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INFANT FEEDING PRACTICES: HISTORY, NUTRIENT NEEDS, ASSESSMENT OF NUTRITURE, AND SPECIAL CONCERNS

by

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Thesis submitted in partial fulfillment of the requirements for the degree

of

DEPARTMENTAL HONORS

in

Coordinated Dietetic Emphasis in the Department of Nutrition and Food Science

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Author's Biography

Katy Lynn Bodily was born in Sandy, Utah. She attended Jordan High School where she participated in theater and the Peer Leadership Team. She graduated high school in 2002 and began her college career later that year at Dixie State College in St. George, Utah. Katy earned an Associate Degree of Science while attending Dixie, and graduated Summa Cum Laude. Katy then transferred to Utah State University where she pursued a degree in Dietetics. She was appointed to the College of Agriculture Dean's List every semester attended over the past three years. She plans to graduate on May 5, 2005 with a Bachelor of Science in Nutrition and Food Science with an emphasis in Coordinated Dietetics. After graduation, Katy plans to works as a clinical dietitian.

Abstract.

Ideas regarding infant feeding practices have changed drastically over the past 100 years. Research discovered the composition of human milk, followed by the invention of human milk substitute (HMS). These discoveries lead to many changes in the way people feed infants. The macro and micronutrient needs of infants have been determined, and are used to develop ideal feeding practices for infants. There are many choices available for feeding infants including human milk, HMS, and solid foods. There are many guidelines available that provided suggestions on what to feed an infant, and at what age. Assessing the adequacy on infant feeding is important for the growth and development of an infant. There are some controversial issues regarding the consumption of cow's milk prior to age one, and juice consumption which need consideration. There are also special concerns for infants such as premature infants and those experiencing failure-to-thrive which differ from recommendations given for the general infant population.

INTRODUCTION

Infant feeding practices have an interesting and dynamic history. As cultures became more modernized, ideas regarding infant feeding practices changed. As new discoveries were made regarding the composition of human milk, practices involving the feeding of infants evolved. Infant nutrition has become an industry with estimations for macronutrient and micronutrient needs, human milk substitutes (HMS) to meet the needs of a variety of infant needs, guidelines for introduction of solid foods, as well as recommendations for exclusion of some foods from the infant diet, such as cow's milk. It is necessary to understand what foods are appropriate for infants and at what age to add certain foods. Assessing nutriture and addressing special concerns on an individual basis is also important.

HISTORY OF INFANT FEEDING

Throughout history, some concepts regarding the feeding of infants have remained unchanged, while others have changed dramatically. Breastfeeding was usually the main source of nutrients for infants in the past. If a mother was unable to breastfeed, a wet nurse could be hired to breastfeed the infant. This practice was considered acceptable for thousands of years (1). For mothers who could not afford a wet nurse and who were unable to breastfeed, the infant was fed beer, gruel, or a bread and water mixture called paps (1). When other mammalian milks were given to infants within the first month, death would often result due to the different composition of animal milks compared to human milk (1). After the infant reached one month of age, other mammalian milks were less likely to cause death in infants (1).

The composition of human milk was determined in 1885 which led to the conclusion that high levels of protein and electrolytes in other mammalian milks compared with human milk lead to protein intoxication and hyperelectrolytemia in infants fed alternate milks (1). Infant formulas were developed in the early 1900's, and the infant feeding market has been constantly changing and advancing ever since (1).

MACRONUTRIENT NEEDS OF INFANTS

Compared with infant feeding practices of the past, there is now much known regarding proper feeding practices of infants. From birth to six months of age, full-term female infants need about 520 calories per day and males need about 570 calories per day. The macronutrient distribution should be about 6% protein, 44% carbohydrate, and 50% percent fat. The older infant between six and 12 months needs about 676 calories per day for females and about 743 calories per day for males. The macronutrient distribution for the older infant should be around 8% protein, 54% percent carbohydrate, and 38% fat (2). These recommended macronutrient distributions show that as the infant ages, the recommendation for fat decreases while the recommendation for carbohydrate and protein increases. The composition of human milk and HMS have about the same macronutrient composition as is recommended, making them the best source of nutrition for infants (2).

