Ross Laboratories, Columbus, Ohio.
Introduction of solid foods followed recommended guidelines established by the American Academy of Pediatrics' Committee on Nutrition, 1980 (Table 1). Mothers in both groups were advised to delay introduction of solids until 56 weeks postconceptual age (approximately four months corrected age). It is that time that growth is thought to be influenced by composition and amount of solid food fed whether the infant is receiving human milk or standard formula. Therefore, comparison of growth ended prior to the time of introduction of solid food.

Hypothesis

Following hospitalization, preterm LBW infants fed their own mother's milk experience growth at rates similar to preterm, LBW infants given standard infant formula upon demand 56 weeks postconceptual age.

Limitations

1. The data were collected on a small sample size of 28 subjects that were selected as randomly as possible within the constraints of the study protocol.

2. It was assumed that compliance in each feeding group occurred, i.e., delayed introduction of solids; no supplemental feedings (commercial formula) were given to the human milk group.

3. The formula-fed group may not have been allowed to feed upon demand.
Definitions

Appropriate for Gestational Age (AGA) - Weight between the 10-90th percentile acceptable norms for the particular gestational age.

Gestational Age (GA) - Estimated number of weeks postconception (term, 38-42 weeks).

Hyaline Membrane Disease/Respiratory Distress Syndrome (HMD/RDS) - Disease in the first days of life characterized by respiratory distress, cyanosis, easy collapsibility of alveoli and lack of pulmonary surfactant. A hyaline membrane lines the alveoli and alveolar ducts when the disease persists for more than a few hours.

Infant - From 1 month to 1 year of age.

Intrauterine Growth Retardation (IUGR) - Any or all growth parameters (weight, length, OFC) <10th percentile acceptable norms for the particular gestational age.

Large for Gestational Age (LGA) - Birth weight >90th percentile acceptable norms for the particular gestational age.

Low Birth Weight (LBW) - Birth weight <2.5 kg.

Neonate - The first 28 days of life.

Occipital-Frontal Circumference (OFC) - Head circumference.

Postconceptual Age (PCA) - Gestational age plus postnatal age.

Premature - Gestational age < 37 weeks.

Rh Incompatibility - Fetal-maternal blood group incompatibility. Complications include hyperbilirubinemia, edema, respiratory distress.

Small for Gestational Age (SGA) - Weight <10th percentile, acceptable norms for the particular gestational age.
CHAPTER II

REVIEW OF THE LITERATURE

The current recommended practices and research related to infant feeding and its effect on growth for normal, full-term (gestation = 38-42 weeks) and premature, low-birth-weight infants is presented in the following review of the literature. The related literature cited in this review has been divided into seven sections: 1) Normal Growth and Development; 2) Nutrient Needs of the Normal, Full-term Infant; 3) Nutrient Needs of the Premature, Low-Birth-Weight Infant; 4) Infant Feedings; 5) Methods of Assessing Growth; 6) Comparison of Growth in Infants Receiving Human Milk versus Proprietary Infant Formula, and 7) The Need for Further Research.

Normal Growth and Development

Growth is defined as an increase in physical size of the entire body or as an increase in any of the body's parts associated with an increase in cell size and number. Development is the attainment of function associated with cell differentiation and maturation in individual organ systems.

Growth and development in a normal healthy child is predetermined by genetics and the interaction of nutritional inadequacy/excesses of their diet and other hormonal and environmental factors (Pipes, 1977). Growth occurs in three critical stages: Stage I, hyperplasia, which is an increase in cell number; Stage II, hypertrophy and hyperplasia, which is an increase in both cell size and cell number and
Stage III, hypertrophy, where only the cell size increases. Undernutrition during Stages I and/or II can result in decreased cell size and number (Elliot and Cheek, 1968). Overnutrition during Stages I and/or II can result in an increased number of cells in the organs (Winick and Noble, 1967). It appears that during hyperplasia, organs are the most vulnerable to undernutrition which may result in a deficit of an individual's acquisition of a normal complement of cells.

Birth weight of the neonate (0-1 month of life) will be influenced by gestational age and maternal size. The normal healthy neonate weighs an average of 3.5 Kg at birth. The neonate will generally experience a 5-10% weight loss following birth, secondary to a loss of extracellular fluid. This weight loss is usually regained by 10-14 days of life. During the first year of life, the neonate/infant (1-12 months of life) experiences an extremely rapid period of growth. Birth weight is doubled by four months of age (Neumann and Alpaugh, 1976) and tripled by one year of age. In general, infants who have been subjected to intrauterine growth retardation will experience catch-up growth and attain normal status by six months of age (Fomon, 1974). The infant will also experience a 50% increase in length the first year, double birth length by four years and triple it by 13 years. After the first year of life, yearly increments in weight and height decrease until adolescence, when a growth spurt occurs (Pipes, 1977). As the child grows, body composition changes as well. Total body water decreases from the time of infancy from about 75% of body weight to 60% at one year of age, which is equivalent to adult total body water. This reduction is almost entirely due to extracellular losses. Factors that cause these decreases include decreased water
contents in adipose tissue, increased lean body mass. It can be shown that there is a relationship between total body water and lean body mass. Water is responsible for 84% of the weight of fat free mass at birth compared to 72-73% in the adult. The tallest children of the same sex will have greater amounts of lean body mass than shorter children (Johnston and Beller, 1976). Males tend to accumulate lean body mass at a greater rate than females. By age 20, males will have one and one-half times more lean body mass than females (Pipes, 1977).

The fat composition of the fetus increases rapidly during the last trimester of pregnancy. At birth, the infant has approximately 11-16% of total weight as fat (Widdowson and Dickerson, 1964). Between 2-6 months of age, the infant experiences a two times greater increase in adipose tissue versus that of muscle tissue. Females deposit a greater percentage of fat than males do, even in infancy (Frisancho, 1974).

Rate of weight gain and height will be influenced by under/over nutrition. Infants who are undernourished tend to be shorter and weigh less. Infants who are overnourished will be taller, heavier and more mature. Infants recovering from an undernutrition and/or illness will experience a phenomenon known as "catch up" growth. "Catch up" growth is defined as a rate of growth greater than what is considered normal for that age child (Neumann and Alpaugh, 1976). In "catch up" growth a child will experience an increase in weight until it is normal for height. Weight gain will decrease as height and weight increase together. It is felt that "catch up" can occur after early malnutrition (Chamberlain and Davey, 1975; Prader, 1978; Davies, 1981). Low birthweight infants that are preterm have a better change for
"catch up" growth than those who have experienced intrauterine growth retardation (IUGR) (Davies et al., 1979).

However, it has been reported that infants suffering from malnutrition severe enough to require hospitalization during the first year of life will experience permanent stunting in their linear growth and head circumference (Pipes, 1977). Infants who experience malnutrition secondary to illness or physical abnormalities have been shown to experience "catch up" growth (such as those infants suffering from celiac disease who are treated with a gluten-free diet). These infants usually catch up to normal growth curves by age three (Karlberg et al., 1968). Eid (1971) compared failure to thrive that was treated versus failure to thrive that was untreated. Significant growth retardation occurred in both groups. It was concluded that the duration of illness and under-nutrition and interaction of these factors were the most significant causes of permanent growth retardation.

Infants experience a critical period for brain growth from midgestation through the second postnatal year. Children malnourished during early infancy were less able to recover from nutritionally induced intellectual deficits than those children malnourished at an older age. Dobbing (1970) hypothesized that during the brain growth spurt, there was increase in cell number, establishment of synaptic connections and myelination. Insults occurring during this critical period will not delay, but will decrease brain growth. An increase in brain growth is also associated with an increase in head circumference. The head grows rapidly during the first year and, by four months, two-thirds of postnatal growth has been achieved. Children who experienced inadequate nutrition for less than four months experienced
lesser developmental handicaps than those who were malnourished greater than four months (Dobbing and Sands, 1973).

Growth velocity of head circumference in different gestational age groups has been observed. Fujimura and Teryu (1977) followed healthy infants either appropriate for gestational age or small for gestational age during the first five months of age ($n = 222$). Term, appropriate for gestational age (AGA) and small for gestational age (SGA) infants showed a steady growth rate of head circumference. In contrast, preterm AGA infants of less than 36 weeks gestation showed an increase in velocity of growth followed by slowing with maximum velocity occurring between 30 and 40 days after birth. The shorter the post-conceptual age at birth, the later maximum velocity occurred. Although the occurrence of maximum velocity of head growth is delayed in the preterm infant, the net effect is such that, at a given post-conceptual age, his head circumference is greater than that of the term infant within the first five postnatal months.

Nutrient Needs of the Normal Infant

It is important that the infant consumes sufficient energy and protein to attain adequate growth. Energy requirements will be influenced by body size and composition, physical activity and rate of growth. Infants have a higher basal metabolic rate than older children. Males' basal metabolic rate is greater than that of females. The cost of growth is thought to be between 5-8 kilocalories/gram of tissue gained. Therefore, with decreased rate of gain, there is decreased energy need. As a child grows older, there are increased caloric needs secondary to greater body size, but energy per unit of
size decreases. The average healthy newborn infant requires approximately 110-120 calories per kg of body weight per day to achieve average growth weight of 20-30 grams per day. This requirement gradually decreases so that, by the end of the first year of life, the infant requires somewhere between 90 and 100 calories/kg of body weight/day. Infants also require approximately two grams of protein per kilogram of body weight per day. This requirement will vary depending upon the rate of growth and the quality of protein in the diet. Sources of protein for the infant include human milk and/or cow milk formulas in addition to table foods. The infant must have adequate calories from carbohydrates and fat so the protein is not utilized for energy, but instead, utilized for building of body tissue. Deficiencies in protein intake will result in a decreased growth rate and, if severe, will result in cessation of linear growth and loss of body protein. Intakes of protein that are considered excessive or greater than 20% of total calories in infants result in an increased solute load and dehydration. Therefore, excessive intake should be avoided (Fomon, 1974).

Fat intake should impose 40-50% of the infant's energy source. Fats are responsible for production of adipose tissue, vitamins, hormones and membrane structures. The normal healthy newborn will absorb approximately 85-90% of the fat found in human milk versus less than 70% of fat found in cow's milk. Fat functions as a source of energy, a carrier for fat soluble vitamins, increases taste and are responsible for satiety. Fats are a component of phospholipids, which are membrane structures that are constituents of all cells and aid in the absorption and transport of fat. Fats are also important for cholesterol, which is a precursor for all products of bile salts, vitamin D
and hormones. It is important that infants receive essential fatty acids or linoleic acid in order to prevent essential fatty acid deficiency from developing. Fomon (1974) recommends that at least 30% of the total calories be fat but not to exceed greater than 50%. Excesses in fat consumption will result in ketosis and/or obesity and will also limit the intake of other foods.

