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ADVANCES IN PEDIATRIC RESEARCH

Energy density and feeding frequency of complementary foods affects meal-specific food consumption and meal duration by healthy, breast fed Bangladeshi children

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Abstract

Background: Appropriate feeding of infants and young children is necessary to prevent growth faltering and optimize health during the first two years of life. There is little information on the effects of dietary energy density and feeding frequency of complementary foods on food consumption during individual meals and the amount of caregiver time expended in child feeding.

Methods: During nine separate, randomly ordered dietary periods lasting 3-6 days each, we measured self-determined intakes of semi-solid cereal porridges by 18 healthy, breastfed children 8-11 months of age. The infants were fed coded porridges with energy densities of 0.5, 1.0 or 1.5 kcal/g, during three, four, or five meals/day. Complementary food intake was measured by weighing the feeding bowl before and after every meal.

Results: Children consumed greater amounts of complementary foods per meal when they received diets with lower energy density and fewer meals per day. Greater time was expended per meal when fewer meals were offered. The time expended per meal did not vary with dietary energy density, but the children ate more and faster for the lower energy density diets.

Conclusions: We conclude that the energy density and feeding frequency of complementary foods affect meal-specific food intake. Meal frequency also influences the duration of individual meals, but energy density does not. These results provide further evidence of young children's ability to regulate their energy intakes, even during infancy, and convey information on factors that affect the amount of time that caregivers must devote to child feeding.

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Introduction

In developing countries, children's weight gain commonly falters in relation to reference data between ~3–15 months of age [1, 2], a period when complementary foods are usually added to their diets. The primary explanations for children's poor growth during this age interval include insufficient or inappropriate dietary intakes and frequent infections. Infants older than six months require complementary foods of appropriate energy and nutrient densities in addition to breast milk to meet their physiological requirements. The relatively high energy requirements of young children, together with their limited stomach capacity, make it difficult for them to satisfy their energy needs, particularly if the energy density of the diet is low or if only a few meals are offered each day [3, 4, 5]. Dietary energy density and feeding frequency are independently related to total daily energy intake; thus, both need to be considered in developing recommendations for infant feeding [5]. With the greater energy density of complementary foods, fewer meals can be provided and, conversely, when more meals are offered, energy requirements can be met with diets of lower energy density.

The effects of dietary energy density and feeding frequency on food intakes from each meal have been studied in fully weaned children recovering from malnutrition [5]. The children consumed the greatest amount of food during the first meal of the day, and the amounts consumed during single meals were inversely related to their energy density and the children's weight-for-length *z*-score [6, 7]. Interestingly, the children consumed a greater amount of complementary food per minute when they received foods with lower energy density. The same relationships between feeding frequency, dietary energy density, and total daily energy intakes have been observed among breastfed children, but no information has been reported on meal-specific food consumption by healthy, breastfed children.

The amount an infant eats during individual feeding episodes reflects not only the appetite of the infant, but also the composition of the meal and the attitudes and behaviors of the caregiver [8, 9]. Satiety is largely determined by the amount of food that is offered at each meal [10, 11, 12] and the palatability of foods. Post-prandial satiety inhibits further eating following a meal and affects the inter-meal interval and the amount consumed when food is next offered [13]. Infants are able to modify their energy intakes when diets with a varied energy density are offered *ad libitum*, even as early as six weeks of age [8]. Dietary studies that collected meal-specific information on energy intake showed considerable meal-to-meal variability [6, 14, 15, 16], whereas total daily energy intake was quite stable [15].

Caregivers' time constraints due to other responsibilities can influence their child's feeding behaviors [16, 17]. In poor households in lower-income countries, women are generally responsible for childcare; but they have multiple other household chores [17]. Thus, caregivers' time availability also can be an important determinant of children's total dietary intake.

In this paper, we have examined under controlled conditions the effects of dietary energy density and feeding frequency of complementary foods on the amount of food consumed and time expended in feeding breastfed children during each meal. We hypothesized that increasing the energy density and feeding frequency of complementary foods would positively affect energy intake from these foods, but would necessitate a greater amount of time for child feeding.

Methods

Study site and participants

The research was conducted in a peri-urban community of Dhaka, Bangladesh, and the Advanced Bio Medical Research Ward (ABRU) of the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b). Eighteen healthy children (8 boys and 10 girls), aged 8–11 months, who reportedly were being breastfed at least six times a day and receiving complementary foods at least twice a day were invited to participate in dietary screening studies in their homes. All children were required to have a length-for-age *z*-score > -2.0 and weight-for-length *z*-score between -1.5 and +1.5 with respect to international reference data [18], and their mothers had to have a body mass index (BMI) >18.5 kg/m^2. Children were excluded if they had any acute or chronic illness or congenital anomalies, or if they were exclusively breastfed, exclusively formula fed, or fully weaned. Written, informed consent was obtained from the mother of each child. The research protocol was approved by the institutional review boards of the University of California, Davis and icddr,b.