TYPES OF INFANT FOODS

The three choices for feeding infants are human milk, HMS, and solid foods. Starting at birth, human milk or HMS is adequate to meet the nutrition needs of most full-term infants until age four to six months (3). After this age it is important to add solid foods to the diet to meet certain nutrient needs that are not met by human milk or HMS. Even after the addition of solid foods, it is still important for the infant to consume 24 to 26 ounces per day of human milk or HMS for the first year of life. Human milk, HMS, and solid foods are all different forms of nutrition for an infant, but can all be part of a nutritious diet.

Human Milk

The American Academy of Pediatrics (AAP) and the American Dietetic Association (ADA) promote breastfeeding as being the best source of nutrition for an infant (3). There are many reasons why human milk is considered superior to HMS: 1) The composition, 2) It is bacteriologically safe, 3) It has immunologic and enzymatic components, 4) It has lower cost and increased convenience, 5) There can be enhanced maternal-infant bonding, 6) Decreased incidence of respiratory and gastrointestinal infections, and 7) Decreased incidence of atopic dermatitis. There are also proclaimed health benefits for the mother (3). According to the Centers for Disease Control (CDC), in 2005, 21 states reported 75% of mothers initiating breastfeeding. At infants sixth months of age, only five states had breasfeeding rates greater than 50%. Only 11 states had more than 25% of mothers who breastfeed until the infant reached 12 months of age (4).

Human milk contains eight main components: Proteins, non-protein nitrogen, carbohydrates, lipids, water-soluble vitamins, minerals and ionic constituents, trace minerals, and cells (5). The concentration of certain components of human milk can vary among and within women depending on genetic individuality, maternal nutrition, and stage of gestation and lactation (5). However, human milk does have a characteristic composition and is similar among most well nourished women.

Table 1. Comparison of Nutrients in Cow's Milk compared to Human Milk

Nutrient	Human Milk (100ml)	Cow Milk (100ml)
Energy (calories)	62-70	61
Protein (grams) (g)	0.9	3.3
Carbohydrate (g)	7.3	4.7
Fat (g)	3-5	3.3

Table 1 shows the composition of the macronutrients of human milk compared with cow's milk (3). The energy content of human milk is similar to that of cow's milk. However the composition of macronutrients within each milk is different. The protein content of human milk is much lower than that of cow's milk. Human maternal diet has been shown to influence protein levels in human milk. Decreased total protein, free amino acid concentration, and immunologic factors have been seen in mothers with deficient protein intake (5). The protein content of human milk is 80% whey and 20% casein. This is almost opposite to that of cow's milk which is 18% whey and 82% percent casein (3).

The carbohydrate content of human milk is mainly lactose (6). Lactose concentration is very stable in human milk, and variability among women is due mainly to genetic differences (5).

Fat is the most variable component of human milk. The fat content of milk is low at the beginning of a feeding in foremilk, and high at the end of a feeding in hindmilk (6). This is why it is important for a mother to empty her breast milk from one breast before allowing the infant to drink from the other breast (3). Human milk is high in essential fatty acids important for neural development (5). Fat digestion and absorption may not be fully developed in the early neonatal stage. Human milk contains enzymes to aid in the process of breaking down long chain fatty acids to allow for absorption (5).

Human milk is adequate in meeting most micronutrient needs until six months of age (7). An exception to this would be an infant born preterm. These infants have increased nutrient needs due to a lack of nutrient stores at birth (3). Another situation in which human milk may not be sufficient in nutrients would be if the mother was malnourished during pregnancy. She may not have adequate nutrient stores for nutritionally adequate milk (3).

The bioavailability of many vitamins and minerals including iron, zinc, vitamin E, vitamin C, and vitamin D, is much higher in human milk compared with cow's milk (2). Despite the increased bioavailability of vitamins and minerals in human milk, there are some nutrients that continue to be of concern with exclusive breastfeeding. Human milk contains 0.4 micrograms (μg) per day of vitamin D, but the Recommended Dietary Allowance (RDA) for an infant is 5 μg per day (2, 7). Humans are able to synthesize adequate vitamin D from 10 to 15 minutes of sunlight exposure each day and may not rely on diet as the sole source of vitamin D. Infants with dark skin, or those who live in areas with limited sunlight exposure are at risk for vitamin D deficiency. The AAP recommends that breastfed infants be supplemented with 5 μg of vitamin D after two months of age to prevent vitamin D deficiency (6).