Carbohydrates are required by the infants for energy and synthesis of glycogen stores. The Food and Nutrition Board, National Research Council (1980) recommends that infants receive between 50 and 100 grams of carbohydrate per day. Intakes inadequate for carbohydrates may result in ketosis secondary to fat breakdown, dehydration, loss of body protein, fatigue and loss of energy. Excessive carbohydrate intake may cause an overload of the disaccharidases found in the small intestine.

The Recommended Daily Allowances (Food and Nutrition Board, National Research Council, 1980) of vitamins and minerals for infants 0-6 months of age are based upon the content found in mature human milk. Deficiencies of vitamin D and iron have been reported in breast-fed infants. Therefore, it is currently advised that the healthy, term neonate/infant be supplemented with vitamin D (400 I.U./day) and iron (7 mg/day). It is also suggested infants be given supplemental fluoride (0.5 mg/d) (Committee on Nutrition, American Academy of Pediatrics, 1976).

Nutrient Needs of the Preterm.

Low-Birth-Weight Infant

The need for nutritional support of the high-risk neonate is extremely important in view of the increased metabolic demands experienced
with stress from traumatic birth, exposure to infection, prematurity and medical/surgical complications (Committee on Nutrition, American Academy of Pediatrics, 1977). Infants who are delivered prematurely (<37 weeks gestation) and/or at low birth weight (LBW, <2500 gms) are more susceptible to complications associated with malnutrition. These infants possess lesser stores of nutrients normally accumulated during the third trimester of intrauterine life (Ziegler, 1976; Shaw, 1974) and may be unable to readily absorb or utilize nutrients secondary to an immature digestive system (Grand, et al., 1976; Sunshine, et al., 1971).

The goal of nutritional management for the low-birth-weight infant is to supply a caloric intake adequate to support growth approximating the rate during the third trimester of intrauterine life (Davidson, 1970). This goal is often complicated by the infant's medical condition and, therefore, the primary objective may be to initially provide a caloric intake that will meet maintenance needs and avoid the development of a starvation state (Rickard and Gresham, 1974). Delays in providing adequate nutrition to the LBW infant early in life may significantly affect the prognosis for favorable physical, neurological and intellectual development (Dobbing, 1970; Dobbing and Sands, 1973; Jackson, 1977). The diet would also need to provide adequate energy and nutrients to promote "catch-up" growth to correct losses exceeding ten percent of birth weight (Davies, 1981). Recommended growth increases are defined as: weight $\geq$20 grams/day, length = 1 centimeter/week, and occiptofrontal head circumference (OFC) = 1 cm/week. These growth parameters are based upon studies of fetal accretion rates (Lubchenco, et al., 1963).
The LBW infant requires greater amounts of nutrients than a full term healthy newborn. Advised nutrient intakes are based upon analysis of body composition of stillborn infants at various gestational ages and the rate of accretion of those nutrients (Widdowson and Dickerson, 1964). The advised intakes account not only for growth but dermal and urinary losses and intestinal absorption. The U.S. RDA for infants was utilized for those nutrients not determined by fetal accretion rates (Ziegler, et al., 1979). The LBW infant is susceptible to multiple deficiencies secondary to their limited nutritional reserves, exposure to infection, trauma and/or acute illness. Nutrients of special concern include protein, major minerals (calcium, phosphorus, sodium, potassium, magnesium), vitamin (D, E, K, C, B₁₂) and folate, and trace minerals (iron, copper, zinc, manganese). Comparison of advised nutrient intake and composition of pooled human milk (per 100 Kcals) would indicate that the use of human milk as a feeding for the low-birthweight infant would lead to the development of specific nutrient deficiencies (Forbes, 1978) (Table 1). These deficient nutrients include protein, sodium, chloride, calcium phosphorus, magnesium, iron, vitamins A, D, E and folate. Studies have shown lesser daily rates of gain in weight at same caloric intake in preterm infants fed pooled term human milk versus preterm infants receiving formula with higher protein content (1.7 gm/dl vs 3.0 gm/dl) (Räihä, et al., 1976). The advised energy intake ranges between 120-130 Kcals/kg body weight/day to achieve desired growth (Sinclair, et al., 1970) (Table 3). Caloric concentration of human milk is variable (range 16-22 Kcals/oz or 56-72 Kcals/dl) (Lawrence, 1980) and the low-birth-weight infant, especially those less than 1500 grams, may not be able to consume a
volume large enough to achieve adequate calories or nutrients (Fomon, et al., 1977; Forbes, 1978).

However, recent data indicate that the composition of human milk from mothers giving birth prematurely differs significantly from the milk of mothers delivering term infants. Atkinson, et al. (1978) in a study of the nitrogen content of human milk from mothers of full term and preterm infants, showed 20% more nitrogen in the preterm mothers' milk versus the full-term mothers' milk. If the distribution between protein and non-protein nitrogen in the milk of a full-term and preterm mother's milk is similar, then the premature infant could receive twice as much protein and utilize nitrogen from an equal volume of his own mother's milk.

Gross, et al. (1980) showed that the milk produced by mothers delivering prematurely (28-36 weeks) contained significantly greater concentrations of protein, sodium and chloride than term milk during the first month of lactation. Atkinson, et al. (1978) analyzed milk of mothers delivering prematurely for Na, Cl, K, Mg, Ca and P concentrations. Content was compared to that of milk of mothers giving birth at term. Composition was found to be similar during the first month of lactation. Estimated intakes for premature infants fed their own mothers' milk were estimated and compared to predicted mineral requirement for LBW infants. They suggest that adequate levels of Na, Cl, K and Mg, but not Ca and P would be provided during the early weeks of lactation. This would be advantageous to the premature infants as they require greater protein and mineral intakes in relation to energy compared to the term infant (Fomon, et al., 1977).
Lemons, et al. (1981) found significantly higher amounts of total nitrogen, protein nitrogen, sodium, chloride, magnesium and iron in milk of mothers delivering prematurely (PT) versus at term (T). Samples were obtained through the first 44 weeks postconceptual age. Lemons, et al. concluded that preterm milk was more suitable for the premature infant than either mature or term human milk when compared to theoretic intrauterine requirements for all nutrients with the exception of calcium and phosphorus. However, they did note that preterm human milk may be deficient in specific nutrients for the very low birth weight infant (<1200 grams).

Anderson, et al. (1981) determined the lactose, lipid, protein and total energy content of milk produced during the first 28 days of lactation from mothers giving birth prematurely and at term. Both groups experienced an increase in lactose, lipid and total energy concentration, a decrease in nitrogen during the first four weeks of lactation. Although these changes were similar, premature milk versus full term milk was consistently 20-30% higher in total energy and lipid concentration, 15-20% higher in total protein and, after the first week, 10% lower in lactose. They also concluded premature infants fed 150-200 ml/kg/d of their own mothers' milk would receive adequate quantities of protein and energy (based on estimated requirements) to meet the infant's needs during the first weeks of life.

Other benefits exist in addition to the unique composition of "pre-term" human milk. These include immune factors (Mata and Wyatt, 1971), increased digestibility and bioavailability of nutrients (György, 1971), low renal solute load (Fomon, 1974) and mother-infant bonding (Klaus, et al., 1970).
Infant Feedings

A discussion of the use of human milk and standard infant formula (Similac*) follows. A summary of the composition, indications for use, and advised supplementation of enteral feedings is included in Table 4.

Human Milk

The use of human milk as the feeding of choice for the full-term, healthy infant during the first year of life is strongly advocated (Committee on Nutrition, American Academy of Pediatrics, 1978). The use of human milk is encouraged for the following reasons: 1) increased digestibility and bioavailability of nutrients (György, 1971); 2) specific protein/essential amino acid composition (Mestyan, et al., 1969; Rääihä, et al., 1976); 3) immunological protection (Mata and Wyatt, 1971); 4) decreased renal solute load (Fomon, 1974); 5) promotion of maternal-infant bonding (Klaus, et al., 1970); 6) decreased cost and risk of contamination versus use of proprietary infant formula (Fomon, et al., 1979).

There are a few situations where the practice of breast feeding would be contraindicated. Example of such situations include psychosocial factors, medical complications in either the mother or infant (i.e., inborn errors of metabolism, cystic fibrosis), passage of certain drugs ingested by the mother into the milk with potential harmful side effects to the infant and inability to produce milk containing sufficient nutrients or volume for growth (Fomon, et al., 1979).

*Ross Laboratories, Columbus, Ohio.
It is known that the nutrient composition of human milk changes with the stage of lactation, time of day, sampling time during a given feeding, maternal nutrition and individual variation (Lawrence, 1980). During the first few days of lactation, colostrum is produced. Colostrum is a thick, yellowish, clear fluid which contains more protein (3.2 grams/dl vs 1.1 grams/ml), less carbohydrate and fats and, therefore, less energy than mature human milk (60 Kcal/dl vs 72 Kcals/dl) (Fomon, 1974). Colostrum aids the establishment of Lactobacillus flora in the digestive tract and also contains antibodies, which may provide the infant with protection against various infections (Mata and Wyatt, 1971).

Human milk undergoes a transitional phase between the colostrum and mature milk stages. During this time the concentration of total protein and immunoglobins decrease with an increase in carbohydrate, fat and total energy levels. Mature human milk is produced by the 10-14th day of lactation. Mature human milk provides approximately 72 Kcals/dl with a nutrient breakdown of carbohydrate (lactose) 38-41%, fat 51-55% and protein 7%. This percentage of protein is equivalent to 1.1 grams/dl or approximately one-third the amount of protein contained in colostrum (Fomon, 1974).

The major protein constituents of human milk are "whey" and casein in a 60:40 ratio. These are also the major protein constituents of cow's milk; however, the whey and casein are in 20:80 ratio. The lower casein, increased whey levels of human milk versus those found in cow's milk increase the digestibility of the protein by the infant.

The predominant carbohydrate of human milk is lactose, or milk sugar. Lactose content is approximately 6.8 g/dl. The activities of
the enzyme required for digestion, lactase, does not develop until the ninth month of gestation. Thus, the premature infant may be unable initially to tolerate or utilize lactose efficiently.

Lipids compose approximately 55% of the total calories of human milk. Triglycerides, diglycerides, monoglycerides, free fatty acids, phospholipids, glycolipids, sterols and sterol esters compose the lipid fraction. Human milk fat is almost totally digestible. Lipases in the milk create a fat emulsion which is easily digested and utilized by the neonate.

The term infant should be able to consume adequate quantities of human milk to meet all vitamin/mineral requirements with the exception of vitamin D, iron and fluoride. It is currently recommended that these nutrients be supplemented (Table 4). The LBW infant may be able to achieve desired growth from human milk feedings. However, the vitamin/mineral content may be lower than the levels required by the LBW infant to simulate fetal accretion rates and must be supplemented (Table 2).

