INTRODUCTION

Nutrient requirements of infants have been based on observations of ad libitum intakes of normal breast-fed populations\(^1,2\) or derived from a factorial approach that sums nutrient needs for growth, maintenance, and activity.\(^3\) Both definitions rely heavily on criteria for normal growth. Estimates derived from ad libitum intakes depend on the identification of populations with normal anthropometric indices. The use of the factorial approach requires a more complex definition of normal growth. Measurements of body composition and anthropometric indices are needed. The combination of body composition and weight gain provides estimates of the net accretion of specific nutrients and the nutrient costs of tissue synthesis and deposition. Current applications of the factorial approach predict that the cost of growth falls from approximately 30 kcal/kg body weight the first month to less than 4 kcal/kg body weight by the end of the first year of life.\(^4\) The decline is not linear, but is more rapid during the first four months of life.

Seldom does either approach for estimating nutrient requirements use growth conceptually as a primary outcome, but instead growth is used as a proxy indicator for functional competence. No one argues credibly for the attainment of specific growth criteria without implying or directly identifying expected functional benefits.\(^5\) Such applications of growth measurements carry an implied warranty of sensitive relationships between growth and function. The sensitivity of growth as a proxy indicator for specific functional competence, however, is not well established.\(^3-7\) The apparent plasticity of growth in response to maternal and paternal genetic endowments, diet, and environment from conception through adolescence complicates the validation of putative relationships.

This discussion will focus on our observations of growth and intake of breast-fed infants 1 to 8 months of age.\(^8-9\) We will emphasize the role of diet as well as the period immediately before and after the introduction of solid foods to an exclusive human milk diet. We also will address briefly the implications of these data in the utilization of energy, composition of tissue gained, and possible effects on behavior.
MATERIALS AND METHODS

Study Design

Three studies were conducted. The first (Study I) was a prospective, longitudinal study of 45 exclusively breast-fed infants during the first 4 months of life. Measurements of milk intake, sampling of milk for compositional studies, and monitoring of infant growth were performed monthly. The second study (Study II) was semi-longitudinal in design. Seventeen infants were studied, nine at months 5 and 6 and eight at months 6 and 7. All were exclusively breast-fed for 5 months. Solid foods were introduced at 6 months. Infants were studied before solid foods were introduced and 30 and 60 days after the addition of solid foods to an exclusive human milk diet. Growth was measured monthly and intakes of milk and other foods were measured for 5 consecutive days.

Intake and growth of infants also have been measured in an on-going study, Study III. Forty-eight of a projected 60 subjects have been recruited. Only women who plan to breastfeed their infants exclusively for 4 to 6 months are eligible and are recruited in the last trimester of pregnancy. Infants are studied longitudinally from birth to at least 3 months after the introduction of solid foods. The timing of the introduction of solid foods is decided by each mother in consultation with the infant's pediatrician. Other than the initial introduction of rice cereal, the sequence in which solid foods are added to the diet is made by the mother and pediatrician. Mothers are asked to offer solid foods only after the infant has nursed to maximize the intake of human milk. Growth measurements are obtained weekly for the first 2 months of life, biweekly during months 3 and 4, and weekly thereafter until 3 months after solid foods have been added. Intakes are measured monthly from 16 weeks of life until 3 months after the introduction of solid foods. All studies have been reviewed by our institutional review boards and informed consent is obtained from each of the participants.

Subjects

Women recruited for these studies represented middle- and upper-income groups who obtain their medical care from private services. Subjects were healthy, on no prescribed or nonprescribed drugs, nonsmokers, and 18 to 35 years of age. Only those with one or two living children were accepted for study. Infants were required to be healthy, term, and appropriate size for gestational age.

Intake Measurements

The amount of milk ingested daily was determined by the test-weighing method during a 24-hour period in Study I. Measurements of milk intake were obtained for 5 consecutive days in Studies II and III. Milk samples were collected monthly for compositional studies. An Egnell pump was used to express milk. Alternate breasts were used for feeding and pumping with successive feeds during a 24-hour period. Compositional analyses were performed on a monthly 24-hour milk sample for each subject in Studies I and III. The analyses included the determination of gross energy by bomb calorimetry. In Study II, milk energy was assumed to be 67 kcal/dl. In estimating the intakes of Study III infants, a conservative energy density of 67 kcal/dl was used for milk samples that remain unanalyzed.

Nutrient intakes from solid foods were determined for 5 consecutive days. Mothers were supplied with preweighted jars of food and detailed instructions for their storage after use. Each jar was reweighed after feeding. Nutrient analyses were performed by our laboratory on each lot of the 12 types of solid foods used in Studies II and III.