Iron is another nutrient of concern for exclusively breastfed infants. Human milk is not a good source of iron, containing between 0.2-0.4mg/L (8). Maternal diets high in iron do not increase the iron concentration in human milk (9). Iron deficiency is only of concern in later infancy because if maternal iron stores are sufficient during pregnancy, and the infant is born full term, the infant should have adequate iron stores for up to four to six months (2). After six months, the introduction of iron fortified cereal and meat into the infant's diet helps to prevent iron deficiency (3).

Despite low amounts of iron in human milk, it is highly bioavailable with an absorption rate of about 50%; which is high compared with nonheme iron sources which can have and absorption efficiency as low as two to three percent (8, 10). HMS are fortified with iron and therefore, infants fed HMS are not at risk for iron deficiency like breastfed infants (3). Iron deficiency in infancy can cause impaired motor development, long-term developmental deficits, and behavior problems (2). Adding solid foods, which are high in iron, to the breastfed infant's diet between four to six months is important in preventing iron deficiency (8).

Human Milk Substitute

According to the results on breastfeeding rates reported by the CDC, about 75% of infants will require infant formula due to cessation of breastfeeding prior to the infant reaching 12 months of age (4). Infant formula is the best alternative to human milk. Its composition was designed to mimic that of human milk (3). The Food and Drug Administration (FDA) is responsible for regulating the composition and safety of infant formula (3). Formulas are designed to provide complete nutrition for infants for the first four to six months of life (3). There are many different categories of formula including: standard, soy, protein hydrolysate, elemental, follow-up, and preterm (3).

Standard cow's milk formula is appropriate for most infants. To make formula from cow milk, the butterfat is removed, vegetable oils and carbohydrate are added, and the protein content is decreased (3). Standard formula provides 20 calories per ounce and 40-50 % of the calories come from fat. The main sources of fat are saturated and polyunsaturated fatty acids. Arachidonic acid and docosahexaenoic acid (DHA) are fatty acids found in human milk and are also added to standard formula (3). The protein content of a standard formula ranges from 1.7 to 3.4 g per 100 calories, which is much lower than the protein content of cow's milk which is 5.4 g per 100 calories (3). The protein source is usually nonfat milk, which is predominantly casein, plus additional whey. There are some formulas which only contain whey as the sole protein source (3). Lactose is the source of carbohydrate for standard formula (2). Most infants are able to tolerate lactose, but there are alternative formulas for those who can not (3). Standard formula is fortified with vitamins and minerals, including iron and vitamin D which are low in human milk (3). Since more infants are formula fed compared with breastfed after six months of age, the incidence of iron deficiency has decreased due to fortification (4, 11). There are formulas with low iron, but the AAP does not recommend their use for most infants due to the risk of iron deficiency (3).

Soy formula was developed for infants who could not tolerate cow's milk protein or lactose (3). Soy formulas contain soy protein isolate as the protein source, vegetable oils as the fat source, and corn syrup and sucrose as the sources of carbohydrate (3). Soy formulas are also fortified with vitamins and minerals (3). With the development of protein hydrolysate and elemental formulas, soy formula is no longer used for infants suspected of having a cow's milk allergy due to the likelihood that the infant may also have a soy protein allergy (3).

Protein hydrolysate formulas were developed for infants with cow's milk allergy, soy allergy, or extreme malabsorption due to certain diseases (3). The protein sources are casein hydrolysates and free amino acids (3). The carbohydrate content varies in each product and can include corn syrup solids, modified corn starch, dextrose, sucrose, modified tapioca starch, or a combination (3). Vitamins and minerals are also fortified in these formulas (3). These formulas are very expensive and should only be recommended if an allergy is identified or if the infant is experiencing significant malabsorption (3, 12, 13)

Amino acid-based, elemental formulas are specially produced for infants who are extremely sensitive to protein and are unable to tolerate protein hydrolysate formulas (3). There are only two elemental formulas on the market, Elecare® and Neocate®, both of which are very expensive (12, 14). The protein source is free amino acids, which are more easily absorbed than proteins. During protein digestion, these proteins are denatured in the stomach by hydrochloric acid, followed by the breaking of peptide bonds by the enzyme pepsin. The end products of stomach digestion are large polypeptides, oligopeptides, and free amino acids. Once in the small intestine, the peptides are further broken down into free amino acids, dipeptides, or tripeptides, which can then be absorbed across the brush border membrane (10). Providing an elemental formula bypasses these steps of protein digestion and allows for easier absorption of amino acids. If an infant has problems with enzyme secretion to break down protein, or the ability to absorb small peptides, an elemental formula is warranted (10).