Study protocol

The caregivers' reported feeding practices were confirmed by direct observation during two consecutive 12-hour periods at their homes, as described previously [19]. Eligible children and their mothers were admitted to the ABRU for a period of 42 days. During the initial three day acclimation period, the study children were provided with a diet containing 1.0 kcal/g three times per day. Thus, we were able to confirm that all the children would accept the study diets and that their mothers were able to adhere to the study procedures. During the subsequent study periods, complementary foods were offered three, four or five times per day at pre-scheduled times. Specifically, the meals were offered at 0800–0900, 1300–1400 and 2000–2100 hours when the feeding frequency was three meals per day; 0700–0800, 1100–1200, 1500–1600 and 2000–2100 hours when the frequency was four meals per day; and 0600–0700, 0930–1030, 1330–1430, 1700–1800 and 2000–2100 hours when the frequency was five meals per day. The mothers were advised to breastfeed according to their usual pre-study feeding pattern, or more frequently if the infant demanded, except that they were requested not to breastfeed during the hour before each of the scheduled complementary feeds.

Each of the three study periods lasted for 13 days. The sequence of the study periods was randomly ordered with regard to the feeding frequency, and within each permutation of feeding frequency the order of the energy densities was also randomly allocated. An example of one dietary sequence is shown in Figure 1.

Measurement of complementary food intake

All feeding episodes took place under the supervision of clinical staff. Food portions were weighed before and after serving on an electronic balance with 0.1 g precision (Sartorius TE 4101, Goettingen, Germany), and the actual amount consumed was calculated by subtracting the amount of the leftover food from the amount offered. Pre-weighed napkins were provided to swab any food that was vomited or spilled, and any such losses were subtracted from the amount offered.

	Adap-tation	Study period 1				Study period 2				Study period 3			
Study day	1	4				17				30			42
Feeding frequency (meals/day)	3	4			3	3			3	5			3
Energy density (kcal/g)	1.0	0.5	1.5	1.0	1	1.0	0.5	1.5	1	1.5	1.0	0.5	1
Measurements													
Complementary food intake (g)	x x x	x x x x y y	x y y	x y y	x	x y y	x x x x y y	x y y	x	x y y	x y y	x x x x y y	x
Body weight (kg)	x x x	x x x x x x	x x x	x x x	x	x x x	x x x x x x	x x x	x	x x x	x x x	x x x x x x	x
Length	x	x			x		x			x		x	x

Figure 1. Example of a sequence of a dietary regimen in study protocol. x indicates the days on which a measurement was made; y indicates the days for which data on complementary food intake were included in the analyses. For different subjects, the order of feeding frequency was randomly assigned by study period, and the sequences of dietary energy density were randomly assigned within each level of feeding frequency. Each of the three study periods was 13 days.

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During each study period, the mothers were asked to spoon feed the respective diet to their child *ad libitum* under the supervision of study personnel. Each meal was continued until the child refused the food on three occasions separated by a one minute 'rest period', as described previously [19, 20]. The total duration of the feeding was recorded excluding these rest periods.

Statistical analysis

The primary response variables were the amount of food consumed per meal (g/meal), energy intake from complementary foods (kcal/meal), and total time required for each meal (min/meal). Data were analyzed from days 5 and 6 for the lowest energy density diet (0.5 kcal/g), and days 2 and 3 for the two higher energy density diets (1.0 kcal/g and 1.5 kcal/g), as explained previously [19]. Descriptive statistics (mean, standard deviation or standard error, as appropriate and median, inter-quartile ranges) were calculated for all continuous variables. The data were analyzed with the SAS Mixed Model procedure, after first confirming the normal distribution of the dependent variables or completing any necessary transformations of data. The main effects that were included in the models were the meal number (meal-1 through meal-5), dietary energy density (three levels), frequency of feeding (three levels), diet periods (three levels), individual (random) effects, and the two-way interactions between energy density and meal number, and between feeding frequency and meal number. An autoregressive covariance structure was assumed for the within-individual error term. If, any of the independent variables was found to be significant (p <0.05), then Tukey's test was performed to examine the pair-wise levels of significance.