**Standard Infant Formula (Similac)**

Standard infant formula is indicated for the feeding of full, term healthy infants or for sick infants who do not have special nutritional requirements. These formulas are designed to provide a feeding comparable to human milk in nutrient composition.

Standard formulas are generally fed at 20 Kcal/oz dilution. The protein source is cow's milk protein (9-11%) in a 20:80 whey:casein ratio. Lactose is utilized as the carbohydrate source. Fat is composed of corn, coconut and soy oils. Vitamins and minerals are
provided at levels consistent with current recommendations (Food and Nutrition Board, National Research Council, 1980). They may or may not contain iron. Fluoride supplementation should be provided.

Standard formulas are available in ready-to-feed, concentrate or powder forms.

**Methods of Assessing Growth**

Standardized growth charts are available to aid in nutrition screening assessment. The new National Center for Health Statistics (Hamill, et al., 1979) can be used to improve identification of potential health and nutritional problems and facilitate the epidemiological comparison of one group of children with others (see Figure I). Babson and Benda (1976) presented two graphs showing means with one and two standard deviations for growth, weight, length and head circumference. The first was based on fetal graphs with lines of growth from 26 weeks of gestational age until one year of age after term has been reached and the second was a similarly constructed graph for children, ages 1 through 10 years. The standards of growth were obtained from published data in which the subjects received optimal health care. Graphs allowed comparison of infants of varying gestational age with standards for their age.

Tanner (1976) recommends that methods of monitoring growth of individuals in a population and the average growth and height in other measurements of populations or sub-populations should be distinguished. Individual monitoring of nutritional status should be by growth in height, chiefly, and weight, if interpreted correctly. Height for age and weight for height, irrespective of age, have been recommended
as monitors. Cole (1979) however, argues that weight for height standards in children are usually constructed on the basis that the expected weight for a given height does not depend on age. Regression standards of age, standardized weight for age, standardized height (the standardization being achieved by expressing weight and height as fractions of the 50th percentile for age from a suitable growth standard) were presented. Data on 4,631 children from five different countries showed that, throughout childhood until puberty, the following ratio was appropriate as a simple and convenient index of weight for height: Age Standardized Weight/Age Standardized Height. This equation may be used to assess degrees of malnutrition or obesity for individuals or groups seen on a single occasion.

Keet, et al. (1970) looked at the validity of skin-fold measurements in the determination of suboptimal nutrition in young children. Weight, height, head circumference, triceps and subscapular skin-folds, mid-upper arm circumference and mid-upper arm muscle circumference values were obtained from healthy children, children suffering from dehydrating gastroenteritis, in children suffering from severe protein calorie malnutrition. Results indicated that there is a significant correlation between skin-fold thickness for age, and weight and height age. It was concluded that skin-fold measurements could be used as an additional, reliable, objective measurement of suboptimal nutrition and early protein calorie malnutrition in group surveys, particularly where the exact ages of children are not known. Gupta, et al. (1974) examined the correlation between weight, height and mid-upper arm circumference in infants. The study revealed that the correlation between weight and mid-upper arm circumference (MAC) was higher than
that of weight and height. The combined influence of height and MAC upon weight was significantly higher than the above simple correlation coefficients. Dauncey, et al. (1977) assessed total body fat in infancy from skinfold thickness measurements. A formula was developed allowing a value for total body fat to be calculated from skin-fold thickness measurements at two sites (subscapular and triceps), in conjunction with nine body dimensions. For newborn infants, total fat so calculated correlated satisfactorily with published data from cadaver analysis. The formula has been tentatively applied to infants up to ages 40 weeks and to preterm infants. The difference between the growth of male and female infants was analyzed in a series of 27 normal infants. Greater growth of musculoskeletal tissue in the male contrasted with the relatively greater growth of fat tissue in the female. Mellbin and Vuille (1976) showed a relationship between weight gain in infancy to subcutaneous fat in relative weight at 10\(\frac{1}{2}\) years of age (n = 895). The risk of being overweight or obese was compared between those who had gained weight rapidly during infancy and those whose weight gain during the first year of life and fatness at 10\(\frac{1}{2}\) years of age was found only in boys; girls were found to have a direct, but very weak, association. Sex-related growth differences were also substantiated by Karlberg, et al. (1968) in which he showed that growth in general for all variables, during the first year of life occurs at a high but gradually decreasing rate. The relative growth and length, on the whole, was similar. The relative gain occurs faster in weights than lengths, widths and circumferences, in accordance with the fact that weight is three dimensional, whereas the others are one dimensional. Karlberg
et al. (1968) also showed a greater total length in boys versus girls as well as higher weight. The only body measurement to be shown greater in girls versus boys were skinfolds, indicating a greater amount of subcutaneous fat in girls. He concluded that the basic difference between boys and girls up to the age of three seems to be a predominance of skeletal tissue in boys and a subcutaneous tissue in girls. Karlberg did not note which different feeding practices predominated in either group.

**Comparison of Growth in Infants Fed Human Milk versus Proprietary Infant Formula**

**Full Term Infants**

There are much data presently available showing the differences in growth between infants who are breast- versus bottle-fed. The majority of these studies involve normal healthy term infants. Fomon, et al. (1970) studied normal full-term breast-fed infants (n = 104: males = 58, females = 46) during the first 112 days of life. Male breast-fed infants experienced a faster rate of gain than female breast-fed infants during the first 112 days of life.

Rate of gain of bottled-fed versus breast-fed infants was then compared during the first 112 days of life (Fomon, et al., 1971). Bottle-fed infants experienced a greater weight of gain and generally gained more weight for a specified gain in length than the breast-fed infants. Fomon, et al. (1971) speculated that these greater gains in weight by formula-fed infants versus breast-fed infants reflected overfeeding of the formula-fed infant.
Saarinen and Siimes (1979) looked at prolonged breast feeding and infant growth. Healthy full-term infants (n = 238) were followed under a carefully monitored nutritional protocol during the first year of life. The infants were weaned at different ages either to proprietary infant milk formula or to a home prepared cow's milk formula. Solid foods were introduced at 3.5 months of age. The 56 (24%) infants who were breast-fed for a period of at least six months were compared to infants weaned prior to one month of age to one of the two milk regimens. In the breast-fed infants, the weight, weight for height age, and skin-fold thicknesses were similar to values in the proprietary formula-fed infants but were lower than the corresponding values in the cow's milk-fed infants at six months of age and subsequently. By using weight for height age as a criteria, no obesity was found among any of the 238 infants and only 1.7% were considered to be overweight.

Evans (1978) compared the growth of 94 normal term infants from birth to six months of age. Thirty-three (35%) of these infants were breast-fed and the others randomly allocated to one of three bottle feeds. The weight, length and head growth velocities were similar in all four groups. The weight gains of all four groups in this study were considerably less than infants fed unmodified milks and early solids, studied in the same region several years earlier. Ferris, et al. (1979, 1980), looked at the effect on diet on weight gain and fat deposition in relation to method of feeding during infancy. Data were obtained from a longitudinal survey of 92 mothers and their female infants. The infants were grouped according to the method of feeding at two months. A difference was found between infants fed formula and solids and infants fed breast milk and food supplements, but not
between infants fed breast milk or formula alone. No significant differ­
ences among the feeding groups were noted in length and weight for
length, but there was a tendency for higher weight in relation to
height and increased mean skinfolds in infants fed formula and solids.
Swiet and Fayers (1977) examined the effect of feeding habit on
weight in infancy (n = 758). Weights were observed at ages 6 weeks
and 6 months. Results did not significantly relate to breast or
bottle feedings, but did correlate with early introduction of solids.
Whitelaw (1977) looked at infant feeding and subcutaneous fat at
birth and at one year. Skinfolds were measured at birth and at one
year in infants who were LGA, AGA, or SGA at birth, infants of obese
mothers and infants of diabetic mothers (IDM). There was no signifi-
cant correlation between skinfold thickness at birth and skinfold
thickness at one year or significant difference in skinfold thick-
ness between any of the groups at one year of age. These findings
were not consistent with the hypothesis that over-nutrition in the last
ten weeks of pregnancy has a permanent effect on the adiposity of the
infant. When compared to a 1967-68 survey of British one-year-olds, the
distribution of triceps and subscapular skinfolds in these one-year-old
infants were considerably lower with a corresponding increased breast
feeding rate and delayed introduction of solids. The influence of for-
mula concentration on caloric intake and growth of normal infants has
been compared by Fomon, et al. (1975) Formulas prepared from the same
ingredients were fed upon demand to two groups (n = 15). Formula concen-
tration was 54 cal/dl for one group and 100 cal/dl for the other. Selec-
ted solid food was permitted after day 28 of life. During the interval,
8-41 days of age, the infants fed 54 cal/dl formula consumed a consider-
ably greater volume of feeding but fewer calories than those fed the 100 cal/dl formula. Those fed the 54 cal/dl formula also experienced a slower rate of gain but was statistically significant. After 41 days of age, the caloric intakes (calories/kg/day) and rates of gain in weight were approximately the same.

Lucas, et al. (1980) looked at the endocrine responses of infants who were breast- or bottle-fed (n = 77). Lucas sought to determine the differences in pancreatic and gut-hormone release between breast-fed and bottle-fed infants. Bottle-fed neonates showed significant changes in plasma concentrations of insulin, motilin, enteroglucagon, neurotensin and pancreatic polypeptide after feeding, whereas in breast-fed infants, these changes were reduced or absent. Basal levels of gastric inhibitory polypeptide, motilin, neurotensin and vaso-active intestinal peptide were also higher in the bottle-fed infants than in those who were breast-fed. This may explain differences in the deposition of subcutaneous fat as well as stool frequency between breast-fed and bottle-fed infants.