Solid Foods

Both the AAP and the World Health Organization (WHO) recommend exclusive breastfeeding for approximately the first six months of life with the introduction of solid foods after six months (15, 9). However, both organizations support the introduction of solid foods as young as four months for those infants who are developmentally ready (3). The ways to determine if an infant is developmentally ready are to assess energy requirements and growth of the infant, consider iron, zinc, and vitamin D status, and the risk of atopic disease (3, 6).

As well as these clinical signs of readiness, parents need to pay attention to the signs that the baby gives when he or she is ready to begin eating solid foods (6). For the first part of life, the infant has an extrusion reflex that only allows the infant to swallow liquids. After four to five months, this reflex disappears which allows for the introduction of solid foods (3). Around four to six months, the infant develops oral skills that enable the infant to move the tongue from side to side, and also to transfer food to the back of the tongue for swallowing (3, 6). The infant must also be able to hold his or her head upright and sit with little support prior to initiating solid foods (6). The infant must also be able to extend the tongue beyond the bottom lip prior to initiating solid foods (6). There are other signs which are more subtle that indicate an infant is ready for solid foods. For example, 1) the infant may start paying attention and showing interest

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in food when others are eating (6), 2) the infant may also open his or her mouth and lean forward when food is presented if there is an interest in starting solid foods (3).

Since human milk and HMS provide adequate nutrition for an infant up to six months, introducing solid foods before that time may not be beneficial. Human milk and formula are better sources of most nutrients than cereal, fruits, vegetables, or meat. Therefore, early initiation of solid foods could displace human milk or HMS consumption and lead to undernutrition in the infant (7).

Despite current recommendations on the introduction of solid foods, many parents are choosing not to follow them. In a study conducted by Anderson et al., 35% of the women studied introduced solid foods prior to three months of age. All of the women involved in the study claimed to know the recommendation of starting solid foods around four to six months, however only half of the women said they were planning on following that recommendation (16). Another study, conducted by Skinner et al., also looked at introduction of solid food practices. The results showed the average age for the introduction of rice cereal, the most common first food in this study, was 3.8 months. However, 18% of infants were offered cereal prior to two months of age. Fruit, juice and vegetables were offered at an average age of five months. Sixteen percent of the sample studied offered fruit to their infants prior to three months of age (17). These studies show there is tremendous variability regarding the introduction of solid foods among parents.

There are many choices for parents when choosing an infant's first foods. The type of food given to infants varies depending on culture and ethnicity (6). Iron-fortified rice cereal is often used as the first food for infants because it is easily digested and hypoallergenic (6). Other foods, such as fruits or vegetables, can also serve as an infant's first food as long as the texture is semiliquid in consistency (3). It is recommended to offer the same food for two to three days in a row without the inclusion of other food, aside from human milk or HMS, to assess intolerance or allergy (3). Signs of intolerance include skin rashes, vomiting, diarrhea, or wheezing (3). Around seven or eight months of age, the infant may be ready for a lumpier texture. Around eight to ten months, soft, mashed, and minced foods can be added to the diet. At ten to twelve months, soft, chopped foods are introduced (3,6). Infants do not develop mature chewing skills until the toddler years, so food needs to continue to be soft (6). The serving size for solid food initially is one to two tablespoons per meal, with one to two meals each day (6). The same principle applies with solid foods as it does with human milk or formula; the infant should decide how much food he or she wants to eat at a meal (3).

DETERMINING FEEDING ADEQUACY

By allowing the infant to decide how much food he or she consumes, it may be difficult to know if the infant is eating enough and has adequate nutrition. Determining grams of fat, carbohydrate, and protein and counting calories would be important for calculating enteral feeding rates, but would not be practical for healthy babies on a daily basis. There are other ways of determining feeding adequacy. Counting the number of feedings, measuring the volume of feedings, counting wet and soiled diapers, and plotting growth are all ways of assessing whether or not an infant is receiving enough nutrients (2, 3, 6).