Results

Study participants

The infants' mean length-for-age and weight-for-length z-scores were less than the reference population medians [18], but all values were within the normal range, as per the study entry criteria. Maternal BMI ranged from 18.7 to 25.8 kg/m^2, so no mothers were considered to be chronically energy deficient or overweight. The mean ages of the children and mothers were ~9 months and ~23 years, respectively (Table 1).

Table 1. Initial characteristics of the mothers and children [a]

Characteristics	Value
Child's age (months)	9.2 ± 0.9 (8, 11)
Child's body weight (kg)	7.46 ± 0.66 (6.36, 8.52)
Child's length (cm)	66.9 ± 1.9 (64.2, 71.0)
Child's length-for-age (z-score)	-1.14 ± 0.6 (-1.80 to 0.56)
Child's weight-for-length (z-score)	-0.30 ± 0.60 (-1.37 to 0.84)
Mother's age (years)	22.7 ± 2.5 (19.0, 28.0)
Mother's body weight (kg)	44.5 ± 3.3 (40.0, 54.3)
Mother's height (m)	1.48 ± 0.04 (1.39, 1.57)
Mother's BMI (kg/m^2)	20.3 ± 1.6 (18.7, 25.8)

[a] All values are mean ± SD; range in parentheses

Sixty-six percent of mothers and 77% of fathers had 1–10 years of school education. All the participants' houses had electricity and most had access to drinking water from nearby standpipes. The median household income was US$ 50.00 per month (Table 2).

Amount of complementary food intake

The amounts of the children's food intake at individual meals (g/meal) are shown in Table 3 in relation to the energy density and feeding frequency of the complementary food. The children consumed a greater amount of complementary foods per meal when they were receiving diets with lower energy density and when fewer meals were offered per day. In other words, when the feeding frequency of complementary foods increased, the amount of food consumption did not change proportionately in each meal. In particular, when fewer meals were offered, intakes per meal increased throughout the day. However, when more meals were provided, intakes tended to increase and then decline during the course of the day.

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Table 2. Socioeconomic characteristics of the study subjects [a]

Variable	Value (%)
Mother's educational status	
No education	5 (28)
1 to 5 years of school	6 (33)
6 to 10 years of school	6 (33)
More than 10 years of school	1 (6)
Father's educational status	
No education	4 (22)
1 to 5 years of school	7 (39)
6 to 10 years of school	7 (39)
More than 10 years of school	0 (0)
Monthly family income (US$)	50 (41, 91)[a]
No. of rooms in the house	1 (1, 1.3)[a]
Roof material	
Concrete	1 (6)
Corrugated tin	11 (61)
Thatched	6 (33)
Floor material	
Concrete	6 (33)
Earthen	10 (56)
Other	2 (11)
Drinking water	
Standpipe	10 (56)
Tube well	2 (11)
Other	6 (33)
Electricity	
Yes	18 (100)
No	0 (0)

[a] median (inter-quartile range)

Similarly, there was a significant interaction between dietary energy density and meal number ($p = 0.044$). Intake per meal tended to increase throughout the day with the lowest energy density diet, but increase and fall with the two higher energy density diets. The data are presented in relation to body weights in Table 4 and Figures 2 and 3, and the same meal-wise patterns were evident as when absolute amounts of food intake were considered.

Table 3. Food intake (g/meal) by dietary energy density, feeding frequency and meal number [a]

		Meal number				
		1	2	3	4	5
Energy density (kcal/g)	0.5					
Feeding frequency (meals/day)	3	129.7 (45.0)	138.2 (44.4)	134.2 (41.9)		
	4	122.3 (34.9)	125.7 (34.5)	127.7 (45.5)	133.0 (29.2)	
	5	117.7 (46.0)	110.4 (55.1)	123.5 (50.3)	128.4 (47.8)	126.4 (48.1)
Energy density (kcal/g)	1.0					
Feeding frequency (meals/day)	3	124.5 (49.6)	129.8 (48.9)	137.4 (55.2)		
	4	112.0 (47.6)	136.0 (52.6)	129.6 (41.3)	121.0 (55.9)	
	5	108.9 (37.6)	101.2 (34.8)	120.4 (42.4)	110.9 (45.6)	106.8 (36.1)
Energy density (kcal/g)	1.5					
Feeding frequency (meals/ day)	3	112.9 (49.6)	118.4 (47.0)	130.5 (65.6)		
	4	105.1 (46.2)	105.7 (38.1)	109.9 (41.6)	100.1 (46.2)	
	5	102.9 (37.0)	95.9 (42.2)	92.7 (45.1)	105.3 (38.2)	87.1 (38.6)

[a] All values are mean (SD); [b] Main effects by mixed model ANOVA: dietary energy density, $p < 0.001$; feeding frequency, $p < 0.001$; meal number, $p = 0.005$; interaction: dietary energy density X meal number, $p = 0.044$; interaction: feeding frequency X meal number, $p < 0.001$

The maximum intake of complementary food from a single meal for any combination of dietary energy density and feeding frequency ranged from 16.5–37.0 g/kg body weight (mean 25.0 ± 6.0) for the different children.