Low-Birth-Weight Infants

At present, published data on follow-up growth of the low-birth-weight infant are limited. Follow-up studies on growth of the low-birth-weight infant born small for gestational age (SGA; birth weight <10th percentile for gestational age) secondary to intrauterine growth retardation (IUGR), have been performed. However, the majority of growth studies on the preterm, low birth weight, appropriate for gestational age (AGA; birthweight >10th - <90th percentiles for gestational age) have been confined to the period of the infant's hospitalization.
Studies of SGA infants have substantiated the phenomenon of "catch up" growth. Ounsted and Sleigh (1975) looked at the infant's self-regulation of food intake and weight gain and differences in metabolic balance after growth constraint or acceleration in utero (n = 191). There were four groups: a hospital sample of infants born to women who had been hypertensive during pregnancy and infants who had been SGA or LGA (large for gestational age; birth weight >90th percentile) at birth. Among bottle-fed infants, the SGA infant took significantly more milk per kilogram body weight than infants in the hospital sample in hypertensive series; LGA took significantly less. Mean weight gain per kilogram birth weight per day was significantly increased in the SGA series and reduced in the LGA series compared with the hospital sample. Although mean milk intake per day at the age of two months was less for SGA infants than for LGA infants, mean weight gain per day was greater for SGA infants. In both extreme groups, there was a tendency for breast-fed babies to revert towards the median faster than bottle-fed. These feeding and growth patterns of SGA and LGA infants suggest that there are self-regulatory controls within the infant and that the metabolic balance of SGA infants is different from that of LGA infants in the early postnatal months. Chamberlain and Davey (1975) looked at physical growth in twins, postmature and SGA children. Three groups of children (multiple births, postmature and SGAS) were selected together with a 10% random sample. The babies that were heavier at birth showed diminished growth velocity and SGA infants showed "catch up" growth. At 22 months, the pattern of distribution of weight was much closer to the normal than that of the infant's birth weight. Davies (1981) looked at growth of SGA infants,
the majority of these SGA infants showed signs of intrauterine undernutrition. The growth patterns of the SGA infants as a group describe upward centile crossing which is commonly known as "catch up" growth over the first six months, but there is considerable diversity in growth patterns of individual infants. Some continue in approximately the same centile channel in which they were born; others show "catch up". The rate of early growth is influenced by the severity of intrauterine undernutrition, but the mode of feeding and variations in protein and calorie intake after birth have little or no effect. Whether the size attained by prenatally undernourished SGA babies represents a complete recovery of their growth deficit or whether more rapid "catch up" growth is even desirable for later physical size and neuropsychological development, remains to be seen.

Larkin, et al. (1976) retrospectively examined the etiology of growth failure in a clinic population of pre-school children whose growth fell below the 97th percentile of their peers. A greater percentage of the growth retarded children were low birth weight infants. Low birth weight nor any other one factor including living conditions, health history or other family characteristics could consistently predict poor growth achievement. Appropriateness of birth weight for gestational age was not determine.

It is generally accepted that hospitalized preterm, low-birthweight infants experience faster rates of gain when receiving specialized commercial formulas versus banked human milk (Usher, 1980). These specialized "premature" infant formulas contain greater amounts of energy and nutrients (per dl) compared to pooled human milk. Thus, they meet the advised levels needed by the low birth weight infant
for desired growth and development (Ziegler, et al. 1979). Recent data suggests that the milk produced by mothers giving birth prematurely contains significantly greater levels of essential nutrients (protein, Na, Cl, K, Mg and Fe) during the first month of lactation than human milk produced by mothers delivering at term (Atkinson, et al. 1978; Lemons, et al. 1981; Anderson, et al. 1981; Gross, et al. 1980; Schan­ler and Oh, 1980). It is suggested that the milk produced by the pre­term infant's own mother may be the feeding of choice. It remains to be shown that hospitalized preterm, low birth weight infants fed their own mothers' milk experience a rate of gain similar to that of hos­pitalized preterm, low birth weight infants receiving specialized commercial formula.

Lasky (1980) observed growth and development of preterm, low birth weight infants fed banked mature human milk versus commercial formula. Followup extended into the first 92 weeks of life. The banked milk group showed delays in head circumference, length and weight until two, three and four months, respectively. Formula-fed infants continued to be significantly heavier and taller at 92 weeks.

Ernst (personal communication, 1982) has looked at growth of a followup clinic population consisting of graduates of a newborn intensive care nursery. A twelve month retrospective study compared growth of all preterm, LBW infants, appropriate or small for gestational age, for the first twelve months corrected age. The absolute data at twelve months corrected age showed that female infants born small for gesta­tional age (SGA) remained significantly smaller than the AGA female infants. Male SGA infants appeared to catch up to both male and
female AGA infants. When comparing weight, length and head circumference to the National Center for Health Statistics, it appeared that AGA female infants achieved higher percentiles for all parameters. Of the total population studied, 30% were less than the 5th percentile for weight and 21% were less than the 5th percentile for length and head circumference. Differences in feeding practices were not considered significant as only 5% of the infants studied were breast-fed at discharge and by two months (corrected age), most breast-feeding had been discontinued.

Need for Further Research

Growth in the full-term infant during the first year of life has been extensively researched. Growth in infants who are born small for gestational age has been examined and the phenomenon of "catch up" growth defined. "Catch up" growth has also been recognized in the premature low birth weight infant during hospitalization. The influence of feeding selection and practices has been reviewed and found to correlate to gains in weight, length, head circumference and skin-fold measurements to all previously defined groups.

It has not been adequately shown that growth of the preterm, LBW infant fed his own mother's milk upon demand simulates that of the rapidly growing fetus (Babson and Benda, 1976). It remains to be shown if mothers of infants delivering prematurely can provide sufficient volume and nutrients to achieve "normal" as well as "catch up" growth during hospitalization and/or into the first year of life.

Therefore, a need exists for the present study. A comparison of growth in preterm, LBW infants fed their own mother's milk versus
preterm, LBW infants of similar weight and gestational age given stan-
dard infant formula upon demand (post-hospitalization) should provide
insight into the adequacy of human milk as a feeding for the preterm
infant as well as demonstrate the infant's ability to self-regulate
volume according to growth needs.
CHAPTER III

METHODOLOGY

Following is a restatement of the objective, population studied, research design, instruments used in the data collection, procedures implemented in the data gathering process and the statistical analysis.

Objective

This study was undertaken to compare growth in preterm, LBW infants fed their own mothers' milk versus preterm, LBW infants of similar weight and gestational age given standard infant formula upon demand between 40 to 56 weeks post conceptual age.

Population Studied

A total of 28 healthy, preterm (28-36 week gestation) appropriate of size, low-birth-weight (<2500 gm) infants completed the study. Infants were initially admitted to the Intermountain Newborn Intensive Care Center, University of Utah Medical Center, Salt Lake City, Utah following delivery. Initial diagnosis was prematurity (n = 9), respiratory distress syndrome or hyaline membrane disease (RDS or HMD) (n = 17), and Rh incompatibility (n = 2). The infant was considered healthy if the admitting diagnosis followed a normal course and complications did not develop during hospitalization.

After discharge, infants were seen in the nutrition follow-up clinic at the following intervals: 40, 42, 48 and 56 days post conceptual age. Of the 28 infants studied, 11 (3 male, 8 female) were fed
their own mothers' milk and 17 (2 male, 15 female) received standard infant formula (Similac) post-hospitalization.

Research Design

The design of this study utilized description and statistical analysis for determining relationships and significance between type of feeding, growth and other variables. The descriptive data consisted of growth parameters: weight, length, occipital frontal circumference (OFC), mid-upper arm circumference (MUAC), tricep and subscapular skinfolds, obtained at predetermined intervals during the 56 week postcon­ceptual age study period (40, 42, 48 and 56 weeks postconceptual age). Statistical analysis using the SAS Statistical Package for analysis of variance was performed to determine relationships between the dependent variables: weight, length, OFC, MUAC and triceps and subscapular skinfolds, to age (in weeks), sex and feeding. Duncan's multiple range analysis at $\alpha = .05$ was performed to compare the dependent variables (anthropometric measures) to individual classes: age, sex and feeding. A student t test was performed on all anthropometric measures at 40, 42, 48 and 56 weeks postconceptual age to compare differences in rates of gain between the two feeding groups.

Instrumentation

The anthropometric data consisted of weight (grams), length (centimeters), occipital frontal circumference (OFC, centimeters), mid-upper arm circumference (MUAC, centimeters) and tricep and subscapular skinfolds (millimeters). Weight, height and OFC were obtained to compare to percentile norms of a growth record published by the National Center for Health Statistics, 1976. This growth record provides
percentile norms from 40 weeks gestational age through the first twelve months of life, based upon growth in normal, healthy, full-term infants (Appendix C). Skin-fold measurements were compared to measurements published by Fomon, 1977, for birth to six years (Appendix D).

All anthropometric data were obtained and recorded by the same observer in the nutrition followup clinic.

Toledo Scale
A Toledo beam balance scale, Toledo Scales Co., Toledo, Ohio 43612 with non-detachable weights with readings to 10 grams was used to obtain weight in grams. Measurements of weight of the infants were made unclothed.

Foot Board
A portable measuring board as described by Falkner, 1961, was utilized to obtain stature measurement (in centimeters).

Measuring Tape
A flexible, narrow steel tape was utilized for OFC and MUAC measurements as they do not stretch as do cloth and plastic and they conform well to the contours of the head.

Skin-fold Calipers
The Lange Skin-fold Caliper, manufactured by Cambridge Scientific Industries, Inc., Cambridge, Maryland 21613, was used for both skin-fold measurements: triceps and subscapular. This caliper is spring-loaded to the closed position and compresses the fold with a constant pressure of 10 grams/mm² throughout its range of openings. Extensive data available at Cambridge Scientific Industries demonstrated that
the spring loading is virtually constant (Fomon, 1974).

Procedures

Approval for study was obtained through the Human Subjects Committee, University of Utah Medical Center.

Parents of the subjects were informed about the purpose of the study during admission to the Newborn ICU. They were asked to voluntarily participate. The purpose of the study was reinforced at the subject's initial nutrition clinic visit. The non-invasive anthropometric procedure required approximately 10 minutes. All data were collected by the author with assistance from clinic personnel.

Recommended Infant Feeding Practice

During the infant's initial and subsequent clinic visits, mothers were educated and instructed regarding current recommended feeding practices. All mothers were instructed to delay introductions of solids until the infant reached four months corrected age (Committee on Nutrition, American Academy of Pediatrics, 1980). Infants were provided appropriate vitamin and mineral supplementation according to type of feeding given (Appendix C).

Weight

The subject's body weight was measured using a Toledo beam balance scale. Measurements of weight were made unclothed. Weight was obtained in grams.

Length

The subject's length was determined by use of a portable measuring board. The infant was placed recumbent upon the board. The infant's
Head was held by one examiner with the Frankfort plane vertical and gentle traction was applied to bring the top of the head into contact with the fixed head board. A second examiner held the infant's feet, toes pointing upward and gentle traction was applied, bringing the moveable footboard to rest firmly against the infant's heels. The measurements were obtained in centimeters.

**Head Circumference**

Measurement of the infant's OFC (in cm) was obtained by placing a steel measuring tape firmly around the head above the supraorbital ridges, covering the most prominent part of the frontal bulge anteriorly and over the part of the occiput which gives maximum circumference (Owen, 1973).