Counting the Number of Feedings

Counting the number of feedings to determine feeding adequacy is important for the breastfed infant. During the first few weeks of life the infant should be fed every two or three hours or eight to twelve feedings each day (3). After breastfeeding becomes stabilized, it is then important for the infant to set his or her own feeding schedule as well as the duration of each feeding (3). It is important to look for signs of hunger in infants such as bringing hands to the mouth and sucking on them and moving the head from side to side with the mouth open (3). Crying is also a sign of hunger but it is a late sign (6). If the infant is eating every couple of hours and the parent or caregiver pays attention to hunger cues, there still may be a question as to whether or not the breastfed infant is receiving milk. Signs that the infant is receiving milk include a slowed and rhythmic sucking, infant swallowing, and milk leaking out of the infants (3, 6).

Volume of Formula

The volume of milk provided each day is an important way to assess feeding adequacy for formula fed infants. Infants from birth to one month should receive 16 to 20 fluid ounces (fl oz) of formula each day. From one to two months, 18 to 26 fl oz, from two to three months 22-30 fl oz and from three to four months 24 to 32 fl oz are recommended (6). At four to six months of age, solid food can be introduced into the infant diet. After that time, fl oz of formula are adjusted on an individual basis depending on solid food consumption, but should remain at a volume of at least 24 to 26 ounces per day (6). It is just as important to allow bottle-fed infants to set their own feeding schedule and to determine the duration of each feeding as it is with breastfed infants (3, 6).

Wet and Soiled Diapers

Paying attention to wet and soiled diapers is another way to assess the adequacy of feedings. A newborn receiving adequate fluid and calories should have at least six to eight wet diapers each day along with a bowel movement with most feedings (3). Infants experiencing failure-to-thrive will have fewer wet diapers with dark yellow, concentrated urine, as well as few bowel movements (6). Having an adequate number of wet diapers and bowel movements is a good indicator that an infant is receiving adequate nutrition.

Growth

The gold standard for determining the adequacy of feeding would be growth. The CDC developed and revised infant growth charts in 2000 (3). These growth charts can aid in plotting weight for age, length for age, weight for length, and head circumference for age (3). Normal growth plotted on a growth chart would show steady growth between the third and ninety-seventh percentile (6). There may be slight peaks and valleys at times due to illness followed by catch-up growth, but the overall curve should be steady (3). Warning signs to watch for when plotting infant growth would be lack of weight, height, or head circumference gain for more than one month (6).

CONTROVERSIAL ISSUES REGARDING INFANT FEEDING

There are some controversial issues regarding infant feeding. Offering cow's milk prior to one year of age is often a topic where there is discrepancy among different cultures. Also the inclusion of juice in the infant diet is sometimes debated as well. Both of these practices can put infants at risk for health problems if recommendations are not followed.

Cow's Milk Prior to Twelve Months of Age

Before the widespread use of infant formula, it was common for parents to alter whole cow's milk and feed it to the infant. A recipe for whole milk formula from The American Journal of Clinical Nutrition in 1953 was: 2/3 whole milk, 1/3 water, and one ounce of sugar for every 20 ounces of fluid (18). This formula was recommended until the infant reached three to four months of age, then unaltered whole cow's milk could be used (18).

Today, much more is known about the risks of consuming cow's milk during infancy. The AAP recommends that cow's milk not be introduced until twelve months of age, and that only whole milk be used until two years of age (3, 6). There are multiple reasons for this recommendation. First, the risk of milk protein allergy and gastrointestinal blood loss can occur with early initiation of whole cow's milk (3). Second, iron deficiency anemia can also occur with early initiation of cow's milk not only because of gastrointestinal blood loss, but also due to the low bioavailability of iron in cow's milk (8). The increased risk of iron deficiency, when infants are fed cow's milk, can be seen in research studies. In a longitudinal study conducted on infants, there was a negative relationship between serum ferritin levels and consumption of whole cow's milk (8). Third, along with the risk of iron deficiency, whole cow's milk does not meet the vitamin C, vitamin E, and essential fatty acid needs of infants (3). Fourth, cow's milk has a higher amount of protein and electrolytes compared to human milk or formula which increases the renal solute load and may lead to dehydration (3).

Juice Consumption

The AAP recommends that juice should not be given to infants younger than six months of age, and infants between six and twelve months can receive up to six ounces daily. They also recommend that infants should not be fed juice in bottles or cups that encourage constant consumption, and juice should not be given in a bottle at bedtime. Furthermore, only one-hundred percent juice should be used.