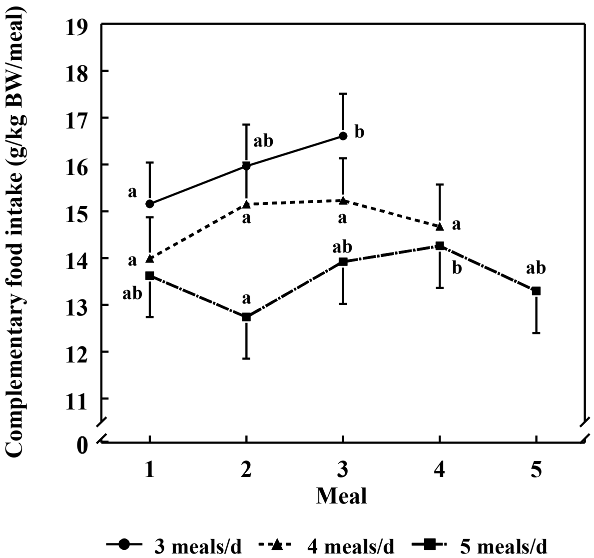

Figure 2. Mean (±standard error (SE) complementary food intake (g/kg BW/meal) by feeding frequency of complementary foods, controlling for dietary energy density. Food intakes per meal were significantly greater when fewer meals were offered ($p < 0.001$) and there was a significant interaction between feeding frequency and meal number, ($p = 0.012$), ANOVA. Within a particular level of feeding frequency, different letters are significantly different, $p < 0.05$, Tukey's test. BW is body weight.

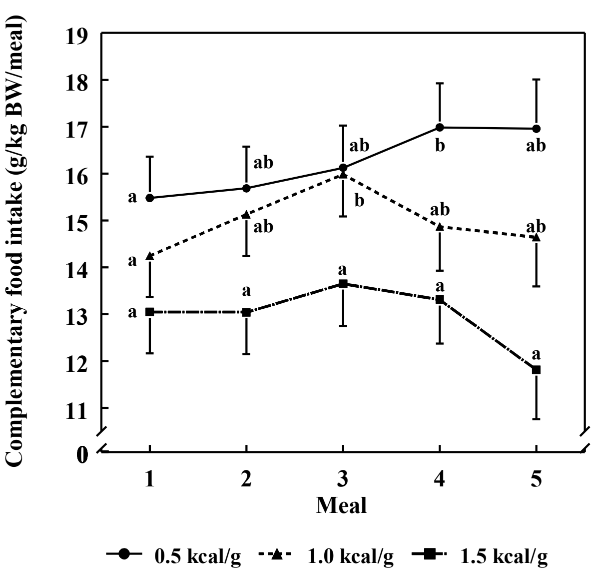

Figure 3. Mean (±SE) complementary food intake (g/kg BW/meal) by dietary energy density of complementary foods, controlling for feeding frequency. Food intakes per meal were significantly greater with lower energy density ($p < 0.001$), and there was a significant interaction between energy density and meal number, ($p = 0.046$), ANOVA. Within dietary energy density level, different letters are significantly different, $p < 0.05$, Tukey's test. BW is body weight.

Table 4. Food intake (g/body weight^{-1} per·meal) by dietary energy density, feeding frequency and meal number [a]

		Meal number				
		1	2	3	4	5
Energy density (kcal/g)	0.5					
Feeding frequency (meals/day)	3	16.2 (7.0)	17.3 (5.1)	16.8 (4.9)		
	4	15.3 (4.4)	15.7 (4.3)	16.0 (5.6)	16.7 (3.9)	
	5	14.9 (6.0)	14.0 (6.9)	15.6 (6.4)	16.2 (6.0)	16.0 (6.2)
Energy density (kcal/g)	1.0					
Feeding frequency (meals/day)	3	15.4 (5.8)	16.1 (5.8)	17.0 (6.3)		
	4	13.7 (5.4)	16.7 (6.2)	16.0 (5.0)	14.8 (6.5)	
	5	13.6 (4.6)	12.5 (4.2)	15.0 (5.3)	13.8 (5.4)	13.3 (4.6)
Energy density (kcal/g)	1.5					
Feeding frequency (meals/day)	3	13.8 (5.8)	14.5 (5.4)	16.0 (7.8)		
	4	12.9 (5.1)	13.0 (4.1)	13.7 (5.2)	12.5 (5.6)	
	5	12.4 (4.2)	11.6 (5.1)	11.2 (5.5)	12.8 (4.6)	10.6 (4.7)