**Mid Upper Arm Circumference and Triceps Skin-Fold**

The infant's bare right arm was used for measurement. The infant was held in the parent's lap in a semi-upright position, his left side leaning against, and head turned toward the parent. The right hand was gently restrained by the parent so that the infant's right upper extremity was as relaxed as possible.

The midpoint of the upper arm was located by measuring with a steel measuring tape from the tip of the acromium process of the scapula to the olecranon process of the ulna. The midpoint was marked with a water soluble marking pen in the position of the midline of the arm. The steel tape was then utilized to obtain the circumference at that point (Grant, 1979).

For measurement of the triceps skin-fold thickness, the examiner grasped the layer of the skin and subcutaneous tissue with the first
finger and thumb at a distance of approximately one centimeter from the midarm mark. The skin-fold was pulled firmly and cleanly from the underlying muscle while the measurement was taken. Lange Skin-fold Calipers were placed over the fat fold at the marked midpoint at a depth equal to the thickness of the fold. The caliper pinch was then exerted and the reading taken three seconds later (Grant, 1979). The calipers were released and reapplied for three readings. The results were averaged and recorded to the nearest 0.5 mm.

Subscapular Skin-fold

The subscapular skin-fold was taken on the right side of the child's back immediately below the inferior angle of the scapula (Jelliffe, 1966). The infant was held in the parent's lap in a semi-upright position, the left side leaning against and head turned toward the parent. The hands were gently restrained by the parent so that the infant's arms were relaxed by body sides. The inferior angle of the scapula was located and marked with a water soluble pen. The area was pinched in line with the natural cleavage lines of the skin. The examiner used the same technique in caliper measurements as with the tricep skin-fold (Grant, 1979). A total of three readings were taken, averaged and recorded to the nearest 0.5 mm.

Data Processing and Analysis

Data were entered on and analyzed by the SAS Statistical Package (SAS Institute, 1979). Data obtained included:

1. Individual date of birth; sex; the infant's gestational age (GA) at birth obtained from maternal obstetrical history and
physical assessment of infant by the attending physician; admitting diagnosis: weight, length and OFC at birth and type of feeding.

2. All individual weight (grams), length (centimeters), OFC (centimeters), MUAC (centimeters), and triceps and subscapular skin-folds (millimeters) taken at the mother's original EDC and 14, 56 and 112 post-original EDC.

Analysis of variance was performed to determine relationships between the dependent variables: weight, length, OFC, MUAC and triceps and subscapular skin-folds and the following classes: age (in days), sex and feeding. Duncan's multiple range analysis at $\alpha = 0.05$ was utilized for analysis of variance.

Comparison of rate of gain for all parameters at 40, 42, 48 and 56 weeks postconceptual age between the two feeding groups was accomplished by Student's t test at $\alpha = 0.05$. 
CHAPTER IV

RESULTS AND DISCUSSION

Subjects

A total of 28 healthy preterm, low-birth-weight infants completed the study. The mean gestational age was 31.96 ± 1.99 weeks (range 28-36 weeks) and mean birth weight was 1.68 ± 0.40 Kilograms (range 0.88-2.67 Kg.). All infants were assessed to be appropriate for gestational age (AGA) (Lubchenco, et al, 1963) by the attending physician. Initial admitting diagnosis was prematurity (n = 9), respiratory distress syndrome or hyaline membrane disease (RDS or HMD) (n = 17) or Rh incompatibility (n = 2). The infant was considered relatively healthy if the admitting diagnosis followed a normal course and complications did not develop during hospitalization.

Of the 28 infants studied, eleven (3 male, 8 female) were breast-fed and 17 (2 male, 15 female) received standard infant formula (Similac) post-hospitalization. Breast-fed infants who required supplementation with standard infant formula (n = 4) were omitted from the study. The major reason for supplemental feedings was mother returning to work prior to completion of the study. Table 5 represents the sample size distribution for mean gestational age, mean birth weight and sex in relation to feeding.

Infants were seen in the follow-up nutrition clinic at the following intervals: 40, 42, 48 and 56 weeks postconceptual age (+ 1 week). Weight, length, head circumference, mid-upper arm muscle circumference
(MUAC), triceps and subscapular skinfolds (TSF, SSF) were obtained during these visits by the same examiner. Linear regression was utilized for analysis of variance of independent variables: age, gestational age, sex, feeding, birth weight, length and head circumference, to the dependent variables: weight, length, head circumference, MUAC, TSF and SSF. Duncan's Multiple Range Test was employed for analysis of variance where statistical significance ($p < .05$) was shown between the two variables by linear regression.

Not all infants showed for their clinic visit within the selected study intervals. Although data was not complete for all subjects, they were not omitted from the study. Variation of the $n$ value for the time intervals was adjusted appropriately during statistical analysis.

Results

Weight

Multivariant analysis of weight to all the independent variables showed statistical significance for age ($p < .0001$), gestational (p < .0001) age (postconceptual age at birth) and type of feeding ($p < .005$) (Table 6). As infants became chronologically older, weight increased indicating growth from birth through 56 weeks postconceptual age. Gestational age at birth influenced weight from 40 to 56 weeks postconceptual age. It appears that the earlier in gestation that birth occurs, weight is influenced, i.e., infants tend to be lighter the younger the gestation versus those born closer to the estimated date of confinement. Formula fed infants weighed significantly more than the human milk infants during the study although rate of weight gain from 40 to 56 weeks postconceptual age did not differ significantly between the two groups. This suggests that the infant's
growth in the two feeding groups diverged before 40 weeks postconceptional age.

Overall mean weight for the formula-fed and breast-fed infants were 4.61 kg and 4.13 kg, respectively (Table 7). Mean weight ± standard error is graphed for 40, 42, 48 and 56 weeks postconceptual age (Figure 1) and included in Table 8. The National Center for Health Statistics (NCHS) Growth Chart (1976) was utilized. The 10, 50 and 90th percentiles are provided. Although formula-fed infants began the study heavier (40 weeks postconceptual age) and exhibited a trend to remain heavier than breast-fed infants, rate of gain at 40, 42, 48 and 56 weeks was not significantly different. Both groups remained at approximately the same percentile for weight throughout the study and were within normal limits (10-90th percentile for appropriate postconceptual age).

Length

Multivariant analysis of length to all independent variables showed statistical significance for age (p < .0001), gestational age (p < .0001) and sex (p < .005) (Table 9). Increasing chronological age correlated with increase in length. Again, gestational age at birth influenced length at 40, 42, 48 and 56 weeks postconceptual age. Female infants were significantly longer than male infants, 55.7 versus 52.2 centimeters, respectively (p < .005). The large discrepancy in the n value of female to male infants, 4.6:1.0, may have influenced this result.

The 10, 50 and 90th percentiles for length in relation to postconceptual age intervals are shown in Figure 2 (NCHS, 1976). Mean length (± SE) for the formula-fed and breast-fed groups are graphed
Fig. 1. Weight (kg) at 40-56 weeks postconceptual age of formula-fed and human milk-fed infants.
Fig. 2. Length (cm) at 40-56 weeks conceptual age of formula-fed and human milk-fed infants.
at 40, 42, 48 and 56 weeks postconceptual age and included in Table 10. Differences in rate of gain in length were not statistically significant by multivariant analysis.

**Occipital Frontal Circumference**

Multivariant analysis of occipital frontal circumference (OFC) to all independent variables showed statistical significance for age ($p < .0001$) (Table 11), indicating growth in OFC with increasing chronological age.

Figure 3 illustrates the 10, 50 and 90th percentiles for occipital frontal circumference (OFC, head circumference) in relation to postconceptual age intervals (NCHS, 1976). Mean OFC (+ SE) measurements for formula-fed infants compared to breast-fed infants are graphed at 40, 42, 48 and 56 weeks postconceptual age and included in Table 8. However, both feeding groups show a general trend for accelerated head growth from 40 to 48 weeks postconceptual age with a slowing towards the median from 48 to 56 weeks postconceptual age. This pattern of head growth in preterm, low birth weight infants has previously been reported by Babson and Benda (1976) and supported by Fijumura and Teryu (1977) in further studies.

**Mid-Upper Arm Circumference**

Multivariant analysis of mid-upper arm circumference measurements to all independent variables showed statistical significance for age ($p < .0001$), gestational age ($p < .05$) and feeding ($p < .0001$) (Table 13). As with the other measurement parameters, as the infants increased in chronological age and experienced growth, their mid-upper arm circumference increased. Gestational age at birth also
Fig. 3. Occipital frontal circumference (cm) at 40-56 weeks postconceptual age of formula-fed and human milk-fed infants.
influenced the mid-upper arm circumference at 40, 42, 48 and 56 weeks postconceptual age in both feeding groups. Formula-fed infants had significantly greater MUAC measurements than the human milk infants during the study although rate of increase from 40 to 56 weeks postconceptual age did not differ. This relates to the divergence in weight gain seen in the two feeding groups prior to 40 weeks postconceptual age.

Mean mid-upper arm circumference (MUAC) (± SE) for the two study groups is graphed for 40, 42, 48 and 56 weeks postconceptual age (Figure 4) and included in Table 8. Data for percentile values for this age group is unavailable. Overall mean MUAC for formula-fed infants and breast-fed infants were 12.4 ± 0.3 cm and 11.3 ± 0.3 cm, respectively (Table 14).

**Triceps Skinfold**

Multivariant analysis of the triceps skinfold measurements to all independent variables showed statistical significance for age (p < 0.0005), gestational age (p < 0.005) and feeding (p < .001) (Table 15). The triceps skinfold increased as growth occurred with increasing chronological age. Gestational age at birth also influenced the triceps skinfold at 40, 42, 48 and 56 weeks postconceptual age. Formula-fed infants had significantly greater triceps skinfold measurements than the human milk infants during the study, although rate of increase from 40 to 56 weeks postconceptual age did not differ. The formula-fed infants experienced greater fat accumulation in conjunction with their greater weight gain prior to 40 weeks postconceptual.
Fig. 4. Mid-upper arm circumference (cm) at 40-56 weeks post-conceptual age of formula-fed and human milk-fed infants.
Overall mean triceps skinfold for the formula-fed and breast-fed groups were 7.6 ± 0.4 mm and 6.0 ± 0.5 mm, respectively (Table 16). The 10, 50 and 90th percentiles for triceps skinfold (TSF) from 44 to 56 weeks postconceptual are provided in Figure 5 (Karlberg, et al., 1968). Data for percentile values for earlier postconceptual ages, i.e., 40, 42 weeks are unavailable. Mean TSF (+ SE) for both groups are graphed for 40, 42, 48 and 56 weeks postconceptual age and included in Table 8. Both groups remained within normal limits (10-90th percentile for postconceptual age) for triceps skinfold measurements.