Despite the AAP recommendations, some parents choose to introduce juice into the infant's diet earlier. A study, conducted on ninety-eight mother/infant pairs, was done to determine the average ages of introduction to different complimentary foods, or foods added to the infant's diet in addition to milk (17). The mean age for the introduction to fruit juice was five months, which is one month earlier than what the AAP recommends (17).

There are many reasons for the AAP recommendations regarding juice consumption in infants. One of the main reasons is the displacement of other nutrient dense foods. Juice is highly caloric, yet very low in fat and protein; both of which are important nutrients for growing infants (6, 19). Juice is also lower in fiber and many vitamins and minerals compared with whole fruit (19). If infants are given large quantities of juice, they will be less able to consume other nutrient-dense foods, such as human milk, HMS, cereal, vegetables or fruit. Prolonged over-consumption of fruit juice, causing underconsumption of breast milk, formula, and other foods, may eventually lead to failure-to-thrive in infants (3).

Another reason for the AAP's recommendations is the increased risk of dental caries with inappropriate juice consumption. When juice is fed in bottles or cups with spouts, the juice can remain on the infant's teeth for prolonged periods of time. The high concentration of carbohydrate in juice, combined with prolonged exposure can lead to dental caries. Giving an infant a bottle with juice at bedtime can lead to even longer exposure of juice to the infant's teeth because when the infant falls asleep, whatever juice is still in the mouth can pool around the teeth creating the optimal environment for bacterial growth, thus leading to tooth decay (2, 3, 6).

Despite these risks of juice consumption, juice can be a beneficial part of the infant diet. The carbohydrate fructose, found in fruit juice, can be helpful in relieving constipation in infants similar to the effects of fiber in an adult (3). The juices with the highest amount of fructose are pear and apple juices (3).

SPECIAL CONCERNS

Deciding what to feed an infant is very individualized. The recommendations presented thus far have been for healthy, full-term infants. There are certain cases where what applies to the majority of the population does not apply to a particular infant. This is the case with preterm infant and those exhibiting failure to thrive (FTT).

Preterm Infants

Preterm refers to infants born prior to 37 weeks of gestation (3). Preterm infants are classified according to their birth weight. Low-birth-weight describes infants who weigh less than 2500g, very-low-birth-weight is less than 1500g, and extremely-low-birth-weight is less than 1000g (6). Preterm infants, especially those with extremely low birth weight, have many disadvantages compared with full-term, appropriate weight infants. Preterm infants have poor nutrient stores because most nutrients are stored during the last three months of pregnancy (3). A 3500 g infant usually has 16% body fat, whereas a 1000 g infant has only one percent body fat, which shows the lack of fat stores in a preterm infant (2). Preterm infants also have a small stomach capacity which limits the amount of nutrition that can be offered at one time (3). Preterm infants have an immature gastrointestinal tract which limits the absorptive capabilities due to low concentrations of lactase, pancreatic lipase and bile salts (2). With the rapid growth experienced by preterm infants, it is difficult to provide enough calories to support that growth (2). Preterm infants experience poor temperature control due a lack of subcutaneous fat. These infants have to use calories to maintain their temperature, and are often kept in isolettes to help maintain their temperature and prevent a large calorie deficit (2). Furthermore, the ability to suck and swallow is not acquired until 32-34 weeks of gestation (2). Feeding tubes are often required by preterm infants due to their inability to breastfeed or drink from a bottle (2).

To meet the high nutrition demand of preterm infants, special formulas have been developed. These formulas have higher concentrations of protein, vitamins and minerals which are required for preterm infants. In addition, they contain medium chain triglycerides to aid in lipid digestion. They are also concentrated to provide higher calories per ounce (2). Human milk does not meet the needs of most preterm infants. Therefore, a human milk fortifier is usually used to supplement the mother's milk (2).

Failure to Thrive

Failure to Thrive (FTT) is described as weight for age, or weight for length, less than the third percentile on the CDC growth charts. A decrease in weight of more than two major percentiles over a three to six month period also indicates FTT. There are many risk factors for the development of failure to thrive including: inability to consume adequate calories, inability to utilize calories, increased calorie needs, altered growth potential, living in poverty, parental psychosocial issues, and lack of parental knowledge (3). When treating FTT, determining the cause is the most important step.