[a] All values are mean (SD); [b] Main effects by mixed model ANOVA: dietary energy density, $p < 0.001$; feeding frequency, $p < 0.001$; meal number, $p = 0.003$; interaction: dietary energy density X meal number, $p = 0.046$; interaction: feeding frequency X meal number, $p = 0.012$

The maximum amount consumed occurred with the lowest density and lowest frequency dietary regimen.

Energy intake from complementary food

Figure 4 illustrates the energy intake per kg at individual meals (kcal/kg body weight $^{-1}$ · meal^{-1}) in relation to feeding frequency while controlling for dietary energy density. Energy intake per meal was greater when three meals were offered, and the intake increased during the course of the day. By contrast, there were no significant meal-related changes during the day when more meals were served.

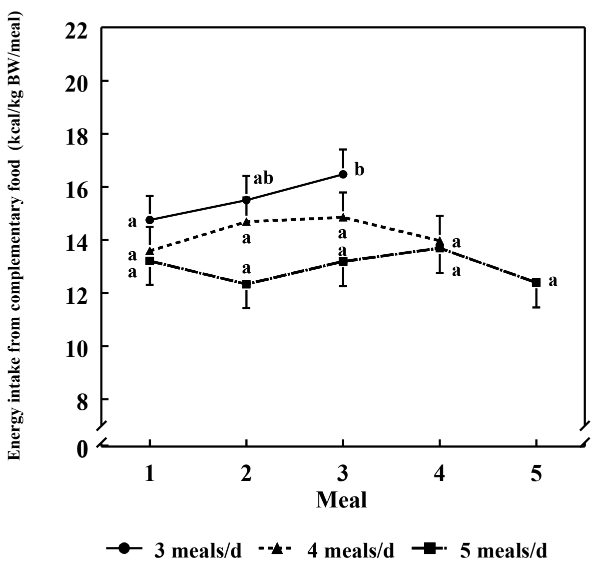

Figure 4. Mean (±SE) energy intake from complementary food (kcal/kg BW/meal) by feeding frequency of complementary foods, controlling for dietary energy density. Energy intake per meal was significantly greater when fewer meals were offered ($p < 0.001$), and there was a significant interaction between feeding frequency and meal number, ($p = 0.019$), ANOVA. Within a particular level of feeding frequency, different letters are significantly different, $p < 0.05$, Tukey's test. BW is body weight.

The meal-specific energy intakes (kcal/kg body weight^{-1} · meal^{-1}) are shown in Figure 5 in relation to dietary energy density controlling for feeding frequency. Energy intakes per meal were significantly greater with higher energy density diets, and energy intakes did not vary by meal number. On the other hand, the energy intakes at each meal tended to increase during the course of the day with the lower energy density diet.

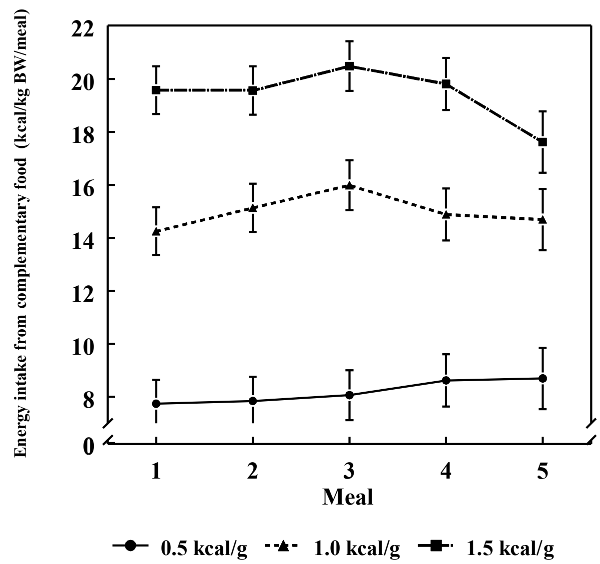

Figure 5. Mean (±SE) energy intake from complementary food (kcal/kg BW/meal) by dietary energy density of complementary foods, controlling for feeding frequency. Energy intake per meal was significantly greater with higher energy density diets ($p < 0.001$) and there was no significant interaction between energy density and meal number, ($p = 0.15$), ANOVA. BW is body weight.