A gradual slowing of gain is shown from 52 weeks postconceptual age and beyond and correlates with the slowing of fat accumulation seen in normal term infants. This increase in fat accumulation corresponds with an increase in lean muscle mass as the infant progresses developmentally and begins using muscles for sitting and crawling (Karlberg, et al., 1968).

**Subscapular Skinfold**

Multivariate analysis of the subscapular skinfold measurements to all independent variables showed statistical significance for age (p < .0005) and feeding (p < .005) (Table 17). The subscapular skinfold increased as growth occurred with increasing chronological age. Formula-fed infants had significantly greater subscapular skinfold measurements than human milk infants during the study although rate of increase from 40 to 56 weeks postconceptual age did not differ. This also correlates with the greater weight gain experienced by the formula-fed group prior to 40 weeks postconceptual age. However, both groups showed a trend to remain at approximately the same percentile
Fig. 5. Triceps skinfold (TSP, mm) measurements at 40-56 weeks postconceptual age of formula-fed versus human milk-fed infants.
for subscapular skinfold measurements from 40 to 56 weeks postconceptual age and remained within normal limits.

Figure 6 shows the 10, 50 and 90th percentiles for subscapular skinfold (SSF) measurements from 44 to 56 weeks postconceptual age (Karlberg, et al., 1968). Data for percentile values for earlier postconceptual ages are unavailable. Mean subscapular skinfold (+ SE) for both groups are graphed for 40, 42, 48 and 56 weeks postconceptual age and included in Table 8. As with the triceps skinfold measurements, a gradual decrease in subscapular skinfold is noted from 52 weeks postconceptual and beyond. This indicates a slowing of fat accumulation with corresponding increasing in lean muscle mass. Overall mean subscapular skinfold (+ SE) for the formula-fed and breast-fed groups were 6.8 ± 0.4 cm and 5.5 ± 0.5 cm, respectively (Table 18).

Discussion

Growth in preterm, low birth weight infants (weight, MUAC, TSF and SSF) was shown to diverge prior to 40 weeks postconceptual age (p < .001), Duncan's) in those infants receiving formula (Similac) versus infants who were breast-fed. It is important to note that, although the formula-fed infants experienced a greater weight gain from birth to 40 weeks postconceptual age versus breast-fed infants, there was not difference statistically or clinically in either group for measurements obtained at 40, 42, 48 or 56 weeks postconceptual age. Both groups remained at approximately the same percentile value from 40 through 56 weeks postconceptual age. Both feeding groups also fell within normal limits (10-90th percentiles) for all parameters (mean ± standard error) (Figures 1-6).
Fig. 6. Subscapular skinfold (mm) measurements at 40-56 weeks postconceptual age of formula-fed and human milk-fed infants.
The greater increases in weight, MUAC, triceps and subscapular skinfolds in the preterm, low birth weight formula-fed infants versus those preterm, low birth weight infants who were breast-fed prior to 40 weeks postconceptual age may be the result of the use of a more calorically dense (24 Kcal/oz), specially formulated premature infant formula. The caloric density of the different mothers' breast milk was not tested during hospitalization but assumed to provide 22 Kcal/oz. Volume of intake was (is) adjusted accordingly to provide all infants approximately 120 Kcals/kg/day (Newborn Intensive Care Unit protocol). It is speculated that the premature infant formula promoted increased growth so that at entry into the study, the formula-fed infants were heavier. This finding is supported by growth studies previously done in hospitalized preterm, low birth weight infants fed specialized formula versus human milk (Usher, 1980).

Recent recommendations regarding infant feeding have advocated delayed introduction of solid foods (4-6 months of age) as well as on demand feeding for formula or breast-fed infants (Committee on Nutrition, American Academy of Pediatrics, 1980). The early introduction of solids has been associated with an increased rate of gain (Evans, 1978; Ferris, et al., 1979, 1980; Swiet and Fayers, 1977). These authors reported rates of growth to be similar for infants fed only formula or human milk. However, when infants received solid foods in addition to formula or human milk, significantly greater rates of weight gain occurred. Introduction of solid foods was delayed in this study until the infant was greater than 56 weeks postconceptual age. The similar rates of growth experienced by the study groups support the previously reported data.
Increases in skinfold measurements appeared to correlate with increases in weight gain for both feeding groups. The use of mid-upper arm circumference (MUAC), triceps and subscapular skinfold measurements were determined to be a useful means of assessing growth in relation to weight gain. Previous studies have also reported the correlation of skinfold measurements to weight in infants (Keet, et al., 1970; Gupta, et al., 1974). Both formula-fed and breast-fed infants showed a gradual slowing of gain for MUAC, triceps and subscapular skinfolds is shown for 52 weeks and beyond (Figures 4-6). This correlates with the slowing of fat accumulation also seen in normal term infants (Karlberg, et al., 1968). This decrease in fat accumulation corresponds with an increase in lean muscle mass as the infant progresses developmentally and begins developing muscles for sitting and crawling.

The significance of the greater increase in length (p < .005) for female infants in both feeding groups versus males is difficult to interpret (Table 10). Previous studies have shown normal term male infants to experience greater linear growth versus female term infants regardless of feeding (Fomon, et al., 1970; Karlberg, et al., 1968). Unpublished data of preterm, low birth weight infants seen during the first twelve months (corrected age) found that preterm, low birth weight, appropriately grown female infants achieved higher percentiles for all parameters (weight, length and head circumference) versus preterm, low birth weight average for gestational age infants (Ernst, 1982). In view of the small number of male preterm, low birth infants enrolled in this study, it is impossible to draw any conclusions. Further study with a more equal sex distribution is required.
Conclusions

It appears that preterm, low birth weight infants experience a significantly greater rate of weight gain when fed formula versus human milk from birth to 40 weeks postconceptual age. However, no statistical or clinical differences were found in rates of growth of preterm, low birth weight infants fed either human milk or standard infant formula (Similac) from 40 to 56 weeks postconceptual age. Both feeding groups remained at approximately the same percentile or followed similar trends from 40 to 56 weeks postconceptual age. Both formula and breast-fed infants were able to attain increases within normal limits for all parameters during the period of study. It appears that the breast-fed infants in this study were able to adequately regulate their volume of intake to meet needs for normal growth.

It would appear reasonable to provide support to any mother delivering a preterm, low birth weight infant who desires to breast-feed as long as the infant continues to experience a rate of growth within normal percentile limits. It has not yet been definitively shown that "preterm" human milk can support normal growth during hospitalization for the preterm, low birth weight infant. It has been our experience that the majority of these infants require supplementation secondary to volume limitations. However, we have shown that breast-fed, preterm, low birth weight infants will experience gains similar to formula fed infants, within percentile normals, following hospitalization (40-56 weeks postconceptual age) when allowed to feed upon demand. Therefore, mothers who desire to breast-feed their infant should be encouraged to maintain lactation (via artificial expression of milk) during their infant's hospitalization and be given support and counsel.
following the infant's discharge to successfully establish breast feeding.

Limitations encountered in this study include:

1. Influence of feeding selection during hospitalization.
2. Small sample size.
3. Predominance of female to male infants (4:1). It is possible that by obtaining a more equal distribution of male and female infants, the difference seen in length would reverse to what is normally seen in healthy, full-term infants, i.e., males attaining greater increases in linear growth.
4. Omission of some subjects at each scheduled interval of measurement. The attainment of measurements via a "house call" is a consideration when subjects are unable to make a scheduled visit.
5. Socio-economic factors or other variables that influenced parental choice of feeding.

Based upon the findings and limitations of this study, it is felt that further research is required in the following areas:

1. Continuation and expansion of the present study population to not only increase numbers but to obtain an equal distribution of male and female subjects.
2. Further studies of growth during hospitalization and the influence of feeding on growth. This would require determination of caloric density of human milk so that volumes are adjusted and energy intakes are equivalent. Balance studies would also be indicated to determine whether or not "preterm" human milk is utilized as well by the preterm, low birth weight infant compared with specially formulated preterm infant feedings.
LITERATURE CITED


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Appendix A

Tables
Table 1. Advised intakes of nutrients for LBW infants and comparisons.

<table>
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<tbody>
<tr>
<td>Protein (g)</td>
<td>2.7-3.1</td>
<td>1.5†</td>
<td>2.5†</td>
<td>2.6†</td>
<td></td>
</tr>
<tr>
<td>Ca (mg)</td>
<td>140-160</td>
<td>50.0†</td>
<td>30.0†</td>
<td>82.0†</td>
<td></td>
</tr>
<tr>
<td>P (mg)</td>
<td>120-140</td>
<td>25.0†</td>
<td>20.0†</td>
<td>62.0†</td>
<td></td>
</tr>
<tr>
<td>Na (mEq)</td>
<td>2.5</td>
<td>1.0†</td>
<td>1.6†</td>
<td>1.6†</td>
<td></td>
</tr>
<tr>
<td>Cl (mEq)</td>
<td>2.2</td>
<td>1.6†</td>
<td>2.4†</td>
<td>2.4†</td>
<td></td>
</tr>
<tr>
<td>K (mEq)</td>
<td>1.9</td>
<td>2.1†</td>
<td>2.2†</td>
<td>3.2†</td>
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<tr>
<td>Mg (mg)</td>
<td>7.0</td>
<td>6.0†</td>
<td>3.5†</td>
<td>6.7†</td>
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<tr>
<td>Fe (mg)</td>
<td>1.6</td>
<td>0.1†</td>
<td>--†</td>
<td>1.9†</td>
<td></td>
</tr>
<tr>
<td>Cu (mcg)</td>
<td>60.0</td>
<td>60.0†</td>
<td>--†</td>
<td>66.0†</td>
<td></td>
</tr>
<tr>
<td>Zn (mg)</td>
<td>0.5</td>
<td>0.5†</td>
<td>--†</td>
<td>0.8†</td>
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<tr>
<td>Mn (mg)</td>
<td>5.0</td>
<td>1.5†</td>
<td>--†</td>
<td>0.54†</td>
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II. Vitamins

<p>| | | | | | |</p>
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<tbody>
<tr>
<td>A (IU)</td>
<td>500‡</td>
<td>250*</td>
<td>--†</td>
<td>400‡</td>
<td>1500</td>
</tr>
<tr>
<td>D (IU)</td>
<td>600-800</td>
<td>3†</td>
<td>--†</td>
<td>64±</td>
<td>800</td>
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<tr>
<td>E (IU)</td>
<td>30</td>
<td>0.3†</td>
<td>--†</td>
<td>2.4±</td>
<td>25</td>
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<tr>
<td>K (mcg)</td>
<td>15</td>
<td>2.5†</td>
<td>--†</td>
<td>0.5±</td>
<td>9</td>
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<tr>
<td>E (mcg)</td>
<td>60</td>
<td>7.8†</td>
<td>--†</td>
<td>8.8±</td>
<td>70</td>
</tr>
<tr>
<td>Folate (mcg)</td>
<td>60</td>
<td>4.0†</td>
<td>--†</td>
<td>8.0±</td>
<td>9</td>
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<tr>
<td>Thiamin (mg)</td>
<td>0.2</td>
<td>0.25†</td>
<td>--†</td>
<td>0.1</td>
<td>0.5</td>
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<tr>
<td>Riboflavin (mg)</td>
<td>0.4</td>
<td>0.6†</td>
<td>--†</td>
<td>1.6</td>
<td>0.6</td>
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<tr>
<td>Nicin (mg)</td>
<td>2.5</td>
<td>2.5</td>
<td>--†</td>
<td>3.1</td>
<td>8.0</td>
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<tr>
<td>B6 (mg)</td>
<td>0.4</td>
<td>1.5</td>
<td>--†</td>
<td>0.06</td>
<td>0.4</td>
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<tr>
<td>B12 (mcg)</td>
<td>0.15</td>
<td>0.15†</td>
<td>--†</td>
<td>0.24</td>
<td>2.0</td>
</tr>
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</table>

* per 100 Kcals
† per day
‡ UHMC, NICU, Salt Lake City, UT
--† Value unknown for preterm in human milk, assume similar to "pooled" term human milk and, therefore,
< advised levels.
++ Similar with iron, Ross Laboratories, Columbus, Ohio.
Table 2. Vitamin/mineral supplementation guide based upon enteral feeding and body weight.