CONCLUSION

Infant nutrition has a rich history full of changes and advances. Macronutrient needs for infants are determined which eases the burden of estimating nutrient needs for infants. Despite this knowledge, it is understood that infants should be given the opportunity to set their own feeding schedule and consume food at the volume that is suitable for him or her. There are many choices of food for an infant including human milk, HMS, and solid foods. Each of these foods can be used to meet an infant's nutritional needs as the infant grows, develops, and has changing macronutrient and micronutrient needs. There are ways to assess the adequacy of infant feedings which include: 1) counting the number of feedings, 2) measuring the volume of each feeding, 3) counting soiled diapers, and 4) measuring growth. There are special concerns in infant nutrition such as the consumption of cow's milk prior to one year of age, juice consumption, and FTT.

Infant nutrition continues to be a changing and advancing field that is crucial for the wellbeing of infants.

REFERENCES

1. Barness LA. History of Infant Feeding Practices. *Am J Clin Nutr*. 1987;46:168-170.
2. Mahan LK, Escott-Stump S. *Krause's Food, Nutrition, and Diet Therapy*. 11th ed. Phiadelphia, PA: Saunders; 2004: 234-258.
3. Samour PQ, King K. Handbook of Pediatric Nutrition. 3rd ed. Sudbury MA: Jones and Bartlett Publishers; 2005.
4. Breastfeeding Practices — Results from the 2005 National Immunization Survey. Available at: http://www.cdc.gov/breastfeeding/data/NIS_data/data_2005.htm. Accessed: April 1, 2007
5. Picciano MF. Nutrient Composition of Human Milk. *Pediatric Clinics of North America*. 2001;48(1):53-66.
6. Brown JE, Isaacs JS, Krinke UB, Murtaugh MA, Sharbaugh C, Stang J, Wooldridge NH. Nutrition Through the Lifecycle. 2^{nd} ed. Belmont CA: Thomson Wadsworth; 2005.
7. Dewey KG. Nutrition, Growth, And Complementary Feeding Of The Breastfed Infant. *Pediatric Clinics of North America.* 2001; 48(1): 87- 103.
8. Krebs NF. Dietary Zinc and Iron Sources, Physical Growth, and cognitive Development of Breastfed Infants. *J. Nutr*. 2000;130(suppl):358S-360S.
9. Fulhan J, Collier S. Duggan C. Update on Pediatric Nutrition: Breastfeeding, Infant Nutrition, and Growth. *Curr Opin Pediatr*. 2003;15;323-332.

10. Gropper SS, Smith JL, Groff JL. Advanced Nutrition and Human Metabolism. 4th ed. Belmont CA: Thomson Wadsworth; 2005.

11. Krebs NF, Hambidge KM. Complementary Feeding: Clinically Relevant Factors Affecting Timing and Composition. *Am J Clin Nutr*. 2007;85(suppl):639S-45S.

12. Pediatric Nutrition Handbook of Ross Products. Available at: http://www.ross.com/productHandbook/pedNut.asp. Accessed March 1, 2007.

13. Enfamil Infant Products. Available at: http://www.meadjohnson.com/app/iwp/Content2.do?dm=mj&id=-8790. Accessed March 1, 2007.

14. Neocate Infant Formula. Available at http://www.neocate.com/aaa_neocate/1128-neocate-home-page.html. Accessed March 1, 2007.

15. Raiten DJ, Kalhan SC, Hay WW. Maternal Nutrition and Optimal Infant Feeding Practices: Executive Summary. Am J Clin Nutr. 2007;85(suppl):577S-83S.

16. Anderson A, Guthrie CA, Alder E, Fprsyth S, Howie P, Williams F. Rattling the Plate – Reasons and Rationales For Early Weaning. Health Educ Res. 2001;16:471-479.

17. Skinner JD, Carruth BR, Houck K, Moran J, Coletta F, Cotter R, Ott D, McLeod M. Transitions in Infant Feeding During the First Year of Life. J am Coll Nutr. 1997;16:209-215.

18. Bakwin H. Infant Feeding. *Am J Clin Nutr*. 1953;1(5):349-354.

19. Pennington JAT, Douglas JS. Bowes and Churches Food Values of Portions Commonly Used. Baltimore, MD: Lippincott Williams and Wilkins; 2005.