Time expended for food consumption

The time expended during individual meals (min/meal) is shown in relation to the energy density and feeding frequency of complementary food in Table 5. The mean amounts of time expended for each meal ranged from 7.6 to 10.4 minutes in relation to different combinations of dietary energy density and feeding frequency.

Significantly more time was expended to complete individual meals when fewer meals were provided per day ($p < 0.001$) (Figure 6), and there was a significant interaction between feeding frequency and meal number ($p = 0.002$). The time expended per meal did not vary significantly throughout the day when three or four meals were offered; however, the time spent feeding each meal decreased during the day when more meals were provided.

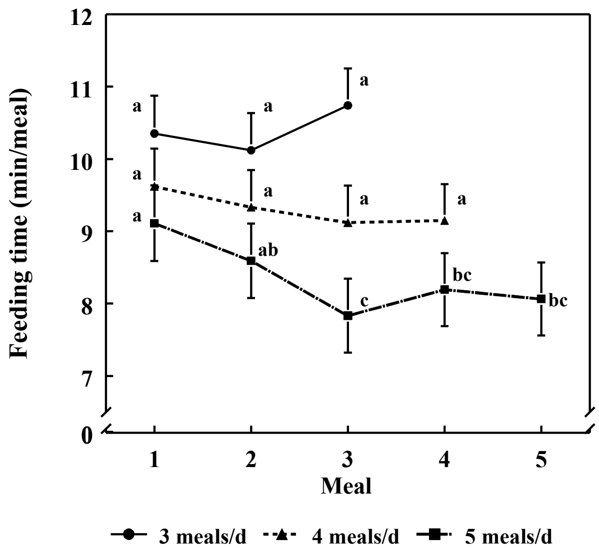

Figure 6. Mean (±SE) complementary feeding time (min/meal) by feeding frequency of complementary foods, controlling for dietary energy density. The time expended per meal was significantly greater when fewer meals were offered per day (p <0.001) and there was a significant interaction between feeding frequency and meal number, (p = 0.002), ANOVA. Within a particular level of feeding frequency, different letters are significantly different, p <0.05, Tukey's test.

There were no significant effects of dietary energy density on time expended per meal (p = 0.77) and no significant interactions between energy density and meal number (Figure 7) (p = 0.144). In general, there was a slight, but non-significant, decline in time per meal during the course of the day, regardless of the dietary energy density.

Food intake velocity

Figure 8 illustrates the velocity of food consumption (g/kg body weight^{-1} · min^{-1}) at each meal in relation to feeding frequency, controlling for dietary energy density. There were no overall differences in feeding velocity by feeding frequency, but there was a significant interaction between feeding frequency and meal number (p = 0.005). When three meals per day were offered there were no meal-wise differences in velocity of food intake, but the velocity of intake increased and declined during the course of the day when four or five meals were provided. Food intake was significantly faster with the low density diet compared with the high density diets (Figure 9), and the intake velocity tended to increase during the day with the low density diets, but not the higher density one.

There was a significant positive relation between the time expended during each meal and the amount of complementary food consumed per minute (p <0.001). Regardless of the energy density and feeding frequency of complementary foods, for each additional minute of duration of each meal, the velocity of food intake (g/min) was 2.7 g greater per meal.

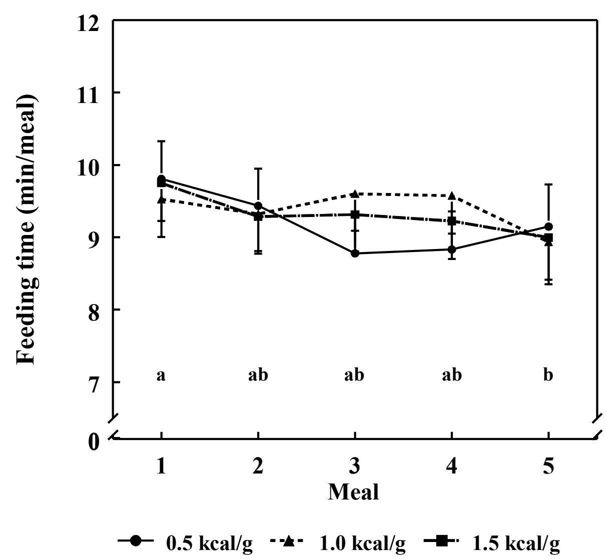

Figure 7. Mean (±SE) complementary feeding time (min/meal) by dietary energy density of complementary foods, controlling for feeding frequency. There was no significant effect of energy density on time expended per meal (p = 0.77) and there was no significant interaction between energy density and meal number, (p = 0.144), ANOVA. For all dietary energy density levels combined, there was significant effect of meal number (p = 0.02) and different letters are significantly different, p <0.05, Tukey's test.