<table>
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<tr>
<th>Supplement</th>
<th>Human Milk</th>
<th>Similac Special Care</th>
<th>Enfamil Premature</th>
<th>Similac MM 60/40</th>
<th>Standard Formula*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neomatal Vits. (1cc b.i.d.)</td>
<td>Yes &lt;2.5 Kg</td>
<td>No</td>
<td>Yes &gt;2.5 Kg</td>
<td>Yes &gt;2.5 Kg</td>
<td>Yes &gt;2.5 Kg</td>
</tr>
<tr>
<td>Standard Multi-Vit.** (1cc q day)</td>
<td>Yes &gt;2.5 Kg</td>
<td>No</td>
<td>No</td>
<td>Yes &gt;2.5 Kg</td>
<td>Yes &gt;2.5 Kg</td>
</tr>
<tr>
<td>Folate (50 mcg q day)</td>
<td>&lt;2.5 Kg</td>
<td>No</td>
<td>&lt;2.5 Kg</td>
<td>&lt;2.5 Kg</td>
<td>&lt;2.5 Kg</td>
</tr>
<tr>
<td>Vit. D (200 IU q day)</td>
<td>No</td>
<td>400 IU q day</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Vit. E*** (25-100 IU q day)</td>
<td>No</td>
<td>25 IU q day</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Vit. C (50 mg q day)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Calcium Gluconate (10%)</td>
<td>&lt;1.8 Kg, 2cc</td>
<td>No</td>
<td>No</td>
<td>&lt;1.8 Kg, 2cc</td>
<td>&lt;1.8 Kg, 2cc</td>
</tr>
<tr>
<td></td>
<td>&lt;1.5 Kg, 3cc</td>
<td></td>
<td></td>
<td>&lt;1.5 Kg, 3cc</td>
<td>&lt;1.5 Kg, 3cc</td>
</tr>
<tr>
<td>Phosphorus (20 mg/kg/day)</td>
<td>&lt;1.8 Kg</td>
<td>No</td>
<td>No</td>
<td>&lt;1.8 Kg</td>
<td>-----</td>
</tr>
<tr>
<td>Iron (2 mg/kg/day)</td>
<td>When body weight has doubled or by 8 weeks of age.</td>
<td>No</td>
<td>No</td>
<td>Not required if receiving formula with iron.</td>
<td></td>
</tr>
</tbody>
</table>

* Enfamil or Similac - 20 Kcal/oz.
** Vi-Daylin or Poly-Vi-Sol.
*** Prevention of hemolytic anemia; advised level = 30 IU/day.
**** Treatment of BPD/RLF; suggested level = 60-100 IU/day.
***** Use potassium phosphate - give 0.25 ml/kg/d p.o.
Table 3. Estimated requirement for calories in a growing low birth weight (1.5 Kg) infant.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Kcals/Kg BW/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal metabolic rate</td>
<td>50</td>
</tr>
<tr>
<td>Intermittent activity</td>
<td>15</td>
</tr>
<tr>
<td>Occasional cold stress</td>
<td>10</td>
</tr>
<tr>
<td>Specific dynamic action</td>
<td>8</td>
</tr>
<tr>
<td>Fecal loss of calories</td>
<td>12</td>
</tr>
<tr>
<td>Growth allowance</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>

Table 4. Nutrient comparison indication for use and recommended supplementation of human milk and standard infant formula (Similac)\textsuperscript{1}.

<table>
<thead>
<tr>
<th></th>
<th>Human Milk (Fomon, 1974)</th>
<th>Similac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caloric Density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Oz.</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Per Ml.</td>
<td>72</td>
<td>67</td>
</tr>
<tr>
<td>Wt./Vol. (grams/dl)</td>
<td>1.1 Protein - 69:40 whey:casein</td>
<td>1.6 Protein - Non-fat cow milk</td>
</tr>
<tr>
<td></td>
<td>3.8 Fat</td>
<td>3.6 Fat - Coconut and soy oils</td>
</tr>
<tr>
<td></td>
<td>7.0 Carbohydrate - Lactose</td>
<td>7.2 Carbohydrate - Lactose</td>
</tr>
<tr>
<td>Na (mEq/L)</td>
<td>7.0</td>
<td>11.0</td>
</tr>
<tr>
<td>K (mEq/L)</td>
<td>14.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Ca (mg/l)</td>
<td>340</td>
<td>510</td>
</tr>
<tr>
<td>P (mg/l)</td>
<td>140</td>
<td>390</td>
</tr>
<tr>
<td>Ca/P Ratio</td>
<td>2.4/1.0</td>
<td>1.2/1.0</td>
</tr>
<tr>
<td>Fe (mg/L)</td>
<td>0.5</td>
<td>0.15(1.2)\textsuperscript{2}</td>
</tr>
<tr>
<td>Renal Solute Load (mOsM/kg H_{2}O)</td>
<td>75</td>
<td>110</td>
</tr>
<tr>
<td>GI Osmotic Load</td>
<td>273</td>
<td>290</td>
</tr>
<tr>
<td>Indications:</td>
<td>Hypoallergenic</td>
<td>For routine feeding of term infant</td>
</tr>
<tr>
<td></td>
<td>Bacteriostatic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Economical</td>
<td></td>
</tr>
<tr>
<td>Recommended</td>
<td>Term: Vitamin D, iron and fluoride.</td>
<td>Term: Supplement with fluoride, adequate for all other nutrients if iron fortified.</td>
</tr>
<tr>
<td>Supplementation:</td>
<td>Preterm: Additional Vitamin E, C, folate, calcium and phosphorus.</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{1} Ross Laboratories, Columbus, Ohio.
\textsuperscript{2} Indicates level if iron fortified.

1. Ross Laboratories, Columbus, Ohio.
2. Indicates level if iron fortified.
Table 5. Type of feeding in relation to sex, postconceptual age at birth, and birth weight (mean ± S.D.).

<table>
<thead>
<tr>
<th>Feeding</th>
<th>Sex</th>
<th>Postconceptual Age at Birth (weeks)</th>
<th>Birth Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similac</td>
<td>15 F, 2 M</td>
<td>31.6 ± 1.7</td>
<td>1.55 ± 0.35</td>
</tr>
<tr>
<td>(n = 17)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human Milk</td>
<td>8 F, 3 M</td>
<td>32.5 ± 2.4</td>
<td>1.90 ± 0.48</td>
</tr>
<tr>
<td>(n = 11)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6. Weight in relation to independent variables.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>F Value</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>3</td>
<td>96.29</td>
<td>95.24</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Gestational Age</td>
<td>1</td>
<td>5.99</td>
<td>17.79</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.23</td>
<td>0.69</td>
<td>0.4102</td>
</tr>
<tr>
<td>Feeding</td>
<td>1</td>
<td>3.75</td>
<td>11.14</td>
<td>0.0014*</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>1</td>
<td>0.05</td>
<td>0.14</td>
<td>0.7131</td>
</tr>
<tr>
<td>Birth Length</td>
<td>1</td>
<td>0.25</td>
<td>0.75</td>
<td>0.3885</td>
</tr>
<tr>
<td>Birth Head Circumference</td>
<td>1</td>
<td>0.32</td>
<td>0.95</td>
<td>0.3325</td>
</tr>
</tbody>
</table>

R Square = 0.838

Table 7. Duncan's multiple range test for weight at 40-56 weeks postconceptual age of formula and human milk fed infants.

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean (Kilogram)+</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>19</td>
<td>3.01a</td>
</tr>
<tr>
<td>42</td>
<td>13</td>
<td>3.67b</td>
</tr>
<tr>
<td>48</td>
<td>21</td>
<td>4.82c</td>
</tr>
<tr>
<td>56</td>
<td>20</td>
<td>6.01d</td>
</tr>
</tbody>
</table>

Feeding

| Formula | 52  | 4.61a            |
| Human milk | 21  | 4.13b            |

+ Means with the same letter are not significantly different.
Table 8. Comparison of feeding groups to anthropometric data at 40, 42, 48 and 56 weeks postconceptual age (mean ± s.e.).

<table>
<thead>
<tr>
<th></th>
<th>PCA (weeks)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40</td>
<td>42</td>
<td>48</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M.</td>
<td>2.61 ± 0.12</td>
<td>3.42 ± 0.13</td>
<td>4.36 ± 0.04</td>
<td>5.55 ± 0.15</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>2.99 ± 0.15</td>
<td>3.58 ± 0.21</td>
<td>4.82 ± 0.23</td>
<td>6.11 ± 0.23</td>
<td></td>
</tr>
<tr>
<td>Length (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M.</td>
<td>48.80 ± 1.00</td>
<td>52.90 ± 0.60</td>
<td>56.00 ± 0.70</td>
<td>60.60 ± 0.80</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>49.30 ± 0.90</td>
<td>51.30 ± 1.00</td>
<td>56.00 ± 0.90</td>
<td>60.70 ± 0.90</td>
<td></td>
</tr>
<tr>
<td>OFC (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M.</td>
<td>34.20 ± 0.30</td>
<td>36.40 ± 0.30</td>
<td>38.80 ± 0.30</td>
<td>41.50 ± 0.60</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>35.30 ± 0.40</td>
<td>36.50 ± 0.50</td>
<td>39.60 ± 0.70</td>
<td>41.60 ± 0.40</td>
<td></td>
</tr>
<tr>
<td>MUAC (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M.</td>
<td>9.50 ± 0.40</td>
<td>9.50 ± 0.80</td>
<td>11.40 ± 0.30</td>
<td>12.50 ± 0.20</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>10.70 ± 0.20</td>
<td>11.50 ± 0.70</td>
<td>12.20 ± 0.40</td>
<td>13.60 ± 0.40</td>
<td></td>
</tr>
<tr>
<td>TSF (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M.</td>
<td>3.50 ± 0.40</td>
<td>4.90 ± 0.40</td>
<td>6.70 ± 0.40</td>
<td>7.50 ± 0.60</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>4.80 ± 0.40</td>
<td>7.20 ± 0.80</td>
<td>7.80 ± 0.50</td>
<td>9.10 ± 0.60</td>
<td></td>
</tr>
<tr>
<td>SSF (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M.</td>
<td>3.20 ± 0.60</td>
<td>4.30 ± 0.30</td>
<td>6.00 ± 0.20</td>
<td>7.10 ± 0.60</td>
<td></td>
</tr>
<tr>
<td>Sim.</td>
<td>5.10 ± 0.70</td>
<td>6.10 ± 0.90</td>
<td>6.80 ± 0.40</td>
<td>7.80 ± 0.40</td>
<td></td>
</tr>
</tbody>
</table>
Table 9. Length in relation to independent variables.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>F Value</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>3</td>
<td>1266.74</td>
<td>66.88</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Gestational Age</td>
<td>1</td>
<td>112.49</td>
<td>17.82</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>60.97</td>
<td>9.66</td>
<td>0.0028*</td>
</tr>
<tr>
<td>Feeding</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.9963</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>1</td>
<td>12.40</td>
<td>1.96</td>
<td>0.1659</td>
</tr>
<tr>
<td>Birth Length</td>
<td>1</td>
<td>1.06</td>
<td>0.17</td>
<td>0.6834</td>
</tr>
<tr>
<td>Birth Head Circumference</td>
<td>1</td>
<td>6.83</td>
<td>1.08</td>
<td>0.3021</td>
</tr>
</tbody>
</table>

R Square = 0.792

Table 10. Duncan's multiple range test for length at 40-56 weeks postconceptual age of formula and human milk fed infants.

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean (Centimeters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>19</td>
<td>49.96a</td>
</tr>
<tr>
<td>42</td>
<td>13</td>
<td>52.31b</td>
</tr>
<tr>
<td>48</td>
<td>21</td>
<td>56.48c</td>
</tr>
<tr>
<td>56</td>
<td>10</td>
<td>60.92d</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>64</td>
<td>55.69a</td>
</tr>
<tr>
<td>Male</td>
<td>9</td>
<td>52.18b</td>
</tr>
</tbody>
</table>

+Means with the same letter are not significantly different.

α < 0.05
Table 11. Head circumference in relation to independent variables.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>F Value</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>3</td>
<td>468.03</td>
<td>48.96</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Gestational Age</td>
<td>1</td>
<td>11.17</td>
<td>3.51</td>
<td>0.0659</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>5.63</td>
<td>1.77</td>
<td>0.1886</td>
</tr>
<tr>
<td>Feeding</td>
<td>1</td>
<td>4.19</td>
<td>1.32</td>
<td>0.2554</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>1</td>
<td>0.39</td>
<td>0.12</td>
<td>0.7275</td>
</tr>
<tr>
<td>Birth Length</td>
<td>1</td>
<td>1.49</td>
<td>0.47</td>
<td>0.4956</td>
</tr>
<tr>
<td>Birth Head Circumference</td>
<td>1</td>
<td>1.87</td>
<td>0.59</td>
<td>0.4468</td>
</tr>
</tbody>
</table>

R Square = 0.722

Table 12. Duncan's multiple range test for head circumference at 40-56 weeks postconceptual age of formula fed and human milk fed infants.

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean (Centimeters)+</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>19</td>
<td>35.00a</td>
</tr>
<tr>
<td>42</td>
<td>13</td>
<td>36.70b</td>
</tr>
<tr>
<td>48</td>
<td>21</td>
<td>39.48c</td>
</tr>
<tr>
<td>56</td>
<td>20</td>
<td>41.65d</td>
</tr>
</tbody>
</table>

*Means with the same letter are not significantly different.
\( \alpha < 0.05 \)
Table 13. Mid-upper arm circumference in relation to independent variables.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>F Value</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>3</td>
<td>52.14</td>
<td>15.33</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Gestational Age</td>
<td>1</td>
<td>5.41</td>
<td>4.78</td>
<td>0.0341*</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.019</td>
<td>0.02</td>
<td>0.8962</td>
</tr>
<tr>
<td>Feeding</td>
<td>1</td>
<td>19.81</td>
<td>17.47</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>1</td>
<td>0.34</td>
<td>0.30</td>
<td>0.5862</td>
</tr>
<tr>
<td>Birth Length</td>
<td>1</td>
<td>1.75</td>
<td>1.55</td>
<td>0.2193</td>
</tr>
<tr>
<td>Birth Head Circumference</td>
<td>1</td>
<td>1.12</td>
<td>0.98</td>
<td>0.3266</td>
</tr>
</tbody>
</table>

R Square = 0.63

Table 14. Duncan's multiple range test for mid-upper arm circumference at 40-56 weeks postconceptual age of formula and human milk fed infants.

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean (Centimeters)+</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>12</td>
<td>10.42a</td>
</tr>
<tr>
<td>42</td>
<td>9</td>
<td>11.83b</td>
</tr>
<tr>
<td>48</td>
<td>18</td>
<td>12.06b</td>
</tr>
<tr>
<td>56</td>
<td>16</td>
<td>13.31c</td>
</tr>
<tr>
<td>Feeding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formula</td>
<td>38</td>
<td>12.38a</td>
</tr>
<tr>
<td>Human milk</td>
<td>17</td>
<td>11.26b</td>
</tr>
</tbody>
</table>

+Means with the same letter are not significantly different.

α <0.05
Table 15. Triceps skinfold in relation to independent variables.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>F Value</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>3</td>
<td>97.53</td>
<td>11.28</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Gestational Age</td>
<td>1</td>
<td>27.96</td>
<td>9.70</td>
<td>0.0032*</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.75</td>
<td>0.26</td>
<td>0.6125</td>
</tr>
<tr>
<td>Feeding</td>
<td>1</td>
<td>37.74</td>
<td>13.09</td>
<td>0.0007*</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>1</td>
<td>2.09</td>
<td>0.72</td>
<td>0.3991</td>
</tr>
<tr>
<td>Birth Length</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.9704</td>
</tr>
<tr>
<td>Birth Head Circumference</td>
<td>1</td>
<td>1.25</td>
<td>0.43</td>
<td>0.5142</td>
</tr>
</tbody>
</table>

R Square = 0.589

Table 16. Duncan's multiple range test for triceps skinfold at 40-56 weeks post-conceptual age of formula and human milk fed infants.

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean (Millimeters)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>12</td>
<td>4.46a</td>
</tr>
<tr>
<td>42</td>
<td>10</td>
<td>7.10b</td>
</tr>
<tr>
<td>48</td>
<td>18</td>
<td>7.67b,c</td>
</tr>
<tr>
<td>56</td>
<td>16</td>
<td>8.59c</td>
</tr>
</tbody>
</table>

Feeding
- Formula 39 7.63a
- Human Milk 17 6.03b

†Means with the same letter are not significantly different.
α < 0.05
Table 17. Subscapular skinfold in relation to independent variables.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>F Value</th>
<th>Pr&gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>3</td>
<td>58.19</td>
<td>7.93</td>
<td>0.0003*</td>
</tr>
<tr>
<td>Gestational Age</td>
<td>1</td>
<td>0.67</td>
<td>0.28</td>
<td>0.6022</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>0.02</td>
<td>0.01</td>
<td>0.9347</td>
</tr>
<tr>
<td>Feeding</td>
<td>1</td>
<td>26.09</td>
<td>10.67</td>
<td>0.0021*</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.9868</td>
</tr>
<tr>
<td>Birth Length</td>
<td>1</td>
<td>5.09</td>
<td>2.08</td>
<td>0.1561</td>
</tr>
<tr>
<td>Birth Head Circumference</td>
<td>1</td>
<td>0.20</td>
<td>0.08</td>
<td>0.7763</td>
</tr>
</tbody>
</table>

R Square = 0.461

Table 18. Duncan's multiple range test for subscapular skinfold at 40-56 weeks postconceptual age of formula and human milk fed infants.

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean (Millimeters)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>12</td>
<td>4.53a</td>
</tr>
<tr>
<td>42</td>
<td>7</td>
<td>6.36b</td>
</tr>
<tr>
<td>48</td>
<td>18</td>
<td>6.64b</td>
</tr>
<tr>
<td>56</td>
<td>16</td>
<td>7.47b</td>
</tr>
</tbody>
</table>

Feeding

<table>
<thead>
<tr>
<th>Feeding</th>
<th>N</th>
<th>Mean (Millimeters)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula</td>
<td>37</td>
<td>6.76a</td>
</tr>
<tr>
<td>Human Milk</td>
<td>16</td>
<td>5.47b</td>
</tr>
</tbody>
</table>

†Means with the same letter are not significantly different.

α < 0.05
Appendix B
Recommendations and Conclusion
"On the Feeding of Supplemental Foods to Infants"

"Supplemental foods should be introduced when the infant is able to sit with support and has good neuromuscular control of the head and neck. At this stage of development, the infant will be able to indicate a desire for food by opening his mouth and leaning forward, and to indicate disinterest or satiety by leaning back and turning his head away. At this time, about 4 to 6 months of age, a variety of foods should be introduced one at a time, at intervals of a week or more. . . . With the background of these guidelines for infants as a group, the age of introduction of supplemental foods for individual infants cannot be set rigidly; rather, it depends on rate of growth, stage of development and level of activity.

On the basis of present knowledge, no nutritional advantage results from the introduction of supplemental foods prior to 4 to 6 months of age. . . ."

Committee on Nutrition
Pediatrics 65(6):1178-81, 1980
Appendix C

Growth Curves
Growth record for infants in relation to gestational age and fetal and infant norms.
GIRLS FROM BIRTH TO 36 MONTHS
LENGTH FOR AGE

Growth record for infants in relation to gestational age and fetal and infant norms.
GIRLS FROM BIRTH TO 36 MONTHS
WEIGHT FOR AGE

Growth record for infants in relation to gestational age and fetal and infant norms.
Appendix D
Skin Fold Growth Curves