Discussion

The results of this study indicate that the amounts consumed and energy intakes from complementary foods by healthy, breastfed infants 8–11 months age, and the time expended during individual meals of the day are affected by the feeding frequency and energy density of these foods.

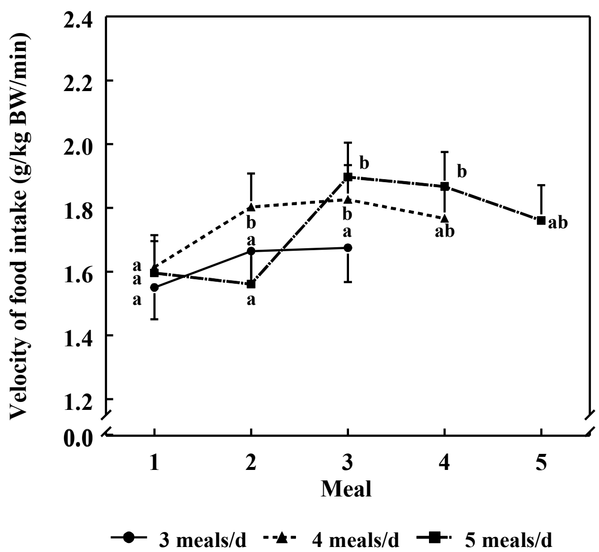

Figure 8. Mean (±SE) velocity of complementary food intake (g/kg BW/min/meal) by feeding frequency of complementary foods, controlling for dietary energy density. The velocity of food intake at each meal was significantly greater when more meals were offered per day ($p < 0.001$), and there was a significant interaction between feeding frequency and meal number, ($p = 0.005$), ANOVA. Within a particular level of feeding frequency, different letters are significantly different, $p < 0.05$, Tukey's test. BW is body weight.

Children tend to consume more during individual meals when they receive lower energy density diets and fewer meals per day. These results are consistent with previously published studies conducted in non-breastfed, recovering malnourished children [5, 6]. Interestingly, children in the current study tended to consume less food during the first meal of the day than the rest of the meals, which was not the case in a previous study [6].

However, the children in the current study were all breastfeeding *ad libitum* day and night. Thus, it is likely that they were partially sated by night-time and early morning breastfeeding before the first meal of the day was served. The children gradually increased their food intake during the first three to four meals of the day and then either decreased or stabilized their intakes during the following meal(s), depending on the different combinations of feeding frequency and energy density. It seems that during periods of higher feeding frequency or energy density the children were more sated earlier in the day, and their intakes declined during the later meals.

The functional gastric capacity of the young children has been defined in previous studies as the amount they consume when energy density and/or feeding frequency is so low that they are unlikely to be meeting their energy needs, and thus consuming maximally.

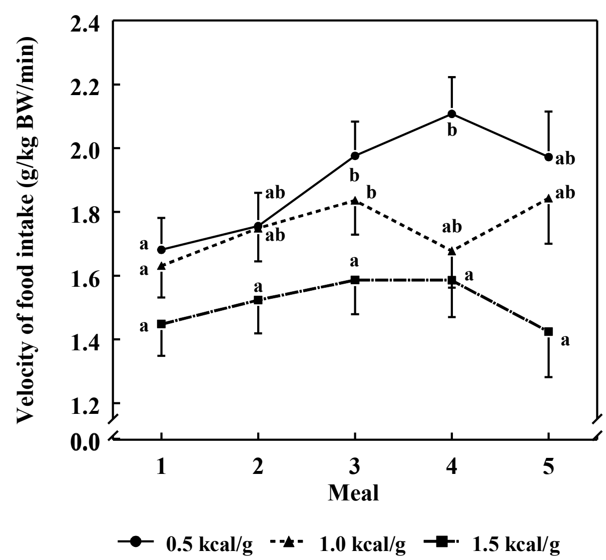

Figure 9. Mean (±SE) complementary food intake (g/kg BW/min/meal) by dietary energy density of complementary foods, controlling for feeding frequency. The velocity of food intake was significantly greater with lower energy density diets ($p < 0.001$), and there was a significant interaction between energy density and meal number, ($p = 0.019$), ANOVA. Within a particular level of dietary energy density, different letters are significantly different, $p < 0.05$, Tukey's test. BW is body weight.

In previous studies of non-breastfed children the functional gastric capacity varied from 40 to 66 g/kg body weight from a single meal when they were receiving a diet containing 0.5 kcal/g five times per day [6].

Table 5. Time expended during individual meals (min/meal), by dietary energy density, feeding frequency and meal number [a]

		Meal number				
		1	2	3	4	5
Energy density (kcal/g)	0.5					
Feeding frequency (meals/day)	3	10.0 (2.7)	9.7 (2.6)	10.0 (2.9)		
	4	9.9 (3.1)	9.4 (3.4)	8.9 (2.7)	8.5 (2.7)	
	5	9.5 (3.3)	9.2 (3.1)	7.4 (2.0)	8.3 (2.6)	8.4 (2.5)
Energy density (kcal/g)	1.0					
Feeding frequency (meals/day)	3	10.4 (3.9)	10.1 (2.9)	10.4 (3.9)		
	4	9.4 (4.8)	9.4 (3.3)	8.6 (3.3)	9.4 (3.5)	
	5	8.8 (3.0)	8.1 (2.6)	8.4 (3.3)	8.4 (2.9)	7.9 (3.0)
Energy density (kcal/g)	1.5					
Feeding frequency (meals/day)	3	10.6 (3.9)	10.1 (2.9)	10.4 (3.9)		
	4	9.6 (3.2)	9.3 (3.3)	9.9 (3.2)	9.5 (3.4)	
	5	9.1 (3.1)	8.5 (3.5)	7.6 (2.5)	7.9 (3.3)	7.9 (2.7)

[a] All values are mean (SD); [b] Main effects by mixed model ANOVA: dietary energy density, $p = 0.78$; feeding frequency, $p < 0.001$; meal number, $p = 0.02$; interaction: dietary energy density X meal number, $p = 0.144$

The maximum single-meal intakes of the children in the present study were considerably less than the previously published information [6, 17, 21], but those studies were conducted in non-breastfed, recovering malnourished children, whose energy intakes from food (and, presumably, the total energy needs) were considerably greater than those of the children in the present study. Thus it is likely that the children in the present study were not eating to their full gastric capacity. Accordingly, the current information on meal-specific amounts of food consumption are probably more realistic estimates of the likely levels of intake by non-malnourished children who are being breastfed *ad libitum*.

The mean feeding times ranged from 7.6 to 10.4 minutes per meal in relation to different combinations of feeding frequency and dietary energy density, which was about half the meal durations observed during previous studies [5, 7, 20]. In two of the three previous studies [5, 7], the children were malnourished, so they may have needed more time to satisfy their higher energy requirements. In the present study, the amount of time required for feeding individual meals varied according to the feeding frequency, but not in relation to dietary energy density. However, the children consumed a greater amount of food per minute when they were fed the lower energy density diets, indicating that they were eating faster under these conditions. These results are consistent with previous observations in non-breastfed children. The children in the current study also ate faster when more meals were provided per day, a finding that differs from a previous study [5]. The reason for the latter difference between studies is uncertain, although the children of the current study were slightly younger than those in previous studies (mean age ~9 months *vs* 12–14 months) and the current children were fed by their mothers, rather than by professional nursing aides. It is possible that the mothers were more responsive to their childrens' feeding cues.

These results provide further evidence of children's self-regulation of food energy intake, even before one year of age. Notably, this regulation occurs at the level of individual meals and is achieved by modifying both the duration of the meal and the velocity of consumption. Not only do these results provide insight into the regulation of food intakes by young children, but they have implications with regard to child feeding practices and caregivers' time requirements for child feeding. Interestingly, there appears to be relatively little variability in total meal duration before satiety is achieved. Thus, it is critical for the caregivers to be attentive to cues that the child is willing to eat and offer sufficient food as it is solicited. In situations where limited caregiver time is available for child feeding, the total amount of time devoted each day can be reduced by lowering the feeding frequency. However, the lower feeding frequency must be compensated for by greater energy density to ensure that adequate energy intake can be achieved, as described elsewhere [19].

Conclusions

Healthy, breastfed children consume a greater amount of food when the food has a lower energy density and fewer meals are offered, but they eat faster under these conditions, thereby practically regulating their daily energy intakes. Moreover, the meal-specific pattern of consumption varies according to the feeding regimen, with intakes increasing progressively when fewer meals and lower energy density diets are offered, but increasing and then declining when higher density diets and more meals are provided